U.S. Department of the Interior
U.S. Geological Survey

Map and data for Quaternary faults and folds in New Mexico

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Open-File Report 98-521 (electronic version)

2000

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ALPHABETICAL LISTING OF FAULTS AND FOLDS

Map and data for Quaternary faults and folds in New Mexico

by

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Prepared as part of the U.S. Geological Survey's
Earthquake Reduction Program (ERP) project on
UNITED STATES MAP OF QUATERNARY FAULTS AND FOLDS
In cooperation with the International Lithosphere Program's
Task Group II-2, World Map of Major Active Faults
Michael N. Machette, Co-chairman

A collaborative effort of the U.S. Geological Survey, New Mexico Bureau
of Mines and Mineral Resources, Academia, and Industry

Introduction

The "World Map of Major Active Faults" Task Group is compiling a series of digital maps for the United States and other countries in the Western Hemisphere that show the locations, ages, and activity rates of major earthquake-related features such as faults and fault-related folds; the companion database includes published information on these seismogenic features. The Western Hemisphere effort is sponsored by International Lithosphere Program (ILP) Task Group II-2, whereas the effort to compile a new map and database for the United States is funded by the Earthquake Reduction Program (ERP) through the U.S. Geological Survey. The maps and accompanying databases represent a key contribution to the new Global Seismic Hazards Assessment Program (ILP Task Group II-0) for the International Decade for Natural Disaster Reduction. This compilation, which describes evidence for surface faulting and folding in New Mexico, is the third of many similar State and regional compilations that are planned for the U.S. The compilation for West Texas is available as U.S. Geological Survey Open-File Report 96-002 (Collins and others, 1996 #993) and the compilation for Montana will be released as a Montana Bureau of Mines product (Haller and others, in press #1750).

This compilation is presented as a traditional map product and printed catalog of data; however both should be available in digital form in the future. The database provides referenced data on a variety of geographic, geologic, and paleoseismologic parameters. The fault data were compiled by the senior authors (Michael Machette and Stephen Personius, USGS; and Keith I. Kelson, WLA) as part of ongoing studies of Quaternary faulting in the New Mexico portion of the Rio Grande rift. The U.S.

Geological Survey authors are responsible for organizing and integrating State and regional products under the national project, including the coordination and oversight of contributions from individuals and groups (Michael N. Machette), database design and management (Kathleen M. Haller), and digitization and manipulation of map data (Richard L. Dart).

Strategy for Map and Database

The primary intention of this compilation is for use in seismic-hazard evaluations. For studies of regions of low to moderate seismicity, it is particularly important to incorporate geologic information on discrete faults that have evidence of Quaternary movement. Paleoseismic studies, which evaluate the history of surface faulting or deformation along a given structure, provide a long-term perspective that helps augment the relatively short historic records of seismicity in many regions. In particular, the frequency and location of large-magnitude earthquakes in many parts of the U.S. is poorly defined by the historic record of seismicity. Thus, an understanding of the seismogenic characteristics of prehistoric (Quaternary) faults may prove vital to improving seismic-hazard assessments in critical regions having low to moderate levels of historic seismicity.

The map and database have been designed for the few well-studied faults that are present in the United States. However, the bulk of seismogenic structures are relatively poorly studied, thus giving the appearance that the database is incomplete (*i.e.*, unnamed faults, fields that have no data, or sparse descriptions). Nevertheless, the fault map and database parameters provide a systematic basis for which these structures can be assessed as potential seismic sources and yet allows us to expand the database with the completion of new studies. Thus, we are assembling a dynamic database (one that will be augmented and updated through time); this report is the first iteration of the database for New Mexico.

The map shows faults and folds that exhibit evidence of Quaternary surface movement related to faulting, including data on timing of most recent movement, sense of movement, slip rate, and continuity of surface expression. Fault traces were taken from original sources and compiled on 1° x 2° quadrangle (1:250,000-scale) or 1/2° x 1° quadrangle (1:100,000 scale) base maps. The traces were digitized for use in *Arc/Info—Geographic Information System (GIS) software that permits rescaling, output in a wide variety or projections, and attribution (assigning colors, line weights, and symbols). In addition to location and style of faulting, the map shows the time of most recent movement and slip-rate category (as a proxy for fault activity) for each structure. These data, as well as name and affiliation of the compiler, date of compilation, and geographic and other paleoseismologic parameters are included in the database. Published data or publicly available data (NEHRP contract reports, theses, etc.) are referenced extensively throughout the report. Citations are in standard USGS format, with the exception that we include a database reference number (e.g., Haller and others, 1993 #655). When the computer version of the database is implemented, the user will be able to search for data in a specific field or a combination of fields. Nonsearchable fields, such as "Comments", document the source of data and any provisions that might exist about its use.

For purposes of map presentation, the timing of most recent fault movement (*i.e.*, surface rupture) is depicted by one of five categories: historic (date), Holocene and latest Pleistocene (<15 ka: category 1, plate 1), late Quaternary (<130 ka: category 2, plate 1), late and middle Quaternary (<750 ka: category 3, plate 1), and Quaternary or suspected Quaternary (<1.6 Ma: category 4, plate 1). These categories permit defining a maximum time of movement without constraining the minimum time, which typically requires more detailed studies. This strategy allows estimates to be made where published data are sparse or where there are conflicts in evidence for timing. For example, if Holocene (<10 ka) movement is suspected but only late Pleistocene (10-130 ka) movement can be documented, then the inclusive late Quaternary (<130 ka) category is used for the time of the most recent movement. In terms of this map, no faults in New Mexico are known to have had surface-rupturing earthquakes in historic time, so only the older four age categories are shown on the map. However, a large earthquake occurred just southeast of the New Mexico/Arizona/Mexico border (in northeastern Sonora, Mexico) in 1887 and caused nearly 75 km of surface rupturing, thereby indicating that the region has potential for large earthquakes. In addition to known surface faults, some Quaternary faults that are suspected or inferred from subsur-

*Use of trade or brand names, such as Arc/Info, are for descriptive purposes and do not constitute endorsement by the U.S. Geological Survey or the Department of Interior.

face or other data are shown as dotted lines (*i.e*., buried structures). Conversely, structures with known late Tertiary (or older) movement are not shown unless there is sufficient evidence of Quaternary movement (geomorphology, offset surficial deposits, etc.). This conservative depiction of faults yields a map with defensible potential sources of future ground rupturing based on Quaternary history (1.6 million years), whereas a less conservative depiction would yield a "neotectonic map" that may or may not be of use for seismic-hazards analyses. Also, the occurrence of seismicity that is associated or aligned with pre-Quaternary (*i.e.,* Neogene) faults or buried faults is not compelling enough evidence (alone) to add these structures to our map and database.

We use slip rate as a graphical representation of fault activity on the map. Fault slip rates (and fold uplift rate) are depicted on the map by categories (and shown by line thicknesses) that encompass all rates on a national scale. Four slip-rate categories have been defined for this project: less than 0.2 mm/yr, 0.2-1 mm/yr, 1-5 mm/yr, and greater than 5 mm/yr. These broad categories segregate most intraplate structures (<1 mm/yr) from major plate-bounding structures (generally >5 mm/yr). The 1-5 mm/yr slip-rate category typically includes major intraplate faults such as the Wasatch fault zone in Utah and strike-slip faults such as the Garlock fault in California. All of the faults in New Mexico are characterized by published or inferred slip rates of less than 1 mm/yr, and all but four faults have published or inferred rates of less than 0.2 mm/yr. If no published slip rate exists (*i.e*., "unknown"), the compiler has assigned the fault to an appropriate slip-rate category as determined from his or her impressions of the activity of this and other associated structures in the region. This assignment to a unique slip-rate category is necessitated by the map's line-thickness portrayal of fault activity. Where available, the length of time for which the estimated slip rate applies is shown in the database. The absence or presence of recent movement over some time interval may be a basis for estimating a crude slip rate and one can use a variety of geomorphic and geologic relations to place a fault in its most likely most recent movement (time)category. For example, a normal fault that does not cut latest Pleistocene (10-15 ka) deposits probably has an average slip rate of less than 1 mm/yr because during this time interval (10-15 k.y.) at least 10-15 m of potential slip would be expected to accumulate at average rates of 1 mm/yr (or greater); this amount of accumulated slip most likely would be released in several large surface-rupturing earthquakes. An exception to this generalization is faults that show evidence of temporal clustering; that is, episodes of movement (several faulting events) separated by longer intervals of tectonic quiescence. In such cases, the average slip rate could be considerably less than that calculated for an intra-cluster interval of time. Cases such as this are becoming more apparent in the literature as researchers conduct paleoseismic studies of faulting, especially in intraplate regions.

The database includes a number of fields that provide supporting information on the previously mentioned parameters, as well as additional descriptive information on geologic and paleoseismologic parameters not depicted on the map. The descriptive information includes fault name and number, a brief synopsis, compilation information, and physical location of the structure. Because the project will integrate data from the entire United States, the database requires that each structure have a unique number (in the text, a fault's number is enclosed by square brackets, such as [900]). In general, most of the structures in a given state or region are sequentially numbered on a geographic basis. Names are determined from the literature and from common usage and although some structures in different regions have the same name or a similar name, no attempt was made to avoid such duplications. Geologic data include geologic setting, geomorphic expression, and age of faulted deposits, all in descriptive form. Additional paleoseismologic data include descriptions of detailed studies (*i.e.*, trenching) that we are aware of and estimates of recurrence intervals. Field names are shown in bold and are defined in Defination of Terms (see also, general guidelines published by Haller and others, 1993 #655). When the computer database version is implemented, the user will be able to search for data in a specific field or a combination of fields. Nonsearchable fields, such as "Comments", document the source of data and any provisions that might exist about its use.

Compilations such as this one provide a useful tool for making comparisons of spatial and temporal patterns of faulting at local, regional, and national scales. However, a database is a powerful tool only if it represents a systematic collection of data, which must inherently rely heavily on the knowledge of the compiler. With this in mind, we favor published or publicly accessible data and reference it as completely as possible. An effort has been made to include all pertinent data, especially where conflicts may be apparent. Where multiple interpretations exist in the literature, we use a hierarchy that defines what data will be presented in the primary database fields in order to achieve some level of consistency. We give highest priority to fault-related studies, particularly those addressing the Quaternary history of a fault (*i.e*., paleoseismic investigations), over general geologic studies (*i.e*., bedrock mapping). In most cases, more recent studies are given priority, although some older studies (pre-1970s) are quite helpful and authoritative. Faults and folds based on detailed mapping (*e.g.*, 1:24,000 scale) are given priority over those based on less detail (*e.g.*, 1:250,000 scale).

Thus, even though we give the most weight to recent topical studies of Quaternary faulting (*i.e.*, paleoseismology*)*, alternative interpretations based on other types of studies are provided in the appropriate “Comments” field.

The majority of the 145 Quaternary faults that we have described for New Mexico (table 1) are characterized by rather limited investigations; however, as previously mentioned the database is designed for well-studied faults in regions of high seismicity and historical faulting, such as California and Nevada. In order to accommodate large differences in the level of study from fault to fault, we established three types of fault descriptions to simplify data compilation and readily convey the level of current knowledge. All structures are described as either simple, or having sections. In general, simple faults are poorly known, have few or no paleoseismologic studies, are characterized by a single time and slip-rate category for their entire length, and are typically less than 20-30 km in length. At the other end of the spectrum are segmented faults—those comprised of seismogenic and structural entities (segments) that are known to act independently of one another during large surface-rupturing earthquakes on the basis of detailed studies. By our standards (and definitions), the timing of surface-rupturing events on segments of a fault must be well established through trenching and dating studies or the presence of historical surface ruptures, and there should be supporting geomorphologic and geologic data (scarp morphology, stratigraphic control on times of faulting, geologic structures that may control physical segmentation, *etc*.). In some cases, pronounced contrasts in the geomorphic expression of faulting along strike combined with paleoseismic studies that define the chronology of the youngest events on the fault are sufficient to permit discussion of the structure in terms of segments. However popular the use of the term segment is, we have decided to treat all fault segments as sections in this compilation. Thus, no faults in New Mexico are described herein as having segments, but rather 15 of the 145 faults are described as having sections. Sections may be defined on the basis of relative-age criteria, by fault geometry, by the presence, morphology or preservation of scarps, from a single trench, or from other geologic data (gravity, structure, *etc*.). All of the simple faults are shown on the map and listed in the database by a three-digit numeric identifier (*e.g.*, [900]). The sectioned faults are identified by an additional lowercase alpha character (*e.g.*, [2007a], [2007b]). The alpha characters (a-d) are unique to each of the sections; “a” is assigned to the northernmost (or westernmost) section and “d” to the southernmost (or easternmost) section.

Synopsis of Quaternary Faulting and Folding in New Mexico

Previous compilations of Quaternary faults in New Mexico were included in regional studies by Howard and others (1978 #312) and Nakata and others (1982 #147). Both compilations were traditional map products that showed location and age of youngest known displacement. The majority of the data for New Mexico came from unpublished studies by Machette. However, no supporting data were included on the map sheets nor were the faults described in additional text. Other regional compilations of faulting (Machette and Personius, 1984 #1113; Personius and Machette, 1984 #1124; Machette and others, 1986 #1033) at 1:250,000 scale included specific data on amount and age of offset deposits. However, faults shown in their oldest category (early Quaternary to Pliocene) are not included herein owing to probable pre-Quaternary movement. Since these early compilations, additional faults have be recognized in this region and at least a dozen detailed studies have been performed to better constrain various paleoseismologic characteristics for selected faults.

Overview of Quaternary faults and folds

This database includes 145 described Quaternary faults or fault zones, and collections of faults having similar characteristics—collectively, there must be at least 250 individual faults with surface expression. Of the described faults, 128 are classified as simple and 15 are classified as having sections. Sixteen faults (11%) have formed recognizable scarps during the Holocene or latest Pleistocene (past 15 ka), whereas late Quaternary (less than 130 ka) movement has occurred on 31 other faults (21%) (see table 1). The Holocene or latest Pleistocene faults may have contributed about 21 large surface-rupturing earthquakes during this time interval because some of the faults (1) have multiple sections (*i.e.*, Alamogordo [2054], Caballo [2088], La Jencia [2109], and southern Sangre de Cristo [2017] faults that might have each had earthquakes), or (2) had multiple latest Quaternary earthquakes (Organ Mountains

[2052]) (see Machette, in press #1751). From this data, one can estimate an average return time for large surface-rupturing earthquake (M.6.25±0.25, Machette, in press #1751) in the rift (or the whole state of New Mexico) of about 1,000 years (16 earthquakes, thus 15 intervals, in 15 k.y.) to 750 years (21 earthquakes, thus 20 intervals, in 15 k.y). Further detailed investigations that document additional Holocene or latest Pleistocene faults or additional faulting events will only lower this calculated return time. Looking back further in the geologic record, there appears to have been late or middle Quaternary (past 750 ka) movement on 54 faults (37%), and Quaternary movement is documented on the remaining 42 faults (30%). To a certain extent, the spatial distribution and evidence for recency of movement on faults is controlled by the age of landforms that the fault crosses. For example, fault scarps preserved on broad isolated surfaces of middle to early Quaternary age will typically be shown as <750 ka, whereas the timing of movement on faults traversing a variety of ages of Quaternary surfaces (late Pleistocene to early Quaternary) can be distinguished more precisely.

Quaternary faults in New Mexico are characterized by recurrence intervals ranging from as little as 5-15 k.y. for the most active structures to at least 100-250 k.y. for the less active structures. The resultant slip rates are typically low: all but the East Franklin Mountains [900], southern Sangre de Cristo [2017], Valle Vidal [2018], Tijeras-Cañoncito [2033], and Organ Mountains [2052] faults (all classified as 0.2-1.0 mm/yr) have rates that fall into the less than 0.2 mm/yr category. However, of the Quaternary faults in New Mexico, most do not have published or well documented slip rates, and are largely characterized as "unknown but probably <0.2 mm/yr."

Much of the data in this compilation is from reconnaissance field studies by the senior authors: only 11 faults in New Mexico have been trenched in order to establish their paleoseismic history. These include the East Franklin Mountain [900], Parajito [2008], Rendija Canyon [2026], Guaje Mountain [2027], County Dump [2038], East Paradise [2040], Organ Mountains [2052], San Andres [2053], Caballo [2088], La Jencia [2109], and Hubble Springs [2120] faults. Paleoseismic studies on these faults, and others in the Rio Grande rift of West Texas (Collins and others, 1996 #993), have shown that recurrent movement is prevalent on the Quaternary faults, but that their recurrence intervals may differ by as much as an order of magnitude (*i.e.*, 10-20 k.y. versus as much as 100-200 k.y.). Of the Quaternary faults in New Mexico, the most active are probably the East Franklin Mountains [900], Parajito [2008], southern Sangre de Cristo [2017], Rendija Canyon [2026], Guaje Mountain [2027], Organ Mountains [2052], San Andres [2053], Alamogordo [2054], Caballo [2088], and Socorro Canyon [2108]. Most of these faults have been studied in a detailed manner, either involving detailed mapping of the trace and associated Quaternary deposits or through trenching and paleoseismic studies.

Although recurrence intervals of >10-20 k.y. may seem long, they are typical of faults in intraplate regions such as the Basin and Range province. However, if one considers that a site may be affected by any of a number of potentially active faults within a certain range (*e.g.*, 50-100 km radius), then the concept of a *composite recurrence interval* should be considered for the sitting of critical facilities, such as dams, powerplants, military facilities, *etc*. For example, if there were 10 faults each having individual average recurrence intervals of 40 k.y. within a certain distance of a critical facility, then the site might be affected by strong ground shaking associated with local surface faulting once every 4,000 years (on average) as a result of an exposure to a large number of low slip-rate faults (and this does not account for the occurrence of background or non-surface rupturing earthquakes). Along similar lines, Machette (1987 #960) has shown that the East Franklin Mountains fault [900] is just the southern one-quarter of a 182-km-long fault system that extends from south of the International Border with Mexico (in the city of Juarez) north through El Paso and Fort Bliss, and into New Mexico along the west side of White Sands Missile Range. The East Franklin Mountains/San Andres fault system (faults [900], [2051], [2052], [2053], and [2054]) forms one of the longest, active normal fault systems in the Rio Grande rift, exceeded in length only by the Sangre de Cristo fault zone, which extends almost 250 km across northern New Mexico and southern Colorado.

The active range-bounding faults in the rift have long histories of recurrent movement as documented by Quaternary scarps as much as 30-120 m high on early Quaternary deposits (see for example, the Parajito fault [2008]). Many of the faults in the rift are long (>30 km) or are linked to form a longer system. Machette (1987 #960) estimated that the East Franklin Mountains/San Andres fault system is comprised of five discrete faults or fault sections that each have probable recurrence intervals of 10-20 k.y. for major surface-rupturing earthquakes (M>6.5). If this is true, then a major surface-rupturing earthquake may occur about once every 2,000-4,000 years somewhere on the fault system. The majority of these earthquakes would most affect the White Sands area of southern New Mexico (military complexes and associated towns such as Alamogordo), although strong ground shaking could also affect the El Paso/Juarez metropolitan area. El Paso has nearly 600,000 people living in a relatively small area (El Paso County), whereas Ciudad Juarez just across the Rio Grande has a burgeoning population roughly estimated to be at least 1.2 million in 1990 (J.R. Keaton, oral commun., 1991).

Seismicity in the rift is relatively diffuse with few meaningful associations with active faults. Much of the felt (pre-instrument) seismicity for the period 1849-1961 (Northrup, 1976 #1752) was concentrated along the Rio Grande Valley between Albuquerque and Socorro. The historical documentation of these earthquakes probably reflects the distribution of population along the river (an agrarian society) and local sources of low to moderate seismicity. The swarm of earthquakes that occurred at Socorro in 1906 (MM VIII Sanford and others, 1991 #1753) was likely a result of magma movement at depth, and Socorro area continues to be a focus of small, but numerous earthquakes of probable intrusive origin. Likewise, the distribution of instrumentally recorded M≥2.5 earthquakes in New Mexico for the period of 1962-86 (figure 5 in Sanford and others, 1991 #1753), shows only a weak association with the rift and some of the transverse structures such as the Jemez lineament that seem to control the geometry of the rift (i.e., accommodation zones, see Machette, in press #1751).

Within New Mexico between 1962 and 1986, there were only six earthquakes larger than M 3.5, and the largest of these (1966 MS 4.6-4.9 in Sanford and others, 1991 #1753) occurred on the Colorado Plateau near the border with Colorado. The largest earthquakes located within the Rio Grande rift have been a M 5.0 in 1989 near Bernardo (between Socorro and Belen, New Mexico) (Sanford and others, 1991 #1753) and a M 6.4 in 1931 near Valentine, Texas (Doser, 1987 #904), about 230 km southeast of El Paso. Although the Valentine earthquake was apparently not quite large enough to cause demonstrable surface faulting, the epicentral area is characterized by Quaternary faults, some of which have been active in the past 15 k.y. Also, it is interesting to note that on the basis of instrumental data (through 1987), the Great Plains and Colorado Plateaus—two provinces adjacent to the Rio Grande rift that are considered to be tectonically stable—had equivalent or greater seismicity than the rift (Sanford and others, 1991 #1753).

Discussion

The fault map for New Mexico (plate 1) reveals a pattern of sparse, but distributed faulting and minor folding within the Rio Grande rift, dominated by normal displacement on north-south faults coupled with normal to oblique(?) displacement on NE-SW-trending transverse (or accommodation) zones (Machette and Hawley, 1996 #1754). The rift faults are primarily intrabasin (> 75 percent), with lesser range-front (about 20 percent) and transverse (< 5 percent) structures. Recent studies have suggested that the transverse zones may compartmentalize deformation, and control basin sedimentation and fault geometry (Hawley and Whitworth, 1996 #1303), as well as control fault geometry and provide structural discontinuities that may allow segmentation of the longer more active (Machette and Hawley, 1996 #1754; Machette, in press #1751). If this is so, then transverse zones may control or greatly influence the potential length, deformation paths, and magnitude of many surface-faulting earthquakes in the rift. For example, detailed analysis of the subsurface stratigraphy of the northern Albuquerque Basin, coupled with new aeromagnetic surveys and mapping of surficial and upper Santa Fe Group sediments, is revealing a complex pattern of Quaternary deformation, much of which is broadly controlled by transverse structures. Few late Quaternary faults have been found outside the commonly accepted bounds of the rift, although there some exceptions in the Colorado Plateaus Province (northwest sector of the map, plate 1). In addition, NW-trending Neogene range-front faults, which bound features such as the Mangas and Winston grabens, generally lack evidence of Quaternary displacement and, thus, are probably artifacts of an earlier and different stress regime.

Distinct tectonic pulses that represent a departure from continuum Neogene deformation in the Rio Grande rift are being recognized from stratigraphic, sedimentologic, and apatite fission-track studies (see (see Chapin and others, 1992 #1755; Kelley and Chapin, 1996 #1756). The most recent pulse (late Miocene to early Pliocene) formed the elongate chain-of-basins that characterize the present rift. As tectonism waned in the Pliocene, these basins became fully integrated by the Rio Grande. Past analyses of the ages of Quaternary deposits and deformation rates were based on an assumed 500 ka age for the Llano de Albuquerque and similar ancient basin-floor surfaces (La Mesa, Cuchillo, Lomas de las Canas) to the south (see Machette, 1985 #1267). However, reinterpretations of stratigraphic relations involving local Quaternary basalts, volcanic tephras, and reworked pumice deposits from the Pleistocene eruptions of the Jemez caldera, reveal an earlier time for the ultimate filling of the rift basins. The culmination of filling and inception of Rio Grande incision occurred at 700-900 ka in Las Cruces area and perhaps ≥1 Ma in the Albuquerque area. If these revised age estimates hold, then the datums for extensional faulting events recorded by these old geomorphic surfaces could be twice as old as previously thought. Average slip rates on the most active rift faults are commonly <0.1-0.2 mm/yr, which may be typical of faulting in extensional regimes of the Western U.S. With respect to age distribution, recurrence interval, and slip rate, fault activity in the Rio Grande rift is comparable to that of the central Basin and Range province. Conversely, some of the highest extensional slip rates in the Western U.S. come from the Wasatch fault zone (1-2 mm/yr for the Holocene) and those basin-range faults affected by the passing of the Yellowstone Hot Spot (see Pierce and Morgan, 1992 #539). These relatively high rates of activity might only have occurred in the rift during tectonic pulses (*i.e.,* late Miocene-Pliocene) when most of the Neogene extension was accomplished.

Summary

Most Quaternary faults in the rift have long recurrence intervals (>50 k.y. to 250 k.y.) and low slip rates (<0.2 mm/yr, but commonly 0.01-0.02 mm/yr), which is consistent with occurrence of primarily low- to moderate-magnitude earthquakes that have been recorded or felt historically in New Mexico (Machette, in press #1751). In general, earthquakes up to magnitude M 5, and occasionally M 6, can occur anywhere in New Mexico, but surface rupturing earthquakes (M>6.25±0.25) are expected to be associated with reactivation of pre-existing Quaternary faults, most of which are concentrated within the Rio Grande rift. Our current estimate is that such earthquakes have striken the rift on an average of once every 750-1000 years (at the most) during the past 15 k.y. The abundance and location of Quaternary faults provides a paleoseismic basis for estimating a level of seismic hazard in the rift greater than indicated only by seismicity or currently perceived by the public and scientific community (see Machette, in press #1751). The rupture lengths and displacement amounts documented for some of the major faults in the rift suggest that they are the result of rare (millennia scale), but major surface-faulting paleoearthquakes having magnitudes of about 6.25 to perhaps as much as 7.5 (M_S). These data also suggest that the 1887 earthquake (M_W 7.2-7.4) on the Piticaychi fault in northern Sonora, Mexico (Bull and Pearthree, 1988 #231), is probably a geologically reasonable historic analog for a major surface-rupturing earthquake (*i.e.*, worst-case scenario) on a major Quaternary fault in the rift.

Acknowledgments

The authors appreciate the support of the National Earthquake Hazards Reduction Program (NEHRP), which has funded much of the work cited in this report, and the assistance of numerous individuals who either reviewed portions of the report or supplied information for the report. In particular, we are grateful to William Seager (New Mexico State University, Las Cruces, New Mexico), Susan Olig (Woodward-Clyde Federal Services, Oakland, California), and David Love, Sean O'Connell, John Hawley, and Richard Chamberlin (New Mexico Bureau of Mines and Mineral Resources, Socorro and Albuquerque, New Mexico) for their careful and constructive review comments. Keith Kelson's work on this compilation was generously supported by William Lettis and Associates (Walnut Creek, California) as part of their professional development program.

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Definition of Database Terms

Specialized fields (shown in bold letters) provide abstracted data, most of which will be in searchable fields when the digital database is released. In addition to the searchable fields, more detailed information is provided in the "Comments" section. If no pertinent information was found in the published literature for a field, we show "none" or "not reported". The following description provides definitions of fields (in alphabetic order) and indicates where various information, if known, can be found. In-text citations of references are presented in a standard format with the exception of the addition of a reference-specific number at the end. This reference number allows us to omit the traditional alpha character for authors having multi-year publications (*e.g.*, 1988a, b). All fault numbers cited in the text are bounded by brackets [ ] to differentiate them from reference numbers.

Age of faulted surficial deposits This field includes the ages of faulted deposits *at the surface*. In general, these data are from surficial geologic mapping, but in a few cases they may be from descriptions in referenced work. In some cases, the age of faulted deposits may not agree with the time of the most recent paleoevent. This inconsistency may arise because of the manner in which particular studies are given preferable citation based on recency and scope of the study.

Average strike The length-weighted average strike of the trace of the structure in azimuthal degrees followed by one standard deviation of the average strike. The standard deviation is given to provide a general impression of the sinuosity or variability in strike of the mapped structure. The azimuthal values are confined to the northwest and northeast quadrants of the compass (*i.e.*, 0°-90° and 271°-359°).

Compiler and affiliation The name and affiliation of the person(s) primarily responsible for compilation or revision of data presented for the structure. Full names and address of these compilers are shown in the list of contributors. If separate faults dip in different directions, multiple directions may be shown.

County If the structure is in more than one county, we list the county in which the majority of the structure is located, followed by county name(s) for the remainder of the structure.

Date of compilation This field shows when data were compiled (or revised) for this project (*e.g.*, 03/13/98; month/day/year).

Detailed studies This field includes a synopsis of detailed site-specific studies, typically those involving exploratory trenching. Sites of morphologic studies or detailed mapping (without trenching) are not herein classified as detailed studies. Study sites are numbered sequentially from north to south or west to east in the format of fault number, section letter, and site number (*e.g.*, 601c-3). Paleoseismic data from these studies are included in appropriate fields that document recurrence interval, slip rate, and time of most recent paleoevent.

Dip Measured dip or range of dip values. In many cases, these data are near-surface measurements at specific locations. Additional data, such as approximate location and the type of material in which the fault is exposed, are included in "Comments".

Dip direction General down-dip direction(s) of the structure defined by compass quadrants: north (N), west (W), south (S), east (E), northwest (NW), northeast (NE), southwest (SW), southeast (SE), or vertical (V).

Geologic setting This statement provides a generalized perspective of the fault in terms of its regional geologic setting, amount of total offset, and general age of offset strata.

Geomorphic expression General description of the structure's geomorphic expression including the presence or absence of fault scarps, offset streams, monoclines, shutter ridges, associated landslides, *etc*.

Historical Surface Faulting This field (and associated fields) describes surface faulting from historical earthquakes. No such evidence is present in New Mexico; thus no descriptions are included. However, there is evidence for such an event in northwestern Sonora, Mexico, just 20 km from the southwest corner of New Mexico.

Length This field specifies two types of length data. The first is the end-to-end length of the Quaternary-age fault as measured from the most distal ends of the digital data. The ends of overlapping or echelon traces are projected to a line defined by the average strike and the length is then determined from those projected end points. In cases where numerous faults are collected under one description, this length is shown as "not applicable". The second type of length is the trace length. This length is the sum of lengths of the actual map traces. Faults or fault zones with multiple (overlapping) strands typically have cumulative trace lengths that exceed the end-to-end length by a factor of 1.5 or more.

Name (**Structure name** or **Section name**) The earliest referenced name for a fault, fold, or fault section (where appropriate) generally is given preference, except in cases where a more commonly accepted name is widely used in the recent literature. "Comments" also contains other names and references in which they are used, the geographic limits of the structure, north to south or west to east, as shown in this compilation; various geographic limits that are different in other studies are also included. Minor changes in original name may have been made for reasons of clarity or consistency where appropriate. We have found no faults in New Mexico that justify using the segment nomenclature.

Number

Structure number The structure (fault or fold) is assigned a number within the predetermined limits for the region. References to the same structure shown in other compilations are included in "Comments".

Section number A lower-case alpha character is assigned to the northernmost or westernmost section of a fault (*e.g.*, fault 207 has three sections: 207a, 207b, and 207c).

Number of sections (only used for faults with sections) Numeric value for number of sections (*e.g.*, 4) defined in studies for this compilation. "Comments" include reference in which sections are discussed; if the term "segment" is used in the literature, an explanation of why "section" is used in the database is provided.

1° x 2° sheet If the structure is mapped in more than one 1° x 2° quadrangle, the name of the quadrangle in which the majority of the structure is located is listed first, followed by quadrangle name(s) for the remainder of the structure.

Province Field contains physiographic province names defined by Fenneman and Johnson (1946 #461).

Recurrence interval Time interval in years (based on historic data, calendric or calibrated radiocarbon dates), in ^{14}C years (based on uncalibrated radiocarbon dates), in k.y. (based on less precise dating methods, stratigraphy, or geomorphology), or not reported. Also included is the time interval (in parenthesis) for which this recurrence interval is valid. (*e.g.*, 10-130 k.y.) Alternative published recurrence intervals, starting with that which applies to the most recent time interval, are included in "Comments. "

References A complete bibliographic citation (USGS style) is included for all references for each structure, and collectively for all structures in the database. In-text citations of references are presented in a standard format with the exception of the addition of a reference-specific number at the end. This reference number allows us to omit the traditional alpha character for authors having multi-year publications (*e.g.*, 1988a, b). All fault numbers cited in the text are bounded by brackets (*i.e.*, [2015]) to differentiate them from reference numbers.

Reliability of location Reliability of location (Good or Poor) is related to the scale of the source map for the trace of the structure and to the method by which the trace of the structure was mapped. To qualify as a "Good" location, the trace of the structure must have been published on a topographic base map at a scale of 1:250,000 or larger (more detailed) and have been accurately located on original map using photogrammetry or similar methods, or the trace of the structure was published on a topographic base map at a scale of 1:100,000 or more detailed, but transferred without photogrammetric methods. Traces that do not meet the above standards (less detailed scale, planimetric base, transfer by inspection, etc.) constitute a "Poor" location. Judgments of reliability may not directly relate to line symbols (solid, dashed, dotted) that are used; however, all concealed or inferred faults are considered poorly located.

Section name (see **Name**)

Section number (see **Number**)

Sense of movement Includes thrust, less than 45° dip; reverse, greater than 45° dip; dextral, right lateral; sinistral, left lateral; or normal. For oblique slip, principle sense of movement is followed by secondary sense (*e.g.*, dextral>normal). Ratios of the slip components are included, where known to better characterize the sense of movement (*e.g.*, dextral/normal 3:1).

Slip-rate category The primary field shows one of four slip-rate categories use for the map part of this compilation: <0.2 mm/yr, 0.2-<1 mm/yr, 1-5 mm/yr, >5 mm/yr. In New Mexico, the only rates that apply are the <0.2 mm/yr and 0.2 to <1 mm/yr categories. "Unknown" precedes the suspected slip-rate category if no published slip rate is known. "Comments" include a synopsis of published slip rates and pertinent documentation. Generally speaking, there are two types of slip rates. The first type is termed a "Geologic slip rate" and is typically derived from the age and amount of offset of surficial geologic deposits. These rates are not precise, but allow one to place broad limits on possible slip rates, and hence characterize the fault in one of the above-mentioned categories. The second type of slip rate is termed a "Paleoseismic slip rate" and is derived from times of faulting events and amounts of offset of geologic datums or piercing points. This type of slip rate is more precise, but is rare owing to the extensive amount of work involved (*i.e.*, detailed paleoseismologic studies involving trenching and numeric dating). Most slip rates for faults in New Mexico are of the geologic type.

State If the structure is in more than one state, the state in which the majority of the structure is located is listed first, followed by the state name(s) for the remainder of the structure.

Structure name (see **Name)**

Structure number (see **Number)**

Synopsis This field provides a short summary that describes the level of study, and provides a snapshot of the scope of data that follows in the database.

Timing of most recent paleoevent (faulting or folding event) The primary field shows one of the four prehistoric time categories: latest Quaternary (Holocene and latest Pleistocene, <15 ka), late Quaternary (Holocene and late Pleistocene, <130 ka), middle and late Quaternary (<750 ka), or Quaternary (<1.6 Ma). This field only documents prehistoric surface faulting. If there is historical surface faulting or folding, it would be documented under "Historical Surface Faulting".

Fault and Fold Database

The following discussion of Quaternary faults and folds in New Mexico are organized by the number we have assigned to the structure. If a fault is present in more than one state, the number was assigned from that state in which the majority of the structure lies. For example, fault [900] (the East Franklin Mountains fault) is primarily in Texas and it represents the first fault in the Texas database (see Collins and others, 1996 #993).

900, East Franklin Mountains fault

Structure Number 900
Comments: Referred to as fault 6 by Machette (1987 #847).

Structure Name East Franklin Mountains fault
Comments: Named by Machette (1987 #847). The fault extends from the northeast margin of the Franklin Mountains in southern New Mexico, south through Texas along the Franklin Mountains and across the Rio Grande along the southeast margin of the Sierra de Juárez in Chihuahua, Mexico.

Synopsis: This long fault forms a series of range-front scarps along the eastern base of the Franklin Mountains, primarily in West Texas. Studies of scarp morphology and reconnaissance mapping of faulted and unfaulted Quaternary deposits are the source of data for this fault. Results from trench investigations (Scherschel and others, 1995 #876; Keaton and others, 1995 #877; Barnes and others, 1995 #909; Keaton and Barnes, 1995 #944) were still preliminary at the time of this compilation. No significant work has been done on the fault in Mexico where its age and southern limit are poorly known.

Date of compilation 05/16/95

Compiler and affiliation E.W. Collins, Bureau of Economic Geology, The University of Texas at Austin; Michael N. Machette, U.S. Geological Survey

State Texas; New Mexico; Chihuahua, Mexico

County El Paso (TX); Dona Ana (NM)

1° x 2° sheet El Paso, Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Location based on 1:250,000-scale map compiled from aerial photos and 1:24,000- to 1:250,000-scale maps of Sayre and Livingston (1945 #850), Morrison (1969 #848), Harbour (1972 #849), Machette (1987 #847), Collins and Raney (1991 #846; 1993 #852), Keaton (1993 #851), and Raney and Collins (1994 #872; 1994 #873).

Geologic setting Down-to-east, range-front fault bounding east side of the Franklin Mountains and Sierra de Juarez. This fault is part of a longer system that includes the Artillery Range [2051], Organ Mountains [2052], and San Andres [2053] faults in New Mexico.

Sense of movement N
Comments: Sense of movement inferred from topography and from trench exposures of Keaton and Barnes (1995 #944).

Dip 76°
Comments: Dip measured in shallow excavation across northern end of fault (Keaton and Barnes, 1995 #944).

Dip direction E

Geomorphic expression Distinct scarps are between 2 and 60 m high (Machette, 1987 #847; Collins and Raney, 1991 #846). Some scarps have compound slopes indicating young morphology superposed on older scarps. Steepest slope-angles are between 13° and 23° depending on height. Scarps are well dissected by streams draining the Franklin Mountains. The fault consists of multiple strands with scarps and grabens along the mountain front. Urbanization of El Paso and Juarez (Mexico) and young alluvium of the Rio Grande cover most of the southern part of the fault.

Age of faulted deposits Mostly Quaternary alluvium along the eastern piedmont of the Franklin Mountains and Sierra de Juarez (Raney and Collins, 1994 #872; Raney and Collins, 1994 #873). Reconnaissance investigations of faulted alluvium indicate deposits at least as young as late Pleistocene are faulted (Machette, 1987 #847; Collins and Raney, 1991 #846; Collins and Raney, 1993

#852; Collins and Raney, 1994 #853; Scherschel and others, 1995 #876; Keaton and others, 1995 #877; Barnes and others, 1995 #909; Scherschel, 1995 #916). Holocene(?) or upper Pleistocene deposits have been faulted during the two most recent events. Colluvium shed from the scarp formed from the most recent event has a radiocarbon age of 10.9 ka (Keaton and Barnes, 1995 #944). The radiocarbon age of colluvium that was eroded from the scarp of the penultimate event is 15.6 ka (Keaton and Barnes, 1995 #944). These ages from colluvium indicate approximate minimum times for the two last scarp-forming events.

Detailed studies A single trench (site 900-1) was excavated across the northern part of the fault in January 1995 by AGRA Earth and Environmental, on contract to the U.S. Geological Survey. Preliminary results of this trenching have been published by Keaton and others (1995 #877), Keaton and Barnes (1995 #944), Barnes and others (1995 #909), and Scherschel (1995 #916). All interpretations suggest 3 or 4 surface rupturing events since middle Pleistocene time (past 130 k.y.) on the basis of relations between colluvial materials, soils, and faults in the exposure. Two radiocarbon dates from colluvial wedges (10.9 ka and 15.6 ka) were reported by Keaton and Barnes (1995 #944). At the trench site, the Jornada II alluvium (late middle Pleistocene) is estimated to be offset vertically 8.5 m (Scherschel, 1995 #916) to as much as 9.8-10.6 m (Keaton and others, 1995 #877).

Timing of most recent paleoevent latest Quaternary (<15 ka)
Comments: Timing based on trenching by Keaton and Barnes (1995 #944) and morphometric analysis of small (single-event) scarps by Machette (1987 #847). Keaton and Barnes(1995 #944) reported that the likely range for the most recent event is 8-12 ka based on scarp morphology and a radiocarbon date of 10.9 ka from scarp-derived colluvium. Additionally, soil studies by Monger (unpublished data, 1995) suggested that the oldest unfaulted deposits adjacent to the trench site are equivalent to the Organ (Holocene) alluvium, which may be as old as 8 ka. However, Barnes and others (1995 #909), Keaton and others (1995 #877), Scherschel and others (1995 #876), and Scherschel (1995 #916) suggested that the most recent event is older than the Isaack's Ranch alluvium, which is considered to be latest Pleistocene in age.

Recurrence interval 9-22 k.y. (<130 ka)
Comments: The most recent work on the East Franklin Mountains fault suggests short episodes of faulting with displacement events recurring every 9-22 k.y., alternating with long stable intervals of 75-100 k.y. at least for the late Pleistocene (Keaton and others, 1995 #877; Barnes and others, 1995 #909), whereas Scherschel (1995 #916) suggested recurrence intervals of about 30 k.y. for an unspecified period of time. Keaton and Barnes (1995 #944) used three probable slip rates and a characteristic displacement value to estimate average recurrence intervals of about 8-40 k.y. Collins and Raney (1993 #852) estimated that the average recurrence interval for large surface ruptures since middle Pleistocene time (<130 ka.) may be 15-30 k.y. These values are based on (1) estimated number of inferred large-displacement (1-to 2-m) surface ruptures since middle Pleistocene time, (2) assumption that faulted middle Pleistocene (Jornada I) deposits are approximately 250-500 ka, and (3) >25-32 m of throw measured on middle Pleistocene surfaces.

Slip-rate category 0.2-1.0 mm/yr
Comments: The short-term slip rate is thought to be higher than the long-term rate due to clustering of events during late Quaternary time; the higher slip rate is used here to define the appropriate slip-rate category. Keaton and Barnes (1995 #944) suggested a slip rate of 0.3 mm/yr for the past 3 events (less than about 30 ka), but a long-term (<500 ka) slip rate of 0.1 mm/yr is also consistent with the data. Scherschel (1995 #916) suggested an even lower average slip rate of 0.065 mm/yr. A long-term slip rate of ≤0.25 mm/yr since middle Pleistocene time can be inferred on the basis of >25-32 m of throw in the past 130 k.y. (Collins and Raney, 1993 #852).

Length End to end (km): 45.2
Trace (km): 52.7

Average strike (azimuth) 002°±27°

Endpoints 32°0′40.83″N, 106°26′47.35″W
31°36′17.10″N, 106°29′14.70″W

References

#909 Barnes, J.R., Keaton, J.R., Scherschel, C.A., and Monger, H.C., 1995, An integrated geomorphic and stratigraphic evaluation of late Quaternary earthquake activity along the East Franklin Mountains fault, El Paso, Texas [abs.] Diversity in engineering geology and groundwater resources: Association of Engineering Geologists, 38th Annual Meeting, Sacramento, California, October 2-8, 1995, p. 33.

#846 Collins, E.W., and Raney, J.A., 1991, Tertiary and Quaternary structure and paleotectonics of the Hueco basin, trans-Pecos Texas and Chihuahua, Mexico: The University of Texas at Austin, [Texas] Bureau of Economic Geology Geological Circular 91-2, 44 p.

#852 Collins, E.W., and Raney, J.A., 1993, Late Cenozoic faults of the region surrounding the Eagle Flat study area, northwestern trans-Pecos Texas: Technical report to Texas Low-Level Radioactive Waste Disposal Authority, under Contract IAC(92-93)-0910, 74 p.

#853 Collins, E.W., and Raney, J.A., 1994, Impact of late Cenozoic extension on Laramide overthrust belt and Diablo Platform margins, northwestern trans-Pecos Texas, *in* Ahlen, J., Peterson, J., and Bowsher, A.L., eds., Geologic activities in the 90s: New Mexico Bureau of Mines and Mineral Resources Bulletin 150, p. 71-81.

#849 Harbour, R.L., 1972, Geology of the northern Franklin Mountains, Texas and New Mexico: U.S. Geological Survey Bulletin 1298, 129 p., 3 pls.

#851 Keaton, J.R., 1993, Maps of potential earthquake hazards in the urban area of El Paso, Texas: Technical report to U.S. Geological Survey, under Contract 1434-92-G-2171, July 28, 1993, 87 p.

#944 Keaton, J.R., and Barnes, J.R., 1995, Paleoseismic evaluation of the East Franklin Mountains fault, El Paso, Texas: Technical report to U.S. Geological Survey, under Contract 1434-94-G-2389, December 1995.

#877 Keaton, J.R., Barnes, J.R., Scherschel, C.A., and Monger, H.C., 1995, Evidence for episodic earthquake activity along the East Franklin Mountains fault, El Paso, Texas: Geological Society of America Abstracts with Programs, v. 27, no. 4, p. 17.

#847 Machette, M.N., 1987, Preliminary assessment of paleoseismicity at White Sands Missile Range, southern New Mexico—Evidence for recency of faulting, fault segmentation, and repeat intervals for major earthquakes in the region: U.S. Geological Survey Open-File Report 87-444, 46 p.

#848 Morrison, R.B., 1969, Photointerpretive mapping from space photographs of Quaternary geomorphic features and soil associations in northern Chihuahua and adjoining New Mexico and Texas, *in* Córdoba, D.A., Wengerd, S.A., and Shomaker, J., eds., Guidebook of the Border Region: New Mexico Geological Society, 20th Field Conference, October 23-25, 1969, Guidebook, p. 116-129.

#872 Raney, J.A., and Collins, E.W., 1994, Geologic map of the El Paso quadrangle, Texas: The University of Texas at Austin, [Texas] Bureau of Economic Geology Open-File Map, 1 sheet, scale 1:24,000.

#873 Raney, J.A., and Collins, E.W., 1994, Geologic map of the North Franklin Mountain quadrangle, Texas: The University of Texas at Austin, [Texas] Bureau of Economic Geology Open-File Map, 1 sheet, scale 1:24,000.

#850 Sayre, A.N., and Livingston, P., 1945, Ground-water resources of the El Paso area, Texas: U.S. Geological Survey Water-Supply Paper 919, 190 p.

#916 Scherschel, C., 1995, Quaternary geologic and geomorphic framework for neotectonic analysis of the northeastern Franklin Mountains, El Paso, Texas [abs.] Diversity in engineering geology and groundwater resources: Association of Engineering Geologists, 38th Annual Meeting, Sacramento, California, October 2-8, 1995, p. 12-13.

#876 Scherschel, C.A., Keaton, J.R., and Monger, H.C., 1995, Quaternary geologic and geomorphic framework for neotectonic analysis of the northeastern Franklin Mountains, El Paso, Texas: Geological Society of America Abstracts with Programs, v. 27, no. 4, p. 53.

901, Hueco fault zone

Structure Number 901

Structure Name Hueco fault zone

Comments: Named by Seager (1980 #843). Refers to numerous Quaternary intrabasin faults in the northwestern part of the Hueco bolson (basin) of west Texas and southern New Mexico (see Machette, 1987 #847). These faults extend from the southern part of the Tularosa basin (about 15 km northeast of White Sands, New Mexico) south-southeastward through the Hueco basin to east of Tornillo, Texas, north of the floodplain of the Rio Grande.

Synopsis: This broad anastomosing fault zone is composed of numerous eolian sand-covered scarps within the northwestern part of the Hueco basin. Reconnaissance mapping and studies of scarp morphology are the only sources of data about Quaternary movement. Detailed studies have not been conducted; most of these faults have a thick cover of eolian sand, generally lack of natural exposure, and most parts of the area have restricted access (various military uses).

Date of compilation 10/31/93

Compiler and affiliation E.W. Collins, Bureau of Economic Geology, The University of Texas at Austin

State Texas; New Mexico

County El Paso (TX); Otero (NM); Dona Ana (NM)

1° x 2° sheet El Paso; Las Cruces

Province Basin and Range

Reliability of location Good

Comments: Location in Texas based on 1:250,000-scale map compiled from 1:24,000- to 1:48,000-scale mapping of Seager (1980 #843), Henry and Gluck (1981 #845), and Collins and Raney (1991 #846). Locations in New Mexico based on 1:125,000-scale map of Seager and others (1980 #843).

Geologic setting These down-to-west and down-to-east faults form a broad N-S elongate zone within the northwestern part of the Hueco basin (Seager, 1980 #843; 1983 #844; 1987 #627) that, where undeformed, forms a rather flat, regular surface.

Sense of movement N

Comments: Not studied in detail; sense of movement inferred from disruption of the basin's generally flat topography.

Dip not reported

Dip direction E; W

Geomorphic expression The Hueco basin (Seager, 1980 #843; Seager, 1983 #844) generally has a rather flat, regular surface, but is deformed by a wide zone of north-trending faults. These faults have subtle scarps between 2 m and 7 m high that are covered by thick deposits of eolian sand (Collins and Raney, 1991 #846; Collins and Raney, 1993 #852). Maximum scarp-slope angles are usually less than 3°. Gentle low-relief alluvial drainageways commonly are present on downthrown fault block and trend subparallel to the fault scarps. The faults are shown as dashed lines on the map (rather than concealed faults) owing to the presence of faulted calcic soils, which are occasionally seen beneath the cover of eolian sand. Burrell and Tilford (1995 #908) suggested that some of the scarp-like features within the Hueco and Tularosa basins may be the result of other processes, such as fluvial erosion, piping, or fissuring.

Age of faulted deposits Middle Pleistocene alluvium (Collins and Raney, 1991 #846); no detailed studies have been conducted to determine if younger (upper Quaternary) deposits are faulted.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)

Comments: Timing of movement is not well constrained, but scarps are present on middle Pleistocene deposits (Collins and Raney, 1991 #846). Cross-cutting relationships with younger deposits are unknown.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: A very low slip rate is inferred from small amounts of displacement (2-7 m) of middle Pleistocene deposits (minimum age 130 ka, probable age at least 400 ka).

Length not applicable

Comments: The fault zone includes numerous faults that have an end to end length of 116.0 km and a cumulative trace length of 504.4 km.

Average strike (azimuth) -7°±24°

Endpoints 32°28′03.27″N, 106°20′33.32″W
31°27′05.47″N, 106°03′02.32″W

References

#908 Burrell, J.K., and Tilford, N.R., 1995, Genesis of closed linear depressions in West Texas—Tectonics, dissolution, or other cause? [abs.] Diversity in engineering geology and groundwater resources: Association of Engineering Geologists, 38th Annual Meeting, Sacramento, California, October 2-8, 1995, p. 39.

#846 Collins, E.W., and Raney, J.A., 1991, Tertiary and Quaternary structure and paleotectonics of the Hueco basin, trans-Pecos Texas and Chihuahua, Mexico: The University of Texas at Austin, [Texas] Bureau of Economic Geology Geological Circular 91-2, 44 p.

#852 Collins, E.W., and Raney, J.A., 1993, Late Cenozoic faults of the region surrounding the Eagle Flat study area, northwestern trans-Pecos Texas: Technical report to Texas Low-Level Radioactive Waste Disposal Authority, under Contract IAC(92-93)-0910, 74 p.

#845 Henry, C.D., and Gluck, J.K., 1981, A preliminary assessment of the geologic setting, hydrology, and geochemistry of the Hueco Tanks geothermal area, Texas and New Mexico: The University of Texas at Austin, [Texas] Bureau of Economic Geology Geological Circular 81-1, 48 p.

#847 Machette, M.N., 1987, Preliminary assessment of paleoseismicity at White Sands Missile Range, southern New Mexico—Evidence for recency of faulting, fault segmentation, and repeat intervals for major earthquakes in the region: U.S. Geological Survey Open-File Report 87-444, 46 p.

#843 Seager, W.R., 1980, Quaternary fault system in the Tularosa and Hueco basins, southern New Mexico and West Texas, *in* Dickerson, P.W., and Hoffer, J.M., eds., Trans-Pecos region southeastern New Mexico and west Texas: New Mexico Geological Society, 31st Field Conference, November 6-8, 1980, Guidebook, p. 131-135.

#844 Seager, W.R., 1983, Possible relations between Quaternary fault system, mode of extension, and listric range boundary faults in the Tularosa and Hueco basins, New Mexico and Texas, *in* Meader-Roberts, S.J., ed. Geology of the Sierra Diablo and southern Hueco Mountains West Texas: Permian Basin Section, Society of Economic Paleontologists and Mineralogists, Field Conference, May 1983, Guidebook, p. 141-150.

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2001, Gallina fault

Structure Number 2001

Structure Name Gallina fault
Comments: The Gallina fault is along the northern extension of the Nacimiento fault (Manley and others, 1987 #1119; Woodward, 1987 #1130), and extends from the northern end of the Sierra Nacimiento, 7 km northeast of Regina, to about 5 km south of El Vado Reservoir.

Synopsis: The Gallina fault forms the western margin of the Gallina-Archuleta arch, and is a high-angle normal fault (Baltz, 1967 #1167; Manley and others, 1987 #1119; Woodward, 1987 #1130). There is no documented geologic evidence for Quaternary activity along the Gallina fault, although the spatial coincidence of diffuse contemporary microseismicity within the Gallina-Archuleta arch suggests that the Gallina fault may be active (Wong and others, 1995 #1155; House and Hartse, 1995 #1160).

Date of compilation 07/19/96

Compiler and affiliation Keith I. Kelson; William Lettis & Associates, Inc.

State New Mexico

County Rio Arriba

1° x 2° sheet Aztec

Province Colorado Plateaus

Reliability of location Good
Comments: Fault location based on map compilation at a scale of 1:250,000 by Manley and others (1987 #1119).

Geologic setting The Gallina-Archuleta arch separates the Chama Basin and the San Juan Basin (Baltz, 1967 #1167; Woodward, 1987 #1130). The arch formed during Laramide deformation, and likely was reactivated during Miocene formation of the Rio Grande rift (Woodward, 1987 #1130). Wong and others (1995 #1155) and House and Hartse (1995 #1160) note that the Gallina-Archuleta arch is spatially coincident with contemporary seismicity, which may represent late Quaternary reactivation of the Laramide structure.

Sense of movement N
Comments: Manley and others (1987 #1119) and Woodward (1987 #1130) show the fault as a high-angle, down-to-the-east normal fault.

Dip 50° to 70° E, preferred average 60° E
Comments: There are no deep structural data published for the Gallina fault. Manley and others (1987 #1119) map a linear fault trace across rugged topography, suggesting high-angle fault strands; Wong and others (1995 #1155) assumed a range in dip values of 50° to 70°, with a preferred value of 60°, on the basis of subsurface geometry of other rift faults.

Dip direction E and W

Comments: Manley and others (1987 #1119) show down-to-the-west and down-to-the-east displacement on various main fault strands. Wong and others (1995 #1155) interpret that main fault strand dips to the E. Easterly dip is more consistent with down-to-the-east reactivation of east-dipping Laramide reverse faults along the western margin of the Sierra Nacimiento.

Geomorphic expression The southern part of the fault lies along the west-facing western margin of Capulin Mesa, although bedrock mapping shows net down-to-the-east vertical separation. If there is an absence of Quaternary activity, the escarpment along the mesa margin likely is related to differential erosion of rock types.

Age of faulted deposits Youngest faulted bedrock is Cretaceous in age, although no Tertiary units are mapped across the fault (Manley and others, 1987 #1119). There are little or no data on the presence or absence of displaced late Quaternary deposits. Manley and others (1987 #1119) map undisplaced Quaternary gravel across the fault trace at Rio Capulin, at the southern end of the fault.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing of the most-recent event is unknown. Possible association with contemporary microseismicity suggests late Quaternary activity (Wong and others, 1995 #1155; House and Hartse, 1995 #1160).

Recurrence interval not reported
Comments: No recurrence data are available at the time of this compilation.

Slip-rate category <0.2 mm/yr

Comments: Wong and others (1995 #1155) conservatively estimate a range in slip rate of 0.01 to 0.23 mm/yr for the Gallina fault, with a preferred value of 0.02 mm/yr, based on analysis of regional slip rates in the Rio Grande rift and a lack of evidence of late Quaternary displacement.

Length End to end (km): 39.3
Trace (km): 58.7

Average strike (azimuth) 017°±28°

Endpoints (lat. - long.) 36°32′57.40″N, 106°44′32.45″W
36°13′10.65″N, 106°54′06.37″W

References

#1167 Baltz, E.H., 1967, Stratigraphy and regional tectonic implications of part of Upper Cretaceous and Tertiary rocks east-central San Juan Basin New Mexico: U.S. Geological Survey Professional Paper 552, 99 p., 1 pl., scale 1:377,000.

#1160 House, L., and Hartse, H., 1995, Seismicity and faults in northern New Mexico, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 135-137.

#1119 Manley, K., Scott, G.R., and Wobus, R.A., 1987, Geologic map of the Aztec 1° by 2° quadrangle, northwestern New Mexico and southern Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-1730, 1 sheet, scale 1:250,000.

#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

#1130 Woodward, L.A., 1987, Geology and mineral resources of Sierra Nacimiento and vicinity, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 42, 84 p., 1 pl., scale 1:100,000.

2002, Nacimiento fault

Structure Number 2002

Structure Name Nacimiento fault
Comments: The Nacimiento fault extends from Red Mesa, 7 km east of San Ysidro on the south, to the northern end of Sierra Nacimiento, 7 km northeast of Regina. The Nacimiento fault forms the western margin of the Laramide Nacimiento uplift. As used herein, the Nacimiento fault includes the Nacimiento and Pajarito faults of Woodward (1987 #1130), to avoid confusion with the Pajarito fault along the western margin of the Rio Grande rift near Los Alamos.

Synopsis: The Nacimiento fault is an east-dipping reverse fault bordering the Nacimiento uplift, an 80-km-long, 10-to 16-km-wide uplift related to Laramide deformation. The fault merges with the Gallina fault to the north, and dies out to the south into a broad anticline. The relatively high level of contemporary microseismicity within the Sierra Nacimiento may be related to deformation in the hanging wall of the fault. Detailed mapping along the southern part of the fault indicates the presence of several short normal faults with both down-to-the-east and down-to-the-west displacements in Quaternary deposits. Down-to-the-east displacements may indicate normal reactivation of the Nacimiento reverse fault in the late Quaternary.

Date of compilation 05/05/97

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.; Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval, Rio Arriba

1° x 2° sheet Albuquerque, Aztec

Province Colorado Plateaus

Geologic setting The Nacimiento fault is a high-angle, west-vergent reverse fault. The Nacimiento uplift is a north-south elongated structural block that lies east of the Jemez Mountains and forms the western margin of the San Juan Basin of the Colorado Plateau. Structural relief of the uplift formed during Laramide deformation, with shortening taking place via folding and reverse movement along the Nacimiento fault. The fault lies west of the western margin of the Rio Grande rift. Quaternary normal faulting near Arroyo Peñasco documented by Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) may indicate normal reactivation of the Nacimiento reverse fault. The relatively high level of contemporary microseismicity within the Sierra Nacimiento supports the interpretation of Quaternary deformation in the hanging wall of the fault (Wong and others, 1995 #1155; House and Hartse, 1995 #1160).

Number of Sections 2
Comments: Woodward (1987 #1130) mapped the Nacimiento and Pajarito faults along the western margin of the Sierra Nacimiento. He noted the lack of continuity between these faults in the vicinity of San Miguel Canyon, about 3 km southeast of the village of San Miguel. North of San Miguel Canyon, the fault generally has a lower dip and is a thrust fault, whereas south of San Miguel Canyon the fault is a high-angle reverse fault. Wong and others (1995 #1155) considered potential fault-rupture scenarios that included rupture on either a northern section or a southern section, and on both sections together. These sections are considered separately here.

Length End-to-end (km): 81.6
Trace (km): 95.4

Average strike (azimuth) -1°±18°

Endpoints (lat. - long.) 36°13′11.33″N, 106°54′05.53″W
35°29′06.31″N, 106°51′24.45″W

2002a, Northern section

Section Number 2002a

Section Name Northern section
Comments: This part of the Nacimiento fault was defined as the northern section by Wong and others (1995 #1155). The northern section extends from San Miguel Canyon about 3 km southeast of the village of San Miguel to the northern end of Sierra Nacimiento, 7 km northeast of Regina.

Reliability of location Good
Comments: Detailed geologic maps at a scale of 1:24,000 are available along the entire fault trace, which are compiled and synthesized by Woodward (1987 #1130). The fault also was mapped by Renick(1931 #1140) at a scale of 1:125,000 and by Wood and Northrop (1946 #1143) at a scale of about 1:95,000.

Sense of movement N?
Comments: West-vergent thrusting occurred during Laramide deformation. Sense of movement associated with contemporary microseismicity is unknown, but normal backslip may be likely in the present extensional regime.

Dip 45° to 60° E
Comments: Bedrock exposures of the fault noted by Woodward (1987 #1130) provide near-surface data on fault dip. Woodward (1987 #1130) speculates that the fault steepens with depth, although there are no published deep structural data for the fault.

Dip direction E

Geomorphic expression Prominent west-facing range front of the Sierra Nacimiento is coincident with the Nacimiento fault. Baltz (1967 #1167) did not identify geomorphic evidence of late Quaternary activity.

Age of faulted deposits Youngest faulted bedrock is Cretaceous in age, although there are little or no data on the presence or absence of displaced late Quaternary deposits. Manley and others (1987 #1119) map undisplaced Quaternary gravel across the fault trace at Rito de los Pinos, about 10 km northeast of the town of Cuba.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing of most-recent event unknown. Prominent geomorphic expression along the range front and possible association with contemporary microseismicity suggest late Quaternary activity (Wong and others, 1995 #1155; House and Hartse, 1995 #1160).

Recurrence interval not reported
Comments: No recurrence data are available at the time of this compilation.

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Wong and others (1995 #1155) conservatively estimate a range in slip rate of 0.01 to 0.23 mm/yr for the Nacimiento fault, with a preferred value of 0.02 mm/yr, based on analysis of regional slip rates in the Rio Grande rift and a lack of evidence of late Quaternary displacement.

Length End-to-end (km): 35.9
Trace (km): 39.8

Average strike (azimuth) 357°±21°

Endpoints (lat. - long.) 36°13′11.33″N, 106°54′05.53″W
35°53′47.83″N, 106°53′16.38″W

2002b, Southern section

Section Number 2002b

Section Name Southern section
Comments: This part of the Nacimiento fault was defined as the southern section by Wong and others (1995 #1155). The southern section extends from U.S. Highway 44 about 7 km east of the village of San Ysidro, northward to San Miguel Canyon about 3 km southeast of the village of San Miguel.

Reliability of location Good
Comments: Detailed geologic maps at a scale of 1:24,000 are available along the entire fault trace, which are compiled and synthesized by Woodward (1987 #1130). The fault also was mapped by Renick(1931 #1140) at a scale of 1:125,000, by Wood and Northrop (1946 #1143) at a scale of about 1:95,000, and by Baltz (1967 #1167) at a scale of 1:63,360. More detailed mapping of Quaternary deposits at 1:24,000 scale in the Arroyo Peñasco area at the southern end of the fault has recently been completed by Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377).

Sense of movement N
Comments: West-vergent reverse faulting occurred during Laramide deformation on the Nacimiento fault (Woodward, 1987 #1130). Sense of movement associated with contemporary microseismicity is unknown, but down-to-the-east and down-to-the-west Quaternary normal faults have been mapped by Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) near Arroyo Peñasco at the southern end of the fault. The down-to-the-west normal faults are in the footwall of the Nacimiento reverse fault, but the down-to-the-east Quaternary movement on one fault strand may be interpreted as normal backslip on a splay of the reverse fault (Formento-Trigilio and Pazzaglia, 1996 #1295; Formento-Trigilio, 1997 #1377).

Dip 75° to 90° E
Comments: Bedrock exposures of the fault noted by Woodward (1987 #1130) provide near-surface data on fault dip. Woodward (1987 #1130) speculated that the fault steepens with depth, although no published subsurface structural data are available to confirm this interpretation.

Dip direction E, W?
Comments: Bedrock exposures of the main trace of the Laramide Nacimiento fault clearly show steep east dips, although west dipping synthetic and antithetic faults are locally present (Woodward, 1987 #1130). Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) map several normal faults in Quaternary deposits with both east and west dips near Arroyo Peñasco at the southern end of the Nacimiento fault (see discussion in detailed studies section below).

Geomorphic expression The prominent west-facing range front of the Sierra Nacimiento is coincident with the Nacimiento fault. Baltz (1967 #1167) did not identify geomorphic evidence of late Quaternary activity, but Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) discuss evidence of multiple fault strands with Quaternary displacement along the southern end of the Sierra Nacimiento near Arroyo Peñasco.

Age of faulted deposits Although the youngest faulted bedrock mapped along the Nacimiento fault is Cretaceous in age (Woodward, 1987 #1130), Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) map fault scarps and infer displacements from geomorphic data in late Pleistocene alluvial deposits near Arroyo Peñasco at the southern end of the Nacimiento fault. Recently acquired uranium-series ages on faulted, travertine-cemented alluvium indicate the faulted alluvium was deposited between about 270 ka and about 60 ka.

Detailed studies Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) have mapped Quaternary deposits and faults in detail near Arroyo Peñasco at the southern end of the Nacimiento fault. Most of the Quaternary faults mapped by Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) dip west, opposite to the dip of the bedrock fault mapped by Woodward (1987 #1130) in the area. These faults are as much as 2 km long and are marked by scarps as much as 17 m high, although some of this apparent displacement may be related to landsliding in the underlying Triassic shale bedrock. Down-to-the-east Quaternary displacement of 4.2 m of travertine-cemented alluvium on one fault strand on the north rim of Arroyo Peñasco may either represent normal reactivation on a trace of the Nacimiento reverse fault mapped by Woodward (1987 #1130), or is an antithetic splay to the down-to-the-west faults mapped further east by Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377).

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing of most-recent event is from recent uranium-series dating of faulted travertine-cemented alluvium by Formento-Trigilio (1997 #1377). Uranium-series ages bracket the age of the offset alluvium between about 270 ka and 60 ka.

Recurrence interval not reported
Comments: No recurrence data are available at the time of this compilation.

Slip-rate category <0.2 mm/yr
Comments: Wong and others (1995 #1155) conservatively estimate a range in slip rate of 0.01 to 0.23 mm/yr for the Nacimiento fault, with a preferred value of 0.02 mm/yr, based on analysis of regional slip rates in the Rio Grande rift.(1996 #1295)(1997 #1377)

Length End-to-end (km): 45.2
Trace (km): 55.6

Average strike (azimuth) -4°±13°

Endpoints (lat. - long.) 35°53′28.92″N, 106°53′39.26″W
35°29′06.31″N, 106°51′24.45″W

References

#1167 Baltz, E.H., 1967, Stratigraphy and regional tectonic implications of part of Upper Cretaceous and Tertiary rocks east-central San Juan Basin New Mexico: U.S. Geological Survey Professional Paper 552, 99 p., 1 pl., scale 1:377,000.

#1377 Formento-Trigilio, M.L., 1997, The tectonic geomorphology and long-term landscape evolution of the southern Sierra Nacimiento, northern New Mexico: Albuquerque, University of New Mexico, unpublished M.S. thesis, 201 p., 1 pl., scale 1:24,000.

#1295 Formento-Trigilio, M.L., and Pazzaglia, F.J., 1996, Quaternary stratigraphy, tectonic geomorphology and long-term landscape evolution of the southern Sierra Nacimiento, *in* Goff, F., Kues, B.S., Rogers, M.A., McFadden, L.D., and Gardner, J.N., eds., The Jemez Mountains region: New Mexico Geological Society, 47th Field Conference, September 25-28, 1996, Guidebook, p. 335-345.

#1160 House, L., and Hartse, H., 1995, Seismicity and faults in northern New Mexico, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 135-137.

#1119 Manley, K., Scott, G.R., and Wobus, R.A., 1987, Geologic map of the Aztec 1° by 2° quadrangle, northwestern New Mexico and southern Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-1730, 1 sheet, scale 1:250,000.

#1140 Renick, B.C., 1931, Geology and ground-water resources of western Sandoval County, New Mexico: U.S. Geological Survey Water-Supply Paper 620, 117 p., 10 pls.

#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

#1143 Wood, G.H., Jr., Northrop, S.A., and Cowan, M.J., 1946, Geology of the Nacimiento Mountains, San Pedro Mountain, and adjacent plateaus in parts of Sandoval and Rio Arriba Counties, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map 57, scale 1:95,000.

#1130 Woodward, L.A., 1987, Geology and mineral resources of Sierra Nacimiento and vicinity, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 42, 84 p., 1 pl., scale 1:100,000.

2003, Cañones fault

Structure Number 2003

Structure Name Cañones fault

Comments: The Cañones fault has been mapped in various configurations by Kelley (1954 #1222), Smith and others (1970 #1125), Kelley (1978 #1107), Manley (1982 #1118), Manley and others (1987 #1119), and Gonzalez and Dethier (1991 #1101). Although Kelley (1954 #1222) originally used the name "Cañones fault" for the entire structure, he later (Kelley, 1978 #1107) split the structure into three faults, a western strand (Gonzales fault), an eastern strand (Cañones fault) and a single northern strand (Cobre fault). Herein we follow Gonzalez and Dethier (1991 #1101) in describing all of these structures as splays of the Cañones fault. As used herein, the Cañones fault consists of a single northern strand that extends northward from Cañones Mesa about 15 km; south of Cañones Mesa, the fault splits into western and eastern splays that extend along the western flanks of Mesa Escoba and Mesa del Medio, respectively.

Synopsis: The Cañones fault is a northeast striking, down-to-the-east normal fault that lies 3 km southeast of Abiquiu Reservoir in the westernmost part of the Abiquiu embayment. Despite the lack of demonstrated Quaternary offset along its length, the fault is thought to be the westernmost rift-margin fault within the Abiquiu embayment, is favorably oriented to accommodate strain in the present stress field, and thus may be capable of Quaternary displacement.

Date of compilation 07/11/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.; Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Rio Arriba

1° x 2° sheet Aztec

Province Southern Rocky Mountains

Reliability of location Good

Comments: Fault traces for this compilation are from Manley and others (1987 #1119) at a scale of 1:250,000, which in turn were compiled from Manley (1982 #1118) at a scale of 1:24,000, Smith and others (1970 #1125) at a scale of 1:125,000, and unpublished mapping by Manley.

Geologic setting The Cañones fault forms the boundary between the Colorado Plateau on the west and the Rio Grande rift on the east. The fault is thought to have been the western margin of the rift between about 10 and 5 Ma (Golombek, 1983 #1100; Gardner and Goff, 1984 #1096; Gonzalez and Dethier, 1991 #1101). The fault separates the Colorado Plateau from the Abiquiu embayment, an isolated, shallow-floored segment of the Española basin (Baldridge and others, 1994 #1175). Total vertical separation across the fault is less than 500 m (Baldridge and others, 1994 #1175). Baldridge and others (1994 #1175) interpret a small amount (3.5%) of extension across the western rift boundary, which includes the Cañones fault. The fault is favorably oriented to accommodate strain in the present stress field (Wong and others, 1995 #1155).

Sense of movement N

Comments: The average rake of lineations on the main fault indicate down-to-the east dip-slip movement, with evidence of a small left-lateral component (Gonzalez and Dethier, 1991 #1101).

Dip 60° E
Comments: There are no published deep structural data on the Cañones fault. Wong and others (1995 #1155) assumed a range in dip values of 50° to 70°, with a preferred value of 60°, on the basis of subsurface geometry of other rift faults.

Dip direction E

Comments: Gonzalez and Dethier (1991 #1101) show primarily easterly dips on the main fault plane and westerly dips on antithetic planes.

Geomorphic expression Linear valleys and topographic escarpments found along the Cañones fault near the Rio Chama are related to differences in erosional resistance of juxtaposed rock types. The fault has no prominent topographic expression across Cañones Mesa.

Age of faulted deposits The Cañones fault does not displace basalt flows mapped as the 8 Ma Lobato Basalt (Manley, 1982 #1118) and is overlain by the 1.2 Ma upper Bandelier Tuff (Smith and others, 1970 #1125). Fluvial deposits younger than 1.2 Ma east of the fault do not extend across fault (Gonzalez, 1993 #1137).

Detailed studies Gonzalez and Dethier (1991 #1101) summarized detailed structural analysis of the fault and geomorphic relations near the fault; this data was later presented in more detail by Gonzalez (1993 #1137). No detailed analyses of Quaternary displacement or paleoseismology have been conducted.

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: The 1.2 Ma Bandelier Tuff lies unfaulted across the Cañones fault at Mesa del Medio (Smith and others, 1970 #1125), but the similar orientations of the Cañones and more active faults in the Abiquiu embayment led Wong and others (1995 #1155) to speculate that Quaternary displacement predating the late Pleistocene may have occurred on the Cañones fault.

Recurrence interval not reported
Comments: No detailed paleoseismic studies are available.

Slip-rate category <0.2 mm/yr
Comments: Gonzalez and Dethier (1991 #1101) estimated a minimum slip rate of 0.07 to 0.08 mm/yr. Wong and others (1995 #1155) estimated a preferred slip rate of 0.02 mm/yr based on comparisons with better studied faults in the region.

Length End to end (km): 29.4
Trace (km): 53.5

Average strike (azimuth) 029°±18°

Endpoints (lat. - long.) 36°17′01.95″N, 106°19′06.70″W
36°04′51.02″N, 106°31′43.16″W

References
#1175 Baldridge, W.S., Ferguson, J.F., Braile, L.W., Wang, B., Eckhardt, K., Evans, D., Schultz, C., Gilpin, B., Jiracek, G.R., and Biehler, S., 1994, The western margin of the Rio Grande rift in northern New Mexico—An aborted boundary?: Geological Society of America Bulletin, v. 105, p. 1538-1551.
#1096 Gardner, J.N., and Goff, F., 1984, Potassium-argon dates from the Jemez volcanic field—Implications for tectonic activity in the north-central Rio Grande rift, New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 75-81.
#1100 Golombek, M.P., 1983, Geology, structure, and tectonics of the Pajarito fault zone in the Española basin of the Rio Grande rift, New Mexico: Geological Society of America Bulletin, v. 94, p. 192-205.
#1137 Gonzalez, M.A., 1993, Geomorphic and neotectonic analysis along a margin of the Colorado Plateau and Rio Grande rift in northern New Mexico: Albuquerque, University of New Mexico, unpublished Ph.D. dissertation, 302 p.

#1101 Gonzalez, M.A., and Dethier, D.P., 1991, Geomorphic and neotectonic evolution along the margin of the Colorado Plateau and Rio Grande rift, northern New Mexico, *in* Julian, B., and Zidek, J., eds., Field guide to geologic excursions in New Mexico and adjacent areas of Texas and Colorado: New Mexico Bureau of Mines and Mineral Resources Bulletin 137, p. 29-45.
#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.
#1107 Kelley, V.C., 1978, Geology of Española basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 48, 1 sheet, scale 1:125,000.
#1118 Manley, K., 1982, Geologic map of the Cañones quadrangle, Rio Arriba County, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1440, 1 sheet, scale 1:24,000.
#1119 Manley, K., Scott, G.R., and Wobus, R.A., 1987, Geologic map of the Aztec 1° by 2° quadrangle, northwestern New Mexico and southern Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-1730, 1 sheet, scale 1:250,000.
#1125 Smith, R.L., Bailey, R.A., and Ross, C.S., 1970, Geologic map of the Jemez Mountains, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-571, 1 sheet, scale 1:125,000.
#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2004, Lobato Mesa fault zone

Structure Number 2004

Structure Name Lobato Mesa fault zone

Comments: Parts of the Lobato Mesa fault zone were mapped, but not named, by Kelley (1954 #1222), Smith and others (1970 #1125), Kelley (1978 #1107), Machette and Personius (1984 #1113), and Manley and others (1987 #1119). The faults were referred to as the Lobato Mesa fault zone by Wong and others (1995 #1155), after the mesa crossed by the fault zone south of Abiquiu, New Mexico. The Lobato Mesa fault zone of Gardner and House (1987 #1097) is referenced to mapping by Dethier and Martin (1984 #1092) east of Lobato Mesa and is considered herein as part of the La Canada del Amagre fault zone [2005]. The Lobato Mesa fault zone is about 4 to 5 km wide, is located west of La Sotella Peak, and extends from about Rio del Oso (22 km west of Española) on the south, to the Rio Chama valley at Abiquiu.

Synopsis: The Lobato Mesa fault zone offsets upper Tertiary volcanic deposits derived from the Valles Caldera and rift-fill sediments in the Abiquiu embayment. Fault strands are identified primarily by field mapping (Smith and others, 1970 #1125; Kelley, 1978 #1107); the fault zone herein mostly includes strands with west-down displacements west of La Sotella Peak. The La Canada del Amagre fault zone [2005] is located along the eastern side of La Sotella Peak and consists of faults having primarily east-down displacements. Together, the Lobato Mesa and La Canada del Amagre fault zones form the western and eastern margins, respectively, of a north-trending horst in Tertiary volcanic and sedimentary rocks. No paleoseismologic data are available for the fault zone at the time of this compilation.

Date of compilation 09/11/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Rio Arriba

1° x 2° sheet Aztec

Province Southern Rocky Mountains

Reliability of location Good
Comments: The trace of the Lobato Mesa fault zone is based on field mapping compiled at scale of 1:125,000 (Smith and others, 1970 #1125; Kelley, 1978 #1107), modified by analysis of 1:58,000-scale aerial photography compiled at a scale of 1:100,000 (Wong and others, 1995 #1155).

Geologic setting The Lobato Mesa fault zone is located within the Abiquiu embayment of the Rio Grande rift, along the northern margin of the Jemez Mountains volcanic edifice. The fault zone may have a weak association with contemporary microseismicity (Wong and others, 1995 #1155; House and Hartse, 1995 #1160).

Sense of movement N

Dip 50° to 70°W preferred average 60°
Comments: Surface and subsurface data are lacking for this fault. However, Baldridge and others (1994 #1175) noted that rift-margin faults in the Abiquiu embayment are high-angle planar normal faults that are distributed over a broad zone. Wong and others (1995 #1155) estimated a range in fault dip of 50° to 70° for the seismogenic crust, based on deep structural interpretations for rift-related faults in the Albuquerque basin.

Dip direction W

Geomorphic expression Prominent west-facing topographic scarps are present along the fault traces, in particular across mesas underlain by Lobato Basalt derived from the Valles Caldera. Scarps on the basalt are as much as 150 m high, although there is little topographic expression where the faults traverse underlying, less resistant rift-fill sediments of the Santa Fe Group.

Age of faulted deposits The fault zone displaces the 7.8 Ma Lobato Basalt, and is mapped as buried by the Miocene to Pliocene Puye Formation (Smith and others, 1970 #1125). However, Machette and Personius (1984 #1113) suggest the faults displace early Pleistocene to Pliocene deposits, and analysis of aerial photography by Wong and others (1995) suggests possible displacement of the Puye Formation and younger surficial deposits on Lobato Mesa. Possible association of the fault zone with contemporary microseismicity (House and Hartse, 1995 #1160) also suggests younger displacements.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: The timing of the most-recent earthquake on the Lobato Mesa fault zone is unknown.

Recurrence interval not reported
Comments: No paleoseismologic data are available at the time of this compilation.

Slip-rate category <0.2 mm/yr
Comments: Wong and others (1995 #1155) estimated a long-term rate of 0.05 mm/yr on the basis of displacement data given by Gardner and House (1987 #1097).

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 21.3 km and a cumulative trace length of 55.0 km.

Average strike (azimuth) 009°±24°

Endpoints (lat. - long.) 36°12′35.10″N, 106°19′22.53″W
36°01′11.84″N, 106°18′32.24″W

References

#1175 Baldridge, W.S., Ferguson, J.F., Braile, L.W., Wang, B., Eckhardt, K., Evans, D., Schultz, C., Gilpin, B., Jiracek, G.R., and Biehler, S., 1994, The western margin of the Rio Grande rift in northern New Mexico—An aborted boundary?: Geological Society of America Bulletin, v. 105, p. 1538-1551.

#1092 Dethier, D.P., and Martin, B.A., 1984, Geology and structure along the northeast Jemez Mountains, New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 145-150.

#1097 Gardner, J.N., and House, L., 1987, Seismic hazards investigations at Los Alamos National Laboratory, 1984-1985: Los Alamos National Laboratory Report LA-11072-MS, 76 p.

#1160 House, L., and Hartse, H., 1995, Seismicity and faults in northern New Mexico, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 135-137.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1107 Kelley, V.C., 1978, Geology of Española basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 48, 1 sheet, scale 1:125,000.

#1113 Machette, M.N., and Personius, S.F., 1984, Map of Quaternary and Pliocene faults in the eastern part of the Aztec 1° by 2° quadrangle and the western part of the Raton 1° by 2° quadrangle, northern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-B, 1 sheet, scale 1:250,000.

#1119 Manley, K., Scott, G.R., and Wobus, R.A., 1987, Geologic map of the Aztec 1° by 2° quadrangle, northwestern New Mexico and southern Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-1730, 1 sheet, scale 1:250,000.

#1125 Smith, R.L., Bailey, R.A., and Ross, C.S., 1970, Geologic map of the Jemez Mountains, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-571, 1 sheet, scale 1:125,000.

#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2005, La Cañada del Amagre fault zone

Structure Number 2005

Structure Name La Cañada del Amagre fault zone

Comments: Faults within the La Cañada del Amagre fault zone were mapped, but not named, by Kelley (1954 #1222), Smith and others (1970 #1125), Kelley (1978 #1107), Machette and Personius (1984 #1113), Dethier and Manley (1985 #1432), Dethier and Martin (1984 #1092), and Manley and others (1987 #1119). Aldrich and Dethier (1990 #1085) also mapped some of these faults and referred to the more continuous features as the La Cañada del Amagre and Clara Peak faults. Wong and others (1995 #1155) refer to the faults in this zone as the La Cañada del Amagre-Clara Peak fault zone. For simplicity, this compilation refers to these faults collectively as the La Cañada del Amagre fault zone, and herein is defined as a 4- to 5-km-wide zone of east-down faults directly east of La Sotella Peak and north of Santa Clara Canyon. The fault zone is about 7 to 11 km west of the town of Chili, and extends north from Arroyo de la Plaza Larga to the Rio Chama valley.

Synopsis: The La Cañada del Amagre fault zone offsets upper Tertiary volcanic deposits derived from the Valles Caldera and rift-fill sediments in the Abiquiu embayment. The fault are identified primarily by field mapping, and herein include only faults with east-down displacements east of La Sotella Peak. The Lobato Mesa fault zone [2004] is located along the western side of La Sotella Peak and consists of faults having primarily west-down displacements. Together, the Lobato Mesa and La Canada del Amagre fault zones form the western and eastern margins, respectively, of a north-trending horst in Tertiary volcanic and sedimentary rocks. No paleoseismologic data are available for the La Cañada del Amagre fault zone at the time of this compilation.

Date of compilation 09/11/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.; Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Rio Arriba

1° x 2° sheet Aztec

Province Southern Rocky Mountains

Reliability of location Good
Comments: The trace of the La Cañada del Amagre fault zone is based on field mapping compiled at a scale of 1:125,000 (Smith and others, 1970 #1125; Kelley, 1978 #1107), at a scale of about 1:66:667 (Dethier and Martin, 1984 #1092), and at a scale of 1:24,000 (Dethier and Manley, 1985 #1432).

Geologic setting The La Cañada del Amagre fault zone is located within the Abiquiu embayment of the Rio Grande rift, along the northern margin of the Jemez Mountains volcanic edifice. The fault zone may have a weak association with contemporary microseismicity (House and Hartse, 1995 #1160; Wong and others, 1995 #1155).

Sense of movement N>D
Comments: Down-to-the-east separation of bedded volcanic rocks was noted by Smith and others (1970 #1125), Kelley (1978 #1107), Machette and Personius (1984 #1113), and Manley and others (1987 #1119). Aldrich and Dethier (1990 #1085) identified dextral offset of a vertical late Tertiary (10.6 Ma) volcanic dike.

Dip 60° to 80° E
Comments: Surface and subsurface structural data are lacking for the La Cañada del Amagre fault zone. However, Baldridge and others (1994 #1175) noted that rift-margin faults in the Abiquiu embayment are high-angle planar normal faults that are distributed over a broad zone. Wong and others (1995 #1155) estimated a range in fault dip of 60° to 80° for the seismogenic crust, based on the large lateral offset observed by Aldrich and Dethier (1990 #1085), and deep structural interpretations for rift-related faults in the Albuquerque basin.

Dip direction E

Geomorphic expression Prominent east-facing topographic scarps are present along the fault traces, in particular across mesas underlain by Lobato Basalt. Scarps on the basalt directly west of Clara Peak are as much as 80 m high, although there is little or no prominent topographic expression where the faults traverse underlying, less resistant rift-fill sediments of the Santa Fe Group.

Age of faulted deposits The La Cañada del Amagre fault zone displaces the 7.8 Ma Lobato Basalt, and Gardner and House (1987 #1097) reference mapping by Dethier and Martin (1984 #1092) that suggests a 15-m-high scarp in early Pleistocene Bandelier Tuff.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: The timing of the most-recent earthquake on the La Cañada del Amagre fault zone is unknown.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr
Comments: Aldrich and Dethier (1990 #1085) estimate 530 m of net slip across the La Cañada del Amagre fault based on offset of 10.6 Ma basalt dikes. From kinematic arguments, they infer that all this slip occurred since 5 Ma, yielding a long-term slip rate of 0.1 mm/yr. The age of dike emplacement (10.6 Ma) yields a longer term slip rate of 0.05 mm/yr. Wong and others (1995 #1155) assumed a

range in slip rate of 0.05 to 0.9 mm/yr using these data and the regional distribution of rates within the Rio Grande rift.

Length (km) not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 17.2 km and a cumulative trace length of 46.8 km.

Average strike (azimuth) -4°±15°

Endpoints (lat. - long.) 36°10′12.44″N, 106°12′41.15″W
36°1′13.36″N, 106°15′41.30″W

References

#1085 Aldrich, M.J., Jr., and Dethier, D.P., 1990, Stratigraphic and tectonic evolution of the northern Española basin, Rio Grande rift, New Mexico: Geological Society of America Bulletin, v. 102, p. 1695-1705.

#1175 Baldridge, W.S., Ferguson, J.F., Braile, L.W., Wang, B., Eckhardt, K., Evans, D., Schultz, C., Gilpin, B., Jiracek, G.R., and Biehler, S., 1994, The western margin of the Rio Grande rift in northern New Mexico—An aborted boundary?: Geological Society of America Bulletin, v. 105, p. 1538-1551.

#1432 Dethier, D.P., and Manley, K., 1985, Geologic map of the Chili quadrangle, Rio Arriba County, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1814, 1 sheet, scale 1:24,000.

#1092 Dethier, D.P., and Martin, B.A., 1984, Geology and structure along the northeast Jemez Mountains, New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 145-150.

#1097 Gardner, J.N., and House, L., 1987, Seismic hazards investigations at Los Alamos National Laboratory, 1984-1985: Los Alamos National Laboratory Report LA-11072-MS, 76 p.

#1160 House, L., and Hartse, H., 1995, Seismicity and faults in northern New Mexico, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 135-137.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1107 Kelley, V.C., 1978, Geology of Española basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 48, 1 sheet, scale 1:125,000.

#1113 Machette, M.N., and Personius, S.F., 1984, Map of Quaternary and Pliocene faults in the eastern part of the Aztec 1 degrees by 2 degrees quadrangle and the western part of the Raton 1 degrees by 2 degrees quadrangle, northern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-B, 1 sheet, scale 1:250,000.

#1119 Manley, K., Scott, G.R., and Wobus, R.A., 1987, Geologic map of the Aztec 1 degrees by 2 degrees quadrangle, northwestern New Mexico and southern Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-1730, 1 sheet, scale 1:250,000.

#1125 Smith, R.L., Bailey, R.A., and Ross, C.S., 1970, Geologic map of the Jemez Mountains, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-571, 1 sheet, scale 1:125,000.

#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2006, Black Mesa fault zone

Structure Number 2006

Structure Name Black Mesa fault zone
Comments: Faults within the Black Mesa fault zone were mapped but not named by Kelley (1978 #1107), Machette and Personius (1984 #1113), and Personius and Machette (1984 #1124). The fault zone is referred to as "Faults of Black Mesa" by Wong and others (1995 #1155). Herein the name has been simplified to the "Black Mesa fault zone" , after the prominent mesa crossed by the faults directly north of the confluence of the Rio Grande and the Rio Chama. The fault zone is expressed across the surface of Black Mesa, from the northeastern end of the mesa, 2 km north of Embudo, to near the southwestern end of the mesa, 3 km northeast of Chili.

Synopsis: The Black Mesa fault zone is a northeast-striking, right-stepping series of down-to-the-southeast and down-to-the-northwest faults that displace late Tertiary basalts on Black Mesa. No evidence of younger displacement has been observed because of lack of Quaternary depositional record. Late Quaternary graben-fill deposits may be present within fault zone on the surface of Black Mesa.

Date of compilation 08/07/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Rio Arriba

1° x 2° sheet Aztec, Raton

Province Southern Rocky Mountains

Reliability of location Good
Comments: Fault zone location is based on field mapping compiled at scale of 1:125,000 by Kelley (1978 #1107), modified at a scale of 1:250,000 by Machette and Personius (1984 #1113) and Wong and others (1995 #1155).

Geologic setting The Black Mesa fault zone is located within or directly north of the boundary zone between the east-tilted San Luis basin and the west-tilted Española basin of the northern Rio Grande rift (Manley, 1979 #1117). In contrast to north-striking faults within the San Luis basin to the north and the Española basin to the south, the Black Mesa fault zone strikes northeast and is subparallel to the Embudo fault [2007]. The Black Mesa and Embudo fault zones together may comprise the accommodation zone between these two major rift basins. The westernmost and easternmost faults within the fault zone border a small northeast-trending graben.

Sense of movement N

Dip 90°
Comments: Surface and subsurface data are lacking for this fault zone. Linear traces of the faults across substantial topographic relief suggest near-vertical dips at the ground surface. It is uncertain which border fault, if any, may be a master fault at depth.

Dip direction V

Geomorphic expression Prominent southwest- and northeast-facing topographic scarps are present across basalt flows that form Black Mesa. The fault zone has little or no geomorphic expression where fault traces cross easily eroded Tertiary rift-fill deposits north and south of Black Mesa.

Age of faulted deposits The Black Mesa fault zone displaces basalt dated at 3.65 Ma by Laughlin and others (1993 #1782), previously dated at 2.78 Ma by Manley (1976 #1115). No evidence of younger displacement was observed by Wong and others (1995 #1155) because of lack of Quaternary surficial deposits. However, possible late Quaternary graben-fill deposits may be present within fault zone on Black Mesa surface.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing of the most-recent event is unknown. No direct evidence of post-3.6 Ma displacement has been documented, although Quaternary displacement cannot be precluded. Spatial association with the Embudo fault [2007] suggests possible Pleistocene displacement.

Recurrence interval not reported
Comments: No paleoseismologic data are available at the time of this compilation.

Slip-rate category <0.2 mm/yr
Comments: Wong and others (1995 #1155) considered a range in slip rate of 0.01 to 0.21 mm/yr, based on analysis of slip rates throughout the Rio Grande rift, and used a preferred value of 0.02 mm/yr. These values are reasonable based on data presented in Wong and others (1995 #1155) indicating the presence of a 19-m-high scarp across 3.6 Ma basalt on Black Mesaand that the cumulative scarp height across the zone, regardless of sense of separation, is about 52 m.

Length End to end (km): 18.6
Trace (km): 27.7

Average strike (azimuth) 038°±15°

Endpoints (lat. - long.) 36°13′39.43′N, 105°57′32.86″W
36°07′28.25″N, 106°07′15.44″W

References

#1107 Kelley, V.C., 1978, Geology of Española basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 48, 1 sheet, scale 1:125,000.
#1782 Laughlin, A.W., Woldegabriel, G., and Dethier, D., 1993, Volcanic stratigraphy of the Pajarito Plateau: Preliminary Report FY93 prepared for the Los Alamos National Laboratory.
#1113 Machette, M.N., and Personius, S.F., 1984, Map of Quaternary and Pliocene faults in the eastern part of the Aztec 1° by 2° quadrangle and the western part of the Raton 1° by 2° quadrangle, northern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-B, 1 sheet, scale 1:250,000.
#1115 Manley, K., 1976, K-Ar are determinations of Pliocene basalts from the Española basin, New Mexico: Isochron/West, v. 16, p. 29-30.
#1117 Manley, K., 1979, Stratigraphy and structure of the Española basin, Rio Grande rift, New Mexico, *in* Riecker, R.E., ed., Rio Grande rift— Tectonics and magmatism: Washington, D.C., American Geophysical Union, p. 71-86.
#1124 Personius, S.F., and Machette, M.N., 1984, Quaternary and Pliocene faulting in the Taos Plateau region, northern New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 83-90.
#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2007, Embudo fault

Structure Number 2007

Structure Name Embudo fault
Comments: The Embudo fault has been mapped by Miller and others (1963 #1121), Kelley (1978 #1107), Muehlberger (1979 #1123), Steinpress (1980 #1392), Leininger (1982 #1759), Dungan and others

(1984 #1181), Aldrich and Dethier (1990 #1085), and Kelson and others (1997 #1374). The southwestern section is called the Santa Clara fault zone by Harrington and Aldrich (1984 #1102). Parts of the fault have also been called the "Velarde fault" by Manley (1979 #1117) and the "frontal fault zone" by Muehlberger (1978 #1391). The Embudo fault extends from an intersection with the southern Sangre de Cristo fault [2017] near the Talpa, southwest to an intersection with the Pajarito fault [2008] near Clara Peak.

Synopsis: The Embudo fault forms the structural boundary between the Española and San Luis basins of the Rio Grande rift. Detailed mapping is present only along parts of the fault; the central part of fault is obscured by large landslides. Most structural analyses suggest that the Embudo fault is a strike-slip accommodation zone with left-lateral slip and a component of either north-down or south-down vertical displacement. Detailed mapping of Quaternary deposits along the northeastern section of fault shows probable repeated late Quaternary ruptures.

Date of compilation 02/16/97

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Rio Arriba, Taos

1° x 2° sheet Aztec, Raton

Province Southern Rocky Mountains

Geologic setting The Embudo fault is described as an accommodation zone between the west-tilted Española basin and the east-tilted San Luis basin of the Rio Grande rift, with probable high-angle fault displacement with different senses of vertical separation along strike (Kelley, 1978 #1107; Muehlberger, 1978 #1391; 1979 #1123; Leininger, 1982 #1759; Machette and Personius, 1984 #1113; Wong and others, 1995 #1155; Kelson and others, 1996 #1191; 1997 #1374).

Number of Sections 2

Comments: Kelley (1978 #1107) and Personius and Machette (1984 #1124) identify a reversal of throw along the Embudo fault on La Mesita near Embudo. Muehlberger (1978 #1391; 1979 #1123) suggests a pivot point on the buried bedrock high near Cerro Azul, about 7 km northeast of Embudo. Wong and others (1995 #1155) identified rupture scenarios that included possible rupture on either a northeastern section or a southwestern section, and on both sections together. These sections are herein informally named the Pilar and Hernandez sections, respectively. The boundary between the two sections is interpreted to be on La Mesita near Embudo.

Length	End to end (km):	65.0
	Trace (km):	87.8

Average strike (azimuth) 057°±29°

Endpoints (lat. - long.) 36°19′45.66″N, 105°35′57.38″W
36°02′06.16″N, 106°13′25.35″W

2007a, Pilar section

Section Number 2007a

Section Name Pilar section

Comments: The Pilar section is herein informally named after the village of Pilar, located on the Rio Grande about 25 km southwest of Taos. This section was termed the "northeastern section" by Wong and others (1995 #1155) and the "northern section" by Kelson and others (1997 #1374). The section extends from an intersection with the southern Sangre de Cristo fault [2017] near Talpa to the change in sense of vertical separation near Embudo (Machette and Personius, 1984 #1113).

Reliability of location Good

Comments: The location is based on analysis of aerial photography and field mapping at a scale of 1:12,000 by Kelson and others (1997 #1374), on analysis of aerial photography and field reconnaissance compiled at scales of 1:250,000 (Machette and Personius, 1984 #1113; Wong and others, 1995 #1155) and about 1:46,000 (Muehlberger, 1979 #1123), and on field mapping at scales of 1:125,000 (Smith and others, 1970 #1125) and 1:16,000 (Leininger, 1982 #1759).

Sense of movement S

Comments: Down-to-the-northwest separation of bedded volcanic and alluvial rift-fill deposits is apparent along the northern part of fault. Left-lateral slip is suggested by field relations (Muehlberger, 1978 #1391; 1979 #1123; Steinpress, 1980 #1392; 1981 #1393; Leininger, 1982 #1759; Hillman, 1986 #1758; Hall, 1988 #1757; Bradford, 1992 #1174; Wong and others, 1995 #1155; Kelson and others, 1997 #1374) including small-scale kinematic indicators, contraction associated with a right-stepover, changes in sense and amounts of vertical displacement along strike, and possible fault-related stream deflections. Fault strands exposed in roadcuts near Arroyo Hondo have been mapped by Muehlberger (1979 #1123) as a northwest-vergent thrust fault, varying to a steeply dipping, down-to-the-northwest fault with possible left-lateral displacement.

Dip 80°E to 80°W, preferred 90°

Comments: Subsurface data are lacking for this fault section. Wong and others (1995 #1155) estimated a range in fault dip for seismogenic crust based on the linear fault trace across topography and analogy to accommodation zones within the Albuquerque basin (Russell and Snelson, 1994 #1186). Muehlberger (1978 #1391; 1979 #1123) and Leininger (1982 #1759) identify the fault exposed in Arroyo Hondo roadcuts as a west-vergent thrust fault, although Wong and others (1995 #1155) and Kelson and others (1996 #1191; 1997 #1374) interpret the strand noted by these previous workers as a secondary thrust fault that merges down-dip with the primary, near-vertical fault.

Dip direction V

Geomorphic expression Prominent northwest-facing topographic scarps are present along the fault trace at Arroyo Hondo, northeast of Pilar (Machette and Personius, 1984 #1113; Personius and Machette, 1984 #1124). Kelson and others (1997 #1374) show a complex pattern of Quaternary deformation, with the heights of fault scarps in similar-aged deposits varying substantially along strike. Overall, there is a decrease in scarp height to the southwest from Talpa to Pilar. The pattern of other potentially fault-related features (*e.g.*, lineaments, stream deflections) also suggest a distributed pattern of surface deformation. Southwest of Pilar, the fault is obscured by large landslides along the Rio Grande gorge.

Age of faulted deposits Pleistocene alluvium is displaced by a thrust fault splay in road cut at Arroyo Hondo at northern end of fault (Personius and Machette, 1984 #1124). Kelson and others (1997 #1374) map faulted alluvial-fan deposits possibly as young as latest Pleistocene.

Detailed studies There have been limited detailed paleoseismic studies of the Embudo fault. Kelson and others (1997 #1374) provide a detailed map of Quaternary surficial deposits and potentially fault-related features between Talpa and Pilar. Machette and Personius (1984 #1113) and Kelson and others (1997 #1374) collected several scarp profiles along the Pilar section of the fault.

Timing of most recent paleoevent late Quaternary (<130 ka)

Comments: The timing of the most-recent event is constrained only on the basis of the estimated age of displaced alluvium at Arroyo Hondo. Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) suggest a Pleistocene age of faulted alluvium, but note that a probable single-event fault scarp has morphology of late Pleistocene normal faults in similar climates. Kelson and others (1996 #1191; 1997 #1374) suggest possible latest Pleistocene movement on the Pilar fault section, although deposit ages are poorly constrained. The structural connection with the southern Sangre de Cristo fault [2017] to the northeast also suggests a probable latest Pleistocene age for this section of the Embudo fault.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr

Comments: Kelson and others (1997 #1374) estimated a poorly constrained slip rate of <0.1 mm/yr for the Embudo fault. Wong and others (1995 #1155) estimated a slip rate of 0.09 mm/yr from slip rate estimates on fault systems along the margins of the San Luis and Española basins.

Length End to end (km): 38.7
Trace (km): 55.8

Average strike (azimuth) 060°±39°

Endpoints (lat. - long.) 36°19′45.66″N, 105°35′57.38″W
36°09′47.36″N, 105°58′41.49″W

2007b, Hernandez section

Section Number 2007b

Section Name Hernandez section

Comments: The Hernandez section is herein informally named after the village of Hernandez on the Rio Chama, located southeast of the fault trace. The section was defined as the "southwestern section" by Wong and others (1995 #1155) and the "southern section" by Kelson and others (1997 #1374). The section extends from the change in sense of vertical separation near Embudo (Machette and Personius, 1984 #1113) to an intersection with the Pajarito fault near Clara Peak (Wong and others, 1995 #1155).

Reliability of location Good

Comments: Location of the Hernandez section is based on analysis of aerial photography and field reconnaissance compiled at scales of 1:250,000 (Machette and Personius, 1984 #1113; Wong and others, 1995 #1155), field mapping at scales of 1:125,000 (Smith and others, 1970 #1125), 1:71,000 (Aldrich and Dethier, 1990 #1085), and 1:24,000 (Dethier and Manley, 1985 #1432).

Sense of movement S? N?

Comments: The Hernandez section exhibits down-to-the-southeast separation of alluvial rift-fill deposits along southern part of the fault. Although right-lateral slip has been suggested by some workers (Aldrich and Dethier, 1990 #1085; Gonzalez and Dethier, 1991 #1101), kinematic analyses by Bradford (1992 #1174) and Hillman (1986 #1758) suggest that the entire Embudo fault is a left-lateral strike-slip accommodation zone similar to those identified by Rosendahl (1987 #1394). S. Baldridge (Los Alamos National Laboratory, personal communication, 1996) suggests predominantly down-to-the-southeast vertical separation on the Hernandez fault section, in part based on geophysical modeling by Biehler and others (1991 #1086) and Binns (1992 #1776).

Dip 80°E to 80°W, preferred 90°

Comments: Although there are no detailed subsurface data on this fault section, Binns (1992 #1776) modeled gravity data across the fault and interpreted a vertical orientation. Wong and others (1995 #1155) estimated a range in fault dip for the seismogenic crust, based on the fault's linear trace across topography and analogy to accommodation zones within the Albuquerque basin (Russell and Snelson, 1994 #1186).

Dip direction V

Geomorphic expression Between Embudo and the Rio Chama, the fault is obscured by large landslides along the southeastern margin of Black Mesa. Between the Rio Chama and Clara Peak, the fault has little or no geomorphic expression across easily eroded rift-fill sediments (Kelley, 1978 #1107; Dethier and Manley, 1985 #1432).

Age of faulted deposits Oligocene to Miocene rift-fill sediments are faulted along the Hernandez fault section; there is no documented evidence of Quaternary displacement. Postulated Holocene displacement noted by Wachs and others (1988 #1766) was investigated and dismissed by Wong and others (1995 #1155).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)

Comments: The timing of the most-recent earthquake is unknown. The possibility of Quaternary movement is based on a structural connection with the Holocene Pajarito fault [2008] to the southwest and the latest Pleistocene Pilar section of the Embudo fault [2007a] to the northeast.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr

Comments: Kelson and others (1997 #1374) estimated a poorly constrained slip rate of <0.1 mm/yr for the Embudo fault. Wong and others (1995 #1155) estimated a slip rate of 0.09 mm/yr from slip rate estimates on fault systems along the margins of the San Luis and Española basins.

Length End to end (km): 31.6
Trace (km): 32.0

Average strike (azimuth) 054°±8°

Endpoints (lat. - long.) 36°19′45.66″N, 105°35′57.38″W
36°02′06.16″N, 106°13′25.35″W

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2008, Pajarito fault

Structure Number 2008

Structure Name Pajarito fault

Comments: The Pajarito fault was originally mapped and named the Los Alamos fault by Kelley (1954 #1222), and later mapped and renamed the Pajarito fault zone by Griggs (1964 #1434). Smith and others (1970 #1125), Kelley (1978 #1107), Dransfield and Gardner (1985 #1093), Gardner and House (1987 #1097) and Rogers (1995 #1386) have also mapped the fault zone in varying detail. The fault extends from an intersection with the Embudo fault [2007] near Clara Peak on the north to an intersection with the La Bajada fault [2032] near Cochiti Lake. The nearby subparallel Rendija Canyon [2026] and Guaje Mountain [2027] faults are structurally associated with the Pajarito fault and together comprise the Pajarito fault system of Wong and others (1995 #1155).

Synopsis: The Pajarito fault offsets early Quaternary volcanic rocks and younger alluvium on the west flank of the Pajarito plateau. The fault is associated with a prominent east-facing topographic scarp that is nearly 200 m high on the early Pleistocene Bandelier Tuff. The Pajarito fault probably accommodates most of the east-west Quaternary extension in this part of the Española basin. The Pajarito, Rendija Canyon [2026], and Guaje Mountain [2027] faults are structurally related, but it is unknown whether these faults rupture simultaneously or behave independently during surface-rupturing earthquakes.

Date of compilation 03/04/97

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Los Alamos, Sandoval, Rio Arriba

1° x 2° sheet Albuquerque, Aztec

Province Southern Rocky Mountains

Reliability of location Good
Comments: Fault location is based on field mapping compiled at scales of 1:125,000 (Smith and others, 1970 #1125) and 1:62,500 (Dransfield and Gardner, 1985 #1093; Gardner and House, 1987 #1097), modified by analysis of 1:6,000 to 1:58,000- scale aerial photography compiled at a scale of 1:100,000 (Wong and others, 1995 #1155; Olig and others, 1996 #1152; 1996 #1156).

Geologic setting The Pajarito fault is the primary structural boundary along the western margin of the Española basin of the Rio Grande rift, which is asymmetric and tilted to the west (Smith and others, 1970 #1125; Golombek, 1983 #1100; Gardner and House, 1987 #1097). The fault probably accommodates most of the roughly east-west Quaternary extension in the basin (Kelson and Olig, 1995 #1147).

Sense of movement N

Dip 50° to 70°, preferred average 60°
Comments: Surface and subsurface data are lacking for this fault. Wong and others (1995 #1155; 1996 #1156) estimated the above range in fault dip for seismogenic crust based on analogy to similar rift-margin faults along the eastern sides of the San Luis and Albuquerque basins. The Pajarito fault may be listric at depths of 10 km or more.

Dip direction E

Geomorphic expression Prominent west-facing topographic scarps up to 200 m in height are present along most mapped traces of the Pajarito fault, in particular across mesas underlain by the 1.2 Ma upper Bandelier Tuff.

Age of faulted deposits Late Pleistocene colluvium is displaced by secondary faults exposed in an exploratory trench. These deposits are estimated to have been deposited 45-55 ka based on two thermoluminescence analyses, and overlying unfaulted reworked airfall pumice deposit estimated to be about 50 to 60 ka (Wong and others, 1995 #1155; Olig and others, 1996 #1152; Reneau and others, 1996 #1264; Wolff and others, 1996 #1385).

Detailed studies Four trenches and three soil test pits were excavated at three sites along the central part of the Pajarito fault during the summer of 1992 (Kelson and others, 1993 #1149; Wong and others, 1995 #1155; Olig and others, 1996 #1152). Limited datable materials were encountered in these excavations. Evidence of multiple late Quaternary surface ruptures was exposed in several of the trenches, although there was no unequivocal exposure of a primary fault strand. The excavations were located at the Water Canyon, Water Tanks, and Pajarito Canyon sites.

Water Canyon (site 2008-1): one trench and three soil test pits were excavated at this site. The trench was excavated in early Holocene stream terrace deposits and extended across the projection of the base of the bedrock topographic scarp. No prominent fault strands were encountered in the trench. The soil pits exposed fluvial deposits and overlying deposits and provided a minimum age estimate of about 9 ka for undisplaced fluvial deposits, derived from two radiocarbon analyses. Holocene surface rupture on the fault cannot be precluded from studies at this site because of the possibility of a potentially younger fault strand west (uphill) of the trench.
Water Tanks (site 2008-2): two trenches were excavated at the base of the easternmost of two major topographic scarps at this site. The trenches were excavated in colluvial deposits and airfall pumice. Secondary faults do not offset but are overlain by 50 to 60 ka pumice deposits, although this unit did not extend across the upslope part of the trenches. Numerous large fissure-fill deposits were exposed and provide evidence of as many as five surface ruptures during a poorly constrained time period (probably late Pleistocene).

Pajarito Canyon (site 2008-3): one trench was excavated in colluvial and fluvial deposits at the base of the easternmost of two major topographic scarps at this site. The trench exposed indirect evidence for as many as five surface-faulting events. Secondary faults, possible fault-scarp colluvium, and shearing at the west end of the trench provide evidence for the youngest event. Structural and stratigraphic relations suggest other events, including formation of a graben during the event preceding the penultimate event. A thermoluminescence age of 137 ka on graben fill deposits provides a minimum age for this event.

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Timing of most-recent event unknown, although multiple events occurred during the late Quaternary (Wong and others, 1995 #1155; Olig and others, 1996 #1152).

Recurrence interval not reported
Comments: No recurrence data are available at the time of this compilation.

Slip-rate category <0.2 mm/yr
Comments: Based on an average net vertical tectonic displacement of 81 m of the 1.2 Ma upper Bandelier Tuff, Wong and others (1995 #1155) and Olig and others (1996 #1152) estimate an average long-term vertical slip rate of 0.07 mm/yr.

Length End to end (km): 49.4
Trace(km): 98.6

Average strike (azimuth) 005°±34°

Endpoints (lat. - long.) 36°02′01.80″N, 106°13′30.81″W
35°36′24.24″N, 106°22′42.91″W

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2009, Puye fault

Structure Number 2009

Structure Name Puye fault
Comments: The Puye fault was originally mapped as an unnamed fault zone by Kelley (1954 #1222), Smith and others (1970 #1125) and Kelley (1978 #1107). Gardner and House (1987 #1097) used the term “fault zone southwest of Hernandez” to describe the northern parts of the Puye fault. LaForge and Anderson (1988 #1111) and Wong and others (1995 #1155) used the name Puye fault zone. The Puye fault extends from an intersection with the Hernandez section of the Embudo fault [2007] between Clara Peak and the village of Hernandez on the north, to a point approximately 4 km west of the San Ildefonso Pueblo.

Synopsis: The Puye fault is a 6 km wide zone of north-trending fault strands in the western part of the Española basin. Fault scarps developed on middle and late Quaternary alluvial deposits show predominantly down-to-the-east displacements with minor down-to-the-west displacements. No paleoseismologic data are available at the time of this compilation.

Date of compilation 08/17/95

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Rio Arriba

1° x 2° sheet Albuquerque, Aztec

Province Southern Rocky Mountains

Reliability of location Good
Comments: The location of the Puye fault is based on field and reconnaissance mapping compiled at a scale of 1:125,000 (Smith and others, 1970 #1125; Kelley, 1978 #1107), modified by analysis of 1:24,000- and 1:58,000- scale aerial photography compiled at a scale of 1:250,000 (Wong and others, 1995 #1155).

Geologic setting The Puye fault is located adjacent to the western margin of the northern Rio Grande rift. The predominantly east-down Puye fault is subparallel to the Pajarito [2008], Guaje Mountain [2027], Rendija Canyon [2026], and Sawyer Canyon [2028] faults. The Puye fault accommodates some of the roughly east-west extension within the Española basin of the rift (Kelson and Olig, 1995 #1147; Carter and Gardner, 1995 #1154).

Sense of movement N
Comments: The Puye fault exhibits predominantly down-to-the-east normal separation of Quaternary deposits, although there are strands of the fault that show west-down separation. Carter and Gardner (1995 #1154) note that the consistency in orientations of slip lineations along the Puye fault, and the lack of vertical-axis rotations, suggests that there has been no significant strike slip or horizontal rotation of rocks along major faults in the area.

Dip 65° to 90°, preferred average 75°
Comments: Wong and others (1995 #1155) estimated a range in fault dip for the seismogenic crust, based on field data of K. Carter (unpublished data cited in Wong and others, 1995 #1155).

Dip direction E

Geomorphic expression Topographic scarps along the fault are present across mesas underlain by middle to late Pleistocene alluvial deposits. The scarps are discontinuous because of substantial incision of east-trending arroyos and dissection of Pleistocene geomorphic surfaces.

Age of faulted deposits The Puye fault displaces the Q1, Q2, and Q3 surfaces mapped by Harrington and Aldrich (1984 #1102), Dethier and Demsey (1984 #1090), Dethier and others (1988 #1146), and Dethier and McCoy (1993 #1168). The age of the Q1 surface is estimated to be early to middle Pleistocene (1100 to 350 ka), the age of the Q2 surface is estimated to be middle Pleistocene (400 to 240 ka), and the age of the Q3 surface is estimated to be middle to late Pleistocene (210 to 130 ka) (Dethier and others, 1988 #1146; Dethier and McCoy, 1993 #1168). The age of the oldest unfaulted deposits is unknown.

Detailed studies No detailed paleoseismic investigations of the Puye fault are available at the time of this compilation. However, LaForge and Anderson (1988 #1111) profiled a prominent topographic scarp along the fault, and note 11.5 m of down-to-the-east separation and a maximum scarp angle of 13°. The scarp profile data suggests multiple Pleistocene ruptures but no Holocene displacement (LaForge and Anderson, 1988 #1111). Wong and others (1995 #1155) also profiled a prominent scarp along the fault and estimate 7.5 m of separation and a maximum scarp angle of 18°. A distinct bevel in the profile also provides evidence of multiple surface ruptures along the fault. Lastly, Wong and others (1995 #1155) and House and Hartse (1995 #1160) observe a clustering of contemporary microseismicity in the vicinity of the Puye fault.

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: The timing of the most-recent event is unknown, but displacement of the Q3 surface mapped by Dethier and others (1988 #1146) and dated by Dethier and McCoy (1993 #1168) provide evidence of possible late Quaternary activity. Wong and others (1995 #1155) interpret scarp data as evidence for a most recent event as old as 100 ka.

Recurrence interval not reported
Comments: No paleoseismologic data are available at the time of this compilation.

Slip-rate category <0.2 mm/yr
Comments: (Carter and Gardner, 1995 #1154)(1995 #1155)Wong and others (1995 #1155) conservatively estimate a range of 0.01 to 0.30 mm/yr for the Puye fault, with a preferred value of 0.03 mm/yr, based on scarp-profile data and analysis of regional slip rates in the Rio Grande rift. Kelson and Olig (1995 #1147) use a preferred value of 0.03 mm/yr for the Puye fault.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 19.0 km and a cumulative trace length of 60.0 km.

Average strike (azimuth) -2°±19°

Endpoints (lat. - long.) 36°03′49.61″N, 106°09′13.86″W
35°53′33.67″N, 106°09′29.14″W

References

#1154 Carter, K.E., and Gardner, J.N., 1995, Quaternary fault kinematics in the northwestern Española basin, Rio Grande rift, New Mexico, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 97-103.

#1090 Dethier, D.P., and Demsey, K.A., 1984, Erosional history and soil development on Quaternary surfaces, northwest Española basin, New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 227-233.

#1146 Dethier, D.P., Harrington, C.D., and Aldrich, M.J., 1988, Late Cenozoic rates of erosion in the western Española basin, New Mexico—Evidence from geologic dating of erosion surfaces: Geological Society of America Bulletin, v. 100, p. 928-937.

#1168 Dethier, D.P., and McCoy, W.D., 1993, Aminostratigraphic relations and age of Quaternary deposits, northern Española basin, New Mexico: Quaternary Research, v. 39, p. 222-230.

#1097 Gardner, J.N., and House, L., 1987, Seismic hazards investigations at Los Alamos National Laboratory, 1984-1985: Los Alamos National Laboratory Report LA-11072-MS, 76 p.

#1102 Harrington, C.D., and Aldrich, M.J., Jr., 1984, Development and deformation of Quaternary surfaces on the northeastern flank of the Jemez Mountains, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 235-239.

#1160 House, L., and Hartse, H., 1995, Seismicity and faults in northern New Mexico, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 135-137.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1107 Kelley, V.C., 1978, Geology of Española basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 48, 1 sheet, scale 1:125,000.

#1147 Kelson, K.I., and Olig, S.S., 1995, Estimated rates of Quaternary crustal extension in the Rio Grande rift, northern new Mexico, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 9-12.

#1111 LaForge, R.C., and Anderson, L.W., 1988, Seismotectonic study for Santa Cruz dam, Santa Cruz dam modification project, New Mexico: U.S. Bureau of Reclamation Seismotectonic Report 88-2, 31 p.

#1125 Smith, R.L., Bailey, R.A., and Ross, C.S., 1970, Geologic map of the Jemez Mountains, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-571, 1 sheet, scale 1:125,000.

#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2010, Pojoaque fault zone

Structure Number 2010

Structure Name Pojoaque fault zone

Comments: Various strands of the Pojoaque fault have been mapped by Denny (1940 #1384), Kelley (1954 #1222), Galusha and Blick (1971 #1094), Baltz (1978 #1383), Kelley (1978 #1107), and Biehler and others (1991 #1086). The prominent fault strand originally mapped by Denny (1940 #1384) 4 km east of Española was named the Road fault by Galusha and Blick (1971 #1094), but this and numerous other strands were included in the Pojoaque fault zone of Kelley (1978 #1107). Wong and others (1995 #1155) continue this usage.

Synopsis: The Pojoaque fault zone is located east of Española, in the central part of the Española Basin. The fault zone consists of several north-trending, generally down-to-the-west subparallel faults in a zone approximately 5 km wide. The fault zone is poorly understood, with considerable uncertainty regarding its location, activity, and amount of displacement.

Date of compilation 07/10/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.; Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Santa Fe, Rio Arriba

1° x 2° sheet Albuquerque, Raton, Santa Fe

Province Basin and Range

Reliability of location Poor
Comments: Numerous variations of the published mapped trace of the Pojoaque fault zone suggest that the true location of this fault zone is poorly known. The mapped trace used herein is from mapping of Kelley (1978 #1107) and Biehler and others (1991 #1086) at a scale of 1:125,000, compiled by Wong and others (1995 #1155) at a scale of 1:250,000. Only the most prominent fault strands are shown.

Geologic setting The Pojoaque fault zone apparently forms part of the eastern boundary of the Velarde graben (Manley, 1976 #1114; 1979 #1117), a narrow structural trough that lies within the broader confines of the central Española basin. Geophysical data indicate that the Española basin probably is a hinged half graben, with a steep western limb and a gentle eastern limb or hinge; faults in the eastern part of the Española basin, including the Pojoaque fault zone, probably have displacements of no more than 100 to 200 m (Biehler and others, 1991 #1086; Ferguson and others, 1995 #1158). Faults that border inner grabens within the rift, such as the Pojoaque fault zone, probably are younger than some of the rift-margin structures (Ferguson and others, 1995 #1158).

Sense of movement N
Comments: Down-to-the-west and down-to-the-east displacements are present on fault strands within the Pojoaque fault zone; overall sense of displacement is down-to-the-west.

Dip 60°
Comments: There are no deep structural data on the Pojoaque fault zone. Biehler and others (1991 #1086) schematically show high-angle normal fault strands. Wong and others (1995 #1155) assumed a range in dip values of 50° to 70°, with a preferred value of 60°, on the basis of subsurface geometry of other rift faults.

Dip direction W; E
Comments: Biehler and others (1991 #1086) and Wong and others (1995 #1155) interpret that the main fault strands dip to the W.

Geomorphic expression The Pojoaque fault zone exhibits little geomorphic expression where fault strands are mapped in dissected, highly erodible rift-fill sediments of the Tesuque Formation.

Age of faulted deposits The Pojoaque fault zone is identified in Miocene Tesuque Formation and older rocks in the subsurface(Kelley, 1978 #1107; Biehler and others, 1991 #1086). No detailed studies of Quaternary deposits have been done across the fault, so the age of the youngest faulted deposit is unknown.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: No data on the presence or absence of displaced Quaternary deposits along the Pojoaque fault zone are available at the time of this compilation. Association of the Pojoaque fault zone with the Velarde graben (Manley, 1979 #1117; Ferguson and others, 1995 #1158) and north-south orientation of the fault suggest possible Quaternary activity.

Recurrence interval not reported
Comments: No detailed paleoseismologic studies have been completed to date.

Slip-rate category <0.2 mm/yr
Comments: (1976 #1114; 1979 #1117)Wong and others (1995 #1155) conservatively estimate a range of 0.01 to 0.23 mm/yr for the Pojoaque fault zone, with a preferred value of 0.02 mm/yr, based on analysis of regional slip rates in the Rio Grande rift and lack of prominent geomorphic expression. Kelson and Olig (1995 #1147) use a preferred value of 0.02 mm/yr for the Pojoaque fault.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 48.4 km and a cumulative trace length of 86.1 km.

Average strike (azimuth) 002°±18°

Endpoints (lat. - long.) 36°05′18.28″N, 106°00′16.00″W
35°39′10.63″N, 106°01′11.06″W

References

#1383 Baltz, E.H., 1978, Résumé of Rio Grande depression in north-central New Mexico, *in* Hawley, J.W., ed., Guidebook to Rio Grande rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 210-228.

#1086 Biehler, S., Ferguson, J., Baldridge, W.S., Jiracek, G.R., Aldern, J.L., Martinez, M., Fernandez, R., Romo, J., Gilpin, B., Braile, L.W., Hersey, D.R., Luyendyk, B.P., and Aiken, C.L., 1991, A geophysical model of the Española basin, Rio Grande rift, New Mexico: Geophysics, v. 56, p. 340-353.

#1384 Denny, C.S., 1940, Santa Fe Formation in the Española Valley, New Mexico: Geological Society of America Bulletin, v. 51, p. 677-693.

#1158 Ferguson, J.F., Baldridge, W.S., Braile, L.W., Biehler, S., Filpin, B., and Jiracek, G.R., 1995, Structure of the Española basin, Rio Grande rift, New Mexico, from SAGE seismic and gravity data, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 105-110.

#1094 Galusha, T., and Blick, J.C., 1971, Stratigraphy of the Santa Fe Group, New Mexico: American Museum of Natural History Bulletin 144, art. 1, 127 p.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1107 Kelley, V.C., 1978, Geology of Española basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 48, 1 sheet, scale 1:125,000.

#1147 Kelson, K.I., and Olig, S.S., 1995, Estimated rates of Quaternary crustal extension in the Rio Grande rift, northern new Mexico, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 9-12.

#1114 Manley, K., 1976, The late Cenozoic history of the Española basin, New Mexico: Boulder, University of Colorado, unpublished Ph.D. dissertation, 171 p.

#1117 Manley, K., 1979, Stratigraphy and structure of the Española basin, Rio Grande rift, New Mexico, *in* Riecker, R.E., ed., Rio Grande rift— Tectonics and magmatism: Washington, D.C., American Geophysical Union, p. 71-86.

#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los

Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2011, Unnamed faults east of Alma

Structure Number 2011

Structure Name Unnamed faults east of Alma
Comments: The faults are mapped between Devils Creek on the north and Whitewater Mesa on the south, about 5 km east of Alma, New Mexico.

Synopsis These suspected north-trending faults are mapped on high-level Quaternary surfaces that flank the western margin of the Mogollon Mountains. Although mapped as lineaments, the features appear to displace the Quaternary surfaces. No detailed studies have been conducted to confirm the presence of faulting.

Date of compilation 04/27/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Catron

1° x 2° sheet Clifton

Province Basin and Range

Reliability of location Good
Comments: Traces generalized and transferred to 1:250,000 scale base map from 1:24,000-scale mapping of Ratte (1981 #1270).

Geologic setting These suspected north-trending faults are mapped as linements that cross high-level Quaternary surfaces flanking the western margin of the Mogollon Mountains. They may represent horsetail-like splays at the northern end of the Tertiary to Quaternary age Mogollon fault [2012]. The surfaces are formed on basin-fill sediment of the Gila Congolmerate (Ratté, 1981 #1270).

Sense of movement N
Comments: Not reported, but inferred by compiler to be normal.

Dip not reported
Comments: Inferred to be high angle.

Dip direction W; E

Geomorphic expression These suspected north-trending faults are mapped as linements that cross eroded remanents of high-level Quaternary surfaces. On the basis of projections of adjacent surfaces from 1:24,000-scale topographic maps, one can speculate that there is a minor (<10 m) amount of vertical offset on the surfaces. Additionally, the faults appear to control the position of north and south-trending drainages that cut into underlying basin-fill sediment. From cursory inspection of aerial photographs (by the compiler), it appears that the faults may be more extensive than mapped by Ratte (1981 #1270).

Age of faulted deposits The surfaces that appear to be deformed are mapped as Quateranry (undifferentiated) and may date from the middle or early Quaternary (500 ka-1.6 Ma), which seems likely from their high-level position in the landscape. The surfaces are formed on basin-fill sediment (Gila Congolmerate, reported Pliocene to Pleistocene), which contains Pleistocene fossils in adjacent areas (Ratté, 1981 #1270).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing based on probable offset of middle to early Quaternary surfaces. However, movement may have occurred later in the Quaternary, but no detailed Quaternary studies or trenching investigations have been conducted.

Recurrence interval not reported

Slip-rate category unknown, probably <0.2 mm/yr
Comments: low slip-rate category assigned because there appears to be less than 10 m of vertical offset associated with these faults (mapped as lineaments).

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 12.0 km and a cumulative trace length of 23.2 km.

Average strike (azimuth) -13°±12°

Endpoints (lat. - long.) 33°28'40.49"N, 108°49'09.29"W
33°22'18.24"N, 108°50'24.33"W

References

#1270 Ratté, J.C., 1981, Geologic map of the Mogollon quadrangle, Catron County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1557, 1 sheet, scale 1:24,000.

2012, Mogollon fault

Structure Number 2012

Structure Name Mogollon fault
Comments: The Mogollon fault was probably named for its location just east of Mogollon Creek, near its junction with the Gila River. As shown by Leopoldt (1981 #1218), the portion of the fault with probable Quaternary movement is restricted to the northeast margin of the Mangas basin and extends from about Davis Canyon on the north to at least latitude 33° on the south (the southern limit of Leopoldt's mapping). However, the older Tertiary trace of the fault extends much farther, from Whitewater Draw (about 5 km west of Mogollon, New Mexico) south to about 10 km northwest of Silver City, New Mexico.

Synopsis This north-trending fault cuts basin-fill sediment (reported Miocene to Pleistocene) that is mapped as or probably is equivalent to the Gila Conglomerate. The Mogollon fault is the primary east-bounding fault of the Mogollon and Mangas grabens through which the Gila River flows. Drewes and others (1985 #1034) showed the fault as an irregular north- and northwest-trending major range-bounding structure on the eastern margin as the southern Mangas basin on the 1:250,000-scale geologic map of the Silver City 1° x 2° quadrangle. No detailed studies of Quaternary movement of the fault have been made.

Date of compilation 04/24/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Grant

1° x 2° sheet Clifton, Silver City

Province Basin and Range

Reliability of location Good

Comments: Trace transferred to 1:250,000-scale base map from 1:24,000-scale map of Leopoldt (1981 #1218). Traces shown on 1:250,000-scale geologic map of Silver City 1° x 2° quadrangle (Drewes and others, 1985 #1034) were not used because Quaternary movement has not been confirmed for this part of the longer Neogene fault.

Geologic setting This fault trends north and northwest and cuts younger basin-fill sediment (reported Pliocene to Pleistocene), which comprises the upper part of the Gila Conglomerate. In many places it juxtaposes basin-fill sediment against Tertiary and older bedrock, which is uplifted in the adjacent ranges to the east and northeast. The Mogollon fault is the primary east-bounding fault of the Mogollon and Mangas grabens through which the Gila River flows.

Sense of movement N

Dip 65° W
Comments: Leopoldt (1981 #1218) showed a single dip measurement of 65°.

Dip direction SW

Geomorphic expression This faults causes 110-m of offset in the projection of remnants of the Clum Mine Ridge pediment-terrace unit (gravel) of Leopoldt (1981 #1218) near the Foster Mine (Sec. 32, T. 14 S., R. 16 W.). In most places, the fault forms a dissected escarpment between Quaternary-Tertiary basin-fill sediment and uplifted Tertiary rock. Progressive west-side down movement on the fault may be responsible for the position of Mogollon Creek, which hugs the northeast margin of the basin.

Age of faulted deposits The fault offsets widely separated erosional remnants of Leopoldt's (1981 #1218) Clum Mine Ridge pediment-terrace unit (gravel). No datable materials have been reported from the deposit, but underlying facies of the basin-fill sediment (Gila Conglomerate) contain late Pliocene volcanic-ash beds (Leopoldt, 1981 #1218) and thus are considered to be upper Pliocene to lower Pleistocene. No surficial deposits of strictly Quaternary age were mapped along the trace of the fault by Leopoldt (1981 #1218). Considering the large amount of post-Pliocene offset, it seems likely that some of the reported offset must have occurred in the Quaternary.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing based on offset of upper Pliocene to lower Pleistocene Clum Mine Ridge pediment-terrace unit (gravel) (Leopoldt, 1981 #1218). If his correlations and stratigraphic assemblage is correct, the timing of most recent movement on this fault is at least early Quaternary, but could be younger. Unfortunately, there does not appear to be younger Quaternary deposits along the trace of the fault as mapped by Leopoldt (1981 #1218).

Recurrence interval not reported

Slip-rate category unknown, probably <0.2 mm/yr
Comments: Low slip rate category assigned based on 110 m of reported offset of the Clum Mine Ridge pediment that occurred since 5 Ma.

Length End to end (km): 15.3
Trace (km): 17.9

Average strike (azimuth) -37°±18°

Endpoints (lat. - long.) 33°07′30.23″N, 108°34′25.55″W
33°00′08.42″N, 108°29′52.95″W

References

#1034 Drewes, H., Houser, B.B., Hedlund, D.C., Richter, D.H., Thorman, C.H., and Finnell, T.L., 1985, Geologic map of the Silver City 1° x 2° quadrangle New Mexico and Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-1310-C, 1 sheet, scale 1:250,000.

#1218 Leopoldt, W., 1981, Neogene geology of the central Mangas graben, Cliff-Gila area, Grant County, New Mexico: Albuquerque, University of New Mexico, unpublished M.S. thesis, 160 p., 1 pl., scale 1:24,000.

2013, Mockingbird Hill fault zone

Structure Number 2013

Structure Name Mockingbird Hill fault zone
Comments: Source of name is unknown. The fault zone, as shown by Leopoldt (1981 #1218), extends from Maldonado Canyon on the north, south and southwest to a point about 0.5 km north of First Creek. At First Creek, the fault curves to the southeast where it may connect with the Silver City fault, a northwest-trending Tertiary fault. The west margin of the fault zone is formed by a basinward splay that extends in a north-northeast direction about 2.5 km, between Northrup and Guerrero Canyons, 2-3 km northeast of Gila.

Synopsis This irregular generally northeast-trending fault zone cuts basin-fill sediment (reported Miocene to Pleistocene) that is probably equivalent to the Gila Conglomerate. The faults of the zone define the eastern margin of the Mangas Graben in the vicinity of Gila, New Mexico. Evidence for late Pliocene to early Pleistocene movement is clear, and there appears to be a discordance in the level of correlative middle Pleistocene pediments. However, no detailed studies of Quaternary movement of the fault zone have been made.

Date of compilation 04/16/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Grant

1° x 2° sheet Silver City

Province Basin and Range

Reliability of location Good
Comments: Trace transferred to 1:250,000-scale base map from 1:24,000 scale map of Leopoldt (1981 #1218). Extensions to the north and southeast are from 1:250,000-scale geologic map of Silver City 1° x 2° quadrangle (Drewes and others, 1985 #1034).

Geologic setting The fault zone trends north-northeast and juxtaposes younger basin-fill sediment (reported Pliocene to Pleistocene) against older basin-fill sediment, both of which comprise the classic Gila Conglomerate. The faults define the eastern margin of the Mangas graben in the vicinity of Gila, New Mexico. The fault curves southeast and may connect with the Silver City, which displaces sediment of the Gila Group (commonly known as the Gila Conglomerate), but not Quaternary surficial deposits.

Sense of movement N

Dip not reported
Comments: Although no specific dip measurements are shown by Leopoldt (1981 #1218), the relatively straight trace of the fault across hills and valleys implies a high-angle dip (>60°).

Dip direction W

Geomorphic expression The eastern margin of the fault zone forms erosional fault-line escarpments between basin-fill sediment and uplifted Tertiary bedrock and appears to control the course of Bear Creek. The western margin (splay) fault causes a slight discordance in the elevation of erosional remnants of Leopoldt's (1981 #1218) unit Qp2 (the Wild Horse Mesa pediment-terrace). No fault scarps appear to be preserved on Quaternary surficial units. Leopoldt suggested that a similar-trending fault(s) controls the course of the Gila River on the basis of discordant elevations of ash beds and differential tilting of the Pliocene portion of the Gila Group east and west of the river, north of Gila.

Age of faulted deposits The western margin fault offsets erosional remnants of Leopoldt's (1981 #1218) unit Qp2. The unit is suspected to be of middle Pleistocene age on the basis of topographic and stratigraphic position, but no datable materials have been reported from the deposits. Unit Qp2 is the middle of three Pleistocene pediment-terrace units mapped by Leopoldt (1981 #1218). The faults on the eastern margin place basin-margin sediment of the Gila Group (reported as Pliocene to lower Pleistocene by Leopoldt (1981 #1218) against uplifted older basin-fill sediment and older Tertiary rock. Movement on the eastern faults may be confined to the Pliocene, but likely continued into the early Pleistocene in association with movement on the western margin fault of the zone (Leopoldt, 1981 #1218).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on offset of middle Pleistocene Wild Horse Mesa pediment-terrace of Leopoldt (1981 #1218). Leopoldt states that upper Pleistocene terrace deposits are not offset by the fault.

Recurrence interval not reported

Slip-rate category unknown; probably<0.2 mm/yr
Comments: The lack of demonstrable late Pleistocene movement and apparent slight offset of the middle Pleistocene pediment suggests that the fault has a low slip rate, probably <0.2 mm/yr. However, no measurement of offset have been made in either the middle Pleistocene or older units, nor have these deposits been dated.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 6.6 km and a cumulative trace length of 8.3 km.

Average strike (azimuth) 018°±21°

Endpoints (lat. - long.) 32°59′59.29″N, 108°30′21.29″W
32°56′29.13″N, 108°31′20.42″W

References

#1034 Drewes, H., Houser, B.B., Hedlund, D.C., Richter, D.H., Thorman, C.H., and Finnell, T.L., 1985, Geologic map of the Silver City 1° x 2° quadrangle New Mexico and Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-1310-C, 1 sheet, scale 1:250,000.

#1218 Leopoldt, W., 1981, Neogene geology of the central Mangas graben, Cliff-Gila area, Grant County, New Mexico: Albuquerque, University of New Mexico, unpublished M.S. thesis, 160 p., 1 pl., scale 1:24,000.

2014, Unnamed fault south of Gila

Structure Number 2014

Structure Name Unnamed fault south of Gila
Comments: This unnamed fault is shown by Leopoldt (1981 #1218) as trending west-northwest, south of the town of Gila, New Mexico. It extends about 3.5 km across a mesa at the head (northeast end) of Pope Canyon.

Synopsis This northwest-trending fault cuts basin-fill sediment (reported Miocene to Pleistocene) that is probably equivalent to the Gila Conglomerate. Additionally, it displaces a middle(?) Pleistocene surface about 3 m suggesting movement of middle Pleistocene or younger age. Drewes and others (1985

#1034) show a similar series of south-trending fault cutting Gila Group sediment on the 1:250,000-scale geologic map of Silver City 1° x 2° quadrangle, west of the Gila River. However, no detailed mapping of the Quaternary deposits nor studies of Quaternary movement of the fault have been made.

Date of compilation 04/21/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Grant

1° x 2° sheet Silver City

Province Basin and Range

Reliability of location Good
Comments: Trace transferred to 1:250,000 scale base map from 1:24,000-scale map of Leopoldt (1981 #1218). Traces shown on 1:250,000-scale geologic map of Silver City 1° x 2° quadrangle (Drewes and others, 1985 #1034) not used because Quaternary movement has not been confirmed for these fault.

Geologic setting This fault trends west-northwest and cuts younger basin-fill sediment (reported Pliocene to Pleistocene), which comprises the upper part of the Gila Group (the classic Gila Conglomerate), and a middle(?) Pleistocene unit. The fault is subparallel, but 2-3 km southwest of the Silver City fault as mapped by Finnell (1982 #1742) which does not have reported Quaternary movement.

Sense of movement N

Dip not reported
Comments: Although no specific dip measurements are shown by Leopoldt (1981 #1218), the trace of the fault across hills and valleys implies a relatively high- angle dip (>60°).

Dip direction SW

Geomorphic expression This fault forms a 3-m high southwest-facing scarp on Leopoldt's (1981 #1218) unit Qp3 (the Mogollon terrace-pediment). No studies of scarp morphology have been made for this scarp.

Age of faulted deposits The fault offsets erosional remnants of Leopoldt's (1981 #1218) unit Qp3, which is suspected to be middle Pleistocene on the basis of topographic and stratigraphic position, but no datable materials have been reported from the associated deposits. Unit Qp3 is the youngest of three Pleistocene pediment-terrace units mapped by Leopoldt (1981 #1218). Unit Qp3 rests unconformably on basin-center facies of younger basin-fill sediment, which is probably equivalent to the upper part of the Gila Group. Leopoldt (1981 #1218) reports an age of Pliocene to lower Pleistocene for the upper basin sediment of the Gila Group.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on offset of middle Pleistocene Mogollon terrace-pediment of Leopoldt (1981 #1218). If his correlations and stratigraphic assemblage are correct, the most recent movement on this fault probably occurred in the later part of the middle Pleistocene.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr
Comments: The lack of late Pleistocene movement and apparent slight (3 m) offset of the middle(?) Pleistocene Mogollon surface suggests that the fault has a slip rate of <0.2 mm/yr. However, there have been no determinations of the timing of the penultimate event or recurrence intervals to help define the actual slip rate.

Length End to end (km): 3.6
Trace (km): 3.6

Average strike (azimuth) -52°±8°

Endpoints (lat. - long.) 32°57′04.49″N, 108°33′52.39″W
32°55′53.41″N, 108°32′2.75″W

References

#1034 Drewes, H., Houser, B.B., Hedlund, D.C., Richter, D.H., Thorman, C.H., and Finnell, T.L., 1985, Geologic map of the Silver City 1° x 2° quadrangle New Mexico and Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-1310-C, 1 sheet, scale 1:250,000.

#1742 Finnell, T.L., 1982, Geologic map of the Dorsey Ranch quadrangle, Grant County, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1431, 1 sheet, scale 1:24,000.

#1218 Leopoldt, W., 1981, Neogene geology of the central Mangas graben, Cliff-Gila area, Grant County, New Mexico: Albuquerque, University of New Mexico, unpublished M.S. thesis, 160 p., 1 pl., scale 1:24,000.

2015, Mesita fault

Structure Number 2015
Comments: The Mesita fault is fault number 108 of Kirkham and Rogers (1981 #792) and fault number 189 of Witkind (1976 #2792).

Structure Name Mesita fault
Comments: The north-trending Mesita fault was mapped by Colton (1976 #1136) and Thompson and Machette (1989 #1382) in southern Colorado, and by Machette and Personius (1984 #1113) in northern New Mexico. The fault name was first used by Kirkham and Rogers (1981 #792) and is derived from Mesita Hill, a prominent Pliocene(?) cinder cone offset by the fault in southern Colorado. The fault extends from the eastern flank of Ute Mountain in New Mexico to about 5 km north of Mesita cone in southern Colorado. The southern end of the fault is about 4 east of Ute Mountain, and the fault crosses the New Mexico-Colorado border about 7 km north-northeast of Ute Mountain. Only the southern 7 km of the Mesita fault are in New Mexico.

Synopsis: The Mesita fault is a north-striking normal fault within the southern San Luis basin; the fault lies 7 to 14 km west of the Sangre de Cristo fault [2017] and has the same down-to-the-west sense of displacement. In southern Colorado, the fault forms prominent topographic scarps of less than 1.5 m on latest Pleistocene alluvium, 8 m on middle Pleistocene alluvium, and 8-10 m on Pliocene(?) basalt. In New Mexico, the fault is marked by 2- to 5-m-high scarps in middle to late(?) Pleistocene alluvium.

Date of compilation 7/30/96

Compiler and affiliation Keith I. Kelson; William Lettis & Associates, Inc., and Stephen F. Personius, U.S. Geological Survey

State New Mexico, Colorado

County Taos, Costilla

1° x 2° sheet Raton, Trinidad

Province Southern Rocky Mountains

Reliability of location Good
Comments: The fault trace in Colorado is from 1:50,000-scale mapping of Thompson and Machette (1989 #1382); the fault trace in New Mexico is from 1:250,000-scale mapping of Machette and Personius (1984 #1113). Parts of the fault have also been mapped at scales of 1:250,000 by Colton (1976 #1136), 1:500,000 by Witkind (1976 #2792), 1:5,000,000 by Howard and others (1978 #312), 1:500,000 by

Kirkham and Rogers (1981 #792), 1:1,000,000 by Colman (1985 #1953), and 1:125,000 by Colman and others (1985 #1954).

Geologic setting The west-down Mesita fault lies within the southern San Luis Basin, and is parallel to the rift-margin Sangre de Cristo fault [2017] to the east.

Sense of movement N

Dip 60°
Comments: No structural data have been published for the Mesita fault, so down-dip fault geometry is unknown. Deep seismic reflection data and two-dimensional modeling of gravity data suggest that the most likely dip of the Sangre de Cristo fault is 60° (Kluth and Schaftenaar, 1994 #1183). Based on the presence of similarly west-dipping faults in seismic reflection data given by Kluth and Schaftenaar (1994 #1183) and Brister and Gries (1994 #1178), a 60° dip is reasonable for the Mesita fault.

Dip direction W

Geomorphic expression The Mesita fault has prominent geomorphic expression along most of its mapped length. The fault displaces the Pliocene(?) Mesita cone in southern Colorado, and crosses Pleistocene alluvium on the floor of the San Luis basin in Colorado and northern New Mexico.

Age of faulted deposits In Colorado, total displacements across the Mesita fault are 15-30 m in Pliocene Servilleta Basalt (Burroughs, 1978 #1381), 8-13 m in Pliocene(?) Andesite of Mesita Hill (Kirkham and Rogers, 1981 #792; Thompson and Machette, 1989 #1382), 8 m in middle Pleistocene (200-600 ka) alluvium, 2-3 m in middle and late Pleistocene (125-150 ka) alluvium, and about 1.5 m in latest Pleistocene (15-25 ka) alluvium (Thompson and Machette, 1989 #1382). In New Mexico, the fault is marked by 2- to 5-m-high scarps on middle to late(?) Pleistocene alluvium (Machette and Personius, 1984 #1113; Personius and Machette, 1984 #1124). The fault is buried by Holocene (<10 ka) alluvium at Costilla Creek in southern Colorado (Thompson and Machette, 1989 #1382).

Detailed studies There have been no detailed paleoseismic investigations along the Mesita fault, although Machette and Personius (1984 #1113), Personius and Machette (1984 #1124), and Thompson and Machette (1989 #1382) measured fault scarp profiles and estimated the ages of offset deposits along the fault.

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: The most recent event post-dates middle to late(?) Pleistocene alluvium in New Mexico (Machette and Personius, 1984 #1113; Personius and Machette, 1984 #1124), and latest Pleistocene (15-25 ka) alluvium in southern Colorado (Thompson and Machette, 1989 #1382). The fault is buried by Holocene (<10 ka) alluvium in Colorado (Thompson and Machette, 1989 #1382).

Recurrence interval Not reported

Slip rate category unknown; probably <0.2 mm/yr
Comments: Personius and Machette (1984 #1124) note that the Mesita fault displaces late Pleistocene alluvium approximately 2 to 5 m, but that the alluvium probably is older than about 25 ka. Assuming an age range of 25 to 130 ka for the late Pleistocene alluvium and a displacement of 2 to 5 m, a slip rate of 0.01 to 0.20 mm/yr can be estimated for the fault in New Mexico. In southern Colorado, offsets of about 1.5 m in latest Pleistocene (15-25 ka) deposits and 8 m in middle Pleistocene (200-600 ka) deposits (Thompson and Machette, 1989 #1382) yield estimated slip rates of 0.01-0.1 mm/yr.

Length End to end (km): 8.6
Trace (km): 9.0

Average strike (azimuth) -9°±24

Endpoints (lat. - long.) 37°00′00.32″N, 105°38′52.23″W
36°55′23.68″N, 105°38′3.61″W

References

#1178 Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa basin (northern San Luis Basin), Rio Grande rift, south-central Colorado, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 39-58.

#1381 Burroughs, R.L., 1978, Northern rift guide 2, Alamosa, Colorado-Santa Fe, New Mexico—Alamosa to Antonito, Colorado, *in* Hawley, J.W., ed., Guidebook to Rio Grande rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 33-36.

#1953 Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations I-1566, 1 sheet,.

#1954 Colman, S.M., McCalpin, J.P., Ostenaa, D.A., and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande Rift, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations I-1594, 2 sheets,.

#1136 Colton, R.B., 1976, Map showing landslide deposits and late Tertiary and Quaternary faulting in the Fort Garland-San Luis area, Colorado-New Mexico: U.S. Geological Survey Open-File Report 76-185, 1 sheet, scale 1:250,000.

#312 Howard, K.A., Aaron, J.M., Brabb, E.E., Brock, M.R., Gower, H.D., Hunt, S.J., Milton, D.J., Muehlberger, W.R., Nakata, J.K., Plafker, G., Prowell, D.C., Wallace, R.E., and Witkind, I.J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U.S. Geological Survey Miscellaneous Field Studies Map MF-916, 2 sheets, scale 1:5,000,000.

#792 Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p., 3 pls.

#1183 Kluth, C.F., and Schaftenaar, C.H., 1994, Depth and geometry of the northern Rio Grande rift in the San Luis Basin, south-central Colorado, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 27-37.

#1113 Machette, M.N., and Personius, S.F., 1984, Map of Quaternary and Pliocene faults in the eastern part of the Aztec 1° by 2° quadrangle and the western part of the Raton 1° by 2° quadrangle, northern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-B, 1 sheet, scale 1:250,000.

#1124 Personius, S.F., and Machette, M.N., 1984, Quaternary and Pliocene faulting in the Taos Plateau region, northern New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 83-90.

#1382 Thompson, R.A., and Machette, M.N., 1989, Geologic map of the San Luis Hills area, Conejos and Costilla Counties, Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-1906, 1 sheet, scale 1:50,000.

#2792 Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-File Report 76-154,.

2016, Sunshine Valley faults

Structure Number 2016

Structure Name Sunshine Valley faults

Comments: The Sunshine Valley faults consist of several parallel, north-trending faults mapped by Colton (1976 #1136), Machette and Personius (1984 #1113), and Personius and Machette (1984 #1124) between Guadalupe and Ute Mountains in Sunshine Valley. The faults were regarded as the southern extension of the Mesita fault [2015] by Colton (1976 #1136), but Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) considered the Sunshine Valley faults as separate structures because of a lack of continuity with and an opposite sense of displacement from the Mesita fault. The longest of these faults extends from a point 5 km due west of the village of El Rito to a point 6 km east of Ute Mountain. The traces of the Sunshine Valley faults have been simplified to a single trace in this compilation.

Synopsis: The Sunshine Valley faults are a series of north-striking normal faults within the southern San Luis basin; these faults lie 7 km west of the Sangre de Cristo fault [2017] and have an opposite (down-to-the-east) sense of displacement. Elongate ridges of middle(?) Pleistocene alluvium on the upthrown side of the fault, alignment of vegetation, and possible ponded alluvium on the downthrown (upstream) side of the fault suggest that the faults have middle to late Pleistocene movement. No prominent topographic scarps are identified along the fault trace.

Date of compilation 07/30/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Taos

1° x 2° sheet Raton

Province Southern Rocky Mountains

Reliability of location Good
Comments: The Sunshine Valley faults were mapped by Colton (1976 #1136), and later compiled and interpreted by Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) at a scale of 1:250,000.

Geologic setting The Sunshine Valley faults lie within the southern San Luis basin, and are parallel to the rift-margin Sangre de Cristo fault [2017] to the east. The limited length of the fault, down-to-the-east displacement, and parallelism with the Sangre de Cristo fault suggest that the Sunshine Valley faults may be antithetic to the main rift-margin fault, comparable to antithetic structures interpreted by Kluth and Schaftenaar (1994 #1183) and Brister and Gries (1994 #1178) in the northern San Luis basin. The total vertical separation of Pleistocene alluvium across the faults is probably less than 5 m (Machette and Personius, 1984 #1113; Personius and Machette, 1984 #1124).

Sense of movement N

Dip 80° E
Comments: There are no deep structural data published for the Sunshine Valley faults, so down-dip fault geometries are unknown. If the faults dip 80° E, they would intersect the 60° W-dipping Sangre de Cristo fault at about 7 to 10 km depth; if the Sunshine Valley faults dip less than 70° E, then they intersect the Sangre de Cristo fault in the shallow crust above the seismogenic depth of large earthquakes.

Dip direction E

Geomorphic expression The Sunshine Valley faults have little geomorphic expression, but are associated with elongate ridges of middle(?) Pleistocene alluvium, ponded younger alluvium, and vegetation lineaments. The faults have uphill-facing scarps that are easily buried by alluvium.

Age of faulted deposits Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) suggest displacement of middle(?) to late Pleistocene alluvium along the Sunshine Valley faults.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: The most recent event post-dates probable middle(?) Pleistocene alluvium (Machette and Personius, 1984 #1113; Personius and Machette, 1984 #1124).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Low slip rate category assigned based on data of Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) who note that the Sunshine Valley faults probably displace late Pleistocene alluvium less than 5 m.

Length End to end (km): 14.1
Trace (km): 14.3

Average strike (azimuth) 004°±11°

Endpoints (lat. - long.) 36°55'31.06"N, 105°36'59.48"W
36°47'55.28"N, 105°37'39.16"W

References

#1178 Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa basin (northern San Luis Basin), Rio Grande rift, south-central Colorado, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 39-58.

#1136 Colton, R.B., 1976, Map showing landslide deposits and late Tertiary and Quaternary faulting in the Fort Garland-San Luis area, Colorado-New Mexico: U.S. Geological Survey Open-File Report 76-185, 1 sheet, scale 1:250,000.

#1183 Kluth, C.F., and Schaftenaar, C.H., 1994, Depth and geometry of the northern Rio Grande rift in the San Luis Basin, south-central Colorado, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 27-37.

#1113 Machette, M.N., and Personius, S.F., 1984, Map of Quaternary and Pliocene faults in the eastern part of the Aztec 1° by 2° quadrangle and the western part of the Raton 1° by 2° quadrangle, northern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-B, 1 sheet, scale 1:250,000.

#1124 Personius, S.F., and Machette, M.N., 1984, Quaternary and Pliocene faulting in the Taos Plateau region, northern New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 83-90.

2017, Southern Sangre de Cristo fault

Structure Number 2017

Structure Name Southern Sangre de Cristo fault

Comments: The Sangre de Cristo fault system borders the eastern margin of the San Luis basin, which extends from Poncha Pass, Colorado, to near Taos, New Mexico. This description addresses only the southern part of the fault system, which extends from the north end of San Pedro Mesa Creek south to its intersection with the Embudo fault at Rio Grande del Rancho, about 8 km south of Taos. Upson (1939 #1142) first mapped the fault in Colorado and northern New Mexico. The southern Sangre de Cristo fault, as used by Menges (1988 #1120; 1990 #1116; 1990 #1387) and herein, includes the Sangre de Cristo fault zone of Lipman and Mehnert (1975 #1955), the Taos fault of Dungan and others (1984 #1181), and the Cedros Canyon, Urraca Ranch, Taos Pueblo, and Cañon faults of Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124).

Synopsis: The Southern Sangre de Cristo fault is a west-dipping fault that in New Mexico forms the border between the Sangre de Cristo Mountains and the San Luis basin, and in Colorado forms the border between San Pedro Mesa to the east and San Luis Valley to the west. At the New Mexico/Colorado border there is an embayment in the Sangre de Cristo range front that causes it to deflect eastward to the Central Sangre de Cristo fault. The Southern Sangre de Cristo fault is divided into five sections, only one of which is in Colorado. In New Mexico the fault sections show evidence of multiple late Quaternary movement, including possible ruptures during the late to middle Holocene. The trace of the fault in Colorado is mainly buried by Quaternary landslide debris.

Date of compilation 04/27/98

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.; Robert Kirkham, Colorado Geological Survey; Michael N. Machette, U.S. Geological Survey

State New Mexico, Colorado

County Taos, Costilla

1° x 2° sheet Raton, Trinidad

Province Southern Rocky Mountains

Geologic setting: The Southern Sangre de Cristo fault is part of a major rift-margin structure of Neogene age that borders the eastern margin of the Rio Grande rift in south-central Colorado and north-central New Mexico. The entire Sangre de Cristo fault zone generally forms the boundary between the San Luis basin, a narrow (10-25 km wide), east-tilted, asymmetrical half-graben on the west, and the Sangre de Cristo Mountains on the east. There is 7-8 km of structural relief on Precambrian basement rock across the Sangre de Cristo fault zone. The western margin of the San Luis basin has comparatively little displacement, and no evidence of late Quaternary displacement. The southern end of the fault merges with or intersects the north-down, sinistral Pilar section of the Embudo fault [2007a] near the village of Talpa, New Mexico. Wong and others (1995 #1155) note that a few well-located earthquakes appear to have occurred in the vicinity of the fault in New Mexico.

Number of Sections 5 (4 in New Mexico, 1 in Colorado)

Comments: The Southern Sangre de Cristo fault is divided into 5 sections. The four sections in New Mexico are better exposed and have been studied in more detail than the single section in Colorado. Menges (1988 #1120; 1990 #1116; 1990 #1387) defined 4 geometric segments and 13 subsegments of the southern Sangre de Cristo fault in New Mexico on the basis of physiographic and geomorphic expression of the fault zone and the morphology of the Sangre de Cristo range front in New Mexico, but did not investigate the part of the fault that extends north into Colorado.

For the New Mexico portion of the fault, Wong and others (1995 #1155) considered a two-segment rupture scenario (segments 3 and 4 of Menges, 1990 #1116; 1990 #1387) and a three-segment rupture scenario (segments 2, 3, and 4 of Menges, 1990 #1116; 1990 #1387). Because of the lack of age control of faulted late Quaternary deposits and surfaces, herein we discuss Menges' four segments as sections.

Length not applicable

Comments: The fault zone includes numerous faults that have an end to end length of 75.0 km and a cumulative trace length of 189.2 km.

Average strike (azimuth) -4°±41°

Endpoints (lat. - long.) 37°00′00.52″N, 105°30′40.10″W
36°19′42.01″N, 105°35′50.86″W

2017a, San Pedro Mesa section

Section Number 2017a

Comments: Fault 109 in Kirkham and Rogers (1981 #792) and fault 1 in Colman (1985 #1953).

Section Name San Pedro Mesa section

Comments: The San Pedro Mesa section of the Southern Sangre de Cristo fault is essentially the same structure as fault 109 of Kirkham and Rogers (1981 #792). The fault begins at Costilla Creek in New Mexico, extends north along the west side of San Pedro Mesa, and terminates or is covered by younger deposits along Culebra Creek, west of San Luis, Colorado.

Reliability of location Good

Comments: The trace of this section of the fault is based on two sources. Most of the trace is from Colman and others (1985 #1954) at a scale of 1:125,000. Most of this section of the fault is concealed by landslide deposits and is poorly mapped. The splays that extend to the northwest off the northern end of the fault are mapped by Thompson and Machette (1989 #1382) at 1:50,000 scale, and are better located. The fault is also mapped at 1:250,000 scale by Colton (1976 #1136), at 1:500,000 by Kirkham and Rogers (1981 #792), and at 1:1,000,000 by Tweto (1978 #1956).

Sense of movement N

Dip 60° W

Comments: Deep seismic-reflection data and two-dimensional modeling of gravity data suggest that the most likely dip of the Sangre de Cristo fault is 60° (Kluth and Schaftenaar, 1994 #1183). Tandon (1992 #1390; cited in Chapin and Cather, 1994 #1180) interpreted the same data set which was processed for deeper resolution, and concludes that the fault dips about 60° to at least 26-28 km depth, which is probably below the brittle-ductile transition zone. Wong and others (1995 #1155) used a preferred value of 60° for the southern Sangre de Cristo fault, and assumed other possible dips of 50° and 70° for the fault within the seismogenic crust.

Dip direction W

Geomorphic expression The San Pedro Mesa section is generally obscured by Quaternary landslide deposits along most of its length. Discontinuous scarps are seen among and between landslide deposits, typically during early morning sunlight. The splays that extend to the northwest off the northern end of the main fault are mapped by Thompson and Machette (1989 #1382) and have subtle scarps associated with them.

Age of faulted deposits Thompson and Machette (1989 #1382) indicated middle Pleistocene alluvium (unit Qa) is offset by this fault.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: The exact timing of the latest paleoevent is unknown. A late Quaternary age is postulated for this fault because it offsets middle Pleistocene alluvium but apparently the trace is generally concealed by undifferentiated Quaternary landslide deposits (Thompson and Machette, 1989 #1382).

Recurrence interval not reported

Slip-rate category unknown, probably <0.2 mm/yr
Comments: Burroughs (1978 #1381) reported that the Servilleta Formation is offset 600 m by the fault near the Colorado-New Mexico line. Thompson and Machette (1989 #1382) reported dates ranging from 3.6 to 4.5 Ma for the Servilleta basalts, suggesting a low long-term slip rate.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 3.4 km and a cumulative length of 3.4 km.

Average strike (azimuth) 011°±10°

Endpoints (lat. - long.) 37°00′00.52″N, 105°30′40.10″W
36°58′11.17″N, 105°31′08.37″W

2017b, Urraca section

Section Number 2017b
Comments: Segment 1 of Menges (1988 #1120; 1990 #1116; 1990 #1387).

Section Name Urraca section
Comments: This section is essentially coincident with segment 1 of Menges (1988 #1120; 1990 #1116; 1990 #1387), but a new name is used to avoid numerical section designations. This section includes the Cedro Canyon and Urraca Ranch faults of Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124). The northern termination of the section is at Costilla Creek, which marks the southern edge of a large re-entrant of the Sangre de Cristo Mountains. The southern end of the section

is at Rito Primero, which coincides with a moderate salient in the range front and is the northern end of segment 2 of Menges (1988 #1120; 1990 #1116; 1990 #1387).

Reliability of location Good
Comments: Menges (1988 #1120) mapped fault traces from aerial photography at scales of 1:15,780 to 1:70,000, and presents mapping at a scale of about 1:400,000. Machette and Personius (1984 #1113) mapped fault traces at a scale of 1:250,000.

Sense of movement N

Dip 60° W
Comments: Deep seismic reflection data and two-dimensional modeling of gravity data suggest that the most likely dip of the Sangre de Cristo fault is 60° (Kluth and Schaftenaar, 1994 #1183). Tandon (1992 #1390; cited in Chapin and Cather, 1994 #1180) interprets the same data set processed for deeper resolution, and concludes that the fault dips about 60° to at least 26 to 28 km, which is probably below the brittle-ductile transition zone. Wong and others (1995 #1155) used a preferred value of 60° for the southern Sangre de Cristo fault, and assumed other possible dips of 50° and 70° for the fault within the seismogenic crust.

Dip direction W

Geomorphic expression Prominent west-facing fault scarps are present on late Pleistocene and possibly Holocene alluvial fans derived from the Sangre de Cristo Mountains. Menges (1988 #1120; 1990 #1116; 1990 #1387) documents the presence of truncated ridge spurs and triangular facets along the Sangre de Cristo range front, and interprets these features as products of long-term displacement.

Age of faulted deposits Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) identify displaced late Quaternary deposits along the fault, including alluvial-fan deposits interpreted as middle to late Pleistocene and possibly early Pleistocene. These workers note that latest Pleistocene to Holocene alluvial-fan sediments bury the fault at the northern end of this section. Menges (1990 #1116; 1990 #1387), in contrast, notes that this fault section has experienced late Pleistocene to late Holocene movement.

Detailed studies none

Timing of most recent paleoevent latest Quaternary (< 15 ka)
Comments: The exact timing of the most-recent event is unknown. However, Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) suggest a late Pleistocene age for the most recent movement based on scarp profile data. Menges (1988 #1120; 1990 #1116; 1990 #1387) conducted a more exhaustive study of fault-related landforms, and suggests the possibility of late to middle Holocene movement along part of the Urraca section.

Recurrence interval 10 to 50 k.y.
Comments: Menges (1988 #1120; 1990 #1116; 1990 #1387) estimates recurrence at a given site along the southern Sangre de Cristo fault as 10^4 years, and states that this is compatible with data from the northern part of the Sangre de Cristo fault system (≈10 to 50 k.y.) given by McCalpin (1982 #791). On the basis of these data, Wong and others (1995 #1155) estimate recurrence intervals of 10, 30, and 50 k.y. and assign equal probabilities to these three values.

Slip-rate category <0.2 mm/yr
Comments: Menges (1988 #1120; 1990 #1116; 1990 #1387) estimates two separate slip rates for the southern Sangre de Cristo fault on the basis of fault scarp data: (1) a post-late Pleistocene (post-Bull Lake) rate of 0.03 to 0.06 mm/yr, and (2) a post-Pliocene (post-4 Ma) rate of 0.12 to 0.23 mm/yr. On the basis of these data and analysis of slip rates throughout the Rio Grande rift, Wong and others (1995 #1155) conservatively estimate a range in slip rate of 0.06 to 0.29 mm/yr for the southern Sangre de Cristo fault, with a preferred (highest-weighted) value of 0.12 mm/yr.

Length not applicable

Comments: The fault zone includes numerous faults that have an end to end length of 21.9 km and a cumulative trace length of 39.0 km.

Average strike (azimuth) 003°±45°

Endpoints (lat. - long.) 36°57′54.32″N, 105°31′12.91″W
36°46′05.70″N, 105°32′02.41″W

2017c, Questa section

Section Number 2017c
Comments: Segment 2 of Menges (1988 #1120; 1990 #1116; 1990 #1387).

Section Name Questa section
Comments: This section is essentially coincident with segment 2 of Menges (1988 #1120; 1990 #1116; 1990 #1387), but a new name is used to avoid numerical section designations. The northern termination of the section is at Rito Primero, which marks the northern edge of a moderate salient of the Sangre de Cristo Mountains. The southern end of the section is at San Cristobal Creek, about 3 km northeast of the village of San Cristobal, which coincides with a large salient in the range front. This southern section boundary coincides with the boundary between segments 2 and 3 of Menges (1988 #1120; 1990 #1116; 1990 #1387).

Reliability of location Good
Comments: Menges (1988 #1120) mapped fault traces from aerial photography at scales of 1:15,780 to 1:70,000, and presents mapping at a scale of about 1:400,000. Machette and Personius (1984 #1113) mapped fault traces at a scale of 1:250,000.

Sense of movement N

Dip 60° W
Comments: Deep seismic reflection data and two-dimensional modeling of gravity data suggest that the most likely dip of the Sangre de Cristo fault is 60° (Kluth and Schaftenaar, 1994 #1183). Tandon (1992 #1390; cited in Chapin and Cather, 1994 #1180) interprets the same data set processed for deeper resolution, and concludes that the fault dips about 60° to at least 26 to 28 km, which is probably below the brittle-ductile transition zone. Wong and others (1995 #1155) used a preferred value of 60° for the southern Sangre de Cristo fault, and assumed other possible dips of 50° and 70° for the fault within the seismogenic crust.

Dip direction W

Geomorphic expression Prominent west-facing fault scarps are present on late Pleistocene and possibly Holocene alluvial fans derived from the Sangre de Cristo Mountains. Menges (1988 #1120; 1990 #1116; 1990 #1387) documents the presence of truncated ridge spurs and triangular facets along the Sangre de Cristo range front, and interprets these as products of long-term displacement.

Age of faulted deposits Pazzaglia (1989 #1170) mapped late Quaternary deposits and some fault strands along this section, and shows faulted late Pleistocene alluvial-fan deposits. Menges (1990 #1116; 1990 #1387) did not map surficial deposits along the fault, but concludes that this fault section has experienced middle to early Holocene movement.

Detailed studies none

Timing of most recent paleoevent latest Quaternary (< 15 ka)
Comments: The exact timing of the most-recent event is unknown. Menges (1988 #1120; 1990 #1116; 1990 #1387) conducted a more exhaustive study of fault-related landforms, and suggests the possibility of middle to early Holocene movement along the northern and southern parts of the Questa section.

Recurrence interval 10 to 50 k.y.

Comments: Menges (1988 #1120; 1990 #1116; 1990 #1387) estimates recurrence at a given site along the southern Sangre de Cristo fault as 10^4 years, and states that this is compatible with data from the northern part of the Sangre de Cristo fault system (≈10 to 50 k.y.) given by McCalpin (1982 #791). On the basis of these data, Wong and others (1995 #1155) estimate recurrence intervals of 10, 30, and 50 k.y. and assign equal probabilities to these three values.

Slip-rate category <0.2 mm/yr

Comments: Menges (1988 #1120; 1990 #1116; 1990 #1387) estimates two separate slip rates for the southern Sangre de Cristo fault on the basis of fault scarp data: (1) a post-late Pleistocene (post-Bull Lake) rate of 0.03 to 0.06 mm/yr, and (2) a post-Pliocene (post-4 Ma) rate of 0.12 to 0.23 mm/yr. On the basis of these data and analysis of slip rates throughout the Rio Grande rift, Wong and others (1995 #1155) conservatively estimate a range in slip rate of 0.06 to 0.29 mm/yr for the southern Sangre de Cristo fault, with a preferred (highest-weighted) value of 0.12 mm/yr.

Length not applicable

Comments: The fault zone includes numerous faults that have an end to end length of 17.8 km and a cumulative trace length of 40.0 km.

Average strike (azimuth) 006°±27°

Endpoints (lat. - long.) 36°47′14.72″N, 105°33′11.92″W
36°37′53.07″N, 105°36′01.53″W

2017d, Hondo section

Section Number 2017d

Comments: Segment 3 of Menges (1988 #1120; 1990 #1116; 1990 #1387).

Section Name Hondo section

Comments: This section is essentially coincident with segment 3 of Menges (1988 #1120; 1990 #1116; 1990 #1387), but a new name is used to avoid numerical section designations. The northern termination of the section is at San Cristobal Creek, about 3 km northeast of the village of San Cristobal, which coincides with a large salient in the Sangre de Cristo range front. The southern end of the section is at Rio Pueblo de Taos, about 7 km northeast of the town of Taos. This boundary coincides with a large re-entrant in the range front and is the boundary between segments 3 and 4 of Menges (1988 #1120; 1990 #1116; 1990 #1387).

Reliability of location Good

Comments: Menges (1988 #1120) mapped fault traces from aerial photography at scales of 1:15,780 to 1:70,000, and presents mapping at a scale of about 1:400,000. Machette and Personius (1984 #1113) mapped fault traces at a scale of 1:250,000.

Sense of movement N

Dip 60° W

Comments: Deep seismic reflection data and two-dimensional modeling of gravity data suggest that the most likely dip of the Sangre de Cristo fault is 60° (Kluth and Schaftenaar, 1994 #1183). Tandon (1992 #1390; cited in Chapin and Cather, 1994 #1180) interprets the same data set processed for deeper resolution, and concludes that the fault dips about 60° to at least 26 to 28 km, which is probably below the brittle-ductile transition zone. Wong and others (1995 #1155) used a preferred value of 60° for the southern Sangre de Cristo fault, and assumed other possible dips of 50° and 70° for the fault within the seismogenic crust.

Dip direction W

Geomorphic expression Prominent west-facing fault scarps are present on late Pleistocene and possibly Holocene alluvial fans derived from the Sangre de Cristo Mountains. Menges (1988 #1120; 1990 #1116;

1990 #1387) documents the presence of truncated ridge spurs and triangular facets along the Sangre de Cristo range front, and interprets these as products of long-term displacement.

Age of faulted deposits Kelson (1986 #1109) mapped late Quaternary deposits and some fault strands along this section, and shows faulted Pleistocene alluvial-fan deposits. Menges (1990 #1116; 1990 #1387) did not map surficial deposits along the fault, but concludes that this fault section has experienced middle to early Holocene movement.

Detailed studies Menges (1988 #1120; 1990 #1116; 1990 #1387) mapped the fault traces and conducted detailed morphometric analyses of the fault scarps. However, there have been no detailed paleoseismic investigations of the southern Sangre de Cristo fault.

Timing of most recent paleoevent latest Quaternary (< 15 ka)
Comments: The exact timing of the most-recent event is unknown. Menges (1988 #1120; 1990 #1116; 1990 #1387) conducted an exhaustive study of fault-related landforms, and suggests the possibility of middle to early Holocene movement along the northern part of the Hondo section.

Recurrence interval 10 to 50 k.y.
Comments: Menges (1988 #1120; 1990 #1116; 1990 #1387) estimates recurrence at a given site along the southern Sangre de Cristo fault as 10^4 years, and states that this is compatible with data from the northern part of the Sangre de Cristo fault system (≈10 to 50 k.y.) given by McCalpin (1982 #791). On the basis of these data, Wong and others (1995 #1155) estimate recurrence intervals of 10, 30, and 50 k.y. and assign equal probabilities to these three values.

Slip-rate category <0.2 mm/yr
Comments: Menges (1988 #1120; 1990 #1116; 1990 #1387) estimates two separate slip rates for the southern Sangre de Cristo fault on the basis of fault scarp data: (1) a post-late Pleistocene (post-Bull Lake) rate of 0.03 to 0.06 mm/yr, and (2) a post-Pliocene (post-4 Ma) rate of 0.12 to 0.23 mm/yr. On the basis of these data and analysis of slip rates throughout the Rio Grande rift, Wong and others (1995 #1155) conservatively estimate a range in slip rate of 0.06 to 0.29 mm/yr for the southern Sangre de Cristo fault, with a preferred (highest-weighted) value of 0.12 mm/yr.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 22.2 km and a cumulative trace length of 70.7 km.

Average strike (azimuth) -30°±37°

Endpoints (lat. - long.) 36°37′53.06″N, 105°36′00.69″W
36°26′41.29″N, 105°30′33.90″W

2017e, Cañon section

Section Number 2017e
Comments: Segment 4 of Menges (1988 #1120; 1990 #1116; 1990 #1387).

Section Name Cañon section
Comments: This section is essentially coincident with segment 4 of Menges (1988 #1120; 1990 #1116; 1990 #1387), but a new name is used to avoid numerical section designations. This section includes the Taos Pueblo and Cañon faults of Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124). The northern termination of the section is at Rio Pueblo de Taos, about 7 km northeast of the town of Taos, which coincides with a large re-entrant in the Sangre de Cristo range front. The southern end of the section is at Rio Grande del Rancho, about 1 km south of the village of Talpa. This boundary coincides with a large bend in the range front and is the southern boundary of segment 4 of Menges (1988 #1120; 1990 #1116; 1990 #1387). This boundary marks the intersection of the Sangre de Cristo fault with the Embudo fault (Kelson and others, 1997 #1374).

Reliability of location Good

Comments: Menges (1988 #1120) mapped fault traces from aerial photography at scales of 1:15,780 to 1:70,000, and presents mapping at a scale of about 1:400,000. Machette and Personius (1984 #1113) mapped fault traces at a scale of 1:250,000.

Sense of movement N

Dip 60° W

Comments: Deep seismic reflection data and two-dimensional modeling of gravity data suggest that the most likely dip of the Sangre de Cristo fault is 60° (Kluth and Schaftenaar, 1994 #1183). Tandon (1992 #1390; cited in Chapin and Cather, 1994 #1180) interprets the same data set processed for deeper resolution, and concludes that the fault dips about 60° to at least 26 to 28 km, which is probably below the brittle-ductile transition zone. Wong and others (1995 #1155) used a preferred value of 60° for the southern Sangre de Cristo fault, and assumed other possible dips of 50° and 70° for the fault within the seismogenic crust.

Dip direction W

Geomorphic expression Prominent west-facing fault scarps are present on late Pleistocene and possibly Holocene alluvial fans derived from the Sangre de Cristo Mountains. Menges (1988 #1120; 1990 #1116; 1990 #1387) documents the presence of truncated ridge spurs and triangular facets along the Sangre de Cristo range front, and interprets these as products of long-term displacement.

Age of faulted deposits Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) indicate late Pleistocene and late Pleistocene to Holocene deposits are displaced along the fault. Kelson (1986 #1109) mapped late Quaternary deposits and some fault strands along this section, and shows faulted Pleistocene alluvial-fan deposits. Menges (1990 #1116; 1990 #1387) did not map surficial deposits along the fault, but concludes that this fault section has experienced late Pleistocene and early Holocene to latest Pleistocene movement.

Detailed studies none

Timing of most recent paleoevent latest Quaternary (< 15 ka)

Comments: The exact timing of the most-recent event is unknown. However, Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) suggest a late Pleistocene age for the most recent movement based on scarp profile data. Menges (1988 #1120; 1990 #1116; 1990 #1387) conducted a more exhaustive study of fault-related landforms, and suggests the possibility of late to middle Holocene movement along part of the Urraca section.

Recurrence interval 10 to 50 k.y.

Comments: Menges (1988 #1120; 1990 #1116; 1990 #1387) estimates recurrence at a given site along the southern Sangre de Cristo fault as 10^4 years, and states that this is compatible with data from the northern part of the Sangre de Cristo fault system (≈10 to 50 k.y.) given by McCalpin (1982 #791). On the basis of these data, Wong and others (1995 #1155) estimate recurrence intervals of 10, 30, and 50 k.y. and assign equal probabilities to these three values.

Slip-rate category <0.2 mm/yr

Comments: Menges (1988 #1120; 1990 #1116; 1990 #1387) estimates two separate slip rates for the southern Sangre de Cristo fault on the basis of fault scarp data: (1) a post-late Pleistocene (post-Bull Lake age) rate of 0.03 to 0.06 mm/yr, and (2) a post-Pliocene (post-4 Ma) rate of 0.12 to 0.23 mm/yr. On the basis of these data and analysis of slip rates throughout the Rio Grande rift, Wong and others (1995 #1155) conservatively estimate a range in slip rate of 0.06 to 0.29 mm/yr for the southern Sangre de Cristo fault, with a preferred (highest-weighted) value of 0.12 mm/yr.

Length not applicable

Comments: The fault zone includes numerous faults that have an end to end length of 15.2 km and a cumulative trace length of 36.0 km.

Average strike (azimuth) 021°±22°

Endpoints (lat. - long.) 36°26′41.28″N, 105°30′33.48″W
36°19′42.01″N, 105°35′50.86″W

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2018, Valle Vidal fault

Structure Number 2018

Structure Name Valle Vidal fault
Comments: Scarps along a 5 km section of the eastern margin of the Valle Vidal in eastern Taos County are interpreted as possible fault scarps by Menges and Walker (1990 #1173). The scarps are probably formed by recurrent faulting in the Quaternary, may alternatively be a result of slope-failure or solifluction processes. The scarps are present from about Ponil Creek on the north to about the southern end of Valle Vidal on the south. If related to coseismic surface rupture, the scarps represent normal reactivation of the Little Costilla fault, a Laramide-age thrust (Bauer and others, 1990 #1171).

Synopsis: Linear topographic features interpreted as fault scarps are present for about 5 km along the eastern margin of Valle Vidal in eastern Taos County. Geomorphic analyses of the scarps suggest recurrent late Quaternary rupture, with the most-recent rupture in the middle to late Holocene.

Date of compilation 07/25/96

Compiler and affiliation Keith I. Kelson; William Lettis & Associates, Inc.; Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Taos

1° x 2° sheet Raton

Province Southern Rocky Mountains

Reliability of location Good

Comments: The Valle Vidal fault was first identified by J. Walker (personal communication, 1986) later was investigated by Menges and Walker (1990 #1173). The northern 5 km of the fault were mapped by Walker (Bauer and others, 1990 #1171) at a scale of 1:33,333; the northern 4 km mapped were by Menges and Walker (1990 #1173) at a scale of about 1:15,580 from field reconnaissance and analysis of aerial photography. Menges and Walker (1990 #1173) also present a regional map of the Little Costilla thrust at a scale of about 1:555,555.

Geologic setting The Valle Vidal fault borders the eastern margin of the Valle Vidal in the eastern Sangre de Cristo Mountains. The Valle Vidal separates the Taos Range of the Sangre de Cristo Mountains from the Raton basin to the east, and is part of a north-south alignment of grabens that include the Mora and Moreno valleys to the south and the Costilla Valley to the north (Bauer and others, 1990 #1171). The topographic scarps in Valle Vidal are interpreted to represent down-to-the-west normal reactivation of the Little Costilla fault, a west-dipping Laramide-age thrust (Bauer and others, 1990 #1171).

Sense of movement N

Comments: West-facing topographic scarps suggest down-to-the-west normal displacement late Quaternary surficial deposits.

Dip 60° W

Comments: There are no published subsurface data on the structural geometry of the Valle Vidal basin. Assumed dip of 60° based on analogy with the Sangre de Cristo fault, although if the Valle Vidal scarps are related to reactivation of the Little Costilla fault, the subsurface geometry of the Quaternary structure may be considerably shallower than 60°.

Dip direction W

Geomorphic expression The Valle Vidal fault has prominent geomorphic expression for about 5 km along the eastern Margin of the Valle Vidal as a complex zone of multiple scarps that vary in height from 2.9 to 22.5 m (Menges and Walker, 1990 #1173).

Age of faulted deposits Menges and Walker (1990 #1173) used soils analysis to estimate ages of late Pleistocene to late(?) Holocene for faulted alluvial fans along the eastern margin of Valle Vidal.

Detailed studies none

Timing of most recent paleoevent latest Quaternary (< 15 ka)

Comments: Menges and Walker (1990 #1173) used scarp-morphologic and soils analyses to estimate a middle to late Holocene age for the most recent event on the Valle Vidal fault.

Recurrence interval 5-20 k.y.

Comments: Menges and Walker (1990 #1173) used scarp ages estimated from linear regression analysis and diffusion modeling of multiple-event scarps to estimate recurrence intervals of 5-20 k.y. for the Valle Vidal fault.

Slip-rate category unknown, probably <0.2 mm/yr

Comments: Menges and Walker (1990 #1173) measured surface offsets of as little as 2 m in middle to late(?) Holocene deposits and as much as 9 m in late Pleistocene deposits. They estimated ages of 5 ka for the youngest faulted deposits and 130 ka for the oldest faulted deposits.

Length End to end (km): 7.3
Trace (km): 7.4

Average strike (azimuth) 007°±14°

Endpoints (lat. - long.) 36°47′14.95″N, 105°14′24.68″W
36°43′21.37″N, 105°15′06.37″W

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2019, Red River fault zone

Structure Number 2019

Structure Name Red River fault zone
Comments: The Red River fault zone was originally identified by McKinlay (1957 #1389) and Lambert (1966 #1112), and later mapped and named the Red River fault zone by Peterson (1981 #1388) on the basis of displaced volcanic flows within the Red River and Rio Grande gorges west and southwest of Questa. Dungan and others (1984 #1181), Machette and Personius (1984 #1113), and Personius and Machette (1984 #1124) map the fault zone based on Peterson (1981 #1388). Menges (1987 #1436) and Wells and others (1987 #1129) summarized unpublished mapping by Menges, who revised details of the fault traces and measured topographic scarps developed on basalt and alluvium. Heffern (1990 #1172) also presented a map of the Red River fault zone based on Wells and others (1987 #1129). Wong and others (1995 #1155) show the fault zone on their map of Quaternary faults in the region, but do not provide further discussion. The Red River fault zone consists of several parallel, northwest-trending faults that lie 8 km east of the village of Questa. The fault zone extends from Cerro Chiflo southward to the southern margin of Red River gorge near the Red River State Fish Hatchery.

Synopsis: The Red River fault zone is a northwest-striking series of normal fault strands that lie 6 to 13 km west of the Sangre de Cristo fault system in the southern San Luis basin. The fault strands have down-to-the-east senses of displacement that are antithetic to the Sangre de Cristo fault system. Individual fault strands are less than 5 km long, form a left-stepping en echelon pattern, and displace late Pliocene basalt exposed in the Rio Grande and Red River gorges. The faults are marked by scarps in Pleistocene alluvium that pre-dates incision of the gorges.

Date of compilation 07/25/96

Compiler and affiliation Keith I. Kelson; William Lettis & Associates, Inc.; Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Taos

1° x 2° sheet Raton

Province Southern Rocky Mountains

Reliability of location Good
Comments: Peterson (1981 #1388) showed the fault strands at a scale of about 1:94,000 based on field observations. These traces were later refined at a scale of 1:24,000 by C.M. Menges (personal communication, 1983) based on field reconnaissance and analysis of aerial photography. Fault traces shown herein are based on summary maps in Menges (1987 #1436) and Wells and others (1987 #1129) at a scale of about 1:90,000.

Geologic setting The Red River fault zone lies within the southern San Luis Basin, and strikes slightly more northwesterly than the rift-margin Sangre de Cristo fault to the east. The limited length of the fault zone and subparallelism with the Sangre de Cristo fault suggest that the Red River fault zone may be an antithetic structure to the main rift-margin fault, comparable to antithetic structures interpreted by Kluth and Schaftenaar (1994 #1183) and Brister and Gries (1994 #1178) in the San Luis basin in southern Colorado.

Sense of movement N

Dip 80° E-90°
Comments: There are no deep structural data published for the Red River fault, so the down-dip geometry is unknown. Geologic mapping (Peterson, 1981 #1388; Wells and others, 1987 #1129; Heffern, 1990 #1172) shows linear fault traces across the Rio Grande and Red River gorges, suggesting near-vertical dip. Menges (1987 #1436) describes exposures of the fault in the Red River and Rio Grande gorges that dip greater than 60°, and commonly dip 80°-90°. If the fault zone dips 80° E, it would intersect the 60° W-dipping Sangre de Cristo fault at about 7 to 10 km depth; if the Red River fault zone dips shallower than 70° E, then it intersects the Sangre de Cristo fault in the shallow crust above the seismogenic depth of large earthquakes.

Dip direction E

Geomorphic expression The Red River fault zone has prominent geomorphic expression from the Red River gorge to the northwestern side of the Rio Grande gorge, where it displaces resistant Servilleta Basalt flows at the surface. A southwest-facing scarp developed on Quaternary alluvium on the southeast side of the Rio Grande (C.M. Menges, unpublished data, 1983; Heffern, 1990 #1172) marks an antithetic fault strand within the fault zone. Geomorphic expression diminishes to the south from the Red River gorge, where the fault scarp is either not preserved or buried by late Pleistocene alluvial-fan deposits shed from the Sangre de Cristo Mountains.

Age of faulted deposits The total vertical separation of upper Servilleta Basalt (approximately 4.5 to 2.8 Ma) across the Red River fault zone is 30-40 m (Peterson, 1981 #1388; C.M. Menges, personal communication, 1983; Menges, 1987 #1436), although different strands show different amounts of displacement of flows within the Servilleta Basalt (Peterson, 1981 #1388). Quaternary surficial deposits are generally not present across the strands of the Red River fault. Menges (unpublished data, 1983;1987 #1436) identified an antithetic scarp developed on Quaternary alluvium on the southeast side of the Rio Grande, as shown by Heffern (1990 #1172). The age of this alluvium is unknown.

Detailed studies No detailed paleoseismic studies have been conducted on the Red River fault zone. Menges (1987 #1436) briefly describes unpublished scarp morphology data on some of the Red River fault strands.

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: The age of displaced alluvium overlying the Pliocene Servilleta Basalt is unknown. Menges (unpublished data, 1983;1987 #1436) identified an antithetic scarp developed on Quaternary alluvium of unknown age on the southeast side of the Rio Grande, and described fault scarp morphology data on several strands of the fault that suggested a late Pleistocene (20-50 ka) age of faulting. Wong and others (1995 #1155) estimate that the latest event on the Red River fault zone occurred in the late Pleistocene (10-150 ka), but provide no discussion to support this estimate.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate cattegory assigned based on the 30-to 40-m-high scarp developed on upper Servilleta Basalt and an assumed age of 2.8 Ma (Peterson, 1981 #1388).(Wells and others, 1987 #1129)

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 10.0 km and a cumulative trace length of 19.2 km.

Average strike (azimuth) -23°±15°

Endpoints (lat. - long.) 36°43'52.10"N, 105°42'52.59"W
36°39'02.71"N, 105°39'46.67"W

References

#1178 Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa basin (northern San Luis Basin), Rio Grande rift, south-central Colorado, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 39-58.

#1181 Dungan, M.A., Muehlberger, W.R., Leininger, L., Peterson, C., McMillan, N.J., Gunn, G., Lindstrom, M., and Haskin, L., 1984, Volcanic and sedimentary stratigraphy of the Rio Grande gorge and the late Cenozoic geologic evolution of the southern San Luis Valley, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 157-170.

#1172 Heffern, E.L., 1990, A geologic overview of the Wild Rivers Recreation Area, New Mexico, *in* Bauer, P.W., Lucas, S.G., Mawer, C.K., and McIntosh, W.C., eds., Tectonic development of the southern Sangre de Cristo Mountains, New Mexico: New Mexico Geological Society, 41st Field Conference, September 12-15, 1990, Guidebook, p. 229-236.

#1183 Kluth, C.F., and Schaftenaar, C.H., 1994, Depth and geometry of the northern Rio Grande rift in the San Luis Basin, south-central Colorado, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 27-37.

#1112 Lambert, W., 1966, Notes on the late Cenozoic geology of the Taos-Questa area, New Mexico, *in* Northrop, S.A., and Read, C.B., eds., Taos—Raton—Spanish Peaks country, New Mexico and Colorado: New Mexico Geological Society, 17th Field Conference, October 14-16, 1966, Guidebook, p. 43-50.

#1113 Machette, M.N., and Personius, S.F., 1984, Map of Quaternary and Pliocene faults in the eastern part of the Aztec 1° by 2° quadrangle and the western part of the Raton 1° by 2° quadrangle, northern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-B, 1 sheet, scale 1:250,000.

#1389 McKinlay, P.F., 1957, Geology of Questa quadrangle, Taos County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 53, 23 p., 1 pl., scale 1:48,000.

#1436 Menges, C.M., 1987, Appendix A.—Stratigraphic and morphologic evidence for recurrent Pliocene-Quaternary activity along the Red River fault zone, southeastern San Luis basin, New Mexico, *in* Menges, C., Enzel, Y., and Harrison, B., eds., Quaternary tectonics, landform evolution, soil chronologies and glacial deposits—Northern Rio Grande rift of New Mexico: Albuquerque, Department of Geology, University of New Mexico, Guidebook, p. 205-213.

#1124 Personius, S.F., and Machette, M.N., 1984, Quaternary and Pliocene faulting in the Taos Plateau region, northern New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 83-90.

#1388 Peterson, C.M., 1981, Late Cenozoic stratigraphy and structure of the Taos Plateau, northern New Mexico: Austin, University of Texas, unpublished M.S. thesis, 58 p., 11 pls.

#1129 Wells, S.G., Kelson, K.I., and Menges, C.M., 1987, Quaternary evolution of fluvial systems in the northern Rio Grande rift, New Mexico and Colorado, *in* Menges, C.M., ed. Quaternary tectonics, landform evolution, soil chronologies and glacial deposits—Northern Rio Grande rift of New Mexico: Friends of the Pleistocene, Rocky Mountain Cell, Guidebook, p. 55-69.

#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2020, Las Tablas fault

Structure Number 2020

Structure Name Las Tablas fault
Comments: The northernmost end of the Las Tablas fault was mapped but not named by Manley and Wobus (1982 #1138) and Manley and others (1987 #1119). The fault was mapped in its entirety but not named by Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124). The Las Tablas fault is informally named herein for the village of Las Tablas located about 11 km southwest of Tres Piedras. The Las Tablas fault is a northwest-trending fault on the western margin of the San Luis Basin that extends from a point about 1 km northeast of Las Tablas to a point about 1 km northeast of Servilleta Plaza along the Rio Tusas.

Synopsis: The Las Tablas fault is a northwest-trending, west-down fault expressed in Tertiary basalt of the Taos Plateau volcanic field and the Miocene Los Pinos Formation on the western margin of the southern San Luis basin. The fault may have 50 to 150 m of displacement in early Pleistocene rocks.

Date of compilation 08/08/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Rio Arriba

1° x 2° sheet Raton, Aztec

Province Southern Rocky Mountains

Reliability of location Good
Comments: The northernmost end of the Las Tablas fault is shown on Manley and others (1987 #1119) at a scale of 1:250,000 and Manley and Wobus (1982 #1138) at a scale of 1:24,000. The fault trace used herein is based on mapping of Machette and Personius (1984 #1113) at a scale of 1:250,000, which was based on field reconnaissance and analysis of aerial photography. Wong and others (1995 #1155) apparently used the mapping of Machette and Personius (1984) in their compilation of Quaternary faults in the region.

Geologic setting The Las Tablas fault lies within the southwestern San Luis basin, and likely is related to minor deformation along the western margin of this east-tilted asymmetric rift basin. The sense of vertical separation suggests uplift of the San Luis basin relative to the Brazos Mountains to the west. The total vertical separation of basalts of the Hinsdale Formation (approximately 26.8 to 4.4 Ma, Lipman, 1975 #1395; Thompson and Machette, 1989 #1382) across the fault zone is about 50 to 150 m (Machette and Personius, 1984 #1113).

Sense of movement N

Dip not reported

Dip direction W

Geomorphic expression The fault has prominent geomorphic expression where resistant Tertiary basalt is exposed in west-facing scarps.

Age of faulted deposits Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) suggest that the fault has had 50 to 150 m of displacement in rocks of early Pleistocene age.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) suggest that the most-recent movement occurred during the early Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Low slip-rate category assigned based on assumed 50 to 150 m (Machette and Personius, 1984 #1113) displacement of basalts of the Hinsdale Formation (26.8 to 4.4 Ma) in the southern San Luis basin (Lipman, 1975 #1395; Thompson and Machette, 1989 #1382) and 50 to 150 m of displacement in rocks of early Pleistocene age (Machette and Personius, 1984 #1113).

Length End to end (km): 14.4
Trace (km): 14.6

Average strike (azimuth) -19°±13°

Endpoints (lat. - long.) 36°33′46.13″N, 106°01′08.31″W
36°26′21.82″N, 105°58′04.63″W

References

#1395 Lipman, P.W., 1975, Evolution of the Platoro caldera complex and related volcanic rocks, southeastern San Juan Mountains, Colorado: U.S. Geological Survey Professional Paper 852, 128 p.

#1113 Machette, M.N., and Personius, S.F., 1984, Map of Quaternary and Pliocene faults in the eastern part of the Aztec 1° by 2° quadrangle and the western part of the Raton 1° by 2° quadrangle, northern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-B, 1 sheet, scale 1:250,000.

#1119 Manley, K., Scott, G.R., and Wobus, R.A., 1987, Geologic map of the Aztec 1° by 2° quadrangle, northwestern New Mexico and southern Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-1730, 1 sheet, scale 1:250,000.

#1138 Manley, K., and Wobus, R.A., 1982, Reconnaissance geologic map of the Las Tablas quadrangle, Rio Arriba County, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1408, 1 sheet, scale 1:24,000.

#1124 Personius, S.F., and Machette, M.N., 1984, Quaternary and Pliocene faulting in the Taos Plateau region, northern New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 83-90.

#1382 Thompson, R.A., and Machette, M.N., 1989, Geologic map of the San Luis Hills area, Conejos and Costilla Counties, Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-1906, 1 sheet, scale 1:50,000.

#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2021, Stong fault

Structure Number 2021

Structure Name Stong fault

Comments: The Stong fault was mapped but not named by Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124). The Stong fault is informally named herein for the nearby village of Stong located on Highway 285 about 33 km south of Tres Piedras. The Stong fault consists of two parallel, northwest-trending faults that extend along the western margin of the San Luis Basin northeast of Stong.

Synopsis: The Stong fault forms a 1-km-wide graben in late Tertiary basalt of the Taos Plateau volcanic field, along the western margin of the southern San Luis basin. The fault may have 5 to 20 m of displacement in Pliocene and early Pleistocene rocks.

Date of compilation 08/08/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Taos

1° x 2° sheet Raton

Province Southern Rocky Mountains

Reliability of location Good
Comments: The Stong fault was mapped by Machette and Personius (1984 #1113) at a scale of 1:250,000 based on field reconnaissance and analysis of aerial photography.

Geologic setting The Stong fault lies in the southwestern San Luis basin, and is probably related to minor deformation along the hinged western margin of this east-tilted asymmetric rift basin.

Sense of movement N

Dip not reported

Dip direction E

Geomorphic expression The faults have moderate geomorphic expression on the southern Taos Plateau, where resistant Pliocene basalt is exposed in east- and west-facing scarps.

Age of faulted deposits Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) map a total of 5 to 20 m of vertical separation of Servilleta Basalt (4.5 to 2.3 Ma, Lipman and Mehnert, 1979 #1169) across the Stong fault.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124) and suggest that the most-recent movement occurred during the early Pleistocene.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr
Comments: Servilleta Basalt in the Taos Plateau volcanic field range in age from about 2.3 to 4.8 Ma (Lipman and Mehnert, 1979 #1169), and displacement on the Stong fault is about 5 to 20 m (Machette and Personius, 1984 #1113; Personius and Machette, 1984 #1124). These data yield a maximum long-term slip rate of 0.01 mm/yr. Assuming a minimum age of 750 ka for the early Pleistocene movement postulated by Machette and Personius (1984), a maximum slip rate of 0.03 mm/yr is estimated.

Length End to end (km): 8.1
Trace (km): 12.3

Average strike (azimuth) -25°±12°

Endpoints (lat. - long.) 36°26′51.41″N, 105°55′00.16″W
36°22′54.97″N, 105°52′40.24″W

References

#1169 Lipman, P.W., and Mehnert, H.H., 1979, The Taos Plateau volcanic field, northern Rio Grande rift, New Mexico, *in* Riecker, R.E., ed., Rio Grande rift—Tectonics and magmatism: Washington, D.C., American Geophysical Union, p. 289-311.

#1113 Machette, M.N., and Personius, S.F., 1984, Map of Quaternary and Pliocene faults in the eastern part of the Aztec 1° by 2° quadrangle and the western part of the Raton 1° by 2° quadrangle, northern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-B, 1 sheet, scale 1:250,000.

#1124 Personius, S.F., and Machette, M.N., 1984, Quaternary and Pliocene faulting in the Taos Plateau region, northern New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 83-90.

2022, Los Cordovas faults

Structure Number 2022

Structure Name Los Cordovas faults
Comments: The Los Cordovas faults were originally shown on a figure by Lambert (1966 #1112), and later mapped and named by Machette and Personius (1984 #1113) and Personius and Machette (1984 #1124). The Los Cordovas faults consist of numerous parallel, north-trending faults in the southeastern San Luis Basin near Los Cordovas. The faults occur in a 8-km-wide zone that extends from the Rio Pueblo de Taos on the south to Highway 64 on the north (Machette and Personius, 1984 #1113).

Synopsis: The Los Cordovas faults form an 8-km-wide zone of north-trending, west-dipping normal faults in the southern part of the San Luis basin. The faults offset Pliocene Servilleta Basalt and early to middle Quaternary (about 0.7 to 1.2 Ma) gravel. Latest movements predate the incision of the Rio Grande into the Taos Plateau volcanic field about 0.69 Ma.

Date of compilation 07/19/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Taos

1° x 2° sheet Raton

Province Southern Rocky Mountains

Reliability of location Good
Comments: The Los Cordovas faults were sketched by Lambert (1966 #1112), and mapped by Machette and Personius (1984 #1113) at a scale of 1:250,000 based on field reconnaissance and analysis of aerial photography. The faults were later mapped by Kelson (1986 #1109) at a scale of 1:15,840 based on analysis of aerial photography and detailed field mapping.

Geologic setting The Los Cordovas faults are intrabasin normal faults in the southeastern San Luis basin, and are subparallel to the rift-margin Southern Sangre de Cristo fault [2017]. The total vertical separation of Pliocene Servilleta Basalt across the fault zone is about 15 m (Kelson, 1986 #1109; Kelson and Wells, 1987 #1110). The faults lie along the northward projection of the Picuris-Pecos fault [2023] (Miller and others, 1963 #1121; Lambert, 1966 #1112).

Sense of movement N

Dip 60° W
Comments: There are no deep structural data published for the Los Cordovas fault. Wong and others (1995 #1155) assumed a range in dip values of 50° to 70°, with a preferred value of 60°, on the basis of subsurface geometry of other rift faults.

Dip direction W

Geomorphic expression The faults have prominent geomorphic expression on the southern Taos Plateau, where resistant Pliocene basalt is exposed in west-facing scarps on the northern margin of Rio Pueblo de Taos. Geomorphic expression diminishes to the north, and there is no geomorphic evidence for the faults on the southern side of the Rio Pueblo de Taos (Kelson, 1986 #1109). The north-flowing

Rio Grande del Rancho drainage is very linear and lies along the projections of the Picuris-Pecos [2023] and Los Cordovas faults.

Age of faulted deposits The Los Cordovas faults offset Pliocene Servilleta Basalt (4.5 to 2.3 Ma Lipman and Mehnert, 1979 #1169) and early to middle Quaternary (about 0.7 to 1.2 Ma) gravel; the oldest unfaulted terraces are younger than 0.69 Ma, because they post-date the initiation of incision of the Rio Grande into the Taos Plateau volcanic field (Kelson, 1986 #1109; Kelson and Wells, 1987 #1110; Wells and others, 1987 #1129). The age of incision is based on estimated ages of pre-incision fluviolacustrine deposits near Alamosa, Colorado (Rogers and others, 1985 #1184).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: The most recent movements on the Los Cordovas faults predate the 0.69 Ma age of incision of the Rio Grande into the Taos Plateau volcanic field (Kelson, 1986 #1109; Kelson and Wells, 1987 #1110; Wells and others, 1987 #1129).

Recurrence interval not reported

Slip-rate category <0.2 mm/yr
Comments: Wong and others (1995 #1155) conservatively estimate a range in slip rate of 0.01 to 0.03 mm/yr for the Los Cordovas fault, with a preferred value of 0.02 mm/yr. This range is based on the amount of vertical displacement (15 m) of the high geomorphic surface mapped by Kelson (1986 #1109), and a conservative age estimate of 0.6 to 1.2 Ma. Kelson and Olig (1995 #1147) use a preferred value of 0.02 mm/yr for the Los Cordovas fault.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 12.2 km and a cumulative trace length of 81.2 km.

Average strike (azimuth) -5°±17°

Endpoints (lat. - long.) 36°28′50.42″N, 105°41′13.65″W
36°22′19.02″N, 105°39′52.88″W

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#1109 Kelson, K.I., 1986, Long-term tributary adjustments to base-level lowering northern Rio Grande rift, new Mexico: Albuquerque, University of New Mexico, unpublished M.S. thesis, 210 p.

#1147 Kelson, K.I., and Olig, S.S., 1995, Estimated rates of Quaternary crustal extension in the Rio Grande rift, northern new Mexico, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 9-12.

#1110 Kelson, K.I., and Wells, S.G., 1987, Present day fluvial hydrology and long-term tributary adjustments, northern New Mexico, *in* Menges, C., ed. Quaternary tectonics, landform evolution, soil chronologies and glacial deposits—Northern Rio Grande rift of New Mexico: Friends of the Pleistocene, Rocky Mountain Cell, Guidebook, p. 95-109.

#1112 Lambert, W., 1966, Notes on the late Cenozoic geology of the Taos-Questa area, New Mexico, *in* Northrop, S.A., and Read, C.B., eds., Taos—Raton—Spanish Peaks country, New Mexico and Colorado: New Mexico Geological Society, 17th Field Conference, October 14-16, 1966, Guidebook, p. 43-50.

#1169 Lipman, P.W., and Mehnert, H.H., 1979, The Taos Plateau volcanic field, northern Rio Grande rift, New Mexico, *in* Riecker, R.E., ed., Rio Grande rift—Tectonics and magmatism: Washington, D.C., American Geophysical Union, p. 289-311.

#1113 Machette, M.N., and Personius, S.F., 1984, Map of Quaternary and Pliocene faults in the eastern part of the Aztec 1° by 2° quadrangle and the western part of the Raton 1° by 2° quadrangle, northern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-B, 1 sheet, scale 1:250,000.

#1121 Miller, J.P., Montgomery, A., and Sutherland, P.K., 1963, Geology of part of the southern Sangre de Cristo Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 11, 106 p.
#1124 Personius, S.F., and Machette, M.N., 1984, Quaternary and Pliocene faulting in the Taos Plateau region, northern New Mexico, *in* Baldridge, W.S., Dickerson, P.W., Riecker, R.E., and Zidek, J., eds., Rio Grande rift—Northern New Mexico: New Mexico Geological Society, 35th Field Conference, October 11-13, 1984, Guidebook, p. 83-90.
#1184 Rogers, K.L., Repenning, C.A., Forester, R.M., Larson, E.E., Hall, S.A., Smith, G.R., Anderson, E., and Brown, T.J., 1985, Middle Pleistocene (late Irvingtonian-Nebraskan) climatic changes in south-central Colorado: National Geographic Research, v. 1, p. 535-563.
#1129 Wells, S.G., Kelson, K.I., and Menges, C.M., 1987, Quaternary evolution of fluvial systems in the northern Rio Grande rift, New Mexico and Colorado, *in* Menges, C.M., ed. Quaternary tectonics, landform evolution, soil chronologies and glacial deposits—Northern Rio Grande rift of New Mexico: Friends of the Pleistocene, Rocky Mountain Cell, Guidebook, p. 55-69.
#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2023, Picuris-Pecos fault

Structure Number 2023

Structure Name Picuris-Pecos fault
Comments: The Picuris-Pecos fault lies within the Sangre de Cristo Mountains, about 15 km east of Santa Fe, between the village of Cañoncito on the south and Talpa on the north. The northern part was originally named the Alamo Canyon tear fault (Montgomery, 1953 #1139); the fault was later mapped in the southern Sangre de Cristo Mountains by Miller and others (1963 #1121), Bauer (1987 #1134), and Moench and others (1988 #1122). Bauer and Ralser (1995 #1159) show the entire fault at a scale of 1:555,555, with detailed maps of selected sections at scales of 1:19,000 and 1:62,500.

Synopsis: The steeply dipping Picuris-Pecos fault strikes north-northeast within the Sangre de Cristo Mountains, and has undergone several episodes of displacement, including movement during the Precambrian, the Pennsylvanian, the late Cretaceous, and possibly the Neogene. The fault is associated with a prominent series of linear valleys and other linear geomorphic features, and is well expressed in the Sangre de Cristo Mountains on remote-sensing imagery. However, evidence for Quaternary activity has not been documented on the Picuris-Pecos fault.

Date of compilation 08/08/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Santa Fe, Taos

1° x 2° sheet Raton

Province Southern Rocky Mountains

Reliability of location Good
Comments: Location of the Picuris-Pecos fault is based on maps by Miller and others (1963 #1121), Moench and others (1988 #1122), and Bauer and Ralser (1995 #1159) at scales of 1:48,000 to 1:62,500.

Geologic setting The Picuris-Pecos fault is located within the Sangre de Cristo Mountains, and has had several episodes of displacement, including movement during the Precambrian, the Pennsylvanian, the late Cretaceous, and possibly the Neogene (Miller and others, 1963 #1121; Chapin and Cather, 1981 #1135; Bauer and Ralser, 1995 #1159). Several investigators suggest that the fault forms the eastern boundary of the Española block, which may have undergone late Cenozoic counterclockwise rotation (Muehlberger, 1979 #1123; Brown and Golombek, 1985 #1087; Aldrich, 1986 #1084). However, more recent detailed paleomagnetic data (Salyards and others, 1994 #1188) and documented sinistral slip on the Embudo fault [2007] (Bradford, 1992 #1174) argue against this hypothesis. Kelley (1995 #1157) suggests that about 400 m of west-down separation occurred during the late Cenozoic, implying that the Picuris-Pecos fault has been involved in deformation related to the Rio Grande rift. Bauer and Ralser (1995 #1159) suggest that the Picuris-Pecos fault, in conjunction with the adjacent Borrego and Jicarilla faults, forms a large positive flower structure related to regional sinistral deformation.

Sense of movement N

Comments: The Picuris-Pecos fault shows about 37 km of sinistral separation of Precambrian structural features (Miller and others, 1963 #1121; Chapin and Cather, 1981 #1135; Bauer, 1987 #1134). Kelley (1995 #1157) suggests that about 400 m of west-down separation occurred during the late Cenozoic, although she notes that the amount of separation varies along strike.

Dip 90°

Comments: Previous workers show that the Picuris-Pecos fault dips steeply, has a linear trace across rugged topography, and has had substantial lateral movement (Miller and others, 1963 #1121; Moench and others, 1988 #1122). Bauer and Ralser (1995 #1159) suggest that the adjacent Borrego and Jicarilla faults dip to the east and west, respectively, toward the Picuris-Pecos fault and merge with it at depth.

Dip direction V

Geomorphic expression The fault is associated with a prominent series of linear valleys and other linear geomorphic features, and is well expressed in the Sangre de Cristo Mountains on remote-sensing imagery (Wong and others, 1995 #1155).

Age of faulted deposits The Picuris-Pecos fault clearly displaces Pennsylvanian strata, but does not appear to displace the 26 Ma Picuris Formation in the Picuris Mountains south of Taos (Bauer and Ralser, 1995 #1159). However, the prominent geomorphic expression and the possibility of late Cenozoic displacement suggested by apatite fission-track analyses (Kelley, 1995 #1157) suggest possible Quaternary activity.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)

Comments: No detailed studies of Quaternary deposits have been conducted on the Picuris-Pecos fault. The Picuris-Pecos fault is included in some compilations of potential seismic sources in the region (Wong and others, 1995 #1155) but not in others (LaForge and Anderson, 1988 #1111).

Recurrence interval not reported

Slip-rate category <0.2 mm/yr

Comments: Wong and others (1995 #1155) conservatively estimate a range of 0.01 to 0.45 mm/yr, with a preferred value of 0.05 mm/yr, based on analysis of regional slip rates in the Rio Grande rift and the prominent geomorphic expression of the Picuris-Pecos fault in the Sangre de Cristo Mountains.

Length End to end (km): 98.2
Trace (km): 119.2

Average strike (azimuth) 016°±14°

Endpoints (lat. - long.) 36°19′45.62″N, 105°36′32.60″W
35°28′17.25″N, 105°52′46.43″W

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#1121 Miller, J.P., Montgomery, A., and Sutherland, P.K., 1963, Geology of part of the southern Sangre de Cristo Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 11, 106 p.
#1122 Moench, R.H., Grambling, J.A., and Robertson, J.M., 1988, Geologic map of the Pecos Wilderness, Santa Fe, San Miguel, Mora, Rio Arriba, and Taos Counties, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1921-B, 2 sheets, scale 1:48,000.
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2024, Nambe fault

Structure Number 2024

Structure Name Nambe fault

Comments: The Nambe fault lies along the western margin of the Sangre de Cristo Mountains between Chimayo and Santa Fe, in the eastern part of the Española Basin. Kelley (1954 #1222; 1978 #1107) mapped a continuous series of fault strands along this margin; a less continuous set of fault strands in this area were later included in the Nambe fault zone of Baltz (1976 #1431). Wong and others (1995 #1155) continued the use of the name Nambe fault to avoid confusion with another Santa Fe fault in the southwestern part of the Albuquerque basin.

Synopsis: The Nambe fault is poorly understood and there is considerable uncertainty as to its presence and activity. If present, the Nambe fault is a series of discontinuous down-to-the-east normal fault strands that juxtapose Precambrian rocks of the Sangre de Cristo Range and Miocene rift-fill sediments in the Española basin.

Date of compilation 07/10/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Santa Fe, Rio Arriba

1° x 2° sheet Santa Fe

Province Basin and Range

Reliability of location Good
Comments: The location of the Nambe fault included herein is based on mapping by Kelley (1978 #1107) at a scale of 1:125,000.

Geologic setting The Nambe fault forms the margin between the eastern Española basin and the western flank of the Sangre de Cristo Mountains. The nature of the contact between Miocene rift-fill sediments (Tesuque Formation) and Precambrian crystalline rock is unclear. Kelley (1954 #1222; 1978 #1107) mapped faults along nearly the entire range front, but Cabot (1938 #1089), Spiegel and Baldwin (1963 #1126), Galusha and Blick (1971 #1094), and Baltz (1976 #1431) mapped the contact as only partially faulted. Miller and others (1963 #1121) mapped the entire contact as depositional, and Manley (1979 #1117; 1984 #1190) noted that the eastern margin of the Española basin appears to lack a border fault. Biehler and others (1991 #1086) used a variety of geophysical data to show a lack of significant faulting along the eastern margin of the Española Basin, but could not rule out down-to-the-west faulting in the Sangre de Cristo uplift.
Sense of movement N
Comments: Fault strands have both down-to-the-west and down-to-the-east displacements within the fault zone, but the overall sense of displacement is down-to-the-west.

Dip 60° W
Comments: Wong and others (1995 #1155) assumed a range of dip values from 60° to 80°, with a preferred value of 60°, based on subsurface geometry of other rift-margin faults.

Dip direction W; E
Comments: A master fault at depth probably dips W.

Geomorphic expression A significant topographic escarpment exists at the eastern margin of the Española basin, but the origin of this escarpment is controversial. Vernon and Riecker (1989 #1128) describe discontinuous lineaments and faceted spurs formed by tectonic processes along part of the escarpment, but most investigators describe the contact between Tertiary and Precambrian rocks that marks the escarpment as mostly depositional (Miller and others, 1963 #1121; Manley, 1979 #1117; 1984 #1190; Smith and Pazzaglia, 1995 #1435).

Age of faulted deposits Vernon and Riecker (1989 #1128) noted that some strands of the Nambe fault cut the Miocene Tesuque Formation (20 to 8 Ma), and infer displacement of 150 ka gravels based on examination of aerial photography. The age of gravels was estimated from the depth of arroyo cutting, compared to incision rates derived by Dethier and others (1988 #1146) along large drainages in the western part of the Española Basin.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: No detailed studies of Quaternary deposits have been conducted across fault, so the age of the youngest faulted deposits is unknown. Preliminary detailed mapping could not confirm or pre-

clude displacement of pediment gravel across the fault (R. Klinger, U.S. Bureau of Reclamation, personal communication, 1992).

Recurrence interval not reported

Slip-rate category <0.2 mm/yr
Comments: Wong and others (1995 #1155) conservatively estimate a slip rate range of 0.01 to 0.23 mm/yr, with a preferred value of 0.02 mm/yr, based on analysis of regional slip rates in the Rio Grande rift and lack of prominent, continuous geomorphic expression. Kelson and Olig (1995 #1147) use a preferred value of 0.02 mm/yr for the Nambe fault.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 47.8 km and a cumulative trace length of 85.9 km.

Average strike (azimuth) -4°±27°

Endpoints (lat. - long.) 36°01′15.29″N, 105°52′57.27″W
35°35′26.49″N, 105°51′05.57″W

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#1126 Spiegel, Z., and Baldwin, B., 1963, Geology and water resources of the Santa Fe area, New Mexico: U.S. Geological Survey Water-Supply Paper 1525, 258 p., 7 pls.
#1128 Vernon, J.H., and Riecker, R.E., 1989, Significant Cenozoic faulting, east margin of the Española basin, Rio Grande rift, New Mexico: Geology, v. 17, p. 230-233.
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2025, Lang Canyon fault

Structure Number 2025

Structure Name Lang Canyon fault
Comments: This fault, mapped by Vincent and Krider (1997 #1193), forms the western margin of both the southern Animas Mountains and the northern San Luis Mountains, which are the southern extension of the Animas Mountains. The fault was named by Vincent and Krider (1997 #1193) for Quaternary scarps at the mouth of Lang Canyon, 1.3 km north of the international border with Chihuahua, Mexico.

Synopsis The middle to late Pleistocene scarp at Lang Canyon is the only reliable surface expression of Quaternary faulting on the western side of the Animas Mountains, south of the Gillespie Mountain fault, which ends 30 km north of Lang Canyon (Vincent and Krider, 1997 #1193). The fault bounds the west margin of the Animas Valley, a major (>100 km long), north-south oriented Basin-and-Range structural feature (graben) in southwestern New Mexico that also extends ca. 7 km into Mexico. No trenching has been done along the fault, and no detailed mapping has been conducted to define possible southern extension of the fault in Mexico.

Date of compilation 04/11/97

Compiler and affiliation Kirk R. Vincent, U.S. Geological Survey

State New Mexico

County Hidalgo

1° x 2° sheet Douglas

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:100,000-scale map compiled from 1:24,000-scale map of Vincent and Krider (1997 #1193).

Geologic setting The Lang Canyon fault is the southernmost fault that bounds the Animas Valley, a major (>100 km long), north-south oriented Basin-and-Range structural feature (graben) in southwestern New Mexico that also extends ca. 7 km into Mexico. The valley is flanked on the west by the Peloncillo (and Guadalupe) Mountains and on the east by the Animas (and San Luis) Mountains. Over much of its length, the valley consists of a full-graben, but in the southern part of the valley the structures (*i.e.*, the west-dipping Gillespie Mountain fault [2096] and the east-dipping Gray Ranch fault zone [2095] of Machette and others (1986 #1033) form a half-graben having a single west-dipping fault. This fault, the Lang Canyon fault, has accommodated eastward tilt of both the Animas and Peloncillo blocks (Vincent and Krider, 1997 #1193).

Sense of movement N

Dip not reported

Dip direction W

Geomorphic expression At the mouth of Lang Canyon there is a 600-m-long fault scarp about 5 m high that trends N 19° E on a fan remnant thought to be of middle Pleistocene age (*i.e.,* 500-750 ka). However, nearby late Pleistocene (ca. 130 ka) deposits cover the fault and are not disturbed (Vincent and Krider, 1997 #1193). The surficial trace of the Lang Canyon fault is preserved only at the Lang Canyon site. Detailed geomorphic surface (landform) mapping by Vincent and Krider (1997 #1193) indicates the surficial trace is not preserved on the landscape north of Lang Canyon, but no detailed mapping has been done in Mexico to define a possible southern extension of the structure.

Age of faulted deposits Vincent and Krider (1997 #1193) suggested that the scarp is formed on alluvial deposits of probable middle Pleistocene age (*i.e.,* 500-750 ka), whereas nearby late Pleistocene (ca. 130 ka) deposits cover the fault and are undisturbed. The age of these deposits was inferred from soil development.

Detailed studies none

Timing of most recent paleoevent middle to late Pleistocene (<750 ka)
Comments: Given the uncertainty in estimates of the age of deposits, the most recent paleoevent certainly occurred in the Quaternary, probably in the middle Pleistocene but prior to late Pleistocene. Vincent and Krider (1997 #1193) reason the timing is probably middle Pleistocene (or older) because the scarp is preserved only at the most erosion-resistant site (Lang Canyon). The Lang Canyon fan remnant is extremely bouldery in texture, unlike deposits of similar age along the range front: this attribute probably contributes to the scarp's local preservation.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Although no detailed offset or age data is available, the long-term slip rate must be low on the basis of no late Pleistocene offset.

Length End to end (km): 0.6
Trace (km): 0.6

Average strike (azimuth) 019°±14°

Endpoints (lat. - long.) 31°20'43.043"N, 108°47'18.06"W
31°20'25.091"N, 108°47'24.50"W

References

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#1193 Vincent, K.R., and Krider, P.R., 1997, Geomorphic surface maps of the southern Animas Valley, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report OF-429, 12 sheets, scale 1:24,000.

2026, Rendija Canyon fault

Structure Number 2026

Structure Name Rendija Canyon fault
Comments: The Rendija Canyon fault was mapped by Griggs (1964 #1434), Smith and others (1970 #1125), Budding and Purtymun (1976 #1088), Kelley (1978 #1107), Dransfield and Gardner (1985 #1093), and Carter and Gardner (1995 #1154). The fault was named for Rendija Canyon by Gardner

and House (1987 #1097). The fault extends from the northern margin of Guaje Canyon, about 8 km north of Los Alamos, New Mexico, south to Pajarito Canyon.

Synopsis: The Rendija Canyon fault is mapped in middle Quaternary volcanic deposits and younger alluvium beneath the Pajarito plateau. The fault is a major component of the Pajarito fault system, which also includes the Pajarito [2008] and Guaje Mountain [2027] faults. This series of north-striking faults defines the active western boundary of the Española basin of the Rio Grande rift. The Rendija Canyon fault is associated with a prominent west-facing topographic scarp nearly 40-m high developed on middle Quaternary volcanic deposits, mainly ash-flow tuff. Paleoseismologic data available for the fault suggest that the Rendija Canyon fault has had multiple late Pleistocene movements, with a possible event in the early Holocene.

Date of compilation 08/17/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Los Alamos, Sandoval

1° x 2° sheet Albuquerque

Province Southern Rocky Mountains

Reliability of location Good
Comments: The location of the Rendija Canyon fault is based on field mapping compiled at a scale of 1:125,000 (1970 #1125) and 1:62,500 (Gardner and House, 1987 #1097), modified by field mapping and analysis of 1:6,000- to 1:58,000- scale aerial photography compiled at a scale of 1:100,000 (Wong and others, 1995 #1155).

Geologic setting The Rendija Canyon fault is one of three major faults within the Pajarito fault system, which is the primary structural boundary along the western margin of the Española basin of the Rio Grande rift. This fault system probably accommodates most of the roughly east-west extension in the basin (Kelson and Olig, 1995 #1147), which is asymmetric and tilted to the west. The Rendija Canyon fault exhibits west-down displacement, which is opposite in sense to the east-down displacement along the Pajarito fault [2008] located about 3 km to the west. The Rendija Canyon fault and subparallel Guaje Mountain fault [2027], which is located about 1 to 2 km to the east, likely are antithetic to the primary east-down, rift-bordering Pajarito fault [2008].

Sense of movement N
Comments: The Rendija Canyon fault exhibits down-to-the-west separation of bedded volcanic deposits, alluvial rift-fill deposits, and fluvial deposits laid down by east-flowing, drainages incised into the Pajarito plateau. Carter and Gardner (1995 #1154) stated that slickenside lineations are steeply plunging to nearly vertical along the fault, and from kinematic analysis of these data interpret that the axis of least principal horizontal stress (extension) trends approximately east.

Dip 60° W to 90°

Comments: Subsurface geometric data are lacking for the Rendija Canyon fault. Fault-plane measurements made during detailed bedrock mapping show dips ranging from 60° to 90° and averaging about 79° (Carter and Gardner, 1995 #1154). Shallow dips are consistent with interpretations of the Rendija Canyon fault as a rift-bounding antithetic structure, and steeper dips are consistent with the linear fault trace and the possibility of lateral slip. Some structural models used by Wong and others (1995 #1155) suggest that the Rendija Canyon fault may intersect the rift-bordering Pajarito fault at shallow crustal depths and thus does not extend to seismogenic depths.

Dip direction W

Geomorphic expression The Rendija Canyon fault is expressed as prominent west-facing topographic scarps on mesas underlain by the 1.2-Ma upper Bandelier Tuff. Scarps are as much as 40 m high, and the average net vertical tectonic displacement of the tuff is 36 ± 10 m (Wong and others, 1995 #1155; Olig and others, 1996 #1152). Fault scarps are also formed on late Quaternary alluvial deposits in major drainages that cross the fault (Wong and others, 1995 #1155; Kelson and others, 1996 #1151).

Age of faulted deposits Late Pleistocene and possibly early Holocene colluvial and alluvial deposits are displaced by the Rendija Canyon fault where it is exposed in a trench at the Guaje Pines Cemetery (Kelson and others, 1993 #1149; Wong and others, 1995 #1155; 1996 #1151). Ages of displaced alluvial and colluvial deposits are estimated from radiocarbon and thermoluminescence analyses, and relative soil development. The youngest scarp-derived colluvial deposit is either 9 ka (based on radiocarbon analyses of charcoal fragments), or 23 ka (based on thermoluminescence analyses of silty colluvium). Deposits that have been faulted three or four times are estimated to be more than 140 ka on the basis of thermoluminescence analysis and relative soil development (Wong and others, 1995 #1155; Kelson and others, 1996 #1151).

Detailed studies Exploratory trenches have been excavated across the Rendija Canyon fault (Wong and others, 1995 #1155; Kelson and others, 1996 #1151) and its projection to the south (Kolbe and others, 1994 #1148) as part of a seismic hazard evaluation for Los Alamos National Laboratory and a fault-rupture hazard evaluation for a laboratory facility. Wong and others (1995 #1155) and Kelson and others (1996 #1151) describe the Guaje Pines trench site in the central part of the fault and the County Landfill exposure at the southern end of the fault, and Kolbe and others (1994 #1148) provide logs of several trenches spanning the southern projection of the fault south of Los Alamos.

Locality 2026-1: Wong and others (1995 #1155) excavated four trenches and three soil test pits at the Guaje Pines site along the central part of the fault during the summer of 1992. Two trenches excavated across the fault exposed faulted alluvium overlain by two packages of scarp-derived colluvial deposits that resulted from scarp degradation after west-down surface-rupturing earthquakes (Kelson and others, 1996 #1151). Ages of the alluvial and colluvial deposits are estimated from radiocarbon and luminescence analyses, and relative soil development. The trench exposures provided evidence of at least three and possibly as many as five surface-faulting events, with the oldest of these occurring prior to about 140 ka. Three or four events occurred since deposition of colluvium that is more than 140 ± 26 ka. The most-recent rupture occurred at about 9 or 23 ka. The thickness of the upper colluvial package suggests 2.0 ± 0.5 m of vertical displacement during the most-recent earthquake. Kelson and others (1996 #1151) estimated an average recurrence interval for surface-rupturing earthquakes of between 33 ky and 66 ky from age-estimates of scarp-derived colluvium, and an interval of about 38-83 ky from the long-term slip rate and displacement-per-event data.

Locality 2026-2: Wong and others (1995 #1155) documented an exposure of a main strand of the Rendija Canyon fault in the Los Alamos County Landfill, located directly south of the town of Los Alamos. The 13-m-deep excavation shows a net vertical tectonic displacement of 4 m of the 1.2-Ma upper Bandelier Tuff, and evidence of multiple ruptures of post-1.2-Ma fluvial deposits overlying the tuff. The plunge of slickensides along fault planes suggests 10-60 m of oblique slip, and an estimated post-1.2-Ma slip rate of 0.01-0.05 mm/yr. There is evidence of at least three surface-rupturing earthquakes in the past several hundred thousand years, although numerical age estimates are not available.

Locality 2026-3: Kolbe and others (1994 #1148) excavated several trenches on Pajarito Mesa across the southern projection of the Rendija Canyon fault. These trenches show evidence for several minor, near-vertical faults within a 30-m-wide zone roughly coincident with an air-photo lineament along the strike of the easternmost trace of the southern Rendija Canyon fault. These faults show predominantly west-down vertical separations of less than 60 cm of alluvium overlying the 1.2-Ma upper Bandelier Tuff. The faults do not offset air-fall and associated deposits of the 50-60 ka (Reneau and others, 1996 #1264) El Cajete Pumice (Kolbe and others, 1994 #1148). These faults thus likely did not rupture during the most-recent and penultimate events interpreted from the Guaje Pines site (locality 2026-1).

Timing of most recent paleoevent late Quaternary (<130 ka)

Comments: The youngest scarp-derived colluvial deposit exposed in trenches at the Guaje Pines trench site is either 9 ka, based on radiocarbon analyses, or 23 ka, based on thermoluminescence analyses (Wong and others, 1995 #1155; Kelson and others, 1996 #1151).

Recurrence interval 33-83 k.y.

Comments: Stratigraphic evidence at the Guaje Pines site suggests large earthquakes on the Rendija Canyon fault have recurrence intervals of a few thousand to several tens of thousands of years. Kelson and others (1996 #1151) estimate that the time between the two most-recent earthquakes is 33-66 k.y. On the basis of a long-term slip rate of 0.03 ± 0.01 mm/yr and a displacement per event of 2.0 ± 0.5 m, Kelson and others (1996 #1151) estimated a range in average recurrence of 38-83 k.y.

Slip-rate category <0.2 mm/yr

Comments: Based on an average net vertical tectonic displacement of 21 m of the 1.2-Ma upper Bandelier Tuff, Wong and others (1995 #1155) estimated an average long-term vertical slip rate of 0.02 mm/yr. Wong and others (1995 #1155; 1996 #1156) conservatively estimated a range in slip rates of 0.01-0.25 mm/yr for the Rendija Canyon fault, with a preferred value of 0.02 mm/yr based on analysis of regional slip rates in the Rio Grande rift. Kelson and Olig (1995 #1147) used a preferred value of 0.02 mm/yr for the Rendija Canyon fault.

Length End to end (km): 11.1
Trace (km): 15.6

Average strike (azimuth) 001°±11°

Endpoints (lat. - long.) 35°57′38.19″N, 106°18′23.52″W
35°51′37.29″N, 106°18′19.82″W

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2027, Guaje Mountain fault

Structure Number 2027

Structure Name Guaje Mountain fault

Comments: The Guaje Mountain fault was mapped by Griggs (1964 #1434), Smith and others (1970 #1125), Budding and Purtymun (1976 #1088), Kelley (1978 #1107), Dransfield and Gardner (1985 #1093), and Carter and Gardner (1995 #1154). The fault was named the Guaje Mountain fault zone by Gardner and House (1987 #1097). The fault extends from the northern margin of the northern branch of Sawyer Canyon on the north, about 10 km north of the town of Los Alamos, through Los Alamos to Threemile Canyon.

Synopsis: The Guaje Mountain fault is identified in middle Quaternary volcanic deposits and younger alluvium on the Pajarito plateau. The fault is a major component of the Pajarito fault system, which also includes the Pajarito [2008] and Rendija Canyon [2026] faults. This series of north-striking faults defines the active western boundary of the Española basin of the Rio Grande rift. The Guaje Mountain fault is associated with a prominent west-facing topographic scarp nearly 30 m high developed on middle Quaternary volcanic deposits. Limited paleoseismologic data available for the fault suggest that the Guaje Mountain fault has had multiple late Pleistocene movements and a probable mid-Holocene most-recent event.

Date of compilation 08/22/96

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Los Alamos

1° x 2° sheet Albuquerque

Province Southern Rocky Mountains

Reliability of location Good

Comments: Location of the Guaje Mountain fault is based on field mapping compiled at scale of 1:125,000 (Smith and others, 1970 #1125) and 1:62,500 (Gardner and House, 1987 #1097), modified by field mapping and analysis of 1:6,000 to 1:58,000- scale aerial photography compiled at a scale of 1:100,000 (Wong and others, 1995 #1155).

Geologic setting The Guaje Mountain fault is one of three major faults within the Pajarito fault system, which is the primary structural boundary along the western margin of the Española basin of the Rio Grande rift. This fault system probably accommodates most of roughly east-west extension in the basin (Kelson and Olig, 1995 #1147), which is asymmetric and tilted to the west. The Guaje Mountain fault exhibits west-down displacement, which is opposite in sense to the east-down displacement along the Pajarito fault located about 4 km to the west. The Guaje Mountain fault and subparallel Rendija Canyon fault [2026], which is located about 1 to 2 km to the west of the Guaje Mountain fault, likely are antithetic to the primary east-down, rift-bordering Pajarito fault [2008].

Sense of movement N

Comments: Down-to-the-west separation on the Guaje Mountain fault is expressed by offset of bedded volcanic deposits, alluvial rift-fill deposits, and fluvial deposits laid down by east-flowing, incised drainages developed into the Pajarito plateau. Gardner and others (1990 #1095) interpret dip slip and oblique slip on small faults within the fault zone, as exposed in a trench across the central part of the fault.

Dip 75° W to 90°

Comments: Subsurface geometric data are lacking for the Guaje Mountain fault. Fault plane measurement made during detailed bedrock mapping shows dips ranging from 75° to 90° (Carter and Gardner, 1995 #1154). Shallow dips are consistent with interpretations of the Guaje Mountain fault as a rift-bounding structure, and steeper dips are consistent with the linear fault trace and the possibility of lateral slip. Some structural models used by Wong and others (1995 #1155) suggest that the Guaje Mountain fault may intersect the rift-bordering Pajarito fault at shallow crustal depths, and therefore does not extend in the subsurface to seismogenic depths.

Dip direction W

Geomorphic expression The Guaje Mountain fault is associated with prominent west-facing topographic scarps across mesas underlain by the 1.2 Ma upper Bandelier Tuff. Scarps are up to about 30 m high, and the average net vertical tectonic displacement of 1.2 Ma tuff is 15 m (Wong and others, 1995 #1155; Olig and others, 1996 #1152). Although there is trench evidence of Holocene displacement along the fault, there is little or no geomorphic expression of the fault across alluvial valley floors.

Age of faulted deposits Pleistocene and middle Holocene colluvial and alluvial deposits are displaced by the Guaje Mountain fault, where it was exposed in a paleoseismologic trench in Cabra Canyon (Gardner and others, 1990 #1095). Ages of displaced alluvial and colluvial deposits are estimated from radiocarbon analyses.

Detailed studies Exploratory trenches have been excavated across the Guaje Mountain fault or its projection to the south, as part of a seismic hazard evaluations for Los Alamos National Laboratory (1990 #1095; Wong and others, 1995 #1155; 1996 #1156) and a fault-rupture hazard evaluation for a laboratory facility (Kolbe and others, 1994 #1148). Gardner and others (1990 #1095) describe the Cabra Canyon trench site along the central part of the fault. Wong and others (1995 #1155) describe detailed geomorphic mapping and a shallow trench across the central part of the fault in Rendija Canyon. Kolbe and others (1994 #1148) provide logs of several trenches spanning the southern projection of the fault south of Los Alamos.

Locality 2027-1: Gardner and others (1990 #1095) excavated a trench across the fault in Cabra Canyon that exposed faulted valley-fill alluvium and colluvial derived from a west-facing escarpment. Gardner and others (1990 #1095) interpret displacement along small faults of deposits that are 4,000 to 6,000 years old, suggesting Holocene movement along the Guaje Mountain fault.

Locality 2027-2: Wong and others (1995 #1155) excavated four trenches within Rendija Canyon in the vicinity of the Guaje Mountain fault. These trenches exposed late Holocene deposits that likely post-date the event interpreted by Gardner and others (1990 #1095) along the fault. No evidence of faulting was observed in these trenches, and Wong and others (1995 #1155) interpret that the fault is located directly west of the westernmost trench.

Locality 2027-3: Kolbe and others (1994 #1148) excavated several trenches across the southern projection of the Guaje Mountain fault both north and south of Pajarito canyon. This series of trenches showed no evidence for displacement of the 1.2 Ma upper Bandelier Tuff, or late Pleistocene colluvium that predates the 50 to 60 ka (Reneau and others, 1996 #1264) El Cajete Pumice (Kolbe and others, 1994 #1148). On this basis, Wong and others (1995 #1155) interpret that the Guaje Mountain fault terminates to the north of the trench site, at about Mortandad Canyon.

M. Gonzalez and J. Gardner conducted field mapping of fluvial terraces and the Guaje Mountain fault in Rendija Canyon, along the central part of the fault (M. Gonzalez and J. Gardner, unpubl. mapping, 1990). Wong and others (1995 #1155) conducted additional detailed mapping of the Rendija Canyon area, which in turn has been investigated more thoroughly by McDonald and others (1996 #1162). Wong and others (1995 #1155) identified eight fluvial terraces along the Rendija Canyon drainage, and produced profiles of these surfaces across the Guaje Mountain fault. Age estimates of the terraces were based on relative soil development. Considering wide age ranges for the terraces and the measured vertical displacements, Wong and others (1995 #1155) calculate a range in slip rate along the Guaje Mountain fault of 0.01 to 0.03 mm/yr. They identify as many as three surface-rupture earthquakes along the fault, the oldest of which occurred prior to about 100 to 200 ka, and the two most recent occurring after about 100 to 200 ka. Wong and others (1995 #1155) postulate that the most-recent of these likely was the mid-Holocene event identified by Gardner and others (1990 #1095).

Timing of most recent paleoevent latest Quaternary (<15 ka)

Comments: Gardner and others (1990 #1095) interpret displacement of deposits that are 4,000 to 6,000 years old, suggesting mid-Holocene movement along the Guaje Mountain fault.

Recurrence interval not reported

Comments: Although Wong and others (1995 #1155) provide estimates of ages of faulted and unfaulted terraces in Rendija Canyon, the timing of surface ruptures is too poorly constrained to estimate recurrence intervals. No other data are available to assess recurrence of large earthquakes along the Guaje Mountain fault.

Slip-rate category <0.2 mm/yr

Comments: Based on an average net vertical tectonic displacement of 15 m of the 1.2 Ma upper Bandelier Tuff, Wong and others (1995 #1155; 1996 #1156) estimated an average vertical slip rate of 0.01 mm/yr. Wong and others (1995 #1155; 1996 #1156) conservatively estimate a range in net slip rate of 0.01 to 0.14 mm/yr for the Guaje Mountain fault, with a preferred value of 0.01 mm/yr, based on analysis of regional slip rates in the Rio Grande rift. Kelson and Olig (1995 #1147) use a preferred value of 0.02 mm/yr for the Guaje Mountain fault.

Length End to end (km): 10.7
Trace (km): 10.8

Average strike (azimuth) 002°±11°

Endpoints (lat. - long.) 35°58′12.81″N, 106°17′11.55″W
35°52′25.35″N, 106°17′31.05″W

References

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#1264 Reneau, S.L., Gardner, J.N., and Forman, S.L., 1996, New evidence for the age of the youngest eruptions in the Valles caldera, New Mexico: Geology, v. 24, p. 7-10.
#1125 Smith, R.L., Bailey, R.A., and Ross, C.S., 1970, Geologic map of the Jemez Mountains, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-571, 1 sheet, scale 1:125,000.
#1156 Wong, I., Kelson, K., Olig, S., Bott, J., Green, R., Kolbe, T., Hemphill-Haley, M., Gardner, J., Reneau, S., and Silva, W., 1996, Earthquake potential and ground shaking hazard at the Los Alamos National Laboratory, New Mexico, *in* Goff, F., Kues, B.S., Rogers, M.A., McFadden, L.D., and Gardner, J.N., eds., The Jemez Mountains region: New Mexico Geological Society, 47th Field Conference, September 25-28, 1996, Guidebook, p. 135-142.
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2028, Sawyer Canyon fault

Structure Number 2028

Structure Name Sawyer Canyon fault

Comments: The Sawyer Canyon fault was originally mapped as an unnamed fault by Smith and others (1970 #1125) and Kelley (1978 #1107). The fault was named by Wong and others (1995 #1155) after the canyon that crosses central part of the fault north of Los Alamos, New Mexico. The Sawyer Canyon fault extends from an intersection with the Pajarito fault [2008] near Santa Clara Canyon on the north to the southern side of Rendija Canyon near the town of Los Alamos.

Synopsis: The Sawyer Canyon fault is located adjacent to the western margin of the northern Rio Grande rift. The east-down fault is subparallel to the Pajarito [2008], Guaje Mountain [2027], Rendija Canyon [2026], and Puye [2009] faults, and may be an element of the Pajarito fault system. The Sawyer Canyon fault accommodates some of the roughly east-west extension within the Española basin of the rift. The fault was identified in middle Quaternary airfall volcanic deposits of the Valles caldera by field mapping, analysis of aerial photography, and detailed mapping. No paleoseismologic data are available for the fault at the time of this compilation.

Date of compilation 08/15/95

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Los Alamos, Sandoval

1° x 2° sheet Albuquerque

Province Southern Rocky Mountains

Reliability of location Good
Comments: The location of the Sawyer Canyon fault is based on field mapping compiled at scale of 1:125,000 (Smith and others, 1970 #1125), modified by analysis of 1:24,000- and 1:58,000- scale aerial photography compiled at a scale of 1:100,000 (Wong and others, 1995 #1155), and detailed field mapping at a scale of 1:24,000 (Carter and Gardner, 1993 #1179; Carter and Gardner, 1995 #1154).

Geologic setting The Sawyer Canyon fault is located adjacent to the western margin of the northern Rio Grande rift. The east-down fault is subparallel to the Pajarito, Guaje Mountain, Rendija Canyon, and Puye faults, and may be part of the Pajarito fault system.

Sense of movement N
Comments: Structural data suggest predominantly dip-slip, down-to-the-east movement (Carter and Gardner, 1995 #1154; Carter and Winter, 1995 #1730).

Dip 65° E to 90°, preferred average 75° E
Comments: Wong and others (1995 #1155) estimated a range in fault dip for the seismogenic crust, based on field data of Carter and Winter (1995 #1730).

Dip direction E

Geomorphic expression Topographic scarps across mesas underlain by 1.2 Ma upper Bandelier Tuff are present along the central part of fault. Carter and Gardner (1995 #1154) note that terraces within Sawyer Canyon proper are apparently displaced by the Sawyer Canyon fault.

Age of faulted deposits The Sawyer Canyon fault displaces 1.2 Ma upper Bandelier Tuff (Smith and others, 1970 #1125; Spell and others, 1990 #1189) and has possible geomorphic expression across probable late Quaternary alluvium (Carter and Gardner, 1995 #1154).

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: The timing of the most-recent event is unknown, but possible displacement of terraces within Sawyer Canyon suggest late Quaternary movement.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr
Comments: Wong and others (1995 #1155; 1996 #1156) conservatively estimate a range of slip rates of 0.01 to 0.30 mm/yr for the Sawyer Canyon fault, with a preferred value of 0.03 mm/yr, based on data used by Carter and Gardner (1993 #1179; 1995 #1154) and analysis of regional slip rates in the Rio Grande rift. Kelson and Olig (1995 #1147) use a preferred value of 0.02 mm/yr for the Sawyer Canyon

fault. Measured vertical stratigraphic displacements of the 1.2 Ma upper Bandelier Tuff range from 21 to 37 m (K. Carter, pers. comm. 1993) also suggest a low slip rate.

Length End to end (km): 8.4
Trace (km): 13.3

Average strike (azimuth) -11°±17°

Endpoints (lat. - long.) 35°58′43.23″N, 106°16′52.09″W
35°54′19.41″N, 106°15′23.18″W

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2029, Jemez-San Ysidro fault

Structure Number 2029

Structure Name Jemez-San Ysidro fault

Comments: The Jemez-San Ysidro fault extends from near Arroyo Piedra Parada, 7 km south of the village of San Ysidro, north to the southern rim of the Valles caldera near Highway 4. As used herein, the Jemez-San Ysidro fault includes the northeast-striking faults referred to as the Jemez fault zone by Goff and Kron (1980 #1099) and Goff and others (1981 #1182), the north-striking Sierrita fault of Woodward and DuChene (1975 #1131), Aldrich (1986 #1084), and Woodward (1987 #1130), and the north-striking San Ysidro fault of Woodward and Ruetschilling (1976 #1133), Hawley and Galusha

(1978 #1103), and Woodward (1987 #1130). All of these faults are grouped together herein because of lateral continuity (Wong and others, 1995 #1155).

Synopsis: The Jemez-San Ysidro fault is an east-dipping normal fault that, in part, forms the active western margin of the Rio Grande rift south of the Valles caldera. The fault is divided into two sections on the basis of a 45° change in fault strike at the latitude of Cañones. The northern, northeast-striking section of the fault is aligned with northeast-striking faults within the collapsed center of the Valles caldera and the Embudo fault, and is coincident with the Jemez Lineament. The southern fault may merge with faults on the Llano de Albuquerque to the south.

Date of compilation 05/05/97

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc. , and Stephen F. Personius, U.S. Geological Survey, Denver, CO.

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Geologic setting: The Jemez-San Ysidro fault forms the northwestern margin of the Albuquerque basin, although the amount of Quaternary vertical separation is less than that along other rift-margin faults. Aldrich (1986 #1084) states that the fault was the western margin of the Rio Grande rift during the Oligocene, and that activity later stepped eastward to the Pajarito fault zone [2008]. Wong and others (1995 #1155) and House and Hartse (1995 #1160) identify seismicity aligned along the northern part of the fault.

Number of Sections 2
Comments: The Jemez-San Ysidro fault consists of a northeast-striking fault (the Jemez fault of Goff and Kron, 1980 #1099), and north-striking faults along the northwestern margin of the Albuquerque basin (the Jemez and San Ysidro faults of Woodward, 1987 #1130). The boundary between the two fault sections is interpreted as the 45° change in fault strike near Cañones. Wong and others (1995 #1155) considered potential fault-rupture scenarios that included rupture on either a northern section or a southern section, and on both sections together. These sections are considered separately here.

Length End to end (km): 48.3
Trace (km): 92.1

Average strike (azimuth) 014°±29°

Endpoints (lat. - long.) 35°49′45.51″N, 106°36′16.83″W
35°25′13.15″N, 106°47′17.08″W

2029a, Jemez section

Section Number 2029a

Section Name Jemez section
Comments: This part of the Jemez-San Ysidro fault was defined as the Jemez section by Wong and others (1995 #1155). The section extends from Highway 4 near Jemez Falls in the Jemez Mountains, southwest to Crow Springs, about 5 km west of Cañones.

Reliability of location Good
Comments: Detailed geologic maps are available at a scale of 1:24,000 along the southernmost part of the Jemez fault (Woodward and others, 1977 #1132), which is compiled and synthesized by Woodward (1987 #1130). Maps of selected parts of the fault are given by Goff and Kron (1980 #1099) at a scale of 1:12,000, and by Goff and Shevenell (1987 #1476) at a scale of 1:66,667.

Sense of movement N

Dip 80° W to 80° E
Comments: The Jemez fault appears to be near vertical at the surface and in the shallow subsurface based on the relatively straight traces across rugged topography. Microseismicity in the vicinity of the Jemez fault appears to be aligned along a near-vertical zone, with a slight westerly dip (L. House, unpublished data, 1993). However, as a rift-margin fault, the Jemez fault probably dips to the east (Woodward and Ruetschilling, 1976 #1133). Wong and others (1995 #1155) considered dip values of 80° W, 90°, and 80° E, without a preferred dip.

Dip direction V

Geomorphic expression The Jemez section is marked by a prominent southeast-facing scarp across Virgin Mesa, which is underlain by the 1.2 Ma upper Bandelier Tuff. Goff and Shevenell (1987 #1476) note a 15 m high fault scarp on older travertine deposits near Soda Dam.

Age of faulted deposits The youngest faulted bedrock is the 1.2 Ma upper Bandelier Tuff; there are few published data on the presence or absence of displaced late Quaternary deposits.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: The timing of the most-recent event is unknown. Prominent geomorphic expression across Virgin Mesa, displaced upper Bandelier Tuff, and possible association with contemporary microseismicity suggest possible middle to late Quaternary activity (Wong and others, 1995 #1155).

Recurrence interval not reported

Slip-rate category <0.2 mm/yr
Comments: Wong and others (1995 #1155; 1996 #1156) conservatively estimate a range in slip rate of 0.01 to 0.52 mm/yr for the Jemez-San Ysidro fault, with a preferred value of 0.06 mm/yr, based on analysis of regional slip rates in the Rio Grande rift and a lack of evidence of late Quaternary displacement. Kelson and Olig (1995 #1147) use a preferred value of 0.05 mm/yr for the Jemez-San Ysidro fault. Woodward (1987 #1130) reports 12 m of separation of 1.2 Ma upper Bandelier Tuff along the Jemez fault, and Goff and Shevenell (1987 #1476) and Goff and others (1989 #1098) note 50 m of separation of the same unit along the fault. These field data support a low slip rate.

Length End to end (km): 24.1
Trace (km): 35.0

Average strike (azimuth) 041°±14°

Endpoints (lat. - long.) 35°49′45.51″N, 106°36′16.83″W
35°41′25.56″N, 106°48′36.36″W

2029b, San Ysidro section

Section Number 2029b

Section Name San Ysidro section
Comments: This part of the Jemez-San Ysidro fault was defined as the San Ysidro section by Wong and others (1995 #1155). This section extends from Crow Springs, about 5 km west of Cañones on the north to near Arroyo Piedra Parada, 7 km south of San Ysidro, where it probably joins with the unnamed fault east of Sand Hill fault [2035].

Reliability of location Good
Comments: Detailed geologic maps at a scale of 1:24,000 are available along the entire fault trace (Woodward and Ruetschilling, 1976 #1133; 1977 #1132), which are compiled and synthesized by Woodward (1987 #1130). Formento-Trigilio (1997 #1377) recently completed mapping Quaternary deposits and faults near Jemez Pueblo and San Ysidro at 1:24,000 scale.

Sense of movement N
Comments: Woodward and DuChene (1975 #1131) characterize movement along the fault as dominantly dip-slip with a minor right-slip component. Down-to-the-east normal displacement is consistent with the occurrence of Tertiary rift-fill sediments (Zia Sand Formation) on the east faulted against Precambrian rocks on the west (Woodward, 1987 #1130).

Dip 50° to 70° E, preferred value of 60° E
Comments: There are no deep structural data published for the San Ysidro fault. Wong and others (1995 #1155) assumed a range in dip values of 50° to 70°, with a preferred value of 60°, on the basis of subsurface geometry of other rift faults.

Dip direction E

Geomorphic expression Moderate geomorphic expression in bedrock is observable on aerial photography, as a result of juxtaposition of different rock types. Short fault scarps and fault exposures in middle and late Pleistocene alluvial deposits have been mapped on several strands of the San Ysidro section near Jemez Pueblo and San Ysidro near the southern end of the fault (Formento-Trigilio and Pazzaglia, 1996 #1295; Formento-Trigilio, 1997 #1377). They measured offsets of 2 to 11 m in middle Pleistocene alluvial deposits along several strands of the fault.

Age of faulted deposits The youngest faulted bedrock mapped along the San Ysidro section is the Miocene Zia Sand Formation (Woodward and Ruetschilling, 1976 #1133; 1987 #1130). Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) map and describe fault scarps in fluvial and alluvial-fan deposits in the Jemez River drainage. The clearest evidence of faulting is found in deposits that contain the Lava Creek B ash, so these sediments were deposited about 620 ka (Izett and Wilcox, 1982 #1708; Sarna-Wojcicki and others, 1987 #1707), and thus are middle Pleistocene in age. Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) also describe probable offset of a 100-200 ka terrace strath, so some offset deposits along the San Ysidro section may be late Pleistocene in age.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: The timing of the most-recent event is unknown. Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) map offsets of 620 ka alluvial deposits, and probable faulting of a middle to late Pleistocene (100-200 ka) fluvial terrace. These relations indicate that the San Ysidro section has been active in the middle and probably the late Pleistocene.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr
Comments: Based on continuity with the Jemez fault, Wong and others (1995 #1155) conservatively estimate a range in slip rate of 0.01 to 0.52 mm/yr for the fault, with a preferred value of 0.06 mm/yr. Kelson and Olig (1995 #1147) use a preferred value of 0.05 mm/yr for the Jemez-San Ysidro fault. Formento-Trigilio and Pazzaglia (1996 #1295) and Formento-Trigilio (1997 #1377) measured offsets of as much as 6-11 m on several strands of the San Ysidro section in alluvial deposits containing the 620 ka Lava Creek B ash; these data support a low long-term slip rate.

Length End to end (km): 33.6
Trace (km): 57.1

Average strike (azimuth) -2°±20°

Endpoints (lat. - long.) 35°43'20.01"N, 106°45'52.92"W
35°25'13.15"N, 106°47'17.08"W

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2030, San Felipe fault zone

Structure Number 2030

Structure Name San Felipe fault zone
Comments: This complex of numerous generally north trending normal faults near Santa \Ana Mesa was first mapped in detail by Soister (1952 #1418). Kelley (1954 #1222) followed Soister's mapping closely in his compilation, and applied the name San Felipe fault zone to these structures. Later maps by Smith and others (1970 #1125), Kelley (1977 #1106), and Kelley and Kudo (1978 #1307) show similar fault patterns. Kelley (1977 #1106) named many of the more prominent structures in the zone, such as the Santa Ana, Luce, Cocida, and Algodones faults and the San Felipe graben. In their recent compilation, Wong and others (1995 #1155) continue the use of the name "San Felipe fault zone" and divide the zone into two sections, the Santa Ana section to the west and the Algodones section to the east. This subdivision is retained herein.

Synopsis: The San Felipe fault zone is a broad zone of normal faults that offset basalts of the San Felipe volcanic field and underlying Santa Fe Group sedimentary rocks. The fault zone is best expressed where individual fault strands offset the volcanic tablelands of Santa Ana Mesa. The fault zone is primarily a graben, centered on the westernmost of two north trending eruptive centers in the volcanic field. This structure, the San Felipe graben, is bound on the west by the down-to-the-east Luce and Santa Ana faults, and on the east by the down-to-the-west Algodones fault. Most of these faults offset the 2.5 ± 0.3 Ma basalt flows of the San Felipe volcanic field. Average displacements on most faults are 15-30 m, although some of the larger structures, such as the Luce fault, have as much as 90-120 m of vertical displacement.

Date of compilation 03/10/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey; Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Geologic setting The fault zone forms a north-trending graben within the San Felipe volcanic field. Although Wong and others (1995 #1155) conclude that this graben is a minor sub-basin within the Rio Grande rift, the narrowing of the fault zone within the volcanic field indicates that the geometry of the fault zone may be in part controlled by volcanic activity (for example, van Wyk de Vries and Merle, 1996 #1422).

Number of sections 2
Comments: Wong and others (1995 #1155) used the polarity of faults in the San Felipe fault zone to delineate two sections: down-to-the-east faults that form the western margin of the San Felipe graben (Santa Ana and Luce faults) are included in the Santa Ana section, and down-to-the-west faults that form the eastern margin of the graben (Algodones fault) are include in the Algodones section. They

assumed that one of these sections is a “master fault” that controls both sections, but they did not have enough subsurface data to support either scenario.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 43.2 km and a cumulative trace length of 293.6 km.

Average strike (azimuth) 000°±18°

Endpoints (lat. - long.) 35°42’21.56”N, 106°34’08.85”W
35°22’07.60”N, 106°32’05.82”W

2030a, Santa Ana section

Section number 2030a

Section name Santa Ana section
Comments: The Santa Ana section includes the Santa Ana, Luce, and Cocida faults of Kelley (1977 #1106) and numerous smaller displacement, generally down-to-the-east faults that form the west flank of the San Felipe graben.

Reliability of location Good
Comments: Fault locations are good where faults cut volcanic rocks, but locations are poor in the less resistant Santa Fe Group rocks. Fault traces are from Soister (1952 #1418), Smith and others (1970 #1125), Kelley (1977 #1106), and Kelley and Kudo (1978 #1307), and recent unpublished mapping in the Jemez Pueblo (Pazzaglia and others, 1998 #2002, unpublished data 1997-1998), Bernalillo NW and Santa Ana Pueblo quadrangle (Personius, in press #2001, unpublished data 1997-1998).

Sense of movement N

Dip 60° E-90°
Comments: An exposed section of the Luce fault along highway 44 west of Bernalillo yielded an east dip of 82° (Kelley, 1977 #1106). Wong and others (1995 #1155) used dips of 60°-90° in their seismic hazard analysis. Numerous fault exposures in Santa Fe Group rocks in the Bernalillo NW and Santa Ana Pueblo quadrangles have dips of 50°-85° E (S.F. Personius, unpublished data, 1997-1998).

Dip direction E

Geomorphic expression The Luce fault and other faults that cut the basalt flows of the San Felipe volcanic field are well preserved as escarpments covered by basalt talus. The Santa Ana fault and other faults that are only located in Santa Fe Group rocks are poorly expressed, except where they are marked in places by clastic dikes (Soister, 1952 #1418) or strongly cemented zones. Soister (1952 #1418) and Kelley (1977 #1106) measured average displacements of 15-30 m in basalts on most structures in the fault zone, and as much as 90-120 m on larger structures such as the Luce fault.

Age of faulted deposits Faults in the Santa Ana section offset the 2.5 ± 0.3 Ma (Bachman and Mehnert, 1978 #1265) basalts of the San Felipe volcanic field and underlying Santa Fe Group sedimentary rocks. Soister (1952 #1418) describes offset of his early Pleistocene Mesita Alta gravel and surface, which overlies San Felipe basalt flows in several places.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: No detailed studies of the age of most recent movement have been conducted. However, 90-120 m of post-San Felipe basalt displacement on some structures in this fault zone indicate a history of recurrent fault movements that probably continued at least into the early Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Wong and others (1995 #1155) calculated slip rates of 0.01-0.04 mm/yr based on 90-120 m of displacement that has occurred on the Luce fault since deposition of the San Felipe basalt, 2.5 ± 0.3 Ma and similar data. They also concluded that it is likely that some of the major faults within the San Felipe fault zone act as independent rupture segments, but could not rule out the possibility that some faults rupture together.

Length (km) not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 43.2 km and a cumulative trace length of 167.2 km.

Average strike (azimuth) 004°±18°

Endpoints (lat. - long.) 35°42′21.56″N, 106°34′08.85″W
35°19′03.14″N, 106°36′19.04″W

2030b, Algodones section

Section number 2030b

Section name Algodones section
Comments: The Algodones section includes the Algodones fault of Kelley (1977 #1106) and numerous smaller displacement down-to-the-west faults that form the east flank of the San Felipe graben. Some strands of the Algodones section of the San Felipe fault zone have been projected southward across the Rio Grande and connected with parts of the Valley View fault (Kelley, 1977 #1106; Wong and others, 1995 #1155), but recent mapping by Connell (1995 #1291) shows that strands of the Valley View fault trend northeasterly at their northern ends and probably do not connect with the San Felipe fault zone.

Reliability of location Good
Comments: Fault locations are good where faults cut volcanic rocks, but locations are poor in the less resistant Santa Fe Group rocks. Fault traces are from Soister (1952 #1418), Smith and others (1970 #1125), Kelley (1977 #1106), and Kelley and Kudo (Kelley and Kudo, 1978 #1307).

Sense of movement N

Dip 60° W-90°
Comments: No published dip measurements are available, but Wong and others (1995 #1155) used dips of 60° W-90° in their seismic hazard analysis.

Dip direction W

Geomorphic expression The Algodones fault and other faults that cut the basalt flows of the San Felipe volcanic field are well preserved as escarpments covered by basalt talus. Where these structures are located in Santa Fe Group rocks, fault expression is poor. Soister (1952 #1418) and Kelley (1977 #1106) measured average displacements of 15-30 m in basalts on most structures in the San Felipe fault zone, and as much as 90-120 m on larger structures such as the Luce fault in the Santa Ana section.

Age of faulted deposits Faults in the Algodones section offset the 2.5 ± 0.3 Ma (Bachman and Mehnert, 1978 #1265) basalts of the San Felipe volcanic field and underlying Santa Fe Group sedimentary rocks. Soister (1952 #1418) describes offset of his early Pleistocene Mesita Alta gravel and surface, which overlies San Felipe basalt flows in several places.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: No detailed studies of the age of most recent movement have been conducted. However, if early Pleistocene gravels are offset in places and 90-120 m of post-San Felipe basalt (2.5 Ma) displacement has occurred across some structures in San Felipe fault zone, then some of this displacement may have continued at least into the early Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Wong and others (1995 #1155) calculated slip rates of 0.01-0.04 mm/yr based on 90-120 m of displacement has occurred on the Luce fault since deposition of the San Felipe basalt, 2.5 ± 0.3 Ma and similar data. They also concluded that it is likely that some of the major faults within the San Felipe fault zone act as independent rupture segments, but could not rule out the possibility that some faults rupture together.

Length not applicable

Comments: The fault zone includes numerous faults that have an end to end length of 15.9 km and a cumulative trace length of 92.1 km.

Average strike (azimuth) -7°±15°

Endpoints (lat. - long.) 35°30′43.40″N, 106°32′09.00″W
35°22′07.60″N, 106°32′05.82″W

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2031, San Francisco fault

Structure Number 2031

Structure Name San Francisco fault

Comments: The San Francisco fault was named by Stearns (1953 #1127) after springs near the village of San Francisco. The fault extends from Cochiti Pueblo south to Placitas. The fault as used herein includes the Placitas fault of Kelley and Northrop (1975 #1308), Menne (1989 #1405), Woodward and Menne (1995 #1428), and Cather and others (1996 #1764) and was termed the San Francisco-Placitas fault by Russell and Snelson (1994 #1186). At its northern end near Cochiti Pueblo, the San Francisco fault may correlate with the Domingo fault of Smith and Kuhle (1998 #1770).

Synopsis: The San Francisco fault has west-down normal displacement and traverses the Santo Domingo basin of the Rio Grande rift , subparallel to the La Bajada fault [2032]. The northern end of the San Francisco fault has a complex intersection with the Pajarito fault [2008] near Cochiti Lake. The southern end intersects or merges with the Rincon fault [2036] and other faults [2043] in a complex transition zone near the town of Placitas. No paleoseismic studies have been completed along the San Francisco fault at the time of this compilation.

Date of compilation 05/14/98

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.; Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good

Comments: The location of the northern part of the San Francisco fault is based on 1:250,000-scale map of Wong and others (1995 #1155). Original mapping was done at scale of 1:63,360 by Stearns (1953 #1127) and compiled at scale of 1:126,720. The geologic map of Stearns (1953 #1127) lacks a topographic base; his original mapping completed on aerial photography and transferred to a planimetric drainage map. Kelley (1977 #1106) also maps the fault at a scale of 1:125,000. The southern part of the fault, including the Placitas fault, is from 1:8,000 scale mapping of Menne (1989 #1405), later modified by Woodward and Menne (1995 #1428), and 124,000 scale mapping of Cather and others (1996 #1764).

Geologic setting The San Francisco fault, in conjunction with the La Bajada fault [2032], forms the eastern margin of the Santo Domingo basin of the Rio Grande rift. Woodward and Menne (1995 #1428) indicate stratigraphic separation of 1800-2100 m along the San Francisco fault, and Kelley and Northrop (1975 #1308) and Russell and Snelson (1994 #1186) suggested as much as 4300 m of displacement of the base of the Santa Fe Group. Vertical separation on the fault likely increases to the south from its intersection with the Pajarito fault [2008] near Cochiti Pueblo to its intersection with the Rincon fault [2036] near Placitas. The southern termination of the San Francisco fault occurs in a complex transition zone that marks the right-stepping margin of the Rio Grande rift at the north end of the Sandia uplift (Kelley, 1982 #1306; Woodward and Menne, 1995 #1428; Cather and others, 1996 #1764). Russell and Snelson (1994 #1186) suggest that the San Francisco fault is listric at depth, and is a primary structure along the eastern rift margin at this latitude.

Sense of movement N

Comments: The San Francisco fault exhibits down-to-the-west normal separation of Miocene rift-fill sediments (Stearns, 1953 #1127; Kelley and Northrop, 1975 #1308; Baltz, 1976 #1431; Russell and Snelson, 1990 #1187; 1994 #1186).

Dip 50° to 78° W, preferred average 60° W

Comments: Picha (1982 #1736) measured a dip of 52°, Menne (1989 #1405) and Woodward and Menne (1995 #1428) measured a dip of 67°, and Cather and others (1996 #1764) measured a dip of 78° on surface fault exposures of the San Francisco fault. Wong and others (1995 #1155) estimated the range in fault dip for seismogenic crust, based on analogy to listric faults interpreted from deep seismic-reflection data in the Albuquerque basin (Russell and Snelson, 1990 #1187; 1994 #1186). However, Russell and Snelson (1994 #1186) suggest that the San Francisco fault may have a shallow dip relative to their more moderately dipping Rio Grande fault to the west.

Dip direction W

Geomorphic expression Topographic escarpments are associated with the northern part of the fault (Wong and others, 1995 #1155). There are no published records of scarps in Quaternary deposits, although the fault traverses an area of extensive dissection.

Age of faulted deposits Hoge (1970 #1104) and Kelley (1977 #1106) map splays of the San Francisco fault displacing Quaternary deposits, but the age of most-recent activity is poorly constrained. Hoge (1970 #1104) considered the last movement on the fault to be early Quaternary based on displacement of older Quaternary gravel north of Placitas, although Kelley (1977 #1106) notes a lack of evidence of displacement of the early(?) Pleistocene Ortiz pediment surface. Cather and others (1996 #1764) describe movement on the Placitas fault that is bracketed between offset of their lower Pleistocene to upper Pliocene(?) unit Qtpf1 and burial by their middle to lower(?) Pleistocene unit Qp2. A possible correlative splay of the fault near its northern end (the Domingo fault of Smith and Kuhle, 1998 #1770) offsets lower Pleistocene Bandelier Tuff about 200 m (Smith and Kuhle, 1998 #1772).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Primarily because of the structural association with the late Quaternary Pajarito fault [2008] to the north and the Rincon fault [2036] to the south, Wong and others (1995 #1155) considered the San Francisco fault as an active structure; thus, it is included in this compilation. However, the timing of movement is not well constrained. Stearns (1953 #1127) interpreted the fault as younger than Miocene to Pliocene sediments of the Santa Fe Group, and Cather and others (1996 #1764) used stratigraphic reasoning to infer that the Placitas fault has not moved since at least the middle Pleistocene. A few earthquakes have been located near the fault (Wong and others, 1995 #1155).

Recurrence interval not reported

Slip-rate category <0.2 mm/yr
Comments: Wong and others (1995 #1155) conservatively estimate a range of 0.01 to 0.58 mm/yr for the San Francisco fault, with a preferred value of 0.07 mm/yr, based on similarity to the La Bajada fault [2032] and analysis of regional slip rates in the Rio Grande rift. Kelson and Olig (1995 #1147) use a preferred value of 0.06 mm/yr for the San Francisco fault. If the Domingo fault of Smith and Kuhle (1998 #1770) is a correlative splay of the San Francisco fault, then offset of 200 m of the lower Pleistocene Bandelier Tuff (Smith and Kuhle, 1998 #1772) near Cochiti Pueblo indicates a higher long term slip rate than the preferred rate cited above. Slip-rate category assigned based on preferred rates.

Length End to end (km): 25.7
Trace (km): 28.1

Average strike (azimuth) 033°±31°

Endpoints (lat. - long.) 35°29′17.17″N, 106°19′13.61″W
35°17′30.18″N, 106°28′14.04″W

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2032, La Bajada fault

Structure Number 2032

Structure Name La Bajada fault

Comments: The La Bajada fault extends from just beyond its intersection with the Rio Grande to ~15 km south of Galisteo Creek. The southern part of the fault, from Tetilla Peak southward to beyond Galisteo Creek, was originally named the Rosario fault (Stearns, 1953 #1127), but most compilations since that time have included at least the northern part of the Rosario fault in the La Bajada fault (Kelley, 1954 #1222; Baltz, 1976 #1431; Kelley, 1977 #1106; Kelley, 1978 #1107; Wong and others, 1995 #1155; Hawley and Whitworth, 1996 #1303). Herein we use the name "La Bajada fault" for the entire structure, because of confusion about where to divide the Rosario and La Bajada faults. Displacement on the La Bajada fault decreases south of Rosario, and may decrease to zero about 10 km north of its apparent intersection with the Tijeras-Cañoncito fault system [2033] near Golden (Bachman, 1975 #1283; Baltz, 1976 #1431). At its northern end, the La Bajada fault intersects with (Smith and others, 1970 #1125) and may be truncated by (Wong and others, 1995 #1155) the Pajarito fault [2008] north of the Rio Grande.

Synopsis: The La Bajada fault forms the margin between the Santo Domingo basin and the eastern edge of the Rio Grande rift, and truncates the western edge of the Cerros del Rio volcanic field. A several-hundred-meter-high west-facing escarpment marks the trace of the La Bajada fault along the northern part of the fault. Much of the footwall is capped by the resistant flows of the Plio-Pleistocene Cerros del Rio volcanic field, which help maintain the steep escarpment. The fault has been active in the Quaternary because it cuts upper Pliocene and lower Pleistocene volcanic rocks northeast of Cochiti Dam. However, the fault trace is commonly covered by extensive toreva block landslides, and no fault scarps in surficial deposits have been found. These relations indicate an active period of faulting in the latest Pliocene and early Pleistocene, perhaps associated in part with volcanic activity in the Jemez and Cerros del Rio volcanic fields. The fault appears to have been quiescent for the last several hundred thousand years.

Date of compilation 05/20/98

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval and Santa Fe

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good

Comments: The southern end of the fault trace in the 15 minute Madrid quadrangle is from Bachman (1975 #1283). The northern part of the fault trace is from Smith and others (1970 #1125) and unpublished 1:24,000 scale mapping (Thompson and others, 1997 #1420; Sawyer and others, in press #1780). Parts of the fault trace are covered by extensive toreva block landslides, so fault locations in these areas are imprecise.

Geologic setting The La Bajada fault forms the eastern edge of the Rio Grande rift and the eastern margin of the Santo Domingo basin. Apparent high rates of faulting associated with Plio-Pleistocene volcanism in the Cerros del Rio volcanic field suggest that some movements on the northern La Bajada fault may be related to volcanic activity.

Sense of movement N

Comments: The La Bajada fault exhibits predominantly normal slip, but some bedrock exposures indicate a component of localized strike-slip movement in the intersection zone with the Pajarito fault [2008], and in local areas where slip is transferred across smaller scale relay or accommodation zones (S.M. Minor, written commun., 1996-1997).

Dip 60°-70° W

Comments: Wong and others (1995 #1155) used a preferred dip of 60 degrees, based on regional seismotectonic relations. Actual measurements of fault planes in bedrock exposures along the surface traces of the main and subsidiary strands of the La Bajada fault mostly range from 60 to 90 degrees (S.M. Minor, written commun., 1996-1997).

Dip direction W

Geomorphic expression A well developed, several hundred meter high, west-facing escarpment marks the trace of the La Bajada fault along most of its length. Much of the footwall is capped by the resistant flows of the Pliocene Cerros del Rio volcanic field, which help maintain the steep escarpment. The fault trace is commonly covered by extensive toreva block landslides. Wong and others (1995 #1155, p. 2-14, 7-11) briefly describe recently identified lineaments and topographic scarps, presumably in surficial deposits, but recent field investigations by the compiler (S.F. Personius, unpublished data, 1996) found no evidence of fault offsets in surficial deposits of any age along the trace of the La Bajada fault.

Age of faulted deposits Parts of the La Bajada fault are covered by extensive toreva block landslides, but the fault clearly cuts upper Pliocene and lower Pleistocene volcanic rocks at its northern end (Smith and others, 1970 #1125; Aubele, 1978 #1282). These rocks include basalts of Cerros del Rio (2.3-2.8 Ma; Bachman and Mehnert, 1978 #1265; Woldegabriel and others, 1996 #1426), which are overlain by the 1.6 Ma Guaje Pumice (the base of the Otowi Member of the Bandelier Tuff; Smith and others, 1970 #1125; Izett and Obradovich, 1994 #1305), which is in turn overlain by the basaltic andesite of Tank Nineteen (Smith and others, 1970 #1125). The basaltic andesite of Tank Nineteen is the youngest bedrock unit offset along the La Bajada fault zone. An age of 1.16 Ma has recently been obtained on these rocks (R.A. Thompson, written commun., 1998). This age is consistent with stratigraphic relations, because they overlie and thus post-date the Otowi and probably the Tshirege members of the Bandelier Tuff (Thompson and others, 1997 #1420).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)

Comments: Wong and others (1995 #1155, p. 2-14, 7-11) briefly describe recently identified lineaments and topographic scarps, presumably in surficial deposits, but recent field investigations by the compiler (S.F. Personius, unpublished data, 1996) found no evidence of fault offsets in surficial deposits of any age along the trace of the La Bajada fault. Surficial deposits that lie unfaulted across the fault trace include extensive toreva block landslides, some with well developed (stage IV) calcium carbonate soil horizons, piedmont surfaces with well developed (stage III) calcium carbonate soil horizons, a 15 m high terrace along the Santa Fe River, a 20 m high terrace along Galisteo Creek, and a 30 m high terrace along the Rio Grande (S.F. Personius, unpublished data, 1996). The ages of these deposits are unknown, but regional correlations suggest that the unfaulted Rio Grande terrace is probably several hundred thousand years old (Dethier, 1997 #1091; D.P. Dethier, written commun., 1996). In addition, the fault is buried by the Plio-Pleistocene Turto gravel of Stearns (1953 #1127) south of Galisteo Creek (Bachman, 1975 #1283). Thus the most recent data point to an active period of faulting in late Pliocene and early Pleistocene time, perhaps associated with the volcanic activity in the Jemez and Cerros del Rio volcanic fields. The fault appears to have been quiescent for the last several hundred thousand years.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr

Comments: Wong and others (1995 #1155, table 7-1) calculated a post-Cerros del Rio (late Pliocene) rate of 0.06 mm/yr. However, slightly higher long-term (Plio-Pleistocene) slip rates across the La Bajada fault are indicated by the offsets of the basalt of Cerros del Rio and the basaltic andesite of Tank 19 (Smith and others, 1970 #1125) northeast of Cochiti Dam near the northern end of the fault. Offsets of these units are about 250 m and 90 m, respectively (S.F. Personius, unpublished data, 1996). The basalt of Cerros del Rio was deposited about 2.5 Ma (Bachman and Mehnert, 1978 #1265) and the basaltic andesite of Tank 19 was deposited about 1.16 Ma (R.A. Thompson, written commun., 1998). Further south, correlation of basalts in a Bureau of Indian Affairs water well with Cerros del Rio basalts in the footwall of the La Bajada fault indicate offset of about 375 m (Smith and Kuhle, 1998 #1772; Sawyer and others, in press #1780).

Length End to end (km): 40.3
Trace (km): 62.1

Average strike (azimuth) -9°±26°

Endpoints (lat. - long.) 35°42′07.57″N, 106°18′07.09″W
35°20′45.97″N, 106°12′50.52″W

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2033, Tijeras-Cañoncito fault system

Structure Number 2033

Structure Name Tijeras-Cañoncito fault system

Comments: The regionally extensive Tijeras-Cañoncito fault system consists of several northeast-striking, subvertical faults, including the Tijeras, Guiterrez, Zuzax, San Lazarus, Los Angeles, and Lamy faults (Lisenbee and others, 1979 #1725; Woodward, 1984 #1735; Maynard and others, 1991 #1732; Abbott and Goodwin, 1995 #1729). The fault system commonly is referred to as the "Tijeras fault zone", but the name Tijeras-Cañoncito fault system is retained herein to denote the entire group of faults. The fault system (or parts thereof) have been mapped by Bachman (1975 #1283), Kelley and Northrop (1975 #1308), Booth (1977 #1733), Kelley {, 1977 #1106}, Lisenbee and others (1979 #1725), Connolly (1982 #1726), Woodward (1984 #1735), Maynard and others (1991 #1732), Maynard (1995 #1728), Abbott and Goodwin (1995 #1729), Abbott and others (1995 #1769), GRAM, Incorporated and William Lettis & Associates, Incorporated (1995 #1430), and Connell (1997 #1765). The fault system extends from an intersection with the Picuris-Pecos fault [2023] near Lamy, about 22 km southeast of Santa Fe, to an intersection with the Sandia [2037] and Hubbell Springs [2120] faults in the Four Hills area, about 16 km southeast of Albuquerque.

Synopsis: Right-lateral slip probably occurred on the Tijeras-Cañoncito fault system during the Laramide orogeny. Structural data suggest left-lateral Neogene displacement occurred on the fault, which is consistent with east-west extension of the Rio Grande rift and the fault's northeasterly strike. There have been no detailed site-specific studies on the earthquake history of the fault at the time of this compilation, and currently there are no paleoseismologic data available. However, displaced Quaternary deposits have been identified along the southwestern section of the fault on Kirtland Air Force Base, in Tijeras Canyon, and near Golden. The fault apparently has a strong influence on near-surface groundwater conditions on Kirtland Air Force Base.

Date of compilation 03/16/97

Compiler and affiliation Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Santa Fe; Sandoval; Bernallilo

1° x 2° sheet Santa Fe; Albuquerque; Socorro

Province Basin and Range

Geologic setting The Tijeras-Cañoncito fault system forms the structural boundary between the Española basin of the Rio Grande rift to the west and the Great Plains tectonic province to the east. The fault system has a history of recurrent movement, including Late Pennsylvanian-Early Permian displacement (Lisenbee and others, 1979 #1725), renewed activity during the late Cretaceous-early Tertiary Laramide orogeny (Cather, 1992 #1773) , and Neogene displacement associated with east-west extension of the Rio Grande rift (Keller and Cather, 1994 #1731; Abbott and Goodwin, 1995 #1729). In addition, the fault system is associated with a series of Oligocene intrusive rocks of the San Pedro-Ortiz porphyry belt (Maynard and others, 1991 #1732). The fault traverses the epicentral area of the 1918 Cerrillos earthquake, the largest (M_L 4.5 to 5.5) historical earthquake in the northern Rio Grande rift (Olsen, 1979 #1724), and may be associated with a moderate (M_L 4.5) earthquake that rattled the towns of San Antonito and Zamora in 1947 (Sanford, 1976 #1734). Wong and others (1995 #1155; 1996 #1156) postulated three possible rupture scenarios along the fault system, and estimated that the fault system can generate earthquakes as large as M_W 7.

Number of Sections 2
Comments: Lisenbee and others (1979 #1725) separated the Tijeras-Cañoncito fault system into five sections on the basis of structural style, fault trace complexity, and sense and amount of separation. Wong and others (1995 #1155) informally named these the Lamy, San Pedro/Ortiz, Monte Largo, Tijeras, and Four Hills sections, and grouped them into three postulated rupture scenarios. Wong and others (1995 #1155; 1996 #1156) assumed that the two southernmost sections (the Four Hills and Tijeras sections) are active based on evidence of Quaternary faulting noted by Lisenbee and others (1979 #1725) and GRAM, Incorporated and William Lettis & Associates, Incorporated (1995 #1430). The northern three sections were assumed to have equal probabilities of being active or inactive, in the absence of conclusive data. More recent findings show that there has been Quaternary activity on the Monte Largo section (Abbott and Goodwin, 1995 #1729; Kelson and others, 1997 #1781), but there are still no data available that suggest Quaternary activity north of Golden. Stearns (1953 #1127) and Bachman (1975 #1283) map faulted early Tertiary gravel north of Golden, but show no faulting of Pleistocene gravel along traces of the fault system. Thus, there are insufficient data to address the activity of the fault system north of Golden (*i.e.*, along the San Pedro/Ortiz and Lamy sections). The fault system herein is subdivided into two sections that group sections previously identified by Lisenbee and others (1979 #1725) and Wong and others (1995 #1155; 1996 #1156). The boundary between the two sections is interpreted to be near Golden, at the boundary between the Monte Largo and San Pedro/Ortiz sections of Wong and others (1995 #1155; 1996 #1156). This boundary also coincides with the intersection of the Tijeras fault and the La Bajada fault [2032] and a cluster of contemporary microseismicity noted by House and Hartse (1995 #1160).

Length End to end (km): 78.9
Trace (km): 137.8

Average strike (azimuth) 046°±31°

Endpoints (lat. - long.) 35°28′42.30″N, 105°52′50.39″W
34°59′13.60″N, 106°30′26.21″W

2033a, Galisteo section

Section Number 2033a

Section Name Galisteo section
Comments: The Galisteo section is herein informally named after the small village along Highway 41, about 32 km south of Santa Fe. This section includes the Lamy and San Pedro/Ortiz sections identified by Wong and others (1995 #1155; 1996 #1156). The Galisteo section extends from an intersection with the Picuris-Pecos fault [2023] near Lamy, to an intersection with the La Bajada fault [2032] near Golden.

Reliability of location Good

Comments: The location is based on compilation of previous data by Lisenbee and others (1979 #1725) at a scale of about 1:385,000, and checked by inspection with maps by Stearns (1953 #1127) at a scale of about 1:127,000, Bachman (1975 #1283) at a scale of 1:62,500, and Abbott and others (1995 #1769) at a scale of about 1:714,000.

Sense of movement S

Comments: Post-Upper Cretaceous left separation of about 5 km is noted by Maynard (1995 #1728), although he also notes that the net amount and direction of true slip is unknown because of a lack of piercing points on the fault surface. There was left-lateral separation during the Neogene, based on regional geologic relations (Abbott and others, 1995 #1769) and structural data collected on the Canyon fault section [2033b] by Abbott and Goodwin (1995 #1729). No piercing points have been documented along the Galisteo section of the fault system.

Dip 80° E to 80° W, preferred 90° (vertical)

Comments: Deep subsurface data are lacking for this fault section. Maynard (1995 #1728) provides detailed shallow geologic data that constrain a vertical fault zone within the upper 0.5 km of the crust. Lisenbee and others (1979 #1725), Kelley and Northrop (1975 #1308), and Abbott and others (1995 #1769) note that the fault system is subvertical, exhibits evidence of predominantly lateral slip during the Neogene, and has a linear trace across linear topography. Based on these relations, Wong and others (1995 #1155) estimate the range given above for the fault's dip through the seismogenic crust.

Dip direction V

Geomorphic expression Linear valleys are present along the fault trace within the Ortiz Mountains, but no prominent fault-related lineaments have been noted by previous workers along the Galisteo fault section. Overall, this suggests that the Galisteo fault section has little or no geomorphic expression related to late Quaternary fault movement.

Age of faulted deposits Post-early Tertiary displacement along the Galisteo section is indicated by faulting of Oligocene volcanics in the Ortiz Mountains (Schutz, 1995 #1727; Maynard, 1995 #1728) and early Tertiary Galisteo Formation between the Ortiz Mountains and Lamy (Stearns, 1953 #1127; Bachman, 1975 #1283).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)

Comments: The timing of the most-recent earthquake on the Galisteo fault section is unknown. In the absence of data on the timing of displacement, Quaternary movement is interpreted based on structural continuity between the Galisteo and Canyon fault sections.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr

Comments: There are no well constrained data on the Quaternary slip rate of the Tijeras-Cañoncito fault system. Wong and others (1995 #1155; 1996 #1156) estimate a range in slip rates of 0.02-0.72 mm/yr and a preferred rate of 0.09 mm/yr, based on regional analysis of slip rates within the Rio Grande rift. Slip-rate category assigned based on Wong and others' (1995 #1155; 1996 #1156) preferred rate.

Length End to end (km): 37.1
Trace (km): 67.7

Average strike (azimuth) 049°±42°

Endpoints (lat. - long.) 35°28′42.30″N, 105°52′50.39″W
35°16′54.85″N, 106°12′38.28″W

2033b, Canyon section

Section Number 2033b

Section Name Canyon section
Comments: The Canyon section is herein informally named after Tijeras Canyon, which parallels the Tijeras-Cañoncito fault system between Albuquerque and the town of Tijeras. This section includes the Monte Largo, Tijeras, and Four Hills sections identified by Wong and others (1995 #1155; 1996 #1156). The Canyon section extends from an intersection with the La Bajada fault [2032] near Golden, to an intersection with the Sandia [2037] and Hubbell Spring [2120] faults on Kirtland Air Force Base. Detailed mapping along this fault section in the Tijeras 1:24,000-scale quadrangle is summarized in Connell (1997 #1765), and is currently underway in the Sandia Park 1:24,000-scale quadrangle by F. Pazzaglia (University of New Mexico, pers. comm., 1996).

Reliability of location Good
Comments: The location is based on compilation of previous data by Lisenbee and others (1979 #1725) at a scale of about 1:385,000, and checked by inspection with maps by Kelley and Northrop (1975 #1308) at a scale of 1:48,000, and Karlstrom (unpublished data, 1995), GRAM, Incorporated and William Lettis & Associates, Incorporated (1995 #1430), and Connell (1997 #1765), at scales of 1:24,000.

Sense of movement S
Comments: Neogene left-lateral separation along the Canyon section is based on structural data collected by Abbott and Goodwin (1995 #1729) near Golden, and by regional geologic relations. The east-down sense of vertical separation noted by Abbott and Goodwin (1995 #1729) is opposite to the west-down vertical separation noted by Lisenbee and others (1979 #1725) within Tijeras Canyon, although this difference may be insignificant if the primary sense of separation on the fault is left lateral. No piercing points have been documented along the Canyon section of the fault system.

Dip 80° E to 80° W, preferred 90° (vertical)
Comments: Subsurface data are lacking for this fault section. Lisenbee and others (1979 #1725), Kelley and Northrop (1975 #1308), and Abbott and others (1995 #1769) note that the fault system is subvertical, exhibits evidence of predominantly lateral slip during the Neogene, and has a linear trace across linear topography. Based on these relations, Wong and others (1995 #1155) estimate the range given above for the fault's dip through the seismogenic crust.

Dip direction V

Geomorphic expression The Tijeras and Guiterrez faults exhibit prominent geomorphic expression, such that virtually the entire Canyon fault section is discernible on the basis of juxtaposition of different rock types. Prominent fault-related scarps are present along the fault sections, although it is presently unclear whether these are related to late Quaternary movement or differences in rock types across the fault. Preliminary analysis of aerial photography and field reconnaissance by Kelson (unpublished data, 1995) suggest the presence of scarps on alluvial surfaces along the fault near the stream-bank exposure documented by Abbott and Goodwin (1995 #1729).

Age of faulted deposits Abbott and Goodwin (1995 #1729) document the presence of faulted alluvium along the Tijeras fault about 5 km southwest of Golden, and interpret the alluvium as Quaternary(?). Inspection by the compiler of the exposure alluvium supports this interpretation. Lisenbee and others (1979 #1725) and Connell (1997 #1765) note that Quaternary alluvium and colluvium are faulted by the Tijeras fault within Tijeras Canyon about 5 km east of Albuquerque. GRAM, Incorporated and William Lettis & Associates, Incorporated (1995 #1430) note the presence of faulted Pleistocene alluvium along a splay of the Tijeras fault on Kirtland Air Force Base, and note prominent lineaments across a Pleistocene rock-cut pediment surface. The ages of all of these faulted surficial deposits are poorly constrained, although most probably are middle to late Pleistocene in age. Abbott and Goodwin (1995 #1729) note that the fault does not displace Holocene alluvium in the stream bank exposure near Golden. Kelson and others (1997 #1781) show that the fault displaces late to middle Pleistocene deposits near Golden.

Detailed studies Exploratory trenches excavated by Kelson and others (1997 #1781) across several strands of the Tijeras fault in September and October, 1997 suggest the occurrence of late Quaternary displacement. Their site is located about 1 km northeast of a stream-bank exposure of the fault described by Abbott and Goodwin (1995 #1729).

Locality 2033b-1: Kelson and others (1997 #1781) excavated three trenches and a stream-bank exposure at the Adobe Camp site, located about 6 km southwest of Golden. Trench and soils studies suggest at least one and possibly two surface ruptures on several strands of the Tijeras fault since the middle to late Quaternary. Evidence of reverse and strike slip faulting revealed in the excavations suggest the possibility that the near-surface fault zone at this locality is a positive flower structure (Kelson and others, 1997 #1781).

Timing of most recent paleoevent late Quaternary (<130 ka)

Comments: Faulted alluvium documented by Lisenbee and others (1979 #1725), Abbott and Goodwin (1995 #1729), GRAM, Incorporated and William Lettis & Associates, Incorporated (1995 #1430), and Kelson and others (1997 #1781), strongly suggest that there has been movement on the Canyon fault section during the late Quaternary.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr

Comments: There are no well constrained data on the Quaternary slip rate of the Tijeras-Cañoncito fault system. Wong and others (1995 #1155; 1996 #1156) estimate a range in slip rates of 0.02-0.72 mm/yr and a preferred rate of 0.09 mm/yr, based on regional analysis of slip rates within the Rio Grande rift. Slip-rate category assigned based on preferred rate.

Length End to end (km): 42.4
Trace (km): 67.0

Average strike (azimuth) 043°±12°

Endpoints (lat. - long.) 35°16′54.84″N, 106°12′37.73″W
34°59′13.60″N, 106°30′26.21″W

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2034, Bernalillo fault

Structure Number 2034

Structure Name Bernalillo fault
Comments: The Bernalillo fault was originally described by Lambert (1978 #1737), and later named the Bernalillo fault and mapped in detail by Connell (1995 #1291).

Synopsis: The Bernalillo fault lies on the piedmont about 5 km west of the Rincon fault [2036] that controls the steep western margin of Rincon Ridge. The exposed length of the Bernalillo fault is about 2 km, and is readily recognized by offset of a white diatomite bed in main stem, middle Pleistocene Rio Grande alluvium. At its northern end, the Bernalillo fault projects beneath the modern floodplain of the Rio Grande. Its southern extent is less clear, but recently acquired high resolution aeromagnetic data indicate that the Bernalillo fault curves southward and probably extends to the vicinity of Sandia Wash.

Date of compilation 03/11/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: Fault trace from 1:24,000 scale mapping of Connell (1995 #1291; written commun., 1997), and unpublished aeromagnetic data (U.S. Geological Survey and SIAL Geosciences Inc., 1997 #1722; Grauch and Millegan, 1998 #1721).

Geologic setting The Bernalillo fault is one of several down-to-the-west faults that are sympathetic to the Rincon fault [2036], which forms the eastern boundary of the Albuquerque basin and the Rio Grande rift at this latitude.

Sense of movement N

Dip 80°-83° W
Comments: Dip measurements are from Lambert (1978 #1737) and Connell (1995 #1291).

Dip direction W

Geomorphic expression The Bernalillo fault is marked by offsets of a distinctive diatomite bed in main stem Rio Grande alluvium (Connell, 1995 #1291); the fault is mostly located in eroded topography, where no fault scarps are preserved. Connell (1995 #1291) measured 6-7 m of displacement in the alluvium of Edith Boulevard and ≥2 m of displacement in the alluvium of Menaul Boulevard.

Age of faulted deposits The Bernalillo fault offsets middle Pleistocene alluvium of Edith Boulevard and middle or late Pleistocene alluvium of Menaul Boulevard (Connell, 1995 #1291).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Connell (1995 #1291) mapped offsets in middle Pleistocene alluvium of Edith Boulevard and middle or late Pleistocene alluvium of Menaul Boulevard of Lambert (1968 #1396) along the Bernalillo fault. The age of these deposits is poorly constrained, but they probably are correlative with

a pre-last glacial maximum glacial period, either an early Pinedale or Bull Lake glacial advance. The displacement data measured by Connell (1995 #1291) indicate a history of recurrent faulting that probably extended into the late Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: If the alluvium of Menaul Boulevard is offset ≥2 m and is correlative with the Bull Lake glaciation (oxygen-isotope stage 6), then a low late Quaternary slip rate is indicated.

Length End to end (km): 5.6
Trace (km): 5.8

Average strike (azimuth) 006°±14°

Endpoints (lat. - long.) 35°18′06.29″N, 106°32′32.32″W
35°15′04.95″N, 106°32′54.85″W

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#1721 Grauch, V.J.S., and Millegan, P.S., 1998, Mapping intrabasinal faults from high-resolution aeromagnetic data: The Leading Edge, v. 17, p. 53-55.

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2035, Calabacillas fault

Structure Number 2035

Structure Name Calabacillas fault
Comments: Part of the Calabacillas fault was originally mapped by Bryan and McCann (Bryan and McCann, 1937 #1288, fig. 4), and later described in detail by Wright (1946 #1427) in the Volcano Ranch 7.5 minute quadrangle. More recently, the fault was mapped and named in the Sky Village SE (now Arroyo de las Calabacillas) quadrangle by Cather and others (1997 #1763). Wright (1946 #1427, p.426-428), Kelley and others (1976 #1380), and Kelley (1977 #1106) included the Calabacillas fault with the Sand Hill fault zone [2039], which lies 1-2 km to the west. However, recent mapping indicates that the Calabacillas fault does not intersect the Sand Hill fault zone [2039], but rather trends northeastward to the north and southeastward to the south of the exposures described by Wright (1946 #1427). At its northern end, the Calabacillas fault appears to join with the Jemez-Ysidro fault [2029] near Arroyo Piedra Parada (Woodward and Ruetschilling, 1976 #1133; G.O. Bachman, unpub. mapping, 1975).

Synopsis: The Calabacillas fault is a prominent down-to-the-east normal fault that offsets the Llano de Albuquerque along the western margin of the Rio Grande rift. It is poorly exposed along most of its length, except where it crosses the Ceja del Rio Puerco, where a sequence of downdropped colluvial deposits and interbedded calcic soils indicate repeated fault movements. These soils and sediments appear to record a fault history similar to that described along the nearby County Dump fault [2038]. Minor offsets of pediment remnants on the northeast-trending section of the fault have been described north of the Ceja del Rio Puerco exposures.

Date of compilation 04/02/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval; Bernalillo

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: The fault trace is from unpublished mapping of G.O. Bachman in the Sky Village NE quadrangle (1975), from recently published mapping in the Sky Village SE quadrangle (Cather and others, 1997 #1763), and unpublished mapping by M.N. Machette and the compiler in the Volcano Ranch quadrangle (1983-1997). The fault location is also evident in recently acquired high resolution aeromagnetic data (U.S. Geological Survey and SIAL Geosciences Inc., 1997 #1722; Grauch and Millegan, 1998 #1721).

Geologic setting The Calabacillas fault is an intrabasin normal fault located near the western active margin of the Rio Grande rift.

Sense of movement N

Dip 60° E
Comments: Dip measurement from Wright (1946 #1427, plate 8).

Dip direction E

Geomorphic expression The Calabacillas fault forms broad, dissected fault scarps across the Llano de Albuquerque, and is exposed in upper Santa Fe Group sediments at several locations where it crosses the Ceja del Rio Puerco. The northeast-trending part of the fault zone mapped by Kelley and others (1976 #1380) and Kelley (1977 #1106) is marked by scattered displaced pediment remnants across the dissected surface of the Llano de Albuquerque.

Age of faulted deposits Wright (1946 #1427), Machette (1978 #1402), and Machette and others (1997 #1403) describe a sequence of downdropped colluvial deposits and interbedded calcic soils associated with repeated fault movements along the Calabacillas fault. These soils and sediments appear to record a fault history similar to that described along the County Dump fault [2038] (Machette and others, 1997 #1403). Kelley (1977 #1106) also described minor offsets of pediment remnants on the northeast-trending section of the fault north of the Ceja del Rio Puerco exposures. The ages of these offset deposits is unknown, but most are probably early and middle(?) Pleistocene in age.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Wright (1946 #1427) described 19 and Machette (1978 #1402) and Machette and others (1997 #1403) described 9 post-Llano de Albuquerque fault-scarp-derived colluvial and soil deposits adjacent to this structure. The soils developed between these fault wedges have extensive carbonate development (Machette and others, 1997 #1403) that indicates a substantial amount of time is recorded in these deposits. Such a sedimentary record is clear evidence of a recurrent fault history that may extend into the late Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Wright (1946 #1427) described about 45 m of accumulated fault-derived colluvial deposits on the downthrown block. A low slip rate is indicated if the Llano de Albuquerque was formed about 1 Ma and is offset about 45 m.

Length End to end (km): 40.2
Trace (km): 44.4

Average strike (azimuth) 007°±16°

Endpoints (lat. - long.) 35°30′01.41″N, 106°47′35.96″W
35°08′24.15″N, 106°50′17.93″W

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#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1380 Kelley, V.C., Woodward, L.A., Kudo, A.M., and Callender, J.F., 1976, Guidebook to Albuquerque basin of the Rio Grande rift, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 153, 31 p.

#1402 Machette, M.N., 1978, Dating Quaternary faults in the southwestern United States by using buried calcic paleosols: U.S. Geological Survey Journal of Research, v. 6, no. 3, p. 369-381.

#1403 Machette, M.N., Long, T., Bachman, G.O., and Timbel, N.R., 1997, Laboratory data for calcic soils in central New Mexico—Background information for mapping Quaternary deposits in the Albuquerque basin: New Mexico Bureau of Mines and Mineral Resources Circular 205, 63 p.

#1722 U.S. Geological Survey, and SIAL Geosciences Inc., 1997, Description of digital aeromagnetic data collected north and west of Albuquerque, New Mexico: U.S. Geological Survey Open-File Report 97-286, 40 p.

#1133 Woodward, L.A., and Ruetschilling, R.L., 1976, Geology of San Ysidro quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 37, 1 sheet, scale 1:24,000.

#1427 Wright, H.E., Jr., 1946, Tertiary and Quaternary geology of the lower Rio Puerco area, New Mexico: Geological Society of America Bulletin, v. 57, p. 383-456.

2036, Rincon fault

Structure Number 2036

Structure Name Rincon fault

Comments: Although the Rincon fault trace appears along the western base of Rincon Ridge on early fault compilations in the region (Bernalillo fault of Stearns, 1953 #1127; unnamed fault of Kelley, 1954 #1222), little detailed work was done on this structure until the geologic investigations of the Sandia Mountains by Kelley and Northrop (1975 #1308). More recently, Connell (1995 #1291) conducted detailed mapping and fault scarp morphology studies along the Rincon fault.

Synopsis: The Rincon fault forms the western flank of Rincon Ridge, near the northwestern end of the Sandia Mountains. The fault is marked along a 4 km long middle section by young fault scarps of varying heights in alluvial fan deposits. Although no definitive fault studies have been conducted to date, fault scarp morphology and soil development studies indicate that the Rincon fault may have experienced Holocene displacement.

Date of compilation 03/12/97

Compiler and affiliation Stephen F. Personius, U.S. Geological survey

State New Mexico

County Bernalillo; Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: Detailed mapping by Connell (1995 #1291) locates the Rincon fault from just south of Juan Tabo Canyon northward about 4 km; further north and south, the fault is less well located because fault scarps are either not present or poorly preserved (Cather and others, 1996 #1764). These latter traces are mostly mapped with subsurface well and geophysical data Connell (1995 #1291; written commun., 1997).

Geologic setting The Rincon fault forms part of the eastern, active margin of the Rio Grande rift and the Albuquerque-Belen basin just north of the latitude of Albuquerque.

Sense of movement N

Dip 65°-76° W
Comments: Surface dip measurements are from Connell (1995 #1291).

Dip direction W

Geomorphic expression The central 4 km of the Rincon fault are well expressed as a series of discontinuous fault scarps in alluvial fan deposits (Connell, 1995 #1291). The western margin of Rincon Ridge exhibits classic faceted spur and ridge topography (Connell, 1995 #1291) that commonly is associated with active, normal-fault controlled mountain fronts. Connell (1995 #1291) measured single event fault scarps with about 2 m of offset in latest Pleistocene to middle Holocene(?) alluvial-fan deposits, and compound scarps with offsets of about 7 m in late Pleistocene deposits.

Age of faulted deposits The Rincon fault offset middle and late Pleistocene to Holocene(?) alluvial-fan deposits along the central part of Rincon Ridge (Connell, 1995 #1291). These age assignments are based on detailed soils studies; no radiometric age data are available.

Detailed studies none

Timing of most recent paleoevent latest Quaternary (<15 ka)
Comments: Connell (1995 #1291) used detailed soil stratigraphic and fault scarp morphologic studies to estimate the age of the most recent faulting event on the Rincon fault. The most recent, single event fault scarps displace latest Pleistocene to middle Holocene(?) alluvial-fan deposits and have offsets of about 2 m and scarp-slope angles of 17-18°. Connell (1995 #1291) used these data to estimate an age of the latest event of ?5 ka. Kelley and Northrop (1975 #1308, p. 81) used the freshness of fault scarps to surmise that the latest event on the Rincon fault occurred within the last 100 years, but the fault studies of Connell (1995 #1291) yield a more likely middle Holocene age.

Recurrence interval 10-95 k.y.
Comments: Connell (1995 #1291) used scarp morphology studies to estimate the age of the penultimate event on the Rincon fault at 15-100 ka. If the latest event occurred ≤5 ka, then the recurrence interval between these two events is 10-95 k.y.

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No estimates of slip rates were made in the only existing detailed fault study of the Rincon fault (Connell, 1995 #1291). However, the relatively long recurrence interval suggested by the scarp morphology data indicate that longer-term slip rates are low.(Connell, 1995 #1291)

Length End to end (km): 12.2
Trace (km): 13.7

Average strike (azimuth) 013°±23°

Endpoints (lat. - long.) 35°17'23.74"N, 106°28'35.69"W
35°11'04.20"N, 106°30'49.12"W

References

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#1291 Connell, S.D., 1995, Quaternary geology and geomorphology of the Sandia Mountains piedmont, Bernalillo and Sandoval Counties, central New Mexico: Riverside, University of California, unpublished M.S. thesis, 414 p., 3 pls.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1308 Kelley, V.C., and Northrop, S.A., 1975, Geology of Sandia Mountains and vicinity, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 29, 136 p., 4 pls., scale 1:48,000.

#1127 Stearns, C.E., 1953, Tertiary geology of the Galisteo-Tonque area, New Mexico: Geological Society of America Bulletin, v. 64, p. 459-508.

2037, Sandia fault

Structure Number 2037

Structure Name Sandia fault
Comments: The Sandia fault is series of structures responsible for most of the uplift of the west flank of the Sandia Mountains; various traces of the Sandia fault have been mapped by Ellis (1922 #1294), Kelley (1954 #1222; 1977 #1106), Kelley and Northrop (1975 #1308), Connell (1995 #1291), GRAM Incorporated and William Lettis and Associates, In (1995 #1430), and Connell (1997 #1765). We include several north trending intrabasin fault strands that lie to the west of the main Sandia range front in this discussion of the Sandia fault.

Synopsis: The Sandia fault forms the steep western flank of the Sandia Mountains, and the eastern margin of the Albuquerque-Belen basin in the vicinity of Albuquerque. Little geomorphic evidence of Quaternary faulting is found along the trace of the Sandia fault, but the presence of a steep mountain front and a few possible fault scarps in unconsolidated deposits indicates that the Sandia fault has probably been active in the Quaternary. The fault strands west of the main range front are mapped on the basis of subsurface well and geophysical data; they appear to offset upper Santa Fe Group sediments.

Date of compilation 03/12/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Bernalillo; Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Poor
Comments: Most published maps show the Sandia fault as dotted along most of its trace; map traces are from Kelley and Northrop (1975 #1308), Connell (1995 #1291; written commun., 1997), GRAM Incorporated and William Lettis and Associates, Incorporated (1995 #1430), and Connell (1997 #1765).

Geologic setting The Sandia fault forms part of the eastern margin of the Rio Grande rift and the Albuquerque basin in the vicinity of Albuquerque.

Sense of movement N

Dip 55° W
Comments: Dip measurements are of a surface fault exposure just north of Tijeras Arroyo (Kelley and Northrop, 1975 #1308; Lambert and others, 1982 #1397).

Dip direction W

Geomorphic expression The range front adjacent to the northern end of the Sandia fault, from Rincon Ridge south to Embudito Canyon (Domingo Baca segment of Connell, 1995 #1291) is deeply embayed; from Embudito Canyon south to Tijeras Canyon, the Sandia range front is steep, linear, and characterized by dissected faceted spurs and ridges. South of Tijeras Canyon to its intersection with the Tijeras-Cañoncito fault system [2033], the Sandia Range front is again embayed. A few small fault scarps have been mapped intermittently in middle Pleistocene alluvial fan deposits at the northern and southern ends of the Sandia fault (Connell, 1995 #1291; GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430; Gustafson, 1996 #1299), but most of the trace is buried by younger fan deposits. The intrabasin faults west of the main range front have little or no geomorphic expression (Connell, 1995 #1291; written commun., 1997).

Age of faulted deposits A few small scarps are preserved in middle Pleistocene alluvial fan deposits along the Sandia Mountain front (Connell, 1995 #1291; GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430; Gustafson, 1996 #1299), but most strands included in the Sandia fault only offset upper Santa Fe Group sediments (Connell, 1997 #1765).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: The Sandia fault offsets probable early Pleistocene upper Santa Fe Group rocks north of Tijeras Arroyo (Kelley and Northrop, 1975 #1308; Lambert and others, 1982 #1397). Evidence for younger movement exists at the southern end of the Sandia fault near Arroyo del Coyote, where GRAM Incorporated and William Lettis and Associates, Incorporated (1995 #1430) have mapped short fault scarps and described a fault exposure in middle to late Pleistocene alluvial fan deposits, and at the northern end of the Sandia fault where Connell (1995 #1291) mapped short fault scarps in middle Pleistocene fan deposits.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No detailed studies of fault offset or age of offset deposits are available; slip rate estimate is based on lack of prominent fault scarps and low rates of slip on other faults in this part of the Rio Grande rift.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 27.8 km and a cumulative trace length of 59.2 km.

Average strike (azimuth) 003°±20°

Endpoints (lat. - long.) 35°13′39.96″N, 106°32′14.29″W
34°58′36.95″N, 106°31′39.49″W

References

#1291 Connell, S.D., 1995, Quaternary geology and geomorphology of the Sandia Mountains piedmont, Bernalillo and Sandoval Counties, central New Mexico: Riverside, University of California, unpublished M.S. thesis, 414 p., 3 pls.

#1765 Connell, S.D., 1997, Cenozoic geology of the Tijeras 7.5-minute quadrangle, Bernalillo County, central New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File OF-425, 11 p. pamphlet, 1 sheet, scale 1:24,000.

#1294 Ellis, R.W., 1922, Geology of the Sandia Mountains: University of New Mexico Bulletin 108, Geology Series, v. 3, no. 4, p. 44.
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#1299 Gustafson, H., 1996, Tectonic geomorphology of the Sandia Mountains and eastern piedmont of the Albuquerque basin, New Mexico [abs.]: New Mexico Geology, v. 18, no. 2, p. 45.
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#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.
#1308 Kelley, V.C., and Northrop, S.A., 1975, Geology of Sandia Mountains and vicinity, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 29, 136 p., 4 pls., scale 1:48,000.
#1397 Lambert, P.W., Hawley, J.W., and Wells, S.G., 1982, Supplemental road-log segment III-S—Urban and environmental geology of the Albuquerque area, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 97-124.

2038, County Dump fault

Structure Number 2038

Structure Name County Dump fault

Comments: The County Dump fault was originally mapped and named by Lambert (1968 #1396) for a down-to-the-east normal fault exposed at the now abandoned Bernalillo County landfill site located about 1.5 km north of Interstate 40. Kelley (1977 #1106) renamed this structure the Nine Mile fault and included a down-to-the west fault south of Interstate 40 that was originally mapped by Lambert (1968 #1396). Machette (1982 #1401) used the name “Bernalillo County Dump fault” for this structure, but most workers since Kelley (1977 #1106) have used either “County Dump fault” (Machette, 1978 #1402; Hawley and Haase, 1992 #1304) or “Nine Mile fault zone” (Hawley and Whitworth, 1996 #1303) when describing this structure. Cather and others (1997 #1763) called the northern end of the County Dump fault the “Centipede fault” in the Sky Village SE quadrangle. Herein we use the name “County Dump fault” as originally named by Lambert (1968 #1396) for the entire fault zone, because the “Nine mile fault” as mapped by Kelley (1977 #1106) and Hawley and Whitworth (1996 #1303) contains faults with both down-to-the-east and down-to-the-west displacements.

Synopsis: The County Dump fault is a down-to-the-east, north-trending normal fault located along the eastern rim of the Llano de Albuquerque. The fault offsets upper Santa Fe Group sediments, well developed calcic soils of the Llano de Albuquerque, and the ~155 ka basalts of the Albuquerque Volcanoes volcanic field. Evidence of recurrent Pleistocene displacement along the fault was recognized during early geologic work in the region. An exposure of the fault at the now abandoned Bernalillo County dump has been the site of two detailed studies of fault history. The latest study used TL ages and detailed soils analyses to constrain the age of the most recent surface-faulting event on the County Dump fault to 28-40 ka.

Date of compilation 03/30/98

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey; Susan S. Olig, Woodward-Clyde Federal Services; James P. McCalpin, GEO-HAZ Consulting, Inc.

State New Mexico

County Bernalillo

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: The trace of the County Dump fault is from Lambert (1968 #1396), Machette (1978 #1402), Cather and others (1997 #1763), air photo mapping by the senior compiler (S.F. Personius, unpublished data, 1997), and recently acquired high resolution aeromagnetic data (U.S. Geological Survey and SIAL Geosciences Inc., 1997 #1722; Grauch and Millegan, 1998 #1721).

Geologic setting The County Dump fault is one of several north-trending intrabasin faults in the northern part of the Albuquerque-Belen basin. The fault also forms the western margin of a broad graben that confines the Albuquerque Volcanoes volcanic field. The spatial association with the volcanic field may suggest a possible relationship with magmatic activity.

Sense of movement N

Dip 75°-85° E
Comments: Surface dip measurements are from fault exposures at the abandoned Bernalillo County landfill site (Lambert, 1968 #1396; Machette, 1978 #1402; McCalpin, 1997 #1767).

Dip direction E

Geomorphic expression The County Dump fault is intermittently exposed in upper Santa Fe Group sediments along the eastern rim of the Llano de Albuquerque. A broad, sand covered, 15- to 20-m-high fault scarp marks the trace of the fault where it crosses the Llano de Albuquerque north of the Bernalillo County Dump exposure. Further north, the County Dump fault skirts the western margin of the Albuquerque Volcanoes volcanic field, and extends northward as a broad escarpment in upper Santa Fe Group sediments and eroded remnants of the Llano de Albuquerque. South of the Bernalillo County dump exposure, the fault is intermittently exposed in upper Santa Fe Group sediments before dying out a few kilometers south of Interstate 40.

Age of faulted deposits Most of the trace of the County Dump fault is located in sands and gravels assigned to the Upper Buff or Ceja members of the Santa Fe Formation (Bryan and McCann, 1937 #1288; Kelley, 1977 #1106) which are now included in the Sierra Ladrones Formation of the upper Santa Fe Group (Hawley and others, 1991 #1302). The upper part of these rocks may be early Pleistocene in age. The fault also cuts the Llano de Albuquerque, an extensive early Pleistocene(?) surface formed at the top of the Santa Fe Group. Detailed soils work by Machette (1978 #1402) suggests that buried soils and scarp colluvial deposits as young as 20-120 ka are offset at the County dump site. In a more recent study, McCalpin (1997 #1767; unpublished data, 1998) used TL ages and quantitative soils data to derive more accurate ages of some of the faulted colluvial deposits located adjacent to the County Dump fault.(Geissman and others, 1990 #1297; Peate and others, 1996 #1411)

Detailed studies Two detailed studies have been conducted along the County Dump fault. One of the first applications of quantitative soil studies to normal faulting was conducted by Machette (1978 #1402) at the Bernalillo County Dump site (site 2038-1). He delineated four buried soils in a sequence of scarp colluvial and eolian deposits, and used pedogenic accumulations of calcium carbonate to estimate ages of four periods of surface faulting. In a more recent study, McCalpin (1997 #1767; unpublished data, 1998) excavated six exposures along the face of the County Dump exposure, and used detailed trench logging, soils data, and TL dating to determine a long-term slip history at the same site studied by Machette. McCalpin (1997 #1767; unpublished data, 1998) used 6 TL ages to determine rates of carbonate soil accumulation for the last ~300 ka, and then calculated ages of displaced colluvial deposits based on these rates.

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Machette (1978 #1402) used accumulations of pedogenic calcium carbonate in faulted and unfaulted deposits to estimate an age of 20 ka for the latest event on the County Dump fault. More recently, McCalpin (1997 #1767; unpublished data, 1998) used TL ages and quantitative soils analysis to estimate the ages of the latest events at the County Dump site. TL ages suggest that the most-recent

surface-faulting event occurred shortly after 41 ± 6 ka and before 38 ± 3.9 ka. In addition, McCalpin (1997 #1767; unpublished data, 1998) found evidence of a possible younger warping event that occurred shortly before deposition of sands that have a TL age of 28 ±3 ka. Soils analysis suggest this possible event occurred about 24 ka.

Recurrence interval 4-193 ka

Comments: McCalpin (1997 #1767; unpublished data, 1998) used TL ages and quantitative soils analysis to estimate three unusually short (4 and 6 ka) and long (193 ka) values for recurrence intervals. He determined an average of 40.5 ± 47.3 ka from the estimated ages of 14 colluvial soils. Even though the large standard deviation is controlled by the extrenme values, most determined recurrence intervals clustered near the mean value. Earlier studies by Machette (1978 #1402) provided average recurrence intervals of 90-190 ka between faulting events determined by using the accumulation of pedogenic calcium carbonate

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Low slip-rate category assigned based on data presented by McCalpin (1997 #1767; unpublished data, 1998). The oldest colluvial soil exposed in the trench has as estimated age of 527 ka and is offset about 20 m.

Length End to end (km): 35.3
Trace (km): 52.2

Average strike (azimuth) 005°±28°

Endpoints (lat. - long.) 35°19′33.58″N, 106°44′57.43″W
35°00′30.25″N, 106°46′30.13″W

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#1288 Bryan, K., and McCann, F.T., 1937, The Ceja del Rio Puerco—A border feature of the Basin and Range province in New Mexico, Part I, Stratigraphy and structure: Journal of Geology, v. 45, p. 801-828.

#1763 Cather, S.M., Connell, S.D., Heynekamp, M.R., and Goodwin, L.B., 1997, Geology of the Sky Village SE 7.5-minute quadrangle, Sandoval County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map OF-DM 9, 8 p. pamphlet, 1 sheet, scale 1:24,000.

#1297 Geissman, J.W., Brown, L., Turrin, B.D., McFadden, L.D., and Harlan, S.S., 1990, Brunhes chron excursion/polarity episode recorded during the late Pleistocene, Albuquerque Volcanoes, New Mexico, USA: Geophysical Journal International, v. 102, p. 73-88.

#1721 Grauch, V.J.S., and Millegan, P.S., 1998, Mapping intrabasinal faults from high-resolution aeromagnetic data: The Leading Edge, v. 17, p. 53-55.

#1304 Hawley, J.W., and Haase, C.S., compilers, 1992, Hydrogeologic framework of the northern Albuquerque basin: New Mexico Bureau of Mines and Mineral Resources Open-File Report 387, 1 pl., scale 1:100,000.

#1302 Hawley, J.W., Love, D.W., Betancourt, J.L., Truner, R.M., and Tharnstrom, S., 1991, Quaternary and Neogene landscape evolution—A transect across the Colorado Plateau and Basin and Range provinces in west-central and central New Mexico, *in* Julian, B., and Zidek, J., eds., Field guide to geologic excursions in New Mexico and adjacent areas of Texas and Colorado: New Mexico Bureau of Mines and Mineral Resources Bulletin 137, p. 105-148.

#1303 Hawley, J.W., and Whitworth, T.M., compilers, 1996, Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modeling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 402-D.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1396 Lambert, P.W., 1968, Quaternary stratigraphy of the Albuquerque area, New Mexico: Albuquerque, University of New Mexico, unpublished Ph.D. dissertation, 329 p., 3 pl., scale 1:48,000.

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#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.
#1767 McCalpin, J.P., 1997, Paleoseismicity of Quaternary faults near Albuquerque, New Mexico: Technical report to U.S. Geological Survey, under Contract 1434-HQ-96-GR-02751, 18 p.
#1411 Peate, D.W., Chen, J.H., Wasserburg, G.J., Papanastassiou, D.A., and Geissman, J.W., 1996, ^{238}U-^{230}Th dating of a geomagnetic excursion in Quaternary basalts of the Albuquerque Volcanoes Field, New Mexico (USA): Geophysical Research Letters, v. 23, p. 2271-2274.
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2039, Sand Hill fault zone

Structure Number 2039

Structure Name Sand Hill fault zone

Comments: The Sand Hill fault zone was first named, mapped, and described by Bryan and McCann (1937 #1288), has subsequently been mapped in various degrees of detail by Wright (1946 #1427), Kelley and others (1976 #1380, fig. 19), and Kelley (1954 #1222; 1977 #1106), and has recently been mapped in detail in the Sky Village SE (new name, Arroyo de las Calabacillas) 7.5 minute quadrangle (Cather and others, 1997 #1763). As originally mapped by Bryan and McCann (1937 #1288), the Sand Hill fault zone extended about 10 km along the western edge of the Llano de Albuquerque. Bryan and McCann (1937 #1288) and Wright (1946 #1427) mapped the southern end of the Sand Hill fault zone 3-5 km south of the Bernalillo-Sandoval County line; Bryan and McCann (1937 #1288) state that the fault is covered by Pleistocene and younger alluvium southward. Kelley (1977 #1106, p. 48) used stratigraphic arguments to extend the Sand Hill fault zone a minimum of 12 km further south. Similarly at the north end, Kelley and others (1976 #1380, fig. 19) and Kelley (1977 #1106, p. 48) extend the Sand Hill fault zone along a northeast-trending splay across the Llano de Albuquerque. Kelley (1977 #1106, p. 48) also suggests that some of the down-to-the-east displacement associated with the Sand Hill fault zone is taken up by the Garcia and Tenorio faults, which extend northward another 23 km along the western edge of the Llano. Recent mapping in the Sky Village SE (Arroyo de las Calabacillas) 7.5 minute quadrangle (Cather and others, 1997 #1763) shows that the Sand Hill fault zone does not trend northeastward across the Llano de Albuquerque, but rather continues northward along the Ceja del Rio Puerco to the vicinity of Cañada de las Milpas in the Sky Village NE quadrangle (G.O. Bachman, unpublished mapping, 1975). Wright (1946 #1427) included in the Sand Hill fault zone a northwest-trending (N. 20° W.) down-to-the-east fault that lies 1-2 km east of the Sand Hill fault zone. However, the trend of this fault, Wright's detailed description of a thick sequence of tectonically-derived sediment on the downthrown block, and recent mapping in the Sky Village SE (Arroyo de las Calabacillas) 7.5 minute quadrangle (Cather and others, 1997 #1763) indicate that this eastern fault strand probably is distinct from the Sand Hill fault zone. This structure is mapped as a separate structure (Calabacillas fault [2035]) in the present compilation.

Synopsis: As used in this compilation, the Sand Hill fault zone is a down-to-the-east normal fault zone that extends from about 9 km south of the Sandoval-Bernalillo County line, northward along the Ceja del Rio Puerco to the vicinity of Cañada de las Milpas. Very little is known about the Quaternary history of the Sand Hill fault zone, other than it cuts probable early Pleistocene sands and gravels of the upper Santa Fe Group and is buried by younger surficial deposits. This fault zone is one of several north-trending faults that forms the active western boundary of the Rio Grande rift in the northern part of the Albuquerque-Belen basin.

Date of compilation 02/05/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval; Bernalillo

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: Fault traces are from Bryan and McCann (1937 #1288), Wright (1946 #1427), Kelley (1977 #1106), Cather and others (1997 #1763), and unpublished mapping by G.O. Bachman (1975).

Geologic setting The Sand Hill fault zone is one of several north-trending faults that forms the active western boundary of the Rio Grande rift in the northern part of the Albuquerque-Belen basin.

Sense of movement N

Dip 63°-82° E
Comments: Fault dips are from surface exposures (Wright, 1946 #1427, plate 8; Cather and others, 1997 #1763).

Dip direction E

Geomorphic expression The fault is well expressed as linear breaks in slope in the eroded Santa Fe Group badlands below the western edge of the Llano de Albuquerque. Bryan and McCann (1937 #1288) note that their northernmost strand has been injected by a sand dike that is more erosion resistant than the surrounding rocks; Wright (1946 #1427) stated that all strands of the Sand Hill fault are marked by sand dikes. No fault scarps in surficial deposits have been described.

Age of faulted deposits The trace of the Sand Hill fault zone as originally mapped by Bryan and McCann (1937 #1288) lies entirely within the Upper Buff Member of the Santa Fe Formation, which is roughly correlative with the Sierra Ladrones Formation (Machette, 1978 #1400) of the Upper Santa Fe Group (Hawley and others, 1991 #1302). In places the upper part of these deposits is early Pleistocene in age. No fault scarps in younger surficial deposits have been described.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: The Sand Hill fault zone only offsets deposits of early Pleistocene age.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No detailed studies of fault offset or age of offset deposits are available; slip rate estimate is based on lack of fault scarps and low rates of slip on other faults in this part of the Rio Grande rift.

Length End to end (km): 35.6
Trace (km): 35.0

Average strike (azimuth) 006°±13°

Endpoints (lat. - long.) 35°27'40.49"N, 106°51'26.37"W
35°08'28.95"N, 106°53'40.99"W

References

#1288 Bryan, K., and McCann, F.T., 1937, The Ceja del Rio Puerco—A border feature of the Basin and Range province in New Mexico, Part I, Stratigraphy and structure: Journal of Geology, v. 45, p. 801-828.

#1763 Cather, S.M., Connell, S.D., Heynekamp, M.R., and Goodwin, L.B., 1997, Geology of the Sky Village SE 7.5-minute quadrangle, Sandoval County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map OF-DM 9, 8 p. pamphlet, 1 sheet, scale 1:24,000.

#1302 Hawley, J.W., Love, D.W., Betancourt, J.L., Truner, R.M., and Tharnstrom, S., 1991, Quaternary and Neogene landscape evolution—A transect across the Colorado Plateau and Basin and Range provinces in west-central and central New Mexico, *in* Julian, B., and Zidek, J., eds., Field guide to geologic excursions in New Mexico and adjacent areas of Texas and Colorado: New Mexico Bureau of Mines and Mineral Resources Bulletin 137, p. 105-148.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1380 Kelley, V.C., Woodward, L.A., Kudo, A.M., and Callender, J.F., 1976, Guidebook to Albuquerque basin of the Rio Grande rift, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 153, 31 p.

#1400 Machette, M.N., 1978, Geologic map of the San Acacia quadrangle, Socorro County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1415, 1 sheet, scale 1:24,000.

#1427 Wright, H.E., Jr., 1946, Tertiary and Quaternary geology of the lower Rio Puerco area, New Mexico: Geological Society of America Bulletin, v. 57, p. 383-456.

2040, East Paradise fault zone

Structure Number 2040

Structure Name East Paradise fault zone

Comments: A probable exposure of the East Paradise fault zone was originally recognized and mapped by Bjorklund and Maxwell (plate 1a, 1961 #1285) in Arroyo de las Calabacillas; the fault was included on some subsequent maps (Baltz, 1976 #1431), but not others (Kelley, 1977 #1106; Hawley and Haase, 1992 #1304; Hawley and others, 1995 #1301). The fault was rediscovered by John Hawley (oral commun., 1996) in exposures opened during construction of a housing development on the north side of Arroyo de las Calabacillas. The fault was informally named the Paloma del Sol fault zone by Personius (1996 #1412), but this name has been superseded by Hawley and Whitworth (1996 #1303), who mapped both this fault and a parallel down-to-the-west fault located approximately 2.5 km west as the Paradise fault zone. Herein we use “East Paradise fault zone” and “West Paradise fault zone” [2042] for the eastern and western strands of the Paradise fault zone of Hawley and Whitworth (1996 #1303).

Synopsis: The East Paradise fault zone is one of several north-trending normal faults that form a wide zone across the interior of the Albuquerque-Belen basin; the East Paradise fault zone also forms the eastern margin of a wide graben that confines the Albuquerque Volcanoes volcanic field. The fault is not well expressed in the landscape, probably because of high rates of eolian sand deposition. North of Arroyo de las Calabacillas, the fault is poorly expressed as isolated offsets and west-facing escarpments in pre-late Pleistocene piedmont alluvium. A single west-facing, ~5 m high scarp in piedmont alluvium is visible on 1967 vintage airphotos just north of the Rio Rancho Golf Course, but this scarp has been destroyed by subsequent development. The fault is visible as aligned drainages and eroded scarps northward from the golf course to the southern edge of Arroyo de las Montoyas. No evidence of the fault has been found north of the arroyo. South of Arroyo de las Calabacillas, most of the fault trace has been destroyed by development of Paradise Hills Golf Course and housing in the surrounding communities. A detailed fault study in a housing development on the north side of Arroyo de las Calabacillas indicates that the latest surface faulting event on the East Paradise fault zone fault zone occurred about 75 ka.

Date of compilation 02/04/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval; Bernalillo

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: Trace from field and airphoto mapping by the compiler (S.F. Personius, unpublished data, 1996-1997).

Geologic setting The East Paradise fault zone is one of several north-trending intrabasin faults in the northern part of the Albuquerque-Belen basin. The fault forms the eastern margin of a wide graben that confines the Albuquerque Volcanoes volcanic field. This association with the volcanic field suggests that some faults in the graben may be associated with magmatic activity.

Sense of movement N

Dip 70°-80° W
Comments: Surface dips measured in 2-m-wide fault zone in middle Pleistocene alluvial and eolian deposits exposed in housing development on north side of Arroyo de las Calabacillas (S.F. Personius, unpublished data, 1996-1997).

Dip direction W

Geomorphic expression Where not destroyed by development, the East Paradise fault zone is poorly expressed as isolated offsets, aligned drainages, and eroded, west-facing escarpments in middle Pleistocene piedmont alluvium between Arroyo de las Calabacillas and Arroyo de las Montoyas (S.F. Personius, unpub. data, 1996-1997). A single west-facing, ~5 m high scarp in middle(?) Pleistocene piedmont alluvium is visible on 1967 (pre-development) airphotos just north of the Rio Rancho Golf Course. South of Arroyo de las Calabacillas, the trace of the East Paradise fault zone has been completely obscured by development, but on 1967 (pre-development) airphotos, the fault zone can be mapped as aligned drainages and small scarps in alluvial deposits (S.F. Personius, unpub. data, 1996-1997).

Age of faulted deposits The East Paradise fault zone offsets late Pleistocene arroyo alluvium along Arroyo de las Calabacillas and Arroyo de las Montoyas. The fault also offsets middle Pleistocene piedmont alluvium north of Arroyo de las Calabacillas, and sediments underlying the Segundo Alto terrace (Lambert, 1968 #1396; Machette, 1985 #1267) along the Rio Grande south of Paradise Hills.

Detailed studies Personius (1996 #1412; 1997 #1414; unpublished data, 1996-1997) conducted a detailed trench investigation of several exposures of the East Paradise fault zone in a housing excavation on the north side of Arroyo de las Calabacillas in 1996 (site 2040-1). He found an approximately 2-m-wide fault zone consisting of two main fault strands dipping 70°-80° W., exposed in three walls of the excavation. The fault zone offsets about 2.75 m a sequence of arroyo alluvial sands and silts, interbedded with eolian sand deposits. Two distinct scarp colluvial wedges consisting primarily of windblown sand were observed in the main exposure; these deposits consist of a faulted wedge apparently related to movement on the easternmost strand, and an overlying younger wedge that was preserved unfaulted against the westernmost strand. The exposure was truncated by a sequence of compacted fill. If the wedge thicknesses approximate the vertical displacements caused by the faulting events (Personius, 1996 #1412), then the first event had a vertical displacement of about 1.0 m. The amount of vertical displacement that accompanied the second event is less certain, because an unknown amount of sediment was removed from the top of the section during construction. If only 2 events were recorded in the complete exposure, then the second event had a vertical displacement of about 1.75 m. Four TL (thermoluminescence) ages were obtained from this exposure. A preliminary TL age of 285 ± 26 ka was obtained on pre-faulting eolian sand that was exposed in both the hanging wall and the footwall. A second preliminary TL age of 208 ± 25 ka was obtained from the older colluvial wedge. The colluvial wedges in this exposure apparently formed primarily by eolian processes soon after faulting (Personius, 1996 #1412), so this TL age probably closely approximates the age of the first event. A third preliminary TL age of 75 ± 7 ka was obtained from the younger wedge; as with the older wedge, this age probably closely approximates the age of the younger event. A fourth TL sample from the overlying compacted fill did not contain a stable TL signal, thus confirming that this deposit is construction fill, consisting of a mixture of sediment of various ages.

Timing of most recent paleoevent late Quaternary (<130 ka)

Comments: The colluvial wedge produced by the latest event still preserved in the exposures mapped by Personius (1996 #1412) was dated by TL at 75 ± 7 ka. The wedge consists primarily of eolian sand blown up against the scarp soon after faulting, so this age probably closely approximates the age of this event. The upper part of the section was removed during construction, however, so there is a possibility that evidence of an even younger event was destroyed. However, the poor geomorphic expression of the East Paradise fault zone supports a relatively old age (tens of thousands of years) for the youngest event (S.F. Personius, unpublished data, 1996-1997).

Recurrence interval 133-137.5 ka

Comments: The TL ages on the two colluvial wedges present in the exposure yield a single geologic recurrence interval of 133 ± 20 ka. An average recurrence interval (Wallace, 1970 #1423) of 137.5 ± 40 ka can be calculated from the slip rate (0.01 ± 0.001 mm/yr) and an average displacement of 1.4 ± 0.4 m per faulting event.

Slip-rate category unknown, probably <0.2 mm/yr

Comments: Low slip rate inferred based on preliminary TL ages from the housing exposures examined by Personius (unpublished data, 1996-1997). Pre-faulting eolian sand yield an age of 285 ± 26 ka; this deposit is offset 2.75 ± 0.1 m across the fault zone.

Length End to end (km): 13.1
Trace (km): 13.3

Average strike (azimuth) 004°±15°

Endpoints (lat. - long.) 35°15′50.57″N, 106°40′35.86″W
35°08′46.80″N, 106°41′15.26″W

References

#1431 Baltz, E.H., 1976, Seismotectonic analysis of the central Rio Grande rift, New Mexico—A progress report on geologic investigations: U.S. Geological Survey Administrative Report, 93 p., 2 pls.

#1285 Bjorklund, L.J., and Maxwell, B.W., 1961, Availability of ground water in the Albuquerque area, Bernalillo and Sandoval Counties, New Mexico: New Mexico State Engineer Technical Report 21, 117 p.

#1304 Hawley, J.W., and Haase, C.S., compilers, 1992, Hydrogeologic framework of the northern Albuquerque basin: New Mexico Bureau of Mines and Mineral Resources Open-File Report 387, 1 pl., scale 1:100,000.

#1301 Hawley, J.W., Haase, C.S., and Lozinsky, R.P., 1995, An underground view of the Albuquerque basin, *in* Ortega-Klett, C.T., ed., The water future of Albuquerque and Middle Rio Grande basin: New Mexico Water Resources Research Institute Technical Report, p. 37-77.

#1303 Hawley, J.W., and Whitworth, T.M., compilers, 1996, Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modeling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 402-D.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1396 Lambert, P.W., 1968, Quaternary stratigraphy of the Albuquerque area, New Mexico: Albuquerque, University of New Mexico, unpublished Ph.D. dissertation, 329 p., 3 pl., scale 1:48,000.

#1267 Machette, M.N., 1985, Calcic soils of the southwestern United States, *in* Weide, D.L., ed., Soils and Quaternary geology of the southwestern United States: Geological Society of America Special Paper 203, p. 1-21.
#1412 Personius, S.F., 1996, Recurrent paleoearthquakes on the Paloma del Sol fault zone—A recently rediscovered active fault zone in the Albuquerque metropolitan area: Geological Society of America Abstracts with Programs, v. 28, no. 7, p. A378.
#1414 Personius, S.F., 1997, Quaternary fault studies in the middle Rio Grande region [abs.], *in* Bartolino, J.R., ed., U.S. Geological Survey Middle Rio Grande basin study—Proceedings of the First Annual Workshop, Denver, Colorado, November 12-14, 1996: U.S. Geological Survey Open-File Report 97-116, p. 19.
#1423 Wallace, R.E., 1970, Earthquake recurrence intervals on the San Andreas fault: Geological Society of America Bulletin, v. 81, p. 2875-2890.

2041, Unnamed faults near Picuda Peak

Structure Number 2041

Structure Name Unnamed faults near Picuda Peak
Comments: Some faults near Picuda Peak were previously described by Black and Hiss (1974 #1287) and Kelley (1977 #1106). These structures were mapped in detail by Manley (1978 #1404) in the Bernalillo NW 7.5 minute quadrangle and by the compiler (S.F. Personius, unpublished data, 1996-1997) in the Loma Machete quadrangle.

Synopsis: Faults near Picuda Peak form a swarm of down-to-the-east and down-to-the-west, north trending normal faults that offset coarse gravels and underlying sands of the upper Santa Fe Group. Most of these faults trend to the northeast at their southern ends near Picuda Peak; further north, they trend generally north. Detailed mapping in the nearly complete exposures of the Santa Fe Group section in the Rincones de Zia show very closely spaced normal faults, most of which have displacements of only a few meters. Only the faults with larger displacements or those that can be mapped continuously for several kilometers are shown on the map. These faults generally offset the uppermost coarse gravels of the Upper Santa Fe Group a few tens of meters.

Date of compilation 03/21/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: Fault traces are from 1:24,000 scale mapping of Manley (1978 #1404) in the Bernalillo NW quadrangle and the compiler (S.F. Personius, unpublished data, 1996-1997).

Geologic setting Faults near Picuda Peak form a swarm of intrabasin faults near the northern margin of the Albuquerque-Belen basin in the Rio Grande rift. In previous publications, these faults were located near the crest of the Ziana anticline (Black and Hiss, 1974 #1287; Kelley and others, 1976 #1380; Kelley, 1977 #1106), but recent work by the compiler (S.F. Personius, unpublished data, 1996-1997) indicates that opposing dips in the region that were thought to be the expression of a large fold may instead be related to intense normal faulting and block rotation.

Sense of movement N

Dip 60°-85°

Comments: Numerous fault exposures mapped by the compiler indicate these faults are steeply dipping (S.F. Personius, unpublished data, 1996-1997).

Dip direction E; W

Geomorphic expression Most faults form narrow topographic ridges and valleys that correlate well with sense of fault displacement. Topographic expression is lost, but numerous fault exposures and juxtaposed bedrock mark these faults in the badlands of the Rincones de Zia.

Age of faulted deposits The ages of offset deposits is poorly known, but the uppermost sands and gravels of the upper Santa Fe Group in this area are thought to be early Pleistocene in age (S.F. Personius, unpublished data, 1996-1997).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: The unnamed faults near Picuda Peak offset early Pleistocene sediments of the upper Santa Fe Group a few tens of meters, but do not appear to offset younger surficial deposits (S.F. Personius, unpublished data, 1996-1997).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Offsets of early Pleistocene gravels across individual faults are probably no more than 20-30 m.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 10.6 km and a cumulative trace length of 58.8 km.

Average strike (azimuth) 001°±19°

Endpoints (lat. - long.) 35°25'19.29"N, 106°40'21.33"W
35°19'40.02"N, 106°39'14.30"W

References

#1287 Black, B.A., and Hiss, W.L., 1974, Structure and stratigraphy in the vicinity of the Shell Oil Co. Santa Fe Pacific No. 1 test well, southern Sandoval County, New Mexico, *in* Siemers, C.T., Woodward, L.A., and Callender, J.F., eds., Ghost Ranch central-northern New Mexico: New Mexico Geological Society, 25th Field Conference, October 10-12, 1974, Guidebook, p. 365-370.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1380 Kelley, V.C., Woodward, L.A., Kudo, A.M., and Callender, J.F., 1976, Guidebook to Albuquerque basin of the Rio Grande rift, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 153, 31 p.

#1404 Manley, K., 1978, Geologic map of Bernalillo NW quadrangle, Sandoval County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1446, 1 sheet, scale 1:24,000.

2042, West Paradise fault zone

Structure Number 2042

Structure Name West Paradise fault zone
Comments: An exposure of this fault zone was originally recognized and mapped by Bjorklund and Maxwell (plate 1a, 1961 #1285) in Arroyo de las Calabacillas; they mapped a down-to-the-west normal fault from Arroyo de las Calabacillas northward about 2.5 km. This fault was not included on subsequent maps, such as Kelley (1977 #1106) and Hawley and Haase (1992 #1304), until more recent compilations (Hawley and others, 1995 #1301; Hawley and Whitworth, 1996 #1303). Hawley and

Whitworth (1996 #1303) mapped both this fault and a parallel down-to the-west fault located approximately 2.5 km east as the Paradise fault zone. Herein we use "West Paradise fault zone" and "East Paradise fault zone" [2040] for the western and eastern strands of the Paradise fault zone of Hawley and Whitworth (1996 #1303).

Synopsis: The West Paradise fault zone is one of several north-trending normal faults that form a wide graben that confines the Albuquerque Volcanoes volcanic field. An excellent exposure of the West Paradise fault zone is present on the north rim of Arroyo de las Calabacillas, at a sharp bend in the arroyo channel. At this site, one or more fault strands offset Santa Fe Group sands and pebble gravels an unknown amount. The fault can be traced about 4 km north of Arroyo de las Calabacillas as aligned drainages and several west-facing escarpments in upper Santa Fe Group sediments. The northern extent of the West Paradise fault zone may be limited by remnants of the Llano de Albuquerque, which extend undisturbed across the projected trace of the fault about 300 m south of Southern Boulevard in the City of Rio Rancho. However, the sharp anomaly in the aeromagnetic data that marks the approximate trace of the fault zone extends 2-3 km north of this location, so movement on the northern part of the West Paradise fault zone may have extended further north before the development of the Llano de Albuquerque. To the south, the fault projects into but does not offset the basalt flows present on the south rim of Arroyo de las Calabacillas. The fault zone can be mapped several kilometers south of Arroyo de las Calabacillas under the basalts with aeromagnetic data and geomorphic indicators such as rubble zones and intermittent linear breaks in slope. These features were caused by preexisting fault scarps along the trace of the West Paradise fault zone that disrupted the basalt flows during emplacement.

Date of compilation 02/04/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval; Bernalillo

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: The trace of the West Paradise fault zone is from field and air photo mapping by the compiler (S.F. Personius, unpublished data, 1996-1997). The trace of the fault beneath the basalts of the Albuquerque Volcanoes volcanic field is based on geomorphic indicators such as rubble zones and intermittent linear breaks in slope and on recently acquired high resolution aeromagnetic data (U.S. Geological Survey and SIAL Geosciences, Inc., 1997; Grauch and Millegan, 1998).

Geologic setting The West Paradise fault zone is one of several north-trending intrabasin faults in the northern part of the Albuquerque-Belen basin, and is one of several faults that form a wide graben confining the Albuquerque Volcanoes volcanic field. This spatial association with the volcanic field suggests that some of these faults may be associated with magmatic activity.

Sense of movement N
Comments: Slickensides visible in fault planes in Santa Fe Group sediments in an exposure on the north flank of Arroyo de las Calabacillas have rakes of about 90°, indicating nearly pure dip-slip normal faulting (S.F. Personius, unpublished data, 1996-1997).

Dip 70°-75° W
Comments: Surface dips were measured in a fault zone in upper Santa Fe Group sands and pebble gravels exposed on the north side of Arroyo de las Calabacillas (S.F. Personius, unpublished data, 1996-1997).

Dip direction W

Geomorphic expression The West Paradise fault zone is weakly expressed as aligned drainages and several west-facing escarpments in upper Santa Fe Group sediments from Arroyo de las Calabacillas northward about 4 km. To the south, the fault does not offset the basalt that forms the southern rim of Arroyo de las Calabacillas. However, in the basalts the fault zone is marked by rubble zones and linear intermittent linear breaks in slope which indicate the presence of preexisting fault scarps that disrupted the flows during emplacement.

Age of faulted deposits The West Paradise fault zone clearly offsets early Pleistocene upper Santa Fe Group sands and gravels, and early Pleistocene, strongly developed calcic soil remnants of the Llano de Albuquerque. Late Pleistocene eolian sand and alluvial deposits are not offset across the fault north of Arroyo de las Calabacillas. South of Arroyo de las Calabacillas, faulting along the West Paradise fault zone predates the ~155 ka (Geissman and others, 1990 #1297; Peate and others, 1996 #1411) basalts of the Albuquerque Volcanoes volcanic field.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: The West Paradise fault zone does not offset ~155 ka (Geissman and others, 1990 #1297; Peate and others, 1996 #1411) basalt flows of the Albuquerque Volcanoes volcanic field, so the latest event predates the age of these deposits. No evidence of fault scarps in surficial deposits are visible, but the fault zone offsets strongly developed calcic soils of the Llano de Albuquerque, remnants of which appear to be offset about 10 m across the fault zone north of Arroyo de las Calabacillas (S.F. Personius, unpublished data, 1996-1997). These relations indicate a recurrent history of faulting that probably extended into the middle Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip rate inferred based on offset about 10 m of the Llano de Albuquerque (formed about 1 Ma).

Length End to end (km): 10.2
Trace (km): 10.4

Average strike (azimuth) -3°±12°

Endpoints (lat. - long.) 35°15′33.06″N, 106°42′28.17″W
35°10′02.57″N, 106°42′07.12″W

References

#1285 Bjorklund, L.J., and Maxwell, B.W., 1961, Availability of ground water in the Albuquerque area, Bernalillo and Sandoval Counties, New Mexico: New Mexico State Engineer Technical Report 21, 117 p.

#1297 Geissman, J.W., Brown, L., Turrin, B.D., McFadden, L.D., and Harlan, S.S., 1990, Brunhes chron excursion/polarity episode recorded during the late Pleistocene, Albuquerque Volcanoes, New Mexico, USA: Geophysical Journal International, v. 102, p. 73-88.

#1304 Hawley, J.W., and Haase, C.S., compilers, 1992, Hydrogeologic framework of the northern Albuquerque basin: New Mexico Bureau of Mines and Mineral Resources Open-File Report 387, 1 pl., scale 1:100,000.

#1301 Hawley, J.W., Haase, C.S., and Lozinsky, R.P., 1995, An underground view of the Albuquerque basin, *in* Ortega-Klett, C.T., ed., The water future of Albuquerque and Middle Rio Grande basin: New Mexico Water Resources Research Institute Technical Report, p. 37-77.

#1303 Hawley, J.W., and Whitworth, T.M., compilers, 1996, Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modeling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 402-D.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1411 Peate, D.W., Chen, J.H., Wasserburg, G.J., Papanastassiou, D.A., and Geissman, J.W., 1996, ^{238}U-^{230}Th dating of a geomagnetic excursion in Quaternary basalts of the Albuquerque Volcanoes Field, New Mexico (USA): Geophysical Research Letters, v. 23, p. 2271-2274.

2043, Faults north of Placitas

Structure Number 2043

Structure Name Faults north of Placitas

Comments: A system of short, northeast trending, down-to-the-northwest normal faults is present in the northwest corner of the Sandia uplift north of Placitas. At least five individual faults are included in this system, from west to east: the Valley View fault, which was first mapped by Kelley and Northrop (1975 #1308) and later named by Kelley (1977 #1106); the Ranchos fault of Kelley and Northrop (1975 #1308) and Kelley (1977 #1106); the Lomas fault of Connell (1995); the Caballo fault of Kelley and Northrop (1975 #1308) and Menne (1989 #1405); and the Escala fault of Kelley (1977 #1106). Menne (1989 #1405), Connell (1995 #1291), and Cather and others (1996 #1764) have recently remapped these structures in greater detail.

Synopsis: The short, mostly northeast trending faults north of Placitas are part of a structural transition zone between the Rincon fault [2036] to the west and the San Francisco fault [2031] to the east. Some strands of the Valley View fault have been projected northward across the Rio Grande as continuations of the Algodones section of the San Felipe fault zone [2030b], but recent mapping shows that most of these fault strands trend northeasterly at their northern ends and do not connect with the San Felipe fault zone. Detailed mapping shows that individual faults in the fault system north of Placitas offset early and middle(?) Pleistocene alluvial deposits and upper Santa Fe Group sedimentary rocks less than 100 m.

Date of compilation 03/14/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good

Comments: These faults have been mapped at scales of 1:8,000 to 1:24,000 by Menne (1989 #1405), Connell (1995 #1291), and Cather and others (1996 #1764). Some strands of the Valley View fault have been projected northward across the Rio Grande as continuations of the Algodones section of the San Felipe fault zone [2030b] (Kelley, 1977 #1106; Wong and others, 1995 #1155), but recent mapping by Connell (1995 #1291) and Cather and others (1996 #1764) shows that most of these fault strands trend northeasterly at their northern ends and do not connect with the San Felipe fault zone.

Geologic setting These faults form a transition zone between major normal faults that form the right-stepping eastern margin of the Rio Grande rift at the north end of the Sandia uplift (Kelley, 1982 #1306; Menne, 1989 #1405; Woodward and Menne, 1995 #1428). This transition zone is bound on the west by the Rincon fault [2036] and on the east by the San Francisco fault [2031].

Sense of movement N

Comments: Detailed analysis of Placitas area structures by Menne (1989 #1405) shows little field evidence of strike-slip movements, but orientations of fold axes indicate a possible right-lateral component on some faults in the area. In contrast, Cather and others (1996 #1764) used fold orientations, and stratigraphic and geomorphic relations to conclude that these faults primarily display normal displacement.

Dip 21°-87° NW
Comments: Menne (1989 #1405) and Connell (1995 #1291) show mostly steep northwesterly dips on these structures.

Dip direction NW

Geomorphic expression These faults generally are poorly expressed as eroded slope breaks in upper Santa Fe group sediments.

Age of faulted deposits Detailed mapping of Connell (1995 #1291) shows that individual faults in the fault system north of Placitas offset early and middle(?) Pleistocene alluvial deposits and upper Santa Fe Group sedimentary rocks.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Mapping of Quaternary deposits by Connell (1995 #1291) and Cather and others (1996 #1764) shows that the youngest deposits offset by these faults are early and middle(?) Pleistocene in age.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No detailed studies of fault offset or age of offset deposits are available, but data from Connell (1995 #1291) indicate that individual faults in the Placitas area have maximum vertical displacements of 20-90 m in middle(?) and early Pleistocene deposits. The slip rate estimate is based on low rates of slip on similar faults in this part of the Rio Grande rift.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 10.5 km and a cumulative trace length of 46.5 km.

Average strike (azimuth) 010°±55°

Endpoints (lat. - long.) 35°22′25.62″N, 106°25′54.64″W
35°16′51.49″N, 106°27′16.41″W

References

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#1291 Connell, S.D., 1995, Quaternary geology and geomorphology of the Sandia Mountains piedmont, Bernalillo and Sandoval Counties, central New Mexico: Riverside, University of California, unpublished M.S. thesis, 414 p., 3 pls.
#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.
#1306 Kelley, V.C., 1982, The right-relayed Rio Grande rift, Taos to Hatch, New Mexico, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 147-151.
#1308 Kelley, V.C., and Northrop, S.A., 1975, Geology of Sandia Mountains and vicinity, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 29, 136 p., 4 pls., scale 1:48,000.
#1405 Menne, B., 1989, Structure of the Placitas area, northern Sandia uplift, Sandoval County, New Mexico: Albuquerque, University of New Mexico, unpublished M.S. thesis, 163 p., 4 pls.
#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House,

L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

#1428 Woodward, L.A., and Menne, B., 1995, Down-plunge structural interpretation of the Placitas area, northwestern part of Sandia uplift, central New Mexico—Implications for tectonic evolution of the Rio Grande rift, *in* Bauer, P.W., Kues, B.S., Dunbar, N.W., Karlstrom, K.E., and Harrison, B., eds., Geology of the Santa Fe region, New Mexico: New Mexico Geological Society, 46th Field Conference, September 27-30, 1995, Guidebook, p. 127-133.

2044, Four Hills Ranch fault

Structure Number 2044

Structure Name Four Hills Ranch fault

Comments: The primary traces of the Four Hills Ranch fault were first mapped, named, and described by GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430). The fault is named after the Four Hills Ranch, whose headquarters are located on the south flank of Tijeras Canyon on the Albuquerque East 7.5 minute quadrangle.

Synopsis: The northeast trending Four Hills Ranch fault is marked by aligned drainages and vegetation lineaments in middle Pleistocene alluvial fan deposits along the southern margin of Tijeras Canyon. The fault may project further to the southwest beneath Holocene alluvium in Tijeras Canyon. The southern strand of the Four Hills Ranch fault is truncated by the Sandia fault [2037] at the mouth of Tijeras Canyon. A short easterly trending fault that offsets the Sandia fault in an apparent right-lateral sense at the mouth of Tijeras Canyon may represent another strand of the Four Hills Ranch fault that lies buried beneath Holocene alluvium in Tijeras Arroyo; the apparent lateral displacement of Sandia fault [2037] at this location could be explained by down-to-the-north dip slip displacement on the Four Hills Ranch fault.

Date of compilation 03/17/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Bernalillo

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good

Comments: Mapped traces are from GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430). A possible strand of the Four Hills Ranch fault buried beneath Tijeras Arroyo may be responsible for the apparent right-lateral offset of the Sandia fault [2037] at the mouth of Tijeras Canyon mapped by Kelley and Northrop (1975 #1308) and Kelley (1977 #1106).

Geologic setting The Four Hills Ranch fault lies in a structurally complex area near the eastern margin of the Rio Grande rift. This area is complicated by the intersections of the north-trending Sandia [2037] and Hubbell Springs [2120] faults and the northeast-trending Tijeras-Cañoncito fault system [2033].

Sense of movement N(?)

Comments: GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430) discuss the offset of the Sandia fault by a possible strand of the Four Hills Ranch fault as limited evidence that the Four Hills Ranch fault is a northwest-dipping normal fault. The nearby Tijeras fault zone has left-lateral strike-slip displacement.

Dip not reported

Dip direction NW(?)
Comments: See comments on sense of movement above.

Geomorphic expression The Four Hills Ranch fault trace is marked by topographic saddles, linear drainages, and vegetation lineaments in middle Pleistocene alluvial fan deposits along the southern margin of Tijeras Canyon (GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430).

Age of faulted deposits GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430) map the Four Hills Ranch fault trace primarily in middle Pleistocene alluvial fan deposits (their unit Pf3.ta).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing of the most-recent event is based on surficial geologic mapping of GRAM, Inc. and William Lettis and Associates, Incorporated (1995 #1430).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No detailed studies of fault offset or age of offset deposits are available. The slip rate estimate is based on lack of prominent fault scarps and low rates of slip on similar faults in this part of the Rio Grande rift.

Length End to end (km): 3.0
Trace(km): 4.5

Average strike (azimuth) 049°±11°

Endpoints (lat. - long.) 35°03′23.68″N, 106°29′57.56″W
35°02′28.46″N, 106°31′32.64″W

References
#1430 GRAM Incorporated, and William Lettis & Associates Incorporated, 1995, Conceptual geologic model of the Sandia National Laboratories and Kirtland Air Force Base: Technical report to Sandia National Laboratories, Albuquerque, New Mexico, December 1995, 15 pls.
#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.
#1308 Kelley, V.C., and Northrop, S.A., 1975, Geology of Sandia Mountains and vicinity, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 29, 136 p., 4 pls., scale 1:48,000.

2045, Unnamed faults near Loma Barbon

Structure Number 2045

Structure Name Unnamed faults near Loma Barbon
Comments: Several north-trending, down-to-the-east and down-to-the-west faults that offset upper Santa Fe Group sediments are present near Loma Barbon. Kelley (1977 #1106) mapped one of these structures as the southern end of one strand of the Santa Ana section of the San Felipe fault [2030a], but more recent mapping in the area (Manley, 1978 #1404; S.F. Personius, unpublished data, 1996-1997) indicates that these faults are separate structures.

Synopsis: These unnamed normal faults are exposed in several places in upper Santa Fe Group sands and gravels. They do not appear to offset younger Quaternary deposits.

Date of compilation 04/02/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: Fault traces from Manley (1978 #1404) and recent mapping by the compiler (S.F. Personius, unpublished data, 1996-1997).

Geologic setting These structures are intrabasin faults near the northern margin of the Albuquerque basin in the Rio Grande rift.

Sense of movement N

Dip 63°-76°
Comments: Dip measurements from the recent mapping by the compiler (S.F. Personius, unpublished data, 1996-1997).

Dip direction W; E

Geomorphic expression These faults are exposed in upper Santa Fe Group sands and gravels, but do not appear to offset extensive piedmont surfaces, and thus have little if any geomorphic expression.

Age of faulted deposits These faults offset probable early Pleistocene upper Santa Fe Group sands and gravels, but do not appear to offset middle Pleistocene piedmont deposits.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Faults near Loma Barbon offset probable early Pleistocene Santa Fe Group sediments, but do not cut middle Pleistocene piedmont deposits, so the most recent movement on these faults probably occurred in the early Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No detailed studies of fault offset or age of offset deposits are available; slip rate estimate is based on lack of prominent fault scarps and low rates of slip on other faults in this part of the Rio Grande rift.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 11.2 km and a cumulative trace length of 19.2 km.

Average strike (azimuth) -3°±21°

Endpoints (lat. - long.) 35°23′17.13″N, 106°37′41.55″W
35°17′14.31″N, 106°37′30.44″W

References

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1404 Manley, K., 1978, Geologic map of Bernalillo NW quadrangle, Sandoval County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1446, 1 sheet, scale 1:24,000.

2046, Zia fault

Structure Number 2046

Structure Name Zia fault
Comments: The Zia fault is one of several north-trending normal faults named by Kelley (1977 #1106) in the Zia badlands in the northern part of the Albuquerque-Belen basin. Galusha (1966 #1296), G.O. Bachman (unpublished mapping, 1975) and Manley (1978 #1404) mapped the northern end of the Zia fault in the Sky Village NE and Bernalillo NW quadrangles, respectively; their traces are used herein to define the northern end of the fault. Galusha (1966 #1296) and Manley used the name "Rincon fault" in the Bernalillo NW quadrangle, but we retain the name Zia fault herein, because of apparent common usage in recent publications (Wong and others, 1995 #1155; Hawley and Whitworth, 1996 #1303). More recent mapping (Hawley and Whitworth, 1996 #1303, S.M. Cather, unpublished mapping 1997, S.F. Personius, unpublished mapping, 1997) extends the Zia fault much further south than the original Zia fault trace mapped by Kelley (1977 #1106).

Synopsis: The down-to-the-east Zia fault offsets Santa Fe Group sediments in the Zia badlands and the Llano de Albuquerque and younger Quaternary deposits. Upper Santa Fe Group sediments may be offset about 60 m across the Zia fault.

Date of compilation 04/02/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range (Rio Grande rift)

Reliability of location Good
Comments: Fault trace from Manley (1978 #1404) in the Bernalillo NW quadrangle, G.O. Bachman (unpublished mapping, 1975) in the Sky Village NE quadrangle, S.M. Cather (unpublished mapping 1997) in the Sky Village SE quadrangle, and unpublished air photo mapping by the compiler (1997) in the Sky Village NE, Sky Village SE, and Volcano Ranch quadrangles. The fault location is also evident in recently acquired high resolution aeromagnetic data (Grauch and Labson, 1997 #1298; Grauch and Sawyer, 1997 #1378).

Geologic setting The Zia fault is one of several down-to-the-east intrabasin faults in the northern part of the Albuquerque-Belen basin.

Sense of movement N

Dip not reported

Dip direction E

Geomorphic expression The Zia fault is well exposed in Santa Fe Group sediments in the Zia badlands; further south, the fault forms broad, dissected fault scarps across the Llano de Albuquerque and younger surficial deposits. Manley (1978 #1404) described a 0.5 m offset of middle or upper(?) Pleistocene alluvium on the Zia fault in the Bernalillo NW quadrangle.

Age of faulted deposits Manley (1978 #1404) described minor offset of middle or upper(?) Pleistocene alluvium on the Zia (Rincon) fault in the Bernalillo NW quadrangle. In most places, the Zia fault offsets the early Pleistocene Llano de Albuquerque and middle(?) Pleistocene surficial deposits.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on age estimate of Manley (1978 #1404).

Recurrence interval not reported

Slip-rate cagegory unknown; probably <0.2 mm/yr
Comments: No detailed studies of fault offset are available, but if the Santa Fe Group sediments described by Kelley (1977 #1106) are early Pleistocene (1.6 Ma) in age and offset about 60 m, then a low long-term slip rate is indicated.

Length End to end (km): 32.4
Trace(km): 37.6

Average strike (azimuth) 014°±14°

Endpoints (lat. - long.) 35°28′14.92″N, 106°44′51.36″W
35°11′20.57″N, 106°50′34.80″W

References

#1296 Galusha, T., 1966, The Zia Sand Formation, new early to medial Miocene beds in New Mexico: American Museum Novitates 2271, 12 p.

#1298 Grauch, V.J.S., and Labson, V.F., 1997, Airborne geophysics for hydrogeologic and geologic mapping of the subsurface—Anticipated results, *in* Bartolino, J.R., ed., U.S. Geological Survey Middle Rio Grande basin study—Proceedings of the First Annual Workshop, Denver, Colorado, November 12-14, 1996: U.S. Geological Survey Open-File Report 97-116.

#1378 Grauch, V.J.S., and Sawyer, D.A., 1997, Detailed aeromagnetic surveys in the middle Rio Grande basin—Preliminary results [abs.]: New Mexico Geology, v. 19, p. 53.

#1303 Hawley, J.W., and Whitworth, T.M., compilers, 1996, Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modeling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 402-D.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1404 Manley, K., 1978, Geologic map of Bernalillo NW quadrangle, Sandoval County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1446, 1 sheet, scale 1:24,000.

#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2047, Unnamed faults near Loma Colorado de Abajo

Structure Number 2047

Structure Name Unnamed faults near Loma Colorado de Abajo
Comments: Some of these unnamed structures have been previously mapped (Wyant and Olson, 1978 #1429; Hawley and Whitworth, 1996 #1303), but only the most recent mapping of the compiler (S.F. Personius, unpublished data, 1996-1997) shows all of these faults. The easterly trending faults northeast of Loma Colorado de Abajo are included in the Loma Colorado transfer zone of Hawley and Whitworth (1996 #1303).

Synopsis: The unnamed faults near Loma Colorado de Abajo can be grouped into two categories based on their strike: a set of north to northwest trending normal faults, and a set of generally east-trending faults. Both fault sets offset upper Santa Fe Group sediments, although poor exposures prevent determination of age relations between the two fault sets. The two westernmost faults on Loma Colorado de Abajo offset strongly developed calcic soils that may be correlative with the Llano de Albuquerque.

Date of compilation 04/03/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: Fault traces are from 1:24,000-scale mapping by the compiler (S.F. Personius, unpublished data, 1996-1997).

Geologic setting These structures are intrabasin faults in the northern part of the Albuquerque-Belen basin of the Rio Grande rift. The easterly trending faults may be part of the Loma Colorado transfer zone, a northeast trending zone that may accommodate differential movement in the northern part of the Albuquerque-Belen basin (Hawley and Whitworth, 1996 #1303).

Sense of movement N
Comments: Sense of displacement on the easternmost of the east-trending faults near Loma Colorado de Abajo is open to question. Hawley and Whitworth (1996 #1303) include this structure in their Loma Colorado transfer zone, and show both left lateral and right lateral displacement on this zone. The exposure of this fault northeast of Loma Colorado de Abajo indicates moderately steep north dips of about 70°, which may be more consistent with down-to-the-north normal faulting. Unfortunately, this fault exposure is developed in soft, muddy sediments, and no slip indicators have been found.

Dip 72°-77° W
Comments: Dip measurements are from the compiler (S.F. Personius, unpublished data, 1996-1997).

Dip direction W; N

Geomorphic expression These faults are only preserved in upper Santa Fe Group sediments, with the exception of the two faults on Loma Colorado de Abajo, which offset calcic soils that may be correlative with the Llano de Albuquerque. No fault scarps are apparent in surficial deposits.). Offsets of 5-15 m of the Upper Santa Fe Group gravels and overlying calcic soils are apparent across the two faults on Loma Colorado de Abajo.

Age of faulted deposits These faults offset upper Santa Fe Group sediments, with the exception of the two faults on Loma Colorado de Abajo, which offset calcic soils that may be correlative with the Llano de Albuquerque. None of these faults offset younger (middle and late Pleistocene) piedmont deposits (S.F. Personius, unpublished data, 1996-1997).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: The two faults on Loma Colorado de Abajo offset strongly developed (stage III-IV) calcic soils on upper Santa Fe Group sands and gravels; these soils may be correlative with the early Pleistocene Llano de Albuquerque. The offsets of these deposits (5-15 m) indicate a recurrent faulting history that may have extended into the middle(?) Pleistocene, but middle and late Pleistocene piedmont deposits are not offset by these structures (S.F. Personius, unpublished data, 1996-1997).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr.
Comments: Inferred low slip rate suggested by about 20 m of offset across two faults on Loma Colorado de Abajo. The surface may correlate with the Llano de Albuquerque based on its strongly developed (stage III-IV) calcic horizon.

Length not applicable

Comments: The fault zone includes numerous faults that have an end to end length of 3.5 km and a cumulative trace length of 9.0 km.

Average strike (azimuth) -12°±43°

Endpoints (lat. - long.) 35°16′56.90″N, 106°39′25.60″W
35°15′01.56″N, 106°39′23.82″W

References

#1303 Hawley, J.W., and Whitworth, T.M., compilers, 1996, Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modeling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 402-D.

#1429 Wyant, D.J., and Olson, A., 1978, Preliminary geologic map of the Albuquerque 1° by 2° quadrangle, northwestern New Mexico: U.S. Geological Survey Open-File Report 78-467, 7 p., 1 pl., scale 1:250,000.

2048, Unnamed faults near Star Heights

Structure Number 2048

Structure Name Unnamed faults near Star Heights
Comments: These north-trending normal faults include parts of the Star Heights fault of Kelley (1977 #1106) and Hawley and Whitworth (1996 #1303). Recent detailed mapping (S.F. Personius, unpublished data, 1996-1997) indicate that the Star Heights fault mapped by Kelley (1977 #1106) and Hawley and Whitworth (1996 #1303) includes parts of at least two separate faults, so this name has been abandoned.

Synopsis: This group of north-trending, mostly down-to-the-east normal faults offsets upper Santa Fe Group sediments, the Llano de Albuquerque, and younger piedmont deposits near the neighborhood of Star Heights. Individual faults have displacements in upper Santa Fe Group sediments of a few tens of meters, 15-20 m of the Llano de Albuquerque, and 5-10 m in probable middle Pleistocene piedmont deposits.

Date of compilation 04/03/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: Fault traces from 124,000-scale mapping (S.F. Personius, unpublished data, 1996-1997). Some faults can be mapped with recently acquired aeromagnetic data (U.S. Geological Survey and SIAL Geosciences Inc., 1997 #1722; Grauch and Millegan, 1998 #1721).

Geologic setting These structures are intrabasin faults in the northern part of the Albuquerque-Belen basin of the Rio Grande rift.

Sense of movement N

Dip 70° E
Comments: Dip data are from the compiler (S.F. Personius, unpublished data, 1996-1997).

Dip direction E; W

Geomorphic expression These faults offset upper Santa Fe Group sediments, form broad scarps on the Llano de Albuquerque, and form smaller scarps on younger piedmont deposits.

Age of faulted deposits These faults offset early Plio-Pleistocene upper Santa Fe Group sediments, the early Pleistocene Llano de Albuquerque, and younger piedmont deposits (S.F. Personius, unpublished data, 1996-1997). The faulted piedmont deposits are characterized by well developed (stage III) calcic soils, so they probably are middle Pleistocene in age.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Some of these structures offset the early Pleistocene Llano de Albuquerque 15-20 m and middle Pleistocene piedmont deposits 5-10 m; these data indicate recurrent histories of movement that in some cases probably extend into the late Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Inferred low slip rate based on presence of broad scarps on the Llano de Albuquerque that offset the surface 15-20 m.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 12.1 km and a cumulative trace length of 43.6 km.

Average strike (azimuth) 004°±24°

Endpoints (lat. - long.) 35°19′37.19″N, 106°44′45.21″W
35°13′09.20″N, 106°43′31.43″W

References

#1721 Grauch, V.J.S., and Millegan, P.S., 1998, Mapping intrabasinal faults from high-resolution aeromagnetic data: The Leading Edge, v. 17, p. 53-55.
#1303 Hawley, J.W., and Whitworth, T.M., compilers, 1996, Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modeling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 402-D.
#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.
#1722 U.S. Geological Survey, and SIAL Geosciences Inc., 1997, Description of digital aeromagnetic data collected north and west of Albuquerque, New Mexico: U.S. Geological Survey Open-File Report 97-286, 40 p.

2049, Unnamed faults near Albuquerque Volcanoes

Structure Number 2049

Structure Name Unnamed faults near Albuquerque Volcanoes
Comments: This group of structures is a series of north trending normal faults located near the Albuquerque Volcanoes. Some of these faults are included in the West Mesa fault zone of Wong and others (1995 #1155) and Hawley and Whitworth (1996 #1303); we recommend abandonment of this name.

Synopsis: Several unnamed north-trending normal faults are located near the Albuquerque Volcanoes. The basaltic volcanic field associated with the volcanoes is apparently confined in a broad graben, defined on the west by the down-to-the-east County Dump fault [2038] and on the east by the down-to-the-west East Paradise fault zone [2040]. A series of smaller fault blocks and grabens are present between these two flanking faults. Most faults appear to be buried by the ~155 ka basalt flows.

However, these faults can be mapped beneath the flows because most are marked by linear breaks in slope, indicating that preexisting fault scarps disrupted the flows during emplacement. The extent of some buried faults are also evident in unpublished high resolution aeromagnetic data. At least two faults are marked by more pronounced linear scarps that indicate small (1-2 m) post-basalt movements: a short down-to-the-east fault located between the East [2040] and West Paradise [2042] fault zones clearly offsets basalt in two places along the eastern edge of the volcanic field, and a longer north-trending down-to-the-west fault marked by small scarps in basalt bisects the volcanic field west of the West Paradise fault. This fault may have been the source of the 1978-1979 earthquake swarm near the Albuquerque Volcanoes. Latest movements on both the County Dump [2038] and East Paradise [2040] faults also post-date basalt emplacement.

Date of compilation 04/03/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval; Bernalillo

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: Fault traces from unpublished field and air photo mapping (S.F. Personius, 1997. The locations of some traces beneath the volcanic field are based on high resolution aeromagnetic data (U.S. Geological Survey and SIAL Geosciences Inc., 1997 #1722; Grauch and Millegan, 1998 #1721).

Geologic setting These structures are intrabasin faults in the central part of the Albuquerque-Belen basin of the Rio Grande rift. The broad graben that confines the Albuquerque Volcanoes volcanic field suggests that movement on some of these faults may be associated with magmatic activity. Recent seismicity may be associated with one of these intrabasin structures. An earthquake swarm in 1978-1979 near the southwestern margin of the volcanic field yielded a composite fault plane solution with a preferred nodal plane striking N. 5° E. and dipping 74° W. (Jaksha and others, 1981 #1760). This fault plane projects to the surface very near the surface trace of an unnamed, ~20 km long fault that lies ~0.5 km east of the Albuquerque Volcanoes cinder cones. Northeast of the cinder cones, this fault is marked by small scarps in basalt that indicate post-basalt displacement. The County dump fault [2038] is located between the surface trace of this fault and the surface projection of the earthquake 1978-1979 earthquake swarm, suggesting that the County Dump may sole into the fault at depth.

Sense of movement N

Dip not reported

Dip direction E; W

Geomorphic expression Outside of the volcanic field, these faults are well expressed as eroded fault scarps in sediments of the upper Santa Fe Group and overlying surficial deposits. Within the Albuquerque Volcanoes volcanic field, these faults are marked by linear breaks in slope and minor fault scarps. Most breaks in slope along these faults appear to be preexisting scarps that disrupted the basalt flows during emplacement. At least two faults are marked by more pronounced linear scarps that indicate small post-basalt movements. Most of the fault traces in the volcanic field have been partly covered by eolian sand.

Age of faulted deposits At least two of these structures offset the basalt of the Albuquerque Volcanoes volcanic field; these rocks have been dated by several methods at about 155 ka (Geissman and others, 1990 #1297; Peate and others, 1996 #1411). Most of the faults cut sediments of the upper Santa Fe Group and surficial deposits that predate emplacement of the basalts.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: At least two faults in this group offset the 155 ka basalts of the Albuquerque Volcanoes volcanic field, indicating probable late Pleistocene displacement. Most of the other faults have most recent movements that predate 155 ka.

Recurrence interval not reported

Slip-rate category unknown; <0.2 mm/yr
Comments: Two of these structures offset the 155 ka basalts of the Albuquerque Volcanoes volcanic field 1-2 m, which suggests a low slip rate.

Length not applicable
Comments: The fault zone includes numerous faults that have an end to end length of 30.1 km and a cumulative trace length of 73.8 km.

Average strike (azimuth) -5°±18°

Endpoints (lat. - long.) 35°15′56.62″N, 106°44′39.21″W
34°59′38.97″N, 106°44′21.77″W

References
#1297 Geissman, J.W., Brown, L., Turrin, B.D., McFadden, L.D., and Harlan, S.S., 1990, Brunhes chron excursion/polarity episode recorded during the late Pleistocene, Albuquerque Volcanoes, New Mexico, USA: Geophysical Journal International, v. 102, p. 73-88.
#1721 Grauch, V.J.S., and Millegan, P.S., 1998, Mapping intrabasinal faults from high-resolution aeromagnetic data: The Leading Edge, v. 17, p. 53-55.
#1303 Hawley, J.W., and Whitworth, T.M., compilers, 1996, Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modeling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 402-D.
#1760 Jaksha, L.H., Locke, J., and Gebhart, H.J., 1981, Microearthquakes near the Albuquerque volcanoes, New Mexico: Geological Society of America Bulletin, v. 92, p. 31-36.
#1411 Peate, D.W., Chen, J.H., Wasserburg, G.J., Papanastassiou, D.A., and Geissman, J.W., 1996, ^{238}U-^{230}Th dating of a geomagnetic excursion in Quaternary basalts of the Albuquerque Volcanoes Field, New Mexico (USA): Geophysical Research Letters, v. 23, p. 2271-2274.
#1722 U.S. Geological Survey, and SIAL Geosciences Inc., 1997, Description of digital aeromagnetic data collected north and west of Albuquerque, New Mexico: U.S. Geological Survey Open-File Report 97-286, 40 p.
#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2050, El Oro fault

Structure Number 2050

Structure Name El Oro fault
Comments: This fault was named by Baltz and O'Neill (1984 #1713) for its proximity to El Oro Mountains, which are immediately south of Mora, New Mexico. El Oro fault extends as mostly a concealed structure from Puertocito (3 km north of Rito Cebolla) north and across the Mora River valley according to mapping of Baltz and O'Neill (1984 #1713). However, it probably continues farther north past Turquillo and up Guadalupita Canyon. The north end of the fault is poorly defined, but taken herein as at Guadalupita according to mapping of O'Neill (1988 #1717). Farther north, the mapped trace of the fault enters bedrock and there is no evidence for Quaternary movement; however, O'Neill

(1988 #1717) maps a continuation of the El Oro fault north and west into the Moreno Valley, where Pliocene basalts are offset.

Synopsis: Backsliding (extension) on this former Laramide reverse fault zone has resulted in a large continuous fault-line escarpment on Precambrian and Paleozoic rocks. Evidence for Quaternary movement is recorded by small isolated scarps (less than 5 percent of the faults length) on alluvial-fan deposits derived from the adjacent fault-line escarpment. Down-to-the-west movement on the fault has caused at least 88 m of offset of the bedrock channel of the Mora River. The timing of this offset is unknown, but nearby Pliocene basalts are also offset in a similar manner. No detailed studies have been conducted to refine the timing or amount of offset recorded by the isolated Quaternary scarps along the length of the fault zone.

Date of compilation 03/25/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Mora; Raton

1° x 2° sheet Santa Fe

Province Southern Rocky Mountains

Reliability of location Good
Comments: Trace from 1:24,000-scale geologic mapping by Baltz and O'Neill (1984 #1713). Northern extension of the fault (north of the Mora 7.5-minute quadrangle) is from 1:125,000-scale map of O'Neill (1988 #1717). Composite trace transferred to 1:250,000-scale topographic base map for digitization.

Geologic setting Backsliding (extension) on this former Laramide reverse fault has resulted in a large continuous fault-line escarpment on Precambrian and Paleozoic rocks. The fault is the source of a prominent strike valley. Down-to-the-west movement on the fault has caused at least 88 m of offset on the base of the bedrock channel of the Mora River according to drilling and geophysical studies. The timing of this offset is unknown, but Pliocene basalts to the north are also offset in a similar manner.

Sense of movement N
Comments: Fault was created as a Laramide reverse fault, but was reactivated in Quaternary time as a normal fault (see Baltz and O'Neill, 1990 #1671).

Dip not reported
Comments: No dips shown on map, but cross sections A and B of Baltz and O'Neill (1984 #1713) show the faults as having a high- to moderate angle in the subsurface. With depth, they show the fault curving (less dip) and merging with thrusts faults of Laramide age.

Dip direction W

Geomorphic expression Down-to-the-west Cenozoic movement on the fault has formed a large continuous fault-line escarpment on Precambrian and Paleozoic rocks, and small isolated scarps (less than 5 percent of length) on alluvial-fan deposits derived from the adjacent fault-line escarpment. No morphometric analyses of the isolated scarps has been made.

Age of faulted deposits Fault offsets locally derived alluvial-fan deposits of Pleistocene age. Baltz and O'Neill's (1984 #1713) units Qfm (middle? Quaternary) and Qfo (middle? to early Quaternary) are offset by the fault, whereas younger deposits (probable middle? to late Pleistocene) bury the Quaternary trace of the fault. No detailed studies of soil development or radiometric dating have been conducted in order to refine the age of faulted and unfaulted deposits. However, the above age estimates are based on the compiler notes from mapping of Quaternary deposits in this and the adjacent quadrangles to the south (see Baltz and O'Neill, 1986 #1714). Northeast of Mora, New Mexico, Pliocene (4.3-4.4 Ma) basalts at El Cerro Colorado (O'Neill and Mehnert, 1988 #1716) are locally offset by the fault; they lie at discordant elevations with the basalts on the eastern (uplifted) side more than 600 ft (183 m) higher than those on the west (see Baltz and O'Neill, 1990 #1671).

Detailed studies none

Timing of most recent paleoevent middle to late Quaternary (<750 ka)
Comments: Based on offset alluvial-fan deposits of probable middle to early Quaternary age, discontinuous (buried) nature of scarps, and large (ca. 100 m) offset of subsurface channel of Mora River.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Late Quaternary slip rate must be low (<0.2 mm/yr) based on the discontinuous nature and size of scarps, whereas earlier (late Pliocene to early? Quaternary) slip may have occurred at a higher rate.

Length End to end (km): 26.9
Trace (km): 29.7

Average strike (azimuth) 010°±24°

Endpoints (lat. - long.) 36°09'18.74"N, 105°13'46.89"W
35°05'08.07"N, 105°17'52.43"W

References

#1713 Baltz, E., and O'Neill, J.M., 1984, Geologic map and cross sections of the Mora River area, Sangre de Cristo Mountains, Mora County, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1456, 2 sheets, scale 1:24,000.
#1714 Baltz, E., and O'Neill, J.M., 1986, Geologic map and cross sections of the Sapello River area, Sangre de Cristo Mountains, Mora and San Miguel Counties, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1575, 2 sheets, scale 1:24,000.
#1671 Baltz, E.H., and O'Neill, J.M., 1990, Third-day road log, from Angel Fire to Las Vegas, via Black Lake, Guadalupita, Mora, Rociada and Sapello, *in* Bauer, P.W., Lucas, S.G., Mawer, C.K., and McIntosh, W.C., eds., Tectonic development of the southern Sangre de Cristo Mountains, New Mexico: New Mexico Geological Society, 41st Field Conference, September 12-15, 1990, Guidebook, p. 67-92.
#1717 O'Neill, J.M., 1988, Late Cenozoic physiographic evolution of the Ocate Volcanic Field, *in* Petrology and physiographic evolution of the Ocate Volcanic Field, north-central New Mexico: U.S. Geological Survey Professional Paper 1478, p. B1-B15.
#1716 O'Neill, J.M., and Mehnert, H.H., 1988, The Ocate Volcanic Field—Description of volcanic vents and the geochronology, petrography, and whole-rock chemistry of associated flows, *in* Petrology and physiographic evolution of the Ocate Volcanic Field, north-central New Mexico: U.S. Geological Survey Professional Paper 1478, p. A1-A30, 1 pl., scale 1:125,000.

2051, Artillery Range fault

Structure Number 2051
Comments: Referred to as fault 5 on figure 1 and table 2 of Machette (1987 #847).

Structure Name Artillery Range fault
Comments: Named by Seager (1981 #968) for fault's location within the Fort Bliss Anti-Aircraft (Artillery) Range. Fault extends from a point about 6.5 km south of White Sands, New Mexico (where it splays southwestward from the Organ Mountains fault [2052]), south and then west into a major embayment east of Anthony Gap. The name was extended by Kelley and Matheny (1983 #1005) southward to the northern end of the Franklin Mountains, where the fault joins the East Franklin Mountains fault [900] about 1 km north of the New Mexico-Texas state boundary.

Synopsis: This major basin-bounding fault crosses the eastern piedmont of the Organ Mountains and bounds bedrock hills (northern part of Franklin Mountains) that underlie the hydrologic divide between the Mesilla and Hueco basins, north of Anthony Gap. The fault trace is entirely within Quaternary deposits: the northern section forms prominent scarps on deposits of middle to late Quaternary age, whereas the southern section forms large, older fault-line scarps on deposits of early to middle Quaternary age. No detailed studies have been performed on this fault owing to its location in a restricted military area.

Date of compilation 01/16/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Geologic setting The fault is part of a longer fault system that extends from the latitude of Capital Peak in northern White Sands Proving Grounds south to Juarez, Mexico. It joins the Holocene-age Organ Mountains fault [2052] on the north and the latest Pleistocene-Holocene age East Franklin Mountains fault [900] on the south. The Artillery Range fault is different in that its trace is entirely within Quaternary deposits, whereas other parts of the long system are at the eastern margin of bedrock-cored ranges. The northern section of the fault forms the western margin of an intermediate-level structural block that is bounded on the east by the Organ Mountains fault [2052].

Number of sections 2
Comments: Fault is divided into two sections on basis of apparent differences in recency of movement and geomorphic expression for the northern and southern parts of fault.

Length End to end (km): 33.7
Trace (km): 57.0

Average strike (azimuth) -7°±4°

Endpoints (lat. - long.) 32°18′51.27″N, 106°28′25.34″W
32°00′40.80″N, 106°26′47.14″W

2051a, northern section

Section number 2051a

Section name northern section
Comments: As defined herein, this section extends from about 6.5 km south of White Sands, New Mexico, to the westernmost trace of the fault in the gap between the Organ and Franklin Mountains. The southern boundary is based on Seager and others (1987 #627) mapping, which shows a fairly continuous trace north of this point. To the south, the fault's trace is primarily concealed beneath surficial deposits.

Reliability of location Good

Sense of movement N

Dip not reported
Comments: High-angle normal fault based on drill holes in basin-fill sediment and gravity data (Seager, 1981 #968). No specific measurements have been made, but dips of 60-75° E. have been observed on the Organ Mountains fault [2052] to the north. Likewise, steep easterly dips were measured along the East Franklin Mountains fault [900] to the south.

Dip direction E

Geomorphic expression The fault forms nearly continuous scarps on piedmont-slope and alluvial-fan deposits of the southern Organ Mountains. Near its northern end, the fault zone forms a complex pattern comprised of a main fault, 4-6 subsidiary normal faults, and a basinward horst. No scarp heights are mentioned specially for the fault by Seager (1981 #968), but topographic maps of the fault commonly show differential relief of 6-12 m across the scarps (Machette, 1987 #847). Seager (written commun., 1998) says the fault scarps are prominent and steep, suggesting a late Pleistocene or Holocene age. The scarps are clearly larger on older parts of the landscape, demonstrating repeated movement through the Quaternary.

Age of faulted deposits Seager (1981 #968) shows the fault as cutting middle to early Pleistocene alluvial-fan deposits (post Camp Rice Formation).

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: In Seager's (1981 #968) discussion of the Organ Mountains [2052] and Artillery Range [2051] faults, he mentioned scarps on Holocene deposits. However, his mapping (Seager, 1981 #968; Seager and others, 1987 #627) showed fault scarps on middle to late Pleistocene deposits (unit Qpo), and no scarps on younger units (Qpa or Qpy). Thus, we can not be sure that latest Pleistocene or Holocene movement has occurred along this section of the fault. No detailed analyses of scarp morphology or detailed mapping of the youngest faulted deposits has been conducted for this fault.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: A low slip rate inferred on the basis of 6- to 12-m high scarps (measured from topographic maps) on deposits that are probably early late Pleistocene (100-130 ka) or older.

Length End to end (km): 21.8
Trace (km): 39.6

Average strike (azimuth) 006°±44°

Endpoints (lat. - long.) 32°18′51.27″N, 106°28′25.34″W
32°07′34.06″N, 106°32′33.60″W

2051b, southern section

Section number 2051b

Section name southern section
Comments: As defined here, this section extends from the westernmost trace of the fault in the gap between the Organ and Franklin Mountains to a point about 1 km north of the New Mexico-Texas state boundary where it joins the Franklin Mountains fault [900]. Along this section, the fault's trace is primarily concealed beneath surficial deposits.

Reliability of location Good

Sense of movement N

Dip not reported
Comments: High-angle normal fault based on drill holes in basin-fill sediment and gravity data (Seager, 1981 #968). No specific measurements have been made, but dips of 60-75° E. have been observed on the Organ Mountains fault [2052] to the north. Likewise, steep easterly dips were measured along the East Franklin Mountains fault [900] to the south.

Dip direction E

Geomorphic expression The fault is mapped as having a nearly continuous but concealed trace beneath piedmont-slope and alluvial-fan deposits between the Organ and Franklin Mountains. No scarp heights are mentioned specially for the fault by Seager (1981 #968), but topographic maps of the fault show differential relief of less than 10-15 m between sediment of the early to middle Pleistocene Camp Rice Formation (on the upthrown block) and younger Quaternary deposits (on the downthrown block). The fault's trace is probably a fault-line escarpment and may reflect considerable retreat from its actual position in the shallow subsurface.

Age of faulted deposits Mapping by Seager (1981 #968) and Seager and others (1987 #627) shows the fault cutting sediment of the early to middle Pleistocene Camp Rice Formation, but not offsetting younger deposits.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on mapping by Seager (1981 #968) and Seager and others (1987 #627). No detailed studies have been made owing to restricted access on the Fort Bliss Anti-Aircraft (Artillery) Range.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: A low slip rate is based on 10-15 meters of differential relief (estimated from topographic maps) between the piedmont slope facies of the Camp Rice Formation (early to middle Pleistocene) and unfaulted deposits of early(?) late Pleistocene age (100-130 ka).

Length End to end (km): 15.7
Trace (km): 17.4

Average strike (azimuth) -36°±29°

Endpoints (lat. - long.) 32°07′34.72″N, 106°32′33.47″W
32°00′40.80″N, 106°26′47.14″W

References

#1005 Kelley, S., and Matheny, J.P., 1983, Geology of Anthony quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 54, 1 sheet, scale 1:24,000.

#847 Machette, M.N., 1987, Preliminary assessment of paleoseismicity at White Sands Missile Range, southern New Mexico—Evidence for recency of faulting, fault segmentation, and repeat intervals for major earthquakes in the region: U.S. Geological Survey Open-File Report 87-444, 46 p.

#968 Seager, W.R., 1981, Geology of Organ Mountains and southern San Andres Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 36, 97 p., 4 pls.

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2052, Organ Mountains fault

Structure Number 2052
Comments: Referred to as fault 4 on figure 1 and table 2 of Machette (1987 #847).

Structure Name Organ Mountains fault
Comments: Seager (1981 #968) first applied the name Organ Mountains to this fault, although Reiche (1938 #972) appears to have been the first to describe the feature and to note its youthfulness. However, Reiche (1938 #972) only recognized about 6 km of the fault south of the Cox Ranch head-quarters. Gile referred to this part of the fault as the Cox Ranch segment, although segment was used in a geometric rather than seismologic sense. As defined here, the Organ Mountains fault extends from a prominent counter-clockwise bend in the fault just south of U.S Highway 70 and Antelope Hill to its intersection with the Artillery Range fault [2051] on the southeast margin of the Organ Mountains.

Seager (1981 #968) extended the fault north of U.S Highway 70 to the latitude of Bear Mountain, but his northern limit was not defined by structural or paleoseismic information. Therefore, the name and limits of the fault are herein restricted to correspond with its namesake, the Organ Mountains.

Synopsis: This north-trending major piedmont fault bounds the eastern margin of the Organ Mountains, although in most places the fault is within Quaternary piedmont-slope deposits. This fault is characterized by prominent, high scarps in middle to late Quaternary deposits and appears to be one of the most recently active faults in this part of the Rio Grande rift. Detailed studies of soils on alluvial-fan deposits that are offset by the fault yielded information on slip rates and the most recent time of movement. A single deep trench across the fault failed to yield conclusive paleoseismic information owing to lack of penetration of fault colluvium on the downdropped block.

Date of compilation 01/16/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Geologic setting The fault is part of a longer system the extends from the latitude of Capital Peak in the northern White Sands Proving Grounds south to Juarez, Mexico. It joins the latest Pleistocene-age San Andres Mountains fault [2053] on the north and the latest Pleistocene age Artillery Range fault [2051] on the south. The trace of the Organ Mountains fault is entirely within Quaternary deposits, although Precambrian bedrock of the Organ Mountains is generally either within close proximity to the fault or at shallow depth on the upthrown fault block.

Number of sections 2
Comments: Fault is divided into two sections on basis of apparent differences in recency of movement and geomorphic expression. The southern 6.5 km of the fault [2052b] appears to be older and have a substantially lower slip rate that the central and northern parts of fault [2052a].

Length End to end (km): 25.3
Trace (km): 33.8

Average strike (azimuth) -3°±41°

Endpoints (lat. - long.) 32°25′00.67″N, 106°29′10.75″W
32°11′26.95″N, 106°29′24.93″W

2052a, Cox Ranch (northern) section

Section number 2052a

Section name Cox Ranch (northern) section
Comments: Named herein for prominent, well-studied fault scarps that are within the J.M. Cox Ranch, due west of White Sands, New Mexico. Seager (1981 #968) referred to the entire fault as the Organ Mountains fault, but did not suggest either sections or segments. Gile (1986 #967) referred to this part of the fault as the Cox Ranch segment, although segment was used in a geometric rather than seismologic sense. Similarly, Beehner (1990 #971) referred to these scarps as the Cox Ranch section. Therefore, it seems appropriate to apply the name Cox Ranch to this section of the fault, which extends from south of Antelope Hill to a point about 6.5 km north of the fault's southern intersection with the Artillery Range fault [2051a]. It includes a single basinward splay near the southern end of the section.

Reliability of location Good
Comments: Location based on 1:31,250-scale mapping of Seager (1981 #968), which was later compiled at 1:125,000 scale (Seager and others, 1987 #627). Gile (1986 #967) studied small portions of the fault

and showed its relation to soils on large-scale aerial photographs, whereas Machette (1987 #847) included a 1:24,000-scale map of the fault scarps near Cox Ranch. The fault was not recognized by Dunham (1935 #973) during initial bedrock mapping of the Organ Mountains.

Sense of movement N

Comments: Inferred from drilling and gravity measurements in the Tularosa Basin. Seager (1981 #968) estimated there may be as much as 4-5 km of throw across the Organ Mountains fault and similar buried faults on the west side of the Tularosa Basin.

Dip 60-75° E

Comments: Seager (1981 #968) reported near-surface dips of 60-75° E. based on a natural exposure of the fault along U.S. Highway 70.

Dip direction E

Geomorphic expression Scarps along this section of the fault are nearly continuous, the exceptions being in areas of late Holocene alluvial deposition. Reiche (1938 #972) reported scarp heights of 5-30 m and scarp slope angles of 29-35°. These perceptive observations led him to speculate that faulting occurred in recent times (herein interpreted as Holocene). Machette (1987 #847) made 11 detailed topographic profiles of the scarps in this same area and recorded scarp heights that range from 1.6-6.3 m on Holocene deposits to as much as 26 m on middle Pleistocene alluvial fans. Most of the scarps >5 m high have slope angles of greater than 25° (Machette, 1987 #847), but the material in the scarps is uniformly coarse grained.

Age of faulted deposits In the vicinity of Cox Ranch, Holocene and older alluvial deposits are offset by the fault (Gile, 1986 #967; Machette, 1987 #847; Gile, 1987 #970; Gile, 1994 #966). Gile's studies of soil development on and across the fault scarps suggests that the Organ II alluvium (1,100-2,100 yr B.P.) is offset as much as 5 m, but the younger Organ II alluvium (<1,100 yr B.P.) is not offset. Deposits that form older surfaces (Holocene to late Pleistocene) are offset by two faulting events, whereas the higher landscapes (Jornada I surface) have scarps approaching 25 m in height, and reflect many faulting events (Machette, 1987 #847; Gile, 1994 #966). In as much as the fault usually lies at the base of the larger scarps, their heights may only represent one-half of the total offset for that age deposit. The Jornada I surface is not well dated but is generally considered to have stabilized in the middle Pleistocene (250-400 ka) (table 1 in Gile, 1987 #970).

Detailed studies Studies at two closely spaced sites. Gile conducted extensive studies of soil geomorphic relations across the scarps south of the Cox Ranch. Trench excavations (site 2052-1) were used to characterize soil texture and development, to place limits on the timing of most recent movement (Gile, 1986 #967; Gile, 1987 #970), and to estimate the time of previous movement (Gile, 1994 #966). (1987 #847)At a second site (site 2052-2), Beehner (1990 #971) made similar geomorphic observations and excavated a single deep trench along an arroyo that crosses a scarp on Organ I/II alluvium (Holocene); unfortunately, the basinward end of the trench only intercepted the uppermost part or strand of the Organ fault and yielded no new paleoseismic information.

Timing of most recent paleoevent: latest Quaternary (<15 ka)

Comments: Gile (1986 #967; 1987 #970) argued that the most recent faulting in the vicinity of Cox Ranch occurred about 1,000 yrs ago. This estimate was based on displacement of the Organ II alluvium (1,100-2,100 yr B.P.) and the degree of soil development on colluvium derived from this faulting event. Machette (1987 #847) estimated that the most recent movement was middle Holocene, but this was based on the morphology of scarps that are probably the result of multiple (2) faulting events. Even though the scarps have been studied in moderate detail, neither the most recent nor penultimate event have been dated directly using analytical methods.

Recurrence interval 4-15 k.y. (<15 ka)

Comments: Machette (1987 #847) estimated a recurrence interval of 4-5 k.y. for this section of the fault on the basis of two different heights of scarps (1.6-2.0 m versus 4.1-6.3 m) on fans correlated with the Organ alluvium. Gile (1994 #966) speculated that the penultimate event on this section of the fault might be latest Pleistocene in age, which would allow the most recent recurrence interval to be as much as 10-15 k.y. However, since neither the most recent or penultimate events are directly dated, the recurrence interval is only crudely estimated.

Slip-rate category unknown; probably 0.2-<1 mm/yr
Comments: Inferred slip rate based on Machette's (1987 #847) detailed measurements of scarp heights indicating that 1.6-2.0 m of displacement (at about 1,000 yrs ago) was released after 4-5 k.y. of fault quiescence. Earlier work by Seager (1981 #968), however, suggests about 10 m of displacement in the past 5 k.y., which yields a much larger slip rate. In terms of longer-term slip rates, the bounds are defined by 25-50 m of displacement of the 250-400 ka Jornada I surface, which yields a slip rate of less than half of the slip rate for the most recent event.

(1981 #968)(1987 #847)**Length** End to end (km): 18.3
Trace (km): 27.0

Average strike (azimuth) -5°±45°

Endpoints (lat. - long.) 32°25'00.67"N, 106°29'10.75"W
32°15'06.03"N, 106°29'11.64"W

2052b, southern section

Section number 2052b

Section name southern section
Comments: This term is applied to the unnamed southern 6.5 km of the fault. It is noticeably older and has less pronounced than scarps on the northern section.

Reliability of location Good
Comments: Location based on 1:31,250-scale mapping of Seager (1981 #968), which was later compiled at 1:125,000 scale (Seager and others, 1987 #627).

Sense of movement N

Comments: Inferred from drilling and gravity measurements in the Tularosa Basin. Seager (1981) estimates there may be as much as 4-5 km of throw across the Organ Mountains fault and similar buried faults on the west side of the Tularosa Basin. However, along this section Tertiary bedrock is exposed between this fault and the Artillery Range fault [2051a] to the east at an intermediate structural positions, suggesting significantly less throw than to the north.

Dip not reported
Comments: Suggested as high-angle dipping normal fault by association with other Quaternary faults in this long system.

Dip direction E (?)

Geomorphic expression Seager (1981 #968) showed the entire trace of this section as concealed, thus the fault has no surficial expression.

Age of faulted deposits The fault is mapped (Seager, 1981 #968) as concealed beneath the surface of the piedmont-facies of the Camp Rice Formation. This surface is generally considered to be of early to middle Pleistocene age (Mack and others, 1993 #1020). Considering the youthfulness of the Cox Ranch section [2052a] and Artillery Range fault [2051a], it seems likely that this part of the fault was active in the Quaternary.

Detailed studies none

Timing of most recent paleoevent: Quaternary (<1.6 Ma)
Comments: Inferred quaternary movement based on spatial association with the Cox Ranch section [2052a] and Artillery Range fault [2051a]. However, it is possible that the fault was either not active in the Quaternary or does not extend south beyond the Cox Ranch section [2052a].

Recurrence interval not reported
Comments: Mapping indicates that there has been no significant faulting in many hundreds of thousands of years.

Slip-rate category unknown, probably <0.2 mm/yr
Comments: Lack of late Pleistocene faulting (<130 ka) implies a low slip rate.

Length End to end (km): 6.8
Trace (km): 6.8

Average strike (azimuth) 003°±5°

Endpoints (lat. - long.) 32°15′06.31″N, 106°29′11.63″W
32°11′26.95″N, 106°29′24.93″W

References

#971 Beehner, T.S., 1990, Burial of fault scarps along the Organ Mountains fault, south-central New Mexico: Bulletin of the Association of Engineering Geologists, v. 27, p. 1-9.
#973 Dunham, K.C., 1935, The geology of the Organ Mountains with an account of the geology and mineral resources of Dona Ana County, New Mexico: New Mexico School of Mines Bulletin 11, 272 p., 14 pls.
#967 Gile, L.H., 1986, Late Holocene displacement along the Organ Mountains fault in southern New Mexico—A summary: New Mexico Geology, v. 8, no. 1, p. 1-4.
#970 Gile, L.H., 1987, Late Holocene displacement along the Organ Mountains fault in southern New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 196, 43 p.
#966 Gile, L.H., 1994, Soils, geomorphology, and multiple displacements along the Organ Mountains fault in southern New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 133, 91 p.
#847 Machette, M.N., 1987, Preliminary assessment of paleoseismicity at White Sands Missile Range, southern New Mexico—Evidence for recency of faulting, fault segmentation, and repeat intervals for major earthquakes in the region: U.S. Geological Survey Open-File Report 87-444, 46 p.
#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.
#972 Reiche, P., 1938, Recent fault scarps, Organ Mountain District, New Mexico: American Journal of Science, v. 36, no. 216, p. 440-444.
#968 Seager, W.R., 1981, Geology of Organ Mountains and southern San Andres Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 36, 97 p., 4 pls.
#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2053, San Andres Mountains fault

Structure Number 2053
Comments: Referred to as fault 3 on figure 1 and table 2 of Machette (1987 #847) and fault 11 on figure 1 of Machette (1987 #960).
Structure Name San Andres Mountains fault
Comments: The young fault scarps along the eastern margin of the San Andres Mountains were first recognized by Kelley (1955 #989) during his bedrock mapping of the mountains. Because of restricted access to White Sands Proving Grounds (missile range) since the mid 1940's, the fault is still largely unstudied. Machette (1987 #847) named the fault for its position along the eastern margin of the San Andres Mountains. The fault extends from the latitude of Capital Peak, in the northern part of the White Sands Proving Ground, south to Antelope Hill, just south of U.S. Highway 70, where it joins the Organ Mountains fault [2052]. Seager (1981 #968) suggested that the San Andres Mountains fault

extends north to Mockingbird Gap, a prominent graben-shaped valley that bisects the northern end of the San Andres Mountains.

Synopsis: Little is known about this long and potentially hazardous fault owing to its location on the White Sands Proving Grounds, which has had limited access for the past 50 years. The fault has been shown on a number of small-scale regional maps, and a limited study of fault scarp morphology by the compiler has been used to suggest a model for segmentation of the fault.

Date of compilation 01/17/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana; Sierra

1° x 2° sheet Las Cruces; Tularosa

Province Basin and Range

Geologic setting This north-trending fault forms the eastern margin of the San Andres Mountains and the western margin of the Tularosa basin (Neogene). The fault has uplifted the San Andres Mountains into a westward-tilted block and exposed Precambrian and lower Paleozoic rocks along most of the footwall. The hangingwall block is characterized by a thick sequence of Tertiary and Quaternary basin-fill sediment; those deposits faulted at the surface are primarily of middle to late Quaternary age.

Number of sections 3
Comments: Machette (1987) suggested three segments for the fault based on geometric and scarp morphology data. However, these data are not compelling from a seismogenic sense, and the segments are treated as sections herein.

Length End to end (km): 113.3
Trace (km): 144.6

Average strike (azimuth) 002°±34°

Endpoints (lat. - long.) 33°26′11.73″N, 106°24′45.28″W
32°25′00.86″N, 106°29′10.53″W

2053a, northern section

Section number 2053a

Section name northern section
Comments: The fault extends from about due east of Capital Peak south to Rhodes Canyon, which marks a prominent eastward concavity in the fault. The section boundary is based on a 3-km-long gap in surface faulting, as well as the fault's change in trend (geometry) and degree of scarp preservation (Machette, 1987 #847).

Reliability of location Good
Comments: Based on aerial reconnaissance by Machette, topographic map interpretation at 1:24,000 scale, and a 1:125,000-scale map of Weir (1965 #982); also shown in a general manner on 1:1,000,000-scale map of Woodward and others (1978 #986). Bachman and Harbour (1970 #988) showed three photo lineaments along the eastern margin of the San Andres Mountains, but did not confirm that they were of fault origin.

Sense of movement N
Comments: Inferred from drilling and gravity measurements in the southern part of the Tularosa Basin. Seager (1981 #968) estimated there may be as much as 4-5 km of throw across the Organ

Mountains fault, San Andres Mountains fault, and similar (major) buried faults on the west side of the Tularosa Basin.

Dip not reported
Comments: High angle as inferred from exposures of the Organ Mountains fault [2052], which joins the San Andres fault on the south.

Dip direction E

Geomorphic expression The fault forms scarps that are mostly continuous on unconsolidated surficial deposits and poorly consolidated basin-fill deposits from 3 km north of Rhodes Canyon to north of Salinas Peak and discontinuous scarps as far north as Capital Peak. No morphology studies, other than characterizations of scarp height (Machette, unpubl. data, 1996), have been conducted owing to limited access in this area.

Age of faulted deposits No detailed work has been done on the age of faulted materials along this section of the fault. However, a brief reconnaissance by Machette (unpubl. data, 1996) suggests that the older faulted landforms are underlain by early to middle Pleistocene sediment equivalent to the Camp Rice Formation as mapped to the west. Scarps on these deposits are large, probably in the 10-20 m range. Piedmont-slope and alluvial-fan surfaces of suspected late to middle Pleistocene age are offset 2-8 m. No scarps were noted on alluvium of suspected Holocene or latest Pleistocene age (<15 ka). The age of these deposits are estimated from degree of landform preservation, occasional glimpses of soils on the deposits, and geomorphic position.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Timing based on offset of late Pleistocene deposits; however, the most recent movement is probably pre-latest Pleistocene (>15 ka).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip rate inferred from 2-8 m high scarps on middle and late Pleistocene landforms. These scarps are smaller and appear older than those on the central section of the fault [2053b].

Length End to end (km): 25.7
Trace (km): 29.0

Average strike (azimuth) 025°±25°

Endpoints (lat. - long.) 33°26′11.73″N, 106°24′45.28″W
33°13′37.21″N, 106°31′52.01″W

2053b, central section

Section number 2053b

Section name central section
Comments: This section extends from about 1 km north of Rhodes Canyon (road), south to the latitude of Lead Camp Canyon, just west of the north end of Lake Lucero. The boundary for the south end of the section is based on consistent differences in fault scarp morphology between the areas north and south of Lead Camp Canyon (fig. 6 in Machette, 1987 #847).

Reliability of location Good
Comments: Trace of fault based on 1:125,000-scale mapping by Seager (1987 #627) supplemented by detailed (1:24,000-scale) fault mapping by Machette (1987 #847).

Sense of movement N
Comments: Inferred from drilling and gravity measurements in the southern part of the Tularosa Basin. Seager (1981 #968) estimated there may be as much as 4-5 km of throw across the Organ

Mountains fault, San Andres Mountains fault, and associated buried (major) faults on the west side of the Tularosa Basin.

Dip not reported
Comments: High angle as inferred from exposures of the Organ Mountains fault [2052], which joins the San Andres fault on the south.

Dip direction E

Geomorphic expression The fault forms nearly continuous scarps from 3 m to more than 29 m high on unconsolidated surficial deposits and poorly consolidated basin-fill deposits that underlie extensive piedmont-slope and alluvial-fan surfaces along the eastern margin of the San Andres Mountains. Morphology studies by Machette (1987) suggested that the scarps are probably latest Pleistocene (but not Holocene) in age.

Age of faulted deposits Little work has been done on the age of offset Quaternary deposits along the fault. However, general reconnaissance by Machette (1987 #847) suggested that the oldest faulted landforms are underlain by early to middle Pleistocene sediment equivalent to the Camp Rice Formation to the west. Although unmeasured, scarps on these deposits are very large, probably in the 50-60 m range. Piedmont-slope and alluvial-fan surfaces of middle (Tortugas alluvium, ca. 250±50 ka) and late Pleistocene (Picacho alluvium, ca. 100±30 ka) age are offset 26-29 m and 6-15 m, respectively. Scarps on the youngest faulted alluvium (late Pleistocene, >15 ka) are 2.7-5.4 m high and suggest that the most recent faulting occurred more than 15 ka, and perhaps about 25-35 ka.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: The morphology of scarps on the youngest faulted alluvium suggest that the most recent faulting occurred more than 15 ka, and perhaps about 25-35 ka (Machette, 1987 #847).

Recurrence interval 20-50 k.y. (<100±30 ka)
Comments: Machette (1987 #847) published a rough estimate of 20-50 k.y. based on an assumption of 2-5 faulting events for deposits correlated with the Picacho alluvium (ca. 100±30 ka), and as many as 10 faulting events for deposits correlated with the Tortugas alluvium (ca. 250±50 ka).

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip rate inferred from 6-15 m offset of Picacho alluvium (ca. 100±30 ka).

Length End to end (km): 50.6
Trace (km): 67.8

Average strike (azimuth) -7°±33°

Endpoints (lat. - long.) 33°12′11.69″N, 106°33′51.55″W
32°45′09.71″N, 106°28′29.34″W

2053c, southern section

Section number 2053c

Section name southern section
Comments: The fault extends from the latitude of Lead Camp Canyon, just west of the north end of Lake Lucero, south to Antelope Hill, just south of U.S. Highway 70. The fault joins the Organ Mountains fault [2052] at its southern end.

Reliability of location Good
Comments: Trace of fault based on 1:125,000-scale mapping by Seager (1987 #627) and detailed (1:24,000-scale) maps by Machette (1987 #847).

Sense of movement N

Comments: Inferred from drilling and gravity measurements in the southern part of the Tularosa Basin. Seager (1981 #968) estimated there may be as much as 4-5 km of throw across southern part of the San Andres Mountains fault, and similar buried (major) faults on the west side of the Tularosa Basin.

Dip not reported
Comments: High angle as inferred from exposures of the Organ Mountains fault [2052], which joins the San Andres fault on the south.

Dip direction E

Geomorphic expression The fault forms nearly continuous fresh-appearing scarps 3 m to >22 m high on unconsolidated surficial deposits and poorly consolidated basin-fill deposits that underlie extensive piedmont-slope and alluvial-fan surfaces that border the eastern margin of the San Andres Mountains. Morphology studies by Machette (1987 #847) suggested that the scarps are probably latest Pleistocene or Holocene in age.

Age of faulted deposits Little work has been done on the age of offset deposits along the fault. However, general reconnaissance by Machette (1987) suggested that the oldest faulted landforms are underlain by early to middle Pleistocene sediment equivalent to the Camp Rice Formation to the west. Although unmeasured, scarps on these deposits are very large, probably in the 50-60 m range. Piedmont-slope and alluvial-fan surfaces of middle (Tortugas alluvium, ca. 250±50 ka) and late Pleistocene (Picacho alluvium, ca. 100±30 ka) age are offset 22 m and 8-15 m, respectively. Scarps on the youngest faulted alluvium (latest Pleistocene) are 2.8-4.8 m high and suggest that the most recent faulting occurred about 10±5 ka (Machette, 1987 #847).

Detailed studies none

Timing of most recent paleoevent latest Quaternary (<15 ka)
Comments: The morphology of scarps on the youngest faulted alluvium suggest that the most recent faulting occurred at 10±5 ka (Machette, 1987 #847). This estimate is supported by the presence of scarps on most Pleistocene landforms.

Recurrence interval 20 k.y. (<100±30 ka)
Comments: Machette (1987 #847) published a rough estimate of 20 k.y. based on an assumption of 3-m offset faulting events and age/offset relations similar to those on the central section. However, if a more typical displacement per faulting event (2 m) is considered. Then the 8-15 m of offset of Picacho alluvium (ca. 100±30 ka) may have occurred during 4-7 faulting events, which shortens the recurrence interval.

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip rate inferred from 8-15 m offset of Picacho alluvium (ca. 100±30 ka).

Length End to end (km): 37.3
Trace (km): 47.9

Average strike (azimuth) -1°±32°

Endpoints (lat. - long.) 32°45′10.28″N, 106°28′29.66″W
32°25′00.86″N, 106°29′10.53″W

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#989 Kelley, V.C., 1955, Regional tectonics of south-central New Mexico Guidebook of south-central New Mexico: New Mexico Geological Society, 6th Field Conference, November 11-13, 1955, Guidebook, p. 96-104.

#847 Machette, M.N., 1987, Preliminary assessment of paleoseismicity at White Sands Missile Range, southern New Mexico—Evidence for recency of faulting, fault segmentation, and repeat intervals for major earthquakes in the region: U.S. Geological Survey Open-File Report 87-444, 46 p.
#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.
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#986 Woodward, L.A., Callender, J.F., Seager, W.R., Chapin, C.E., Gries, J.C., Shaffer, W.L., and Zilinski, R.E., 1978, Tectonic map of Rio Grande rift region in New Mexico, Chihuahua, and Texas, *in* Hawley, J.W., ed., Guidebook to Rio Grande rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, 1 pl., scale 1:1,000,000.

2054, Alamogordo fault

Structure Number 2054
Comments: Referred to as fault 7 on figure 1 and table 2 of Machette (1987 #847).

Structure Name Alamogordo fault
Comments: First mapped by Otte (1959 #983) and later by Pray (1961 #984), this fault was named by Machette (1987 #847) for its proximity to the town of Alamogordo, New Mexico. The Quaternary trace of the fault is conspicuous from the northern end of the Phillips Hills (about 56 km north of Alamogordo, New Mexico), south through Tularosa and Alamogordo and into the McGregor Bombing Range. The southernmost scarps end just north of Otero County Road 506, about 43 km south of Alamogordo. The compilers have seen the entire length of the fault on the ground with the exception of scarps in the northernmost 5 km of the McGregor Bombing Range.

Synopsis: Few details are known about the paleoseismic history of this long and potentially hazardous fault. It is a major range-bounding fault that forms the western base of the Sacramento Mountains and has conspicuous scarps from at least 56 km north to 43 km south of the town of Alamogordo. Only limited studies involving aerial photographic interpretation and scarp morphology have been conducted along the fault, although scarps along its entire length have been confirmed on the ground.

Date of compilation 09/30/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey; Keith I. Kelson, William Lettis & Associates, Inc.

State New Mexico

County Otero; Lincoln

1° x 2° sheet Carlsbad; Roswell; Tularosa

Province Basin and Range

Geologic setting Down-to-west, range-front fault bounding west side of the Sacramento Mountains and basinward foothills to the north and south along the east side of Tularosa Valley. The fault places Ordovician through Permian bedrock, which forms the gently east-tilted Sacramento Mountains, against Quaternary basin-fill sediment. The fault forms the main range-bounding structure of the Sacramento Mountains from the Coyote Hills at Temporal Creek south several kilometers past Pipeline Canyon. North of La Luz, the fault departs from the Sacramento Mountains and bounds the west margin of a series of intrabasin hills (Coyote and Phillips), whereas south of Bug Scuffle Canyon, the fault forms small scarps across the piedmont slope and along low-relief bedrock hills.

Number of sections 3

Comments: The sections are defined herein on the basis of fault location relative to the mountain front and on continuity and apparent age of scarps. No detailed studies have been made that would allow these sections to be defined as segments.

Length End to end (km): 109.5
Trace (km): 134.0

Average strike (azimuth) -9°±27°

Endpoints (lat. - long.) 33°29'34.04"N, 106°07'12.84"W
32°31'09.84"N, 105°55'24.27"W

2054a, Three Rivers section

Section number 2054a

Section name Three Rivers section

Comments: Grant (1984 #2003) used the term "Three Rivers-Sacramento fault" for the northern extension of the Alamogordo fault [2054]. However, the simple section name "Three Rivers" is accepted herein for its proximity to the small town of Three Rivers, which is about 27 km north of Tularosa, New Mexico. The Quaternary trace of this section of the fault is conspicuous from the northern end of the Phillip Hills (about 19 km north of Three Rivers) south to Temporal Creek (about 16 km south-southeast of Three Rivers). Quaternary scarps have been traced north to North Mill Arroyo, about 6 km west of Oscura, whereas the southern end of the fault is taken as a 1.4-km right-step in faulting at Temporal Creek, which separates the Three Rivers section from the Sacramento section [2054b] of the Alamogordo fault.

Reliability of location Good

Comments: Trace from 1:250,000-scale compilation based on aerial photograph interpretation and separate 1:24,000-scale field reconnaissance by Kelson and Machette in 1996. Northwest of Three Rivers, the fault is on the White Sands Proving Grounds (missile range), where public access is limited. This trace represents minor modifications from that shown on the small-scale map of Machette (1987 #847).

Sense of movement N

Dip not reported

Comments: Suspected to be a high-angle normal dip-slip fault from regional geologic studies and from other faults associated with downdropping of the Tularosa basin.

Dip direction W

Geomorphic expression Scarps along this section are quite obvious on aerial photographs (even where they as little as 1-2 m high), suggesting recent movement. West-facing piedmont scarps are as much as 18-m-high on Quaternary(?) alluvium (equivalent to Camp Rice Formation piedmont facies?). These size scarps are clearly the product of multiple faulting events, but there are some piedmont scarps about 2-2.5 km north of Temporal Creek that appear small enough to be the result of a single large faulting event or two smaller events. These small scarps are about 2-3 m high where they cross Otero County Road B2 to the High Nogal Ranch (previously known as the Stover Ranch) and have morphology that suggests late Pleistocene movement. Conversely, scarps at the bedrock/alluvial contact along the western side of the Phillips Hills have steep scarp angles (>33°) where only 1-2 m high, which suggests Holocene activity. At least in the Phillips Hills area, the continuous nature and fresh appearance of the scarps suggest Holocene movement. Such young movement is harder to detect on the larger (composite) scarps south of the Phillip Hills.

Age of faulted deposits There are no published (detailed) studies of the Quaternary deposits along this fault. The high scarps on Quaternary alluvium probably reflect a minimum amount for surface offset owing to pervasive burial on the downdropped side of the fault. The youngest faulted deposits are certainly of middle or late Quaternary age, but Holocene deposits may be faulted along the northern part of the section. The 2-m-high piedmont scarps near Temporal Creek are near the south end of the fault and are on deposits that have a moderately well developed soil (*i.e.*, late Pleistocene).

Detailed studies none

Timing of most recent paleoevent latest Quaternary (<15 ka)
Comments: Timing poorly controlled but based on scarp's fresh morphology along the Phillip Hills, continuity in faulting, and on suspected age of faulted deposits. No detailed studies have been conducted to confirm this age estimate.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on small (2-3 m) scarps on deposits of late Pleistocene age, and on 18-m-high scarps on Quaternary(?) alluvium.

Length End to end (km): 34.6
Trace (km): 48.0

Average strike (azimuth) -14°±27°

Endpoints (lat. - long.) 33°29'34.04"N, 106°07'12.84"W
33°11'11.74"N, 106°02'43.86"W

2054b, Sacramento Mountains section

Section number 2054b

Section name Sacramento Mountains section
Comments: This section constitutes the main, range-bounding fault and is informally referred to as the Sacramento Mountains section. It extends along the western front of the Sacramento Mountains from the north end of the Coyote Hills (at Temporal Creek) south to Bug Scuffle Canyon, where the fault trace departs from the base of the mountain front.

Reliability of location Good

Comments: Based on limited mapping at 1:24,000 scale by Machette (1987 #847), topographic map and aerial photographic interpretation (about 1:24,000 scale) by Machette, and from bedrock geologic mapping at 1:31,680 scale by Otte (1959 #983) and Pray (1961 #984).

Sense of movement N

Dip not reported
Comments: Suspected to be a high-angle normal dip-slip fault from regional geologic studies and from other faults associated with downdropping of the Tularosa basin.

Dip direction W

Geomorphic expression The Sacramento Mountains section has scarps that range from about 2-10 m in height on deposits believed to be early Holocene to late Pleistocene in age (respectively). The scarps have fresh morphology and are relatively continuous, suggesting that the most recent movement is relatively young. Scarp morphology studies by Machette (1987 #847) suggested that the youngest scarps are either latest Pleistocene or Holocene in age (*i.e.*, <15 ka). Otte (1959 #983) discussed evidence for abundant Pleistocene displacement along the fault, including the presence of "piedmont scarps" as much as 7 m in height and isolated gravels that are uplifted 30-60 m above present drainage.

Age of faulted deposits No detailed studies of fan-surface or alluvial-deposit age have been conducted yet, either along this section of the fault or along the western piedmont of the Sacramento Mountains. However, Machette (1987 #847) argued that the scarps are latest Pleistocene or Holocene in age, and the nearly continuous character of the scarps along the main range front tend to support this young age estimate.

Detailed studies none

Timing of most recent paleoevent: Holocene and post glacial (<15 ka)
Comments: Based on scarp morphology studies by Machette (1987 #847). Small (2-3 m high) scarps have morphologies that are similar to the Drum Mountains scarps (see Fig. 19 in Machette, 1987 #847). At that time, the Drum Mountain scarps were considered to be about 5 ka. However, recent studies by Crone (1983 #552) indicate that the Drum Mountain scarps are probably early Holocene in age. The Sacramento Mountain scarps also plot above (younger than) the 15-ka Bonneville shoreline (Bucknam and Anderson, 1979 #332). Thus, it appears that the youngest scarps on this section of the fault may have been formed between 10 ka and 15 ka. However, additional dating studies are needed to refine and/or substantiate this estimate.

Recurrence interval 20-25 k.y. (<35 ka)

Comments: Even though there are no definitive studies of the ages of offset deposits, Machette (1987 #847) suggested there could have been two episodes of movement in the latest Pleistocene (past 35 k.y. cited), which relates to a maximum interval of about 20-25 k.y. He also suggested that the fault may have a Quaternary movement history (*i.e.*, recurrence interval) similar to that of the central segment of the Andres Mountains fault [2053b] (20-50 k.y.) or Franklin Mountains fault [900] (9-22 k.y.).

Slip-rate category <0.2 mm/yr

Comments: The slip rate on the fault is poorly documented in terms of age of offset deposits. However, by using data presented by Machette (1987 #847),Salyards (1991 #1061) suggested a slip rate of 0.11 mm/yr.

(1987 #847)(1987 #847)(1991 #1061)(1987 #847)**Length** End to end (km): 62.0
Trace (km): 68.5

Average strike (azimuth) -14°±21°

Endpoints (lat. - long.) 33°11′13.40″N, 106°0′50.18″W
32°38′37.53″N, 105°51′21.80″W

2054c, McGregor section

Section number 2054c

Section name McGregor section
Comments: This section of the fault is named for the McGregor Bombing Range, which occupies the northeastern part of Fort Bliss. This section of the fault departs from the range front, crosses a broad piedmont, and forms the western margin of low bedrock-cored hills southeast of the Sacramento Mountains. It extends from Bug Scuffle Canyon south to Otero County Road 506 (Pipeline Canyon 7.5-minute quadrangle).

Reliability of location Good
Comments: Trace based on aerial-photographic and topographic-map interpretation and field studies by Machette in 1996, which were compiled at 1:24,000 scale and transferred to a 1:250,000-scale base map. The southern portion of the fault is within McGregor Bombing Range, which has limited public access.

Sense of movement N

Dip not reported

Comments: Suspected to be a high-angle normal dip-slip fault from regional geologic studies and from other faults associated with downdropping of the Tularosa basin.

Dip direction W

Geomorphic expression The scarps along this section depart from the Sacramento Mountain front at Bug Scuffle Canyon, and extend south across a west-sloping piedmont. The scarps are west-facing and as much as 25 m high on dissected Quaternary alluvium (Camp Rice Formation piedmont facies?). These size scarps are clearly the product of multiple faulting events, but smaller scarps on late(?) Quaternary piedmont-deposits may be the result of only one or two faulting events. Machette's brief (1996) reconnaissance of these scarps indicates they are probably as young as late Pleistocene, but are not of latest Pleistocene age. The fault forms prominent and conspicuous scarps as far south as Otero County Road 506; no conspicuous scarps were found south of the road.

Age of faulted deposits There have been no detailed studies of the Quaternary deposits or scarps along this section of the fault. The high scarps are probably on older (early?) Quaternary alluvium, which may represent Camp Rice piedmont facies. The faulted deposits are certainly as young as middle to late Quaternary, but it is unknown whether latest Pleistocene or Holocene deposits are faulted.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Timing poorly controlled but based on presence of small, yet clear scarps on piedmont slope deposits of suspected late Quaternary age.

Recurrence interval not reported

Slip-rate category unknown, probably <0.2 mm/yr
Comments: Low slip rate category assigned is based on lower rate of activity (smaller scarps) than along main section of the Alamogordo fault.

Length End to end (km): 14.9
Trace (km): 17.5

Average strike (azimuth) 021°±28°

Endpoints (lat. - long.) 32°38′42.74″N, 105°52′02.71″W
32°31′09.84″N, 105°55′24.27″W

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#1061 Salyards, S.L., 1991, A preliminary assessment of the seismic hazard of the southern Rio Grande rift, New Mexico, *in* Barker, J.M., Kues, B.S., Austin, G.S., and Lucas, S.G., eds., Geology of the Sierra Blanca, Sacramento and Capitan Ranges, New Mexico: New Mexico Geological Society, 42nd Field Conference, October 9-12, 1991, Guidebook, p. 199-202.

2055, Unnamed fault/monocline

Structure Number 2055

Structure Name Unnamed fault/monocline
Comments: This unnamed structure was shown by Seager and others (1987 #627) as extending from the center of the Hueco basin (about 4 km west-northwest of Hueco siding, New Mexico), east and south along the western edge of the Hueco uplift into Texas. The southern end of the structure has not been defined; although it probably extends south into Texas, it was not shown by Collins and others (1996 #993) on their fault map of West Texas.

Synopsis: Little is known about this structure. It forms a west-trending monocline within the Hueco basin but becomes a south-trending fault along the east margin of the basin (Seager and others, 1987 #627). No studies of scarp morphology or detailed mapping have been performed.

Date of compilation 02/02/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Otero

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Location taken from 1:125,000-scale mapping of Seager and others (1987 #627).

Geologic setting This intrabasin to basin-marginal fault and monocline lie along the eastern margin of the Hueco basin. Few faults exist in this part of the basin, although farther north, the Alamogordo fault forms the eastern margin of the Hueco basin and the western margin of the Sacramento Mountains and Otero Hills.

Sense of movement N

Dip not reported

Dip direction SW

Geomorphic expression The structure is expressed at the surface as a gentle southside-down monocline that trends east-west and a gentle west-side-down fault scarp that trends south to southeast. The area of transition between the two different expressions is taken as the midpoint of its inferred (dashed) trace on Seager and other's (1987 #627) map.

Age of faulted deposits Seager and others (1987 #627) show the fault and monocline developed in sediment the Camp Rice Formation (Pliocene to early or middle Pleistocene).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: The structure deforms the surface of the Camp Rice Formation (Pliocene to early or middle Pleistocene), and thus must postdate its stablization, which in the Mesilla basin is considered to have occurred between 0.7-0.9 Ma (Mack and others, 1993 #1020).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip rate inferred from other similar faults of the Hueco basin.

Length End to end (km): 19.6
Trace (km): 21.9

Average strike (azimuth) -54°±27°

Endpoints (lat. - long.) 32°6′18.16″N, 106°18′17.51″W
32°0′6.17″N, 106°8′9.88″W

References

#993 Collins, E.W., Raney, J.A., Machette, M.N., Haller, K.M., and Dart, R.L., 1996, Map and data for Quaternary faults in West Texas and adjacent parts of Mexico: U.S. Geological Survey Open-File Report 96-002, 74 p., 1 pl., scale 1:500,000.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2056, Jornada Draw fault

Structure Number 2056

Structure Name Jornada Draw fault
Comments: Named by Seager and Mack (1995 #963) for the fault's apparent control of the course of Jornada Draw, an ephemeral stream that drains the axial portion of the southern Jornada del Muerto. The fault extends south-southeast from near Engle to south of the Point of Rocks Hills, a distance of about 64 km. A similarly positioned unnamed fault was shown by Woodward and others (1978 #986) on a regional map of the Rio Grande rift, but subsequent studies of the suballuvial geology showed that the existence of that fault was based on mistaken interpretations (Seager and Mack, 1995 #963). Seager and Mack (1995 #963) suggested three segments for the fault, but this scheme is not supported by paleoseismic or geomorphic data nor were the limits of the segments defined; therefore they are referred here to as sections.

Synopsis: The fault is marked by a series of low, subtle scarps on Quaternary deposits, by the eastward termination and offset of Tertiary bedrock units, and by tectonically induced physiography, such as playa lakes along the downthrown (eastern) side of the fault. No specialized studies have been conducted along the fault, although it is seen in several natural exposures. Soil development has been used to estimate the timing of most recent movement on the fault.

Date of compilation 01/10/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana; Sierra

1° x 2° sheet Las Cruces; Tularosa

Province Basin and Range

Geologic setting The Jornada Draw fault is the mutual boundary between two major late Tertiary structural blocks; it appears to have accommodated growing structural relief between the eastward-tilted

Caballo Mountains horst on the west and the broad, shallow Jornada del Muerto syncline (pre-Quaternary) on the east. On the basis of drill-hole information (Seager and others, 1987 #627), it appears that early Tertiary rocks are offset as much as 305-564 m along the fault. Although most of the fault's offset apparently occurred in Pliocene time, its most recent movement probably was in the middle Pleistocene. Quaternary offset locally exceeds 30 m, and a late Pliocene (?) basaltic cinder cone is offset along the northern section of the fault.

Number of sections 3
Comments: Although originally defined as segments by Seager and Mack (1995 #963), their scheme was not supported by paleoseismic or geomorphic data nor were the limits of the segments defined. Therefore, we consider these portions of the fault to be sections for descriptive purposes.

Length End to end (km): 62.0
Trace (km): 72.1

Average strike (azimuth) -27°±27°

Endpoints (lat. - long.) 33°10'33.56"N, 107°4'40.59"
32°40'44.81"N, 106°46'27.53"W

2056a, northern section

Section number 2056a

Section name northern section
Comments: Referred to as the northern segment of the Jornada Draw fault by Seager and Mack (1995 #963). This part of the fault extends from about 3 km west of Engle to the north side of the Prisor Hill. The southern boundary is at 33° 00', just west of the Aleman Ranch headquarters.

Reliability of location Good
Comments: General trace of the fault shown on 1:125,000-scale map of Seager and Mack (1995 #963), but detailed trace is based on 1:24,000-scale mapping of Seager (in press #1261) and Mack and Seager (in press #1262).

Sense of movement N
Comments: Seager and Mack (1995 #963) show this as a normal fault.

Dip 60° E
Comments: Fault dip measured in natural exposure along Aleman Draw near southern end of section. Seager and Mack (1995 #963). However, Seager and Mack (1995 #963) suggested that the fault may have an east-dipping listric geometry on the basis of gentle (1°) west-dipping strata that could represent reverse drag on the fault.

Dip direction E

Geomorphic expression The northern section of the fault is characterized by small subtle scarps on piedmont-slope deposits of the Palomas Formation that forms the constructional Cuchillo surface. The scarps are locally as high as 30 m, but appear quite variable. For example, just north of New Mexico State Highway 52 (Engle to Truth or Consequences), the upper beds of the Palomas Formation are only offset 4.5-6 m, although 3 km farther south the associated Cuchillo surface is offset about 30 m. At Black Hill, the fault has produced 15-30 m of displacement of the basaltic cinder cone, which probably dates from late Pliocene time (Seager and Mack, 1995 #963).

Age of faulted deposits The fault displaces early Tertiary bedrock, late Pliocene basalts, Pliocene and Pleistocene basin-fill deposits of the Palomas Formation, and the 700-900 ka (Mack and others, 1993 #1020) constructional Cuchillo surface. There is no evidence that late Pleistocene and Holocene deposits are disturbed by the fault.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Seager and Mack (1995 #963) argued that the piedmont scarps are clearly younger than the Cuchillo surface (900-700 ka, Mack et al, 1993), but are older than well developed calcic soils (probably at least 400 ka) that have formed on the scarps. The relations between faulted and unfaulted soils on the southern section suggest that the most recent displacement probably occurred closer to 400 ka (Seager and Mack, 1995 #963).

Recurrence interval not reported
Comments: No information exists about the timing of discrete events along the fault. However, owing to the size of the scarps (15-30 m), they are clearly the product of multiple faulting events during the middle Pleistocene. Conversely, no faulting events are known to have occurred during the past 400 k.y.

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip rate category assigned based on assumption that 15-30 m of slip occurred between 900-700 ka and 400 ka, and there has been demonstrable no slip in the past 400 k.y.

(1995 #963)**Length** End to end (km): 20.6
Trace (km): 24.9

Average strike (azimuth) -20°±16°

Endpoints (lat. - long.) 33°10′33.56″N, 107°4′40.59″
32°59′59.30″N, 107°0′30.13″W

2056b, central section

Section number 2056b

Section name central section
Comments: Referred to as the central segment of the Jornada Draw fault by Seager and Mack (1995 #963). This part of the fault extends from the north side of Prisor Hill (at the Aleman Ranch headquarters) to the south side of the Point of Rocks Hills at the Sierra/Dona Ana County line.

Reliability of location Good
Comments: General trace of the fault shown on 1:125,000-scale map of Seager and others (1987 #627).

Sense of movement N
Comments: Seager and Mack (1995 #963) show this as a normal fault.

Dip not reported
Comments: Seager and Mack (1995 #963) suggested that the fault may have an east-dipping listric geometry on the basis of gentle (1°) west-dipping strata that could represent reverse drag on the fault.

Dip direction NE

Geomorphic expression This section of the fault is characterized by remnants of once more extensive bedrock exposures (Prisor, Upham, and Point of Rocks Hills) on the footwall (west) side of the fault. In general, the position of the fault is obscured by piedmont-slope and alluvial-fan surfaces that cross the fault with only subtle (small) breaks in slope, although the course of the fault probably controls Jornada Draw. No measurements of scarp heights or offset were mentioned by Seager and Mack (1995 #963).

Age of faulted deposits The piedmont-slope deposits are probably related to constructional surfaces of the Camp Rice and Palomas Formations, which are as young as 700-900 ka (Mack and others, 1993 #1020).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)

Comments: In as much as this section has few piedmont scarps on the Cuchillo or La Mesa surfaces, the minimum time for fault movement is probably best characterized as early to possibly middle Pleistocene. Thus, we classify the fault as Quaternary.

Recurrence interval not reported

Slip-rate category unknown, probably <0.2 mm/yr
Comments: A low slip rate is inferred from slip rates estimated for adjacent sections of the fault, and from the lack of moderately large (10-30 m high) scarps. Seager and Mack (1995 #963) argued that the fault's net offset (and perhaps its younger displacement pattern) mimics the structural relief along the Caballo Mountains horst, and thus slip (and slip rates) might be greatest in the central section. Nevertheless, the Quaternary slip rate for this fault is most likely <0.2 mm/yr, especially for the past 400 k.y.

Length End to end (km): 25.5
Trace (km): 27.1

Average strike (azimuth) -17°±23°

Endpoints (lat. - long.) 32°59′59.30″N, 107°0′29.52″W
32°46′46.98″N, 106°55′43.76″W

2056c, southern section

Section number 2056c

Section name southern section
Comments: Referred to as the southern segment of the Jornada Draw fault by Seager and Mack (1995 #963). This part of the fault extends from the south side of the Point of Rocks Hills to its southern end, which is due east of Hatch, New Mexico.

Reliability of location Good
Comments: General trace of the fault shown on 1:125,000-scale map of Seager and others (1987 #627).

Sense of movement N
Comments: Seager and Mack (1995 #963) show this as a normal fault.

Dip not reported
Comments: Seager and Mack (1995 #963) suggested that the fault may have an east-dipping listric geometry on the basis of gentle (1°) west-dipping strata that could represent reverse drag on the fault.

Dip direction NE

Geomorphic expression The southern section of the fault is characterized by small subtle scarps on piedmont-slope deposits of the Camp Rice Formation that form the constructional La Mesa surface. The scarps are a maximum of 9 m high and appear degraded. For example, just south of Point of Rocks, the scarp has maximum slope angles of 20° or less. In this area, there are a series of playas along the foot of the scarp, indicating local tilting and formation of closed-basin drainages.

Age of faulted deposits The fault cuts Pliocene and Pleistocene basin-fill deposits of the Camp Rice Formation and the constructional La Mesa surface (middle to early Pleistocene). There is no evidence that late Pleistocene and Holocene deposits are disturbed by the fault.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Seager and Mack (1995 #963) argued that the piedmont scarps along this section are clearly younger than the La Mesa surface (700-900 ka, Mack and others, 1993 #1020), and are older than well developed calcic soils (probably at least 400 ka) that have formed on the scarps. However, the relations between faulted and unfaulted soils suggest that the most recent displacement probably occurred closer to 400 ka (Seager and Mack, 1995 #963).

Recurrence interval not reported

Comments: No information exists about the timing of discrete events along the fault. However, owing to the size of the scarps (<9 m), they are probably the product of multiple faulting events during the middle Pleistocene. Conversely, no faulting events are known to have occurred during the past 400 k.y.

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Low slip rate category assigned based on assumption that 9 m of slip occurred between 900-700 ka and 400 ka, and there has been demonstrable no slip in the past 400 k.y.

(1995 #963)**Length** End to end (km): 18.3

Trace (km): 20.1

Average strike (azimuth) -51°±27°

Endpoints (lat. - long.) 32°46′48.01″N, 106°55′43.76″W

32°40′44.81″N, 106°46′27.53″W

References

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#1262 Mack, G.H., and Seager, W.R., in press, Geology of Engle quadrangle, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 79, 2 sheets, scale 1:24,000.

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

#963 Seager, W.R., and Mack, G.H., 1995, Jornada Draw fault—A major Pliocene-Pleistocene normal fault in the southern Jornada Del Muerto: New Mexico Geology, v. 17, no. 3, p. 37-43.

#1261 Seager, W.R., and Mack, G.H., in press, Geology of Cutter quadrangle, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 80, 2 sheets, scale 1:24,000.

#986 Woodward, L.A., Callender, J.F., Seager, W.R., Chapin, C.E., Gries, J.C., Shaffer, W.L., and Zilinski, R.E., 1978, Tectonic map of Rio Grande rift region in New Mexico, Chihuahua, and Texas, *in* Hawley, J.W., ed., Guidebook to Rio Grande rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, 1 pl., scale 1:1,000,000.

2057, Unnamed fold

Structure Number 2057

Structure Name Unnamed fold

Comments: This unnamed fold is shown by Seager and others (1987 #627) as extending north-south for about 3 km in the southern part of the Tularosa basin (within White Sands National Monument).

Synopsis: Little is known about this structure. It is manifested at the surface as a north-trending fold that deforms basin-floor deposits of latest Pleistocene to Holocene age. No studies of morphology or detailed mapping have been performed.

Date of compilation 02/08/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Otero

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Location taken from 1:125,000-scale mapping of Seager and others (1987 #627).

Geologic setting This intrabasin fold may reflect faulting in the subsurface, or perhaps diapiric movement of low-density materials (shales, gypsum, etc.). The relatively small size of the fold implies that it is related to a source in the shallow subsurface.

Sense of movement Anticline

Dip not reported
(1987 #627)

Dip direction E, W
Comments: The limbs of this anticline dip toward the margins of the Tularosa Basin and the axis plunges north and south at their respective ends.

Geomorphic expression The structure is expressed at the surface as a gentle dome-like fold that is elongate north-south.

Age of faulted deposits Seager and others (1987 #627) showed the fold developed in fine-grained basin floor deposits (Holocene to latest Pleistocene). The structure deforms the surface of the deposits, and thus must postdate their deposition. The fold is mapped between two areas of stabilized (inactive) gypsiferous sand dunes.

Detailed studies none

Timing of most recent paleoevent: latest Quaternary (<15 ka)
Comments: Timing based on Seager and others (1987 #627) estimate of the age of folded sediment, which is the uppermost unit in the area. However, no detailed mapping or dating of the basin-floor deposits have been performed to document this relatively young time of movement.

Recurrence interval not reported

Uplift-rate category unknown; probably <0.2 mm/yr
Comments: Low uplift rate inferred from slip rates on associated faults in the Hueco basin to the south. However, the presence of the structure in young (<15 ka) deposits suggests it may have a much higher uplift rate associated with it.

Length End to end (km): 3.1
Trace (km): 3.1

Average strike (azimuth) -7°±7°

Endpoints (lat. - long.) 32°43′50.99″N, 106°20′18.12″W
32°42′10.66″N, 106°20′4.20″W

References

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2058, Guadalupe fault

Structure Number 2058

Structure Name Guadalupe fault
Comments: Young movement on the Guadalupe fault is demonstrated by a relatively short scarp that extends from about 3 km north to 2 km south of the Chaves/Otero County line, 1-2 km east of Pinon

Creek. The scarp was first mentioned by Kelley (1971 #990) as part of a regional geologic study of southeastern New Mexico. It is named by Kelley (fig 4. in 1971 #990) for its location along the base of the Guadalupe Mountains.

Synopsis Little is known about this short but recently active portion of the Guadalupe fault, which forms scarps on unconsolidated Quaternary deposits at the western base of the Guadalupe Mountains. No detailed studies have been made, with the exception of scarp morphology studies by the compiler.

Date of compilation 02/02/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Chaves; Otero

1° x 2° sheet Carlsbad

Province Basin and Range

Reliability of location Good
Comments: Scarps first shown on photograph (fig. 13 in Kelley, 1971 #992) and registered to roadlog for field trip (mile 126.8, Kelley and Singletary, 1971 #990). Machette relocated the scarps in the field (unpublished 1:24,000-scale mapping, 1981) and transferred their location to a 1:250,00-scale base map.

Geologic setting The scarps are along the Guadalupe fault, which forms the northern part of the western escarpment (The Rim) of the Guadalupe Mountains. Kelley (p. 38 1971 #992) considered the Guadalupe Mountains as largely a late Tertiary Basin and Range fault block. If so, the scarps reflect minor late Quaternary reactivation of the uplift.

Sense of movement N

Dip not reported

Dip direction W
Comments: Inferred from topography and structure (uplift) of the Guadalupe Mountains (Kelley, 1971 #992) and from fault scarps. King (1948 #857) showed the fault as dipping to the west.

Geomorphic expression The fault forms a short but continuous scarp on unconsolidated sediment (alluvial fans and colluvium) shed from the Guadalupe Mountains. Scarps are formed on three different levels of alluvial surfaces, and show progressively more offset on higher (hence, older) surfaces. Five topographic profiles (M32-1 to -5, M.N. Machette, 1981) across the fault show that the scarps are about 2-12 m high and have maximum scarp-slope angles of 16.5°-24.4°. The youngest surface has scarps that are 2.1-3.3 m high, whereas the next higher surface has scarps that are 4.3-5.1 m high and thus are the product of at least two discrete faulting events. The highest surface has a young scarp element (6 m high) superposed on a larger compound scarp that is nearly 12 m high.

Age of faulted deposits No studies have been made of the age of the faulted surficial deposits. However, the presence of three discrete alluvial surfaces suggests that the highest one could be as old as the penultimate glaciation (130 ka). At this location, the fault separates unconsolidated Quaternary deposits on the west from Permian Yeso Formation on the east.

Detailed studies none

Timing of most recent paleoevent latest Quaternary (<15 ka)
Comments: Data from the youngest measured scarps, which are 2.1 and 3.3 m high and have maximum slope angles of 16.5° and 19°, plot above (younger than) the 15-ka Bonneville shoreline (see Bucknam and Anderson, 1979 #332). These data suggest that the most recent scarp-forming event occurred in the early Holocene or latest Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably, <0.2 mm/yr
Comments: A low slip rate is inferred from the short length of scarps and from relatively small amounts (2-6 m) of displacement of the two younger alluvial surfaces.

Length End to end (km): 5.6
Trace (km): 5.6

Average strike (azimuth) -5°±10°

Endpoints (lat. - long.) 32°33′07.58″N, 105°08′55.60″W
32°30′06.82″N, 105°08′37.91″W

References

#332 Bucknam, R.C., and Anderson, R.E., 1979, Estimation of fault-scarp ages from a scarp-height—slope-angle relationship: Geology, v. 7, p. 11-14.
#992 Kelley, V.C., 1971, Geology of the Pecos country, southeastern New Mexico: [New Mexico] Bureau of Mines and Mineral Resources Memoir 24, 75 p., 7 pls.
#990 Kelley, V.C., and Singletary, C.E., 1971, Road log of a route from Roswell to Rio Penasco, Dunken uplift, Guadalupe escarpment, and to Carlsbad (Second Day), *in* Kelley, V.C., ed. Stratigraphy and structure of the Pecos country, southeastern New Mexico: West Texas and Roswell Geological Societies Publication 71-58, October 27-29, 1971, Guidebook, p. 21-29.
#857 King, P.B., 1948, Geology of the southern Guadalupe Mountains Texas: U.S. Geological Survey Professional Paper 215, 183 p., 1 pl., scale 1:48,000.

2059, Unnamed fault northeast of Longhorn Ranch

Structure Number 2059

Structure Name Unnamed fault northeast of Longhorn Ranch
Comments: This unnamed Quaternary fault was mapped by Johnpeer and others (1987 #1672) in a study for the proposed Estancia Basin, New Mexico, Superconducting Super Collider (SSC) site. The fault is located northeast of Longhorn Ranch (8 miles east of Moriarty), and extends from U.S. Highway 66 north to the vicinity of El Cuervo Butte.

Synopsis: Little is known about this recently mapped bedrock and Quaternary fault along the eastern margin of the Estancia basin. Most of the trace of the fault is mapped in either Permian and Triassic bedrock or in Pliocene(?) to Pleistocene deposits. The fault has been drilled and trenched as part of a regional reconnaissance study of a potential site for the now defunct Superconducting Super Collider (SSC). Post-Permian throw on the fault is no more than 108 ft. (33 m), and no quantitative information has been published about the fault's movement history in the Quaternary.

Date of compilation 03/24/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Santa Fe; Torrance

1° x 2° sheet Santa Fe

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:62,500-scale map of Stanley 15-minute quadrangle, which was enlarged to 1:24,000-scale by Johnpeer and others (1987 #1672). The fault trace was transferred to a 1:250,000-scale topographic base and digitized.

Geologic setting This north-trending fault forms a gentle scarp (on alluvium) to locally steep escarpment (on bedrock) on the eastern margin of the northern part of the Estancia basin. It is mapped as offsetting Pliocene(?) to Pleistocene deposits (QTa) and a variety of bedrock units, such as Triassic mudstones and claystones, and the Permian Yeso Formation and Glorieta Sandstone. On the basis of drill-hole data, there does not appear to be no more than 108 ft. (33 m) of throw on the fault.

Sense of movement N

Dip 60° W-90°
Comments: The trench log of Johnpeer and others (1987 #1672) shows a near surface dip of about 60°, with the fault plane steepening to vertical within 3 m of the surface. The fault is probably high-angle at depth.

Dip direction W
Comments: As shown on figure 3.2-1B of Johnpeer and others (1987 #1672).

Geomorphic expression Johnpeer and others (1987 #1672) reported that the fault forms a gentle scarp on alluvium to a locally steep escarpment on bedrock. No topographic-profile data was collected to quantify the morphology of the scarps on alluvium.

Age of faulted deposits The fault offsets deposits that underlie the older (Quaternary) alluvium of Johnpeer and others (1987 #1672). These unbroken cover units contain a moderately well-developed calcic horizon (Bk) of pedogenic origin, thus indicating that the fault last moved well in excess of 10 ka. No descriptive or laboratory data are presented from which one might estimate the probable age of the unfaulted soil.

Detailed studies Site 2050-1: Johnpeer and others (1987 #1672) excavated an exploratory trench across the mapped trace of this unnamed fault. Their site (SSC-BH-10, fig. 3.2-1B) was located on the north bank of a small unnamed stream channel about 2.8 km NNE of Erramousbe Ranch (Stanley 15-minute quadrangle). The trench showed evidence of Quaternary offset of sandy to silty gravels, gravelly silty clay, and silty to fine sands (units 4-8). Unit 3 buries the scarp associated with the fault plane in the trench, and units 1 and 2 form a fairly uniform ground surface that does not display evidence of deformation (these interpretations were made by the compiler from trench log SSC-BH-10, fig. 3.2-1B). The upper three units (1-3) are referred to as older alluvium (see p. 3-31 in Johnpeer and others, 1987 #1672). No information about the age of faulted and unfaulted materials are included on the log or the discussion in the text of the report.

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Quaternary movement indicated by Johnpeer and others (1987 #1672); however, they conclude that the fault has not been active for more than 10,000 years.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: A very low slip rate is probably associated with movement on this fault owing to the probable time of last movement (pre-Holocene) and lack of surficial expression in the older alluvium.

Length End to end (km): 10.0
Trace (km): 11.3

Average strike (azimuth) 006°±38°

Endpoints (lat. - long.) 35°05′42.59″N, 105°51′05.06″W
35°00′23.77″N, 105°52′18.27″W

References

#1672 Johnpeer, G., Robinson-Cook, S., Bobrow, D., Barrie, D., Kelliher, J., and McNeil, R., 1987, Geology and tunneling, *in* Estancia Basin, New Mexico superconducting super collider: New Mexico Bureau of Mines and Mineral Resources Open-File Report 258, p. 3-1 to 3-224.

2060, Engle Lake fault

Structure Number 2060
Comments:

Structure Name Engle Lake fault
Comments: The Engle Lake fault was named by Mack and Seager (in press #1262) for Engle Lake, an ephemeral lake (playa) located about 2 km southwest of Engle, New Mexico. The fault extends south and southeast from the latitude of Cedar Lake, to the west side of Engle Lake. It is parallel to the Jornada Draw fault [2056], which has similar characteristics.

Synopsis: The fault is marked by a series of low, subtle scarps on early Quaternary deposits and a larger (25 m? high) scarp on a late Pliocene basalt flow. It causes tectonically induced physiography such as backtilted Quaternary surfaces and has playa lakes along the downthrown (eastern) side of the fault. It forms the eastern margin of the Central horst, an uplifted Neogene fault block cored by Cretaceous rocks. No specialized studies have been conducted along the fault, although it is seen in several natural exposures.

Date of compilation 05/07/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace of the fault shown on the 1:24,000-scale map of Mack and Seager (in press #1262).

Geologic setting The Engle Lake fault forms the eastern margin of the Central horst, an uplifted Neogene fault block cored by Cretaceous rocks. The western margin of the horst is formed by the Main-Central fault (not documented as Quaternary), which may link southward with the Jornada Draw fault [2056]. The Engle Lake fault may have as much as 330 m of stratigraphic offset in Cretaceous rock, and appears to deform Pliocene to Pleistocene sediment of the Palomas Formation as much as 15 m.

Sense of movement N
Comments: Inferred from regional extension related to the Rio Grande rift and from dips measured on faults of similar age and orientation in the region.

Dip not reported

Dip direction E

Geomorphic expression The fault is characterized by small subtle scarps on piedmont-slope deposits that form the Cuchillo surface, which is the constructional top of the Palomas Formation. On the northern part of the fault, there is a larger (25 m?) scarp on a late Pliocene basalt flow, as determined from inspection of the Engle 7.5-minute topographic map. Near Engle Lake, both the piedmont-slope deposits and the Cuchillo surface are tilted west-southwest 1°-3°. Mack and Seager (in press #1262) report as much as 15 m of stratigraphic separation on the early(?) Pleistocene Cuchillo surface, although the fault is shown on their maps as entirely concealed beneath this surface. Engle Lake appears to be an axial playa on the hangingwall dip slope, adjacent (east of) to the fault.

Age of faulted deposits The fault displaces Cretaceous bedrock, Pliocene to early Pleistocene basin-fill deposits of the Palomas Formation, and the 700-900 ka (Mack and others, 1993 #1020) constructional Cuchillo surface. There is no evidence that late Pleistocene and Holocene deposits are disturbed by the fault.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Mack and Seager (in press #1262) indicated that the piedmont scarps are clearly younger than the Cuchillo surface (900-700 ka in Mack and others, 1993 #1020) and suggested that the faulting may be as recent as late Pleistocene. However, because deformation is only documented for the Cuchillo surface, the most recent faulting event is herein considered to be <750 ka.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on 15 m scarps on the Cuchillo surface (900-700 ka) as reported by Mack and Seager (in press #1262).

(in press #1262)**Length** End to end (km): 9.2
Trace (km): 11.6

Average strike (azimuth) -13°±19°

Endpoints (lat. - long.) 33°14’07.98”N, 107°03’59.89”W
33°09’18.63”N, 107°02’39.20”W

References

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#1262 Mack, G.H., and Seager, W.R., in press, Geology of Engle quadrangle, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 79, 2 sheets, scale 1:24,000.

2061, East Tonuco fault/fold

Structure Number 2061

Structure Name East Tonuco fault/fold
Comments: Named by Seager and others (1971 #994) for the fault/fold along the eastern side of the Tonuco uplift. The most prominent peak in this uplift is San Diego Mountain. Surficial expression of the structure extends from the northwest margin of San Diego Mountain, along the east side of the uplift, and south into the Jornada basin. The southern 9.5 km of the structure is mapped as a north-side-down monocline and fault. From this point southeast and south, the fault is shown as the Jornada fault, which shows no evidence of post early Quaternary movement at the surface.

Synopsis: Little is known about this fault, which is also expressed as a fold. It forms the southeastern structural margin of the Jornada del Muerto, a late Tertiary sedimentary basin. The fault forms scarps and a monocline on deposits of early to middle Pleistocene age, thus suggesting movement since 750 ka. No detailed studies have been conducted to better define the timing or amount of Quaternary movement on the structure.

Date of compilation 02/06/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good

Comments: Generalized trace of the fault is from 1:125,000-scale map in Seager and others (1987 #627).

Geologic setting The fault forms the eastern side of the Tertiary Tonuco uplift. It places Pliocene and Pleistocene sediment of the Camp Rice Formation (on the north and east) against Precambrian, Paleozoic (minor amounts), and Tertiary rocks in the uplifted block. The La Mesa surface, which stabilized between 700 ka and 900 ka (Mack and others, 1993 #1020), is offset by the fault where it crosses Interstate Highway I-25; therefore it is more than just a monocline at that point. From I-25 north to the Tonuco Uplift, it is difficult to distinguish between a fault and monoclinal expression; it may be both. To the south of I-25, the structure is mapped as a monocline that merges with the northern part of the subsurface Jornada fault (pre-middle Pleistocene), east of the Dona Ana Mountains. Seager and others (1971 #994) cited at least 30 m of offset of Camp Rice sediment along the fault.

Sense of movement N

Dip 60°-80°
Comments: Seager and others (1971 #994) show three measurements of dip along the fault. Along the eastern side of the Tonuco uplift, 60° and 80° dips are recorded. A single relatively low-angle dip of 40° is recorded from Picture Rock Canyon on the north flank of San Diego Mountain, although the majority of Seager and others (1971 #994) cross sections show the fault as having a high-angle dip.

Dip direction N, E

Geomorphic expression The majority of the fault is expressed geomorphically as an escarpment formed by sediment against bedrock, although in at least three areas, the fault is entirely within Camp Rice sediment. No detailed examination has been made of the fault scarps, but Seager and others (1971 #994) summarized its expression as being essentially an uneroded fault scarp. In retrospect, Seager (written commun., 1988) considers that the steepness of the degraded scarp is the result of resistant sandstone beds of the Camp Rice Formation, which are present in both the hangingwall and footwall of the fault.

Age of faulted deposits Seager and others (1971 #994) mentioned that the fault is within sediment of the Camp Rice Formation. The La Mesa surface, which stabilized between 700 ka and 900 ka (Mack and others, 1993 #1020), is offset by the fault. Seager and other's (1971 #994) plate 1 shows a dashed fault (position approximate) in young alluvium, but from their discussion, we suspect that this unit is not offset. Thus, it appears that the fault cuts material that is as young as early to middle Pleistocene (Mack and others, 1993 #1020).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on deformation of constructional surface of fluvial facies of the Camp Rice Formation (Seager and others, 1971 #994), which probably is between 700 ka and 900 ka (Mack and others, 1993 #1020), although we cannot preclude younger movement.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: A low slip rate is inferred from an estimate of 30 m of offset in Camp Rice Formation sediment and an estimate of 700-900 ka for age of the youngest part of this material.

Length End to end (km): 14.5
Trace (km): 17.6

Average strike (azimuth) -44°±34°

Endpoints (lat. - long.) 32°36'58.59"N, 106°59'21.61"W
32°31'57.56"N, 106°52'16.43"W

References
#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.
#994 Seager, W.R., Hawley, J.W., and Clemons, R.E., 1971, Geology of San Diego Mountain area, Doña Ana County, New Mexico: New Mexico State Bureau of Mines and Mineral Resources Bulletin 97, 38 p., 2 pls.
#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2062, Unnamed intrabasin faults

Structure Number 2062

Structure Name Unnamed intrabasin faults
Comments: This series of unnamed faults forms a wide band of intrabasin deformation between the south-southeast-trending Jornada Draw fault [2056] on the north and the similar-trending East Tonuco fault [2061] on the south.

Synopsis: This zone of intrabasin faults deforms a high-level (old) geomorphic surface (Jornada del Muerto) related to ancient floodplain of the ancient Rio Grande. The faults have relatively small displacement in materials that are probably 700-900 ka. However, younger movement cannot be precluded without detailed studies of scarp morphology or trenching, neither of which have not been conducted.

Date of compilation 02/08/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the fault shown on 1:250,000-scale map of Seager and others (1987 #627).

Geologic setting This zone of intrabasin faults resemble the southern end of the Jornada Draw fault [2056c]. They deform a high-level geomorphic surface (Jornada del Muerto) that represents ancient floodplain of the Rio Grande. The faults have relatively small displacement at the surface as determined from 1:24,000-scale topographic maps of the area.

Sense of movement N
Comments: Inferred from regional extension related to the Rio Grande rift and from dips measured on faults of similar age and orientation in the region.

Dip not reported

Dip direction W; N; E
Comments: This zone includes north-trending faults that dip either east or west, and a single east-west fault that dips north.

Geomorphic expression These faults form a series of subdued yet conspicuous scarps that are easily seen on the rather flat surface of the southern Jornada del Muerto. No information is available about scarp heights or morphology. Most of the scarps appear to be between 5 m and 20 m high as viewed on 1:24,000-scale topographic maps of the area.

Age of faulted deposits The faults displace the constructional surface of the Camp Rice Formation (fluvial facies), which probably became stabilized about 700-900 ka (Mack and others, 1993 #1020). No detailed mapping has been done along the faults to determine if younger deposits are offset.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: The faults are younger that the surface of the Camp Rice Formation (fluvial facies), which probably became stabilized about 700-900 (Mack and others, 1993 #1020). However, the scarps are readily visible on aerial photographs, suggesting that they are considerably younger than sediment of the Camp Rice Formation.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: A low slip-rate category is assigned based on the amount of surface displacement (5-20 m, estimated from 1:24,000-scale topographic maps) on a surface estimated to be of 700-900 k.y. old.

Length not applicable
Comments: This zone includes several faults that have an end to end length of 27.9 km and a cumulative trace length of 39.8 km.

Average strike (azimuth) -16°±39°

Endpoints (lat. - long.) 32°45′34.88″N, 106°58′14.28″W
32°32′42.23″N, 106°48′55.63″W

References

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2063, East Robledo fault

Structure Number 2063

Structure Name East Robledo fault
Comments: This fault was first mapped by Kottlowski (1960 #1010), but he did not name it. Ruhe (1962 #1637) applied the name Robledo to the fault, and it was used by De Hon (1965 #1018) and Hawley and Kottlowski (1969 #1009). However, the name was later changed to the East Robledo fault (Clemons and others, 1975 #1011) to differentiate it from the West Robledo fault [2064]. The surface trace of the East Robledo fault extends from the north edge of Robledo Mountain (about 3 km southwest of Fort Selden), south along the mountain front to about 10 km west of Las Cruces, New Mexico. From here, the fault extends south-southwest across high-level geomorphic surfaces; its mapped surface trace ends about 3 km southwest of Afton (siding) according to Seager and others (1987 #627).

Synopsis: This major Quaternary fault bounds the uplifted Robledo Mountain and forms intrabasin scarps on the upper and lower La Mesa (geomorphic) surfaces west of Las Cruces. No detailed studies have been made of the fault or its scarp's morphology.

Date of compilation 02/12/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the entire fault is from the 1:125,000-scale map of Seager and others (1987 #627). Kottlowski (1960 #1010) appears to have been the first to show the fault on a Quaternary geologic map, and Ruhe (1967 #1008) mapped the northern part at 1:62,500 scale during a regional study of Quaternary geology.

Geologic setting This major range-bounding fault forms the eastern side of the Robledo Mountain block and places Quaternary sediment against bedrock. The Robledo Mountain block is a horst that bounds the western edge of the Rio Grande valley, north and west of Las Cruces. South of the Robledo Mountains, it is entirely within sediment of the Camp Rice Formation and younger material along its southern half.

Sense of movement N

Dip not reported
Comments: The fault is shown as a high-angle structure on Seager and others' (1987 #627) cross sections (C and D). However, no specific dip values are shown on their small-scale map.

Dip direction E

Geomorphic expression The fault bounds the uplifted Robledo Mountain block and places Paleozoic and Tertiary rock in the hanging (west) wall against Quaternary sediment on the footwall. In some places, the fault is entirely within sediment of the Camp Rice Formation, but south of Picacho Mountain the fault forms a southward-widening zone of intrabasin scarps on the upper and lower La Mesa (geomorphic) surfaces west of Las Cruces. The fault separates the upper (western block) and lower (eastern block) La Mesa surfaces, and although both are formed by aggrading deposits of Camp Rice Formation, the upper surface is probably a local, tectonically uplifted surface that is not regionally significant as a stratigraphic datum. The fault offsets Camp Rice Formation sediment about 90 m on the east side of Robledo Mountain (Clemons and others, 1975 #1011) and the La Mesa surfaces as much as 61 m along Interstate Highway 10, but the amount of surficial throw decreases to the south (Ruhe, 1967 #1008). For example, the scarp is about 40 m high at Norwood Ranch, 23 m high at Perry Ranch, and is hardly discernible at Brook Tank (Ruhe, 1962 #1637). No detailed studies have been made of the fault or its scarp morphology.

Age of faulted deposits A variety of Quaternary units are offset as shown on the maps of Ruhe (1967 #1008) and Seager and others (1987 #627). Quaternary units that are faulted include the upper part of the Camp Rice Formation (early to middle? Pleistocene), the upper and lower La Mesa surfaces (contructional surfaces of the Camp Rice Formation) and a sequence of older (middle Pleistocene) alluvial-fan and river-terrace deposits (Qvo) that are equivalent to the Tortugas alluvium (ca. 250±50 ka) (Hawley and Kottlowski, 1969 #1009). Geomorphic equivalents of the lower La Mesa surface are believed to have stabilized about 700-900 ka (Mack and others, 1993 #1020), whereas the upper La Mesa is older, but probably still Quaternary. The Tortugas and La Mesa surfaces are offset from 6 to 61 m respectively, and there are indications of slight warping and faulting of the Picacho surface (possibly late middle to late Pleistocene; ca. 100±30 ka) (Hawley and Kottlowski, 1969 #1009).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on offset of Tortugas (middle Pleistocene, ca. 250±50 ka) alluvial-fan and river-terrace deposits (Qvo) as well as the lower La Mesa surface (700-900 ka). However, faulting may have occurred in the late Pleistocene (Hawley and Kottlowski, 1969 #1009) based on indications of

slight warping and faulting of the Picacho surface (possibly late middle to late Pleistocene; ca. 100±30 ka).

Recurrence interval not reported

Slip-rate category unknown, probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on 6 m scarps on the Tortugas surface (250±50 ka), and on 60-m-high scarps on the lower La Mesa surface (700-900 ka).

Length not applicable
Comments: This fault includes several splays that have an end to end length of 46.7 km and a cumulative trace length of 103.8 km.

Average strike (azimuth) 003°±27°

Endpoints (lat. - long.) 32°28′12.90″N, 106°55′25.44″W
32°03′02.20″N, 106°58′15.40″W

References

#1011 Clemons, R.E., Hawley, J.W., Hoffer, J.M., and Seager, W.R., 1975, Second day, road log from Las Cruces to the Sierra de las Uvas and Aden volcanic area, and return, *in* Seager, W.R., Clemons, R.E., and Callender, J.F., eds., Guidebook of the Las Cruces country: New Mexico Geological Society, 26th Field Conference, November 13-15, 1975, Guidebook, p. 17-34.

#1018 De Hon, R.A., 1965, Maare of La Mesa, *in* Fitzsimmons, J.P., and Lochman-Balk, C., eds., Guidebook of southwestern New Mexico II: New Mexico Geological Society, 16th Field Conference, October 15-17, 1965, Guidebook, p. 204-209.

#1009 Hawley, J.W., and Kottlowski, F.E., 1969, Quaternary geology of the south-central New Mexico border region, *in* Kottlowski, F.E., and Lemone, D.V., eds., Border stratigraphy symposium: [New Mexico] Bureau of Mines and Mineral Resources Circular 104, p. 89-115.

#1010 Kottlowski, F.E., 1960, Reconnaissance geologic map of Las Cruces thirty-minute quadrangle: [New Mexico] Bureau of Mines and Mineral Resources Geologic Map 14, 1 sheet, scale 1:126,720.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#1637 Ruhe, R.V., 1962, Age of the Rio Grande valley in southern New Mexico: Journal of Geology, v. 70, p. 151-167.

#1008 Ruhe, R.V., 1967, Geomorphic surfaces and surficial deposits in southern New Mexico: [New Mexico] Bureau of Mines and Mineral Resources Memoir 18, 66 p., 2 pls., scale 1:62,500.

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2064, West Robledo fault

Structure Number 2064

Structure Name West Robledo fault
Comments: This fault was first mapped by Kottlowski (1960 #1010), but he did not name it. The first and only name applied is the West Robledo fault (Seager and Clemons, 1975 #1002), which serves to differentiate it from the East Robledo fault [2063]. Its surface trace extends from the north edge of Robledo Mountain (about 3 km southwest of Fort Selden), southwest along the west side of Robledo Mountain (Seager and others, 1987 #627). It crosses Interstate Highway 10 about 25 km west of Las Cruces, New Mexico. From here, the fault extends southwest across the La Mesa surface, along the west side of the Aden Hills, and south through basalt flows of the West Potrillo Mountains (Seager and others, 1987 #627).

Synopsis: This Quaternary fault bounds the west side of Robledo Mountain and the Aden Hills to form the western margin of a wide horst block. Much of the fault offsets the upper La Mesa (geomorphic) surface of probable early Quaternary age. No detailed studies have been made of the fault or its scarp morphology.

Date of compilation 02/12/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the entire fault is from 1:125,000-scale maps of Seager and others (1987 #627) and Seager (1995 #975). Kottlowski (1960 #1010) appears to have been the first to show the fault on a Quaternary geologic map, although he only mapped the northern portion, which is on the Las Cruces 15′ quadrangle.

Geologic setting The fault bounds the uplifted Robledo Mountain block and Aden Hills and places Paleozoic and Tertiary rock in the footwall (east side) against Quaternary sediment on the hanging-wall (west side). Between these two uplifts, the fault is entirely within sediment of the Camp Rice Formation and deforms the upper La Mesa (geomorphic) surface. South of the Aden Hills, the fault is entirely within Quaternary basalt flows of the West Potrillo Mountains. The West Robledo [2064] and East Robledo [2063] faults form a southward-widening horst block that separates the Mesilla Basin (to the east) and Mimbres Basin (to the west).

Sense of movement N

Dip not reported
Comments: The fault is shown as a high-angle structure on Seager and others (1987 #627) (cross section C and E). However, no specific dip values are shown on their small-scale map.

Dip direction W

Geomorphic expression The fault offsets (upper?) La Mesa surface <10 m near Interstate Highway 10, and the throw does not appear to increase much to the south. To the north of Corralitos Ranch, the fault controls north-northwest-trending stream drainages. No detailed studies have been made of the fault or its scarp morphology.

Age of faulted deposits As shown on the map of Seager and others(1987 #627), faulted Quaternary units include the upper part of the Camp Rice Formation (early to middle? Pleistocene), the upper? La Mesa surface (contructional top of Camp Rice Formation) and Quaternary basalts of the West Potrillo Mountains. The upper La Mesa is probably a local, tectonically uplifted surface that is not regionally significant as a stratigraphic datum; however it clearly pre-dates the lower La Mesa, which is believed to have stabilized about 700-900 ka (see Mack and others, 1993 #1020). The presence of 1.2-Ma basalt on the upper La Mesa surface (Seager, 1995 #975) suggests it is of early Quaternary age . No measurements of offset of La Mesa surface or the basalt are published; however, topographic maps indicate little (<10 m) offset of La Mesa surface in the vicinity of Interstate Highway 10.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing based on offset of upper(?) La Mesa surface (>1.2 Ma). However, middle Pleistocene or younger faulting may have occurred.

Recurrence interval not recorded

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Low slip-rate category assigned based on 10 m scarps on the upper La Mesa surface (1.2 Ma). There may be considerably more offset across the fault towards its northern end, and much of this offset may have occurred later. However, the suggested amount and timing of faulting to the north does not indicate including it in a higher slip-rate category.

Length End to end (km): 102.5

Trace (km): 117.6

Comments: Fault continues into Mexico as MX-94. Lengths do not include this portion of the fault.

Average strike (azimuth) 008°±25°

Endpoints (lat. - long.) 32°28′12.90″N, 106°55′25.13″W

31°33′19.90″N, 107°04′54.65″W

References

#1010 Kottlowski, F.E., 1960, Reconnaissance geologic map of Las Cruces thirty-minute quadrangle: [New Mexico] Bureau of Mines and Mineral Resources Geologic Map 14, 1 sheet, scale 1:126,720.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.

#1002 Seager, W.R., and Clemons, R.E., 1975, Middle to Late Tertiary geology of Cedar Hills-Selden Hills area, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 133, 24 p., 2 pls.

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2065, Fitzgerald fault

Structure Number 2065

Structure Name Fitzgerald fault

Comments: This fault was first mapped as an unnamed structure by Kottlowski (1960 #1010), but by 1965 De Hon (1965 #1018) had referred to it as the Fitzgerald Ranch fault (name shown on 1943 version of the Afton 15′ quadrangle, New Mexico). Its surface trace extends from just northeast of Phillps Hole (a Quaternary maar crater), north about 27 km to the latitude of San Tomas, New Mexico. according to mapping by Seager and others (1987 #627). The northern part of the fault splits into two subparallel strands.

Synopsis: This intrabasin Quaternary fault forms west-facing scarps on the lower La Mesa (geomorphic) surface, southwest of Las Cruces. The position of the fault is inferred from these scarps and from a linear alignment of closed depressions. No detailed studies have been made of the fault or its scarp morphology.

Date of compilation 02/12/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces; El Paso

Province Basin and Range

Reliability of location Good

Comments: Generalized trace of the entire fault is from 1:125,000-scale map in Seager and others (1987 #627). Kottlowski (1960 #1010) appears to have been the first to show the fault on a Quaternary geologic map, whereas Hoffer (1973 #1718) showed the fault with a more western position.

Geologic setting This intrabasin fault deforms the lower La Mesa (geomorphic) surface. In addition, the position of the fault is inferred from a linear alignment of closed depressions on this rather planar surface. Hoffer (1973 #1718) inferred that the southern part of the fault controls the location of Hunts and Kilborne Holes, which is possibly late Pleistocene in age (Seager and others, 1987 #627), as well as Gardner Cone, and thus mapped it further to the west. However, Seager and others (1987 #627) map the southern part of the fault further east and as extending nearly as far south as Phillips Hole.

Sense of movement N

Dip not reported

Comments: The fault is shown as a high-angle structure on Seager and others (1987 #627) cross sections (E and F). However, no specific dip values are shown on their small-scale map.

Dip direction W

Geomorphic expression The trace of the fault is entirely on the lower La Mesa (geomorphic) surface. The trace is characterized by relatively small, west-facing scarps and by closed (trough) depressions. The fault may displace the lower La Mesa surface as much as 20 m at Fitzgerald Ranch, but topographic maps of the area (8-m contours) indicate that scarp heights of 6-15 m are more common. Much of the trace is covered by thick eolian deposits, which are common on La Mesa surfaces. No detailed studies have been made of fault scarp morphology.

Age of faulted deposits The surface deformation associated with the fault postdates formation of the lower La Mesa surface (contructional top of Camp Rice Formation), which is believed to have stabilized about 700-900 ka (Mack and others, 1993 #1020). As mapped by Seager and others (1987 #627), the fault does not cross the adjacent Afton basalt field.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)

Comments: Timing based on offset of the lower La Mesa surface (700-900 ka). However, evidence for younger (late Pleistocene) faulting may be obscured by eolian deposits.

Recurrence interval not reported

Slip-rate category unknown, probably <0.2 mm/yr

Comments: Low slip-rate category assigned based on 18 m scarps on the lower La Mesa surface (700-900 ka).

Length End to end (km): 27.1
Trace (km): 38.6.

Average strike (azimuth) 007°±22°

Endpoints (lat. - long.) 32°10′26.31″N, 106°49′41.48″W
31°55′57.12″N, 106°52′00.68″W

References

#1018 De Hon, R.A., 1965, Maare of La Mesa, *in* Fitzsimmons, J.P., and Lochman-Balk, C., eds., Guidebook of southwestern New Mexico II: New Mexico Geological Society, 16th Field Conference, October 15-17, 1965, Guidebook, p. 204-209.

#1718 Hoffer, J.M., ed., 1973, The geology of southcentral Dona Ana County, New Mexico: El Paso Geological Society, 7th Field Trip, April 7, 1973, Guidebook, p. 67.

#1010 Kottlowski, F.E., 1960, Reconnaissance geologic map of Las Cruces thirty-minute quadrangle: [New Mexico] Bureau of Mines and Mineral Resources Geologic Map 14, 1 sheet, scale 1:126,720.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.
#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2066, East Potrillo fault

Structure Number 2066

Structure Name East Potrillo fault
Comments: This fault was shown on a small-scale figure by De Hon (1965 #1018). Although the fault is named for the East Potrillo Mountains (see Seager and Mack, 1994 #1015), the first record we could find was Reeves' (1969 #1017) use of the term "Potrillo fault" for the southward extension of the East Robledo [2063] and Fitzgerald [2065] faults into Mexico. The fault's surface trace extends from the north edge of the East Potrillo Mountains (about 5 km east of Mount Riley), south along the east side of the mountain front and the Potrillo maar. It crosses the International Boundary with Mexico at a point about 3 km east of 107° (which is 9 km west of Noria, New Mexico) and extends south-southeast into Mexico an unknown distance. Reeves (1969 #1017) reported that the fault extends at least 24 km, and perhaps as much as 64 km, southeast into Mexico, although the trace has not been shown on a topographic base map.

Synopsis: This south-southeast trending fault bounds the eastern margin of the uplifted and tilted East Potrillo Mountain and forms east-facing intrabasin scarps on the La Mesa (geomorphic) surface southwest of Las Cruces and in northern Chihuahua, Mexico. No detailed studies have been made of the fault, but scarp-morphology data have been collected along a short part of the fault in New Mexico.

Date of compilation 02/12/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico; Chihuahua (Mexico)

County Dona Ana

1° x 2° sheet El Paso; Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the fault in New Mexico is from 1:125,000-scale maps of Seager and others (1987 #627) and Seager (1995 #975), but Seager and Mack (1994 #1015) also mapped the U.S. part of the fault at 1:24,000 scale. Parts of the fault have been shown on various small- to intermediate-scale maps, primarily in articles about the bedrock geology of the East Potrillos or regional studies of Quaternary geology in both the U.S. and Mexico.

Geologic setting This range-bounding fault forms the eastern side of the southwest-tilted East Potrillo Mountain block (asymmetrical horst). It forms persistent east-facing scarps on Quaternary sediment of the Camp Rice Formation (and equivalent units in Mexico) and locally on younger Quaternary surfical materials.

Sense of movement N

Dip 75° E
Comments: The fault is shown as a high-angle structure on the cross sections of Seager and Mack (1994 #1015). They reported a dip of 75° for the fault where it cuts tuffaceous deposits of the Potrillo maar.

Dip direction NE

Geomorphic expression The fault forms persistent east-facing scarps on sediment of the Camp Rice Formation and on younger alluvial-fan and piedmont-slope deposits. Scarp morphology studies by Machette (unpublished, 1980) indicate scarp heights of about 7-17 m and maximum scarp-slope angles of about 9.5-14.5° along the southern 5 km of the East Potrillo Mountains. Measurements were made from 9 profiles of multiple-event fault scarps on deposits of late middle Pleistocene age, which he estimated to be 250-400 ka on the basis of soil development. Where bevels were obvious on the crest and toe of the scarps, the smallest height elements of these scarps are about 5-7 m, which in themselves suggest two or more faulting events. Even plotting the smaller scarp elements against maximum scarp-slope angle (see Machette and McGimsey, 1983 #1024) yields morphologies considerably more degraded than that of the 15-ka Bonneville shoreline (Bucknam and Anderson, 1979 #332), but less degraded that that of the 100-ka Santa Rita fault scarp (Pearthree and Calvo, 1987 #1023). The scarp morphology data are clear evidence of recurrent movement in the middle to late Pleistocene, with the most recent event probably in late, but not latest Pleistocene time.

Age of faulted deposits Quaternary units that are faulted include the upper part of the Camp Rice Formation (early to middle? Pleistocene), the upper and lower La Mesa surfaces (contructional surfaces of the Camp Rice Formation), airfall tuff deposits of the Potrillo maar (180,000 yrs old Seager and Mack, 1994 #1015), and a sequence of older (middle late? Pleistocene) alluvial-fan and piedmont deposits that may be equivalent to the Jornada and Tortugas or Picacho alluviums (ca. 250±50 ka and 100±30 ka, respectively). Geomorphic equivalents of the lower La Mesa surface are believed to have stabilized about 700-900 ka (Mack and others, 1993 #1020), whereas the upper La Mesa is early Quaternary where overlain by the West Potrillo basalt (about 1.2 Ma).

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Timing based on offset of 180-ka airfall tuff deposits of the Potrillo maar, middle to late(?) Pleistocene surfaces, and scarp morphology. The most recent faulting event probably occurred since 100 ka, but well before 15 ka as indicated by scarp morphology comparisons.

Recurrence interval not reported

Slip-rate category unknown, probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on 7-10 m scarps on the lower of two faulted surfaces (Tortugas?) and 12-17 m on the upper of two faulted surfaces (Jornada), both of which are believed to be middle Pleistocene in age.

Length End to end (km): 30.7
Trace (km): 42.6

Average strike (azimuth) -24°±24°

Endpoints (lat. - long.) 32°′02′39.04″N, 107°04′39.91″W
31°47′03.48″N, 106°57′55.94″W

References

#332 Bucknam, R.C., and Anderson, R.E., 1979, Estimation of fault-scarp ages from a scarp-height—slope-angle relationship: Geology, v. 7, p. 11-14.

#1018 De Hon, R.A., 1965, Maare of La Mesa, *in* Fitzsimmons, J.P., and Lochman-Balk, C., eds., Guidebook of southwestern New Mexico II: New Mexico Geological Society, 16th Field Conference, October 15-17, 1965, Guidebook, p. 204-209.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.
#1023 Pearthree, P.A., and Calvo, S.S., 1987, The Santa Rita fault zone—Evidence for large magnitude earthquakes with very long recurrence intervals, Basin and Range province of southeastern Arizona: Bulletin of the Seismological Society of America, v. 77, p. 97-116.
#1017 Reeves, C.C., Jr., 1969, Pluvial Lake Palomas northwestern Chihuahua, Mexico, *in* Córdoba, D.A., Wengerd, S.A., and Shomaker, J., eds., Guidebook of the border region: New Mexico Geological Society, 20th Field Conference, October 23-25, 1969, Guidebook, p. 143-154.
#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.
#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.
#1015 Seager, W.R., and Mack, G.H., 1994, Geology of East Potrillo Mountains and vicinity, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 113, 28 p., 3 pls.

2067, Mastodon fault

Structure Number 2067

Structure Name Mastodon fault
Comments: First mapped by Seager and others (1987 #627), this fault was later named by Hawley and Lozinsky (1992 #985), most likely for the Mastodon railroad siding (Strauss 7.5' quadrangle, 1955 version).

Synopsis: No studies have been made on this down-to-the-west intrabasin fault that offsets La Mesa surface by 3-6 m. It produces a west-facing scarp that has a thick cover of eolian sand in many places. The fault trace appears as an irregular escarpment on topographic maps and aerial photographs.

Date of compilation 02/16/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet El Paso

Province Basin and Range

Reliability of location Good
Comments: Location from 1:125,000-scale map of Seager and others (1987 #627), and extended northwest on basis of the 1:100,000-scale map (plate 1) of Hawley and Lozinsky (1992 #985) with trace fitted to 1:24,000-scale topography.

Geologic setting This down-to-the-west intrabasin fault offsets La Mesa surface, which is underlain by the Camp Rice Formation. It produces a west-facing fault scarp which is obscured in many places by a thick cover of eolian sand. It is one of many intrabasin faults in the southern Mesilla Basin.

Sense of movement N
Comments: Inferred from cross sections of Seager and others (1987 #627) and regional geology (Cenozoic extension).

Dip not reported

Dip direction SW

Comments: Inferred from geometry of other intrabasin faults shown on cross sections of Seager and others (1987 #627) and from aspect of fault scarps.

Geomorphic expression This fault forms west-facing scarps that are largely obscured by a thick cover of eolian sand. The surface of the relatively flat La Mesa surface appears to be offset 3-6 m as determined from generalized surface elevations on either side of the fault. In addition, the trace of the fault is irregular, suggesting substantial erosion of the scarp (*i.e.*, a fault-line scarp) in many places.

Age of faulted deposits La Mesa surface and underlying Camp Rice Formation are offset by the fault. Elsewhere in the Mesilla basin, the lower La Mesa (which is recognized to the north, west of Las Cruces) is considered to have been established between 700-900 ka (Mack and others, 1993 #1020).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on offset of La Mesa surface. However, younger movement may have occurred.

Recurrence interval not reported

Slip-rate catgory unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on small (3-6 m) scarps on middle Quaternary surface.

Length End to end (km): 13.8
Trace (km): 14.3

Average strike (azimuth) -38°±18°

Endpoints (lat. - long.) 31°52′54.57″N, 106°45′36.56″W
31°47′02.08″N, 106°40′14.59″W

References

#985 Hawley, J.W., and Lozinsky, R.P., 1992, Hydrogeologic framework of the Mesilla Basin in New Mexico and western Texas: New Mexico Bureau of Mines and Mineral Resources Open-File Report 323, 50 p., 17 pls.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2068, Unnamed fault southeast of Strauss

Structure Number 2068

Structure Name Unnamed fault southeast of Strauss
Comments: As mapped by Seager and others (1987 #627), the fault extends south and southeast from near Strauss, New Mexico, to a point about 2 km north of the international boundary between the United States and Mexico.

Synopsis: No studies have been made on this down-to-the-east intrabasin fault that may offset La Mesa surface by several meters. The east-facing scarp that has a thick cover of eolian sand in many places. The escarpment is quite irregular on topographic maps and aerial photographs, with a pronounced scalloped trace; these features suggest that the scarp may be the result of landsliding rather than faulting. However, no specific studies have been made of this feature.

Date of compilation 02/16/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet El Paso

Province Basin and Range

Reliability of location Good
Comments: Location from 1:125,000-scale map of Seager and others (1987 #627).

Geologic setting This possible down-to-the-east intrabasin fault offsets the La Mesa surface and sediment of the underlying Camp Rice Formation. The fault (slip plane) trends parallel to the southwestern edge of the Rio Grande valley and forms a scarp that is obscured in many places by a thick cover of eolian sand.

Sense of movement N
Comments: Inferred from cross sections of Seager and others (1987 #627) and regional geology (Cenozoic extension).

Dip not reported

Dip direction NE
Comments: Inferred from geometry of other intrabasin faults shown on cross sections of Seager and others (1987 #627) and from orientation of scarp.

Geomorphic expression This fault forms an east- to north-facing scarp that is largely obscured by a thick cover of eolian sand. The relatively flat La Mesa surface appears to be offset several meters as determined from generalized surface elevations on either side of the fault. The trace of the escarpment is quite irregular on topographic maps and aerial photographs, with a pronounced scalloped shape and possible backtilted(?) topography, suggesting that it may be the result of landsliding rather than faulting.

Age of faulted deposits The La Mesa surface and underlying Camp Rice Formation are offset by the fault. Elsewhere in the Mesilla basin, the lower La Mesa (which is recognized to the north, west of Las Cruces) is considered to have been established between 700-900 ka (Mack and others, 1993 #1020).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka))
Comments: Timing based on offset of La Mesa surface. However, younger movement may have occurred much more recently, especially if the escarpment is the result of landsliding.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip rate category assigned based on only several meters of offset having occurred in that past half million years or more.

Length End to end (km): 9.1
Trace (km): 11.4

Average strike (azimuth) -43°±40°

Endpoints (lat. - long.) 31°51'44.09"N, 106°41'06.63"W
31°48'14.02"N, 106°37'04.87"W

References

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2069, Unnamed fault north of Strauss

Structure Number 2069

Structure Name Unnamed fault north of Strauss
Comments: Mapped by Seager and others (1987 #627). Fault extends north from the railroad alignment starting at a point about 3 km northwest of Strauss, New Mexico.

Synopsis: No studies have been made of this north-trending, down-to-the-east intrabasin fault that offsets La Mesa surface. The east-facing scarp that has a thick cover of eolian sand and is marked by closed depressions on the east (downdropped) side.

Date of compilation 02/16/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet El Paso

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:125,000-scale map of Seager and others (1987 #627).

Geologic setting This down-to-the-east intrabasin fault offsets La Mesa surface and sediment of the underlying Camp Rice Formation along a north-south trend. It produces an east-facing fault scarp that is marked by closed depressions on the downdropped (east) side and is covered in many places by a thick mantle of eolian sand.

Sense of movement N
Comments: Inferred from cross sections of Seager and others (1987 #627) and regional geology (Cenozoic extension).

Dip not reported

Dip direction E
Comments: Inferred from geometry of other intrabasin faults shown on cross sections of Seager and others (1987 #627) and from orientation of scarp.

Geomorphic expression This fault forms an east-facing scarp that is largely obscured by a thick cover of eolian sand. The surface of the relatively flat La Mesa surface appears to be offset 3-7 m as determined from generalized surface elevations on either side of the fault. The escarpment has several elongate closed depressions on the downdropped side, suggesting local blockage of fault-parallel drainage by eolian sand, which has moved from west-to-east across La Mesa.

Age of faulted deposits La Mesa surface and sediment of the underlying Camp Rice Formation are offset by the fault. Elsewhere in the Mesilla basin, lower La Mesa surface (which is recognized to the north, west of Las Cruces) is considered to have been established between 700-900 ka (Mack and others, 1993 #1020).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)

Comments: Timing based on offset of La Mesa surface. However, younger movement may have occurred more recently, but such evidence is probably obscured by eolian sand.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip rate category assigned based on only several meters of offset having occurred in that past half million years or more.

Length End to end (km): 6.9
Trace (km): 6.6

Average strike (azimuth) -1°±8°

Endpoints (lat. - long.) 31°56′27.21″N, 106°43′26.54″W
31°52′41.87″N, 106°43′18.03″W

References

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2070, Unnamed fault east of Black Mountain

Structure Number 2070

Structure Name Unnamed fault east of Black Mountain
Comments: Mapped by Seager and others (1987 #627). Fault trends northwest across the dissected western margin of the Rio Grande valley, due east of Black Mountain. The fault is located about 2-3 km west of Chamberino, New Mexico.

Synopsis: No studies have been made of this northwest-trending, down-to-the-northeast intrabasin fault that offsets sediment of the Camp Rice Formation along the western margin of the Rio Grande valley, northwest of Anthony, New Mexico.

Date of compilation 02/16/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Location from 1:125,000-scale map of Seager and others (1987 #627).

Geologic setting This down-to-the-northeast intrabasin fault offsets sediment of the Camp Rice Formation an unknown amount along a northwest trend. It is mapped for only a short distance within the bluffs of the Rio Grande valley.

Sense of movement N
Comments: Inferred from cross sections of Seager and others (1987 #627) and regional geology (Cenozoic extension).

Dip not reported

Dip direction NE
Comments: Inferred from geometry of other intrabasin faults shown on cross sections of Seager (1995 #975).

Geomorphic expression No expression as a recognizable scarp. The fault only is exposed in sediment of the Camp Rice Formation (basin-fill deposits).

Age of faulted deposits As shown by Seager and others (1987 #627), the upper part of the Camp Rice Formation is offset by the fault. The upper part of these deposits are considered to be Quaternary, and may be as young as 700-900 ka (Mack and others, 1993 #1020) immediately below the lower La Mesa surface, such as at this location. However, the fault does not appear to offset La Mesa surface, thereby limiting it most recent (recognized) movement as >700 ka.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Quaternary, but >700 ka. Timing based on offset of Camp Rice Formation beneath lower La Mesa surface but no recognized offset of the lower La Mesa surface (700-900 ka).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: A very low slip rate is inferred from calculated or estimated slip rates on other intrabasin faults in the area. No measurements of offset have been reported.

Length End to end (km): 3.0
Trace (km): 2.8

Average strike (azimuth) -48°±8°

Endpoints (lat. - long.) 32°02′57.43″N, 106°42′42.39″W
32°01′51.58″N, 106°41′17.05″W

References
#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.
#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.
#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2071, Mount Riley fault zone

Structure Number 2071

Structure Name Mount Riley fault (zone)
Comments: This fault zone was named for Mount Riley (see Seager and Mack, 1994 #1015). The zone is several kilometers wide in bedrock, but only a single surface trace is preserved on the southwestern margin of the zone.

Synopsis: This fault bounds the western margin of the uplifted East Potrillo Mountains (a horst) and forms a west-facing scarp on dissected sediment of the Camp Rice Formation, northwest of the Potrillo maar, and cuts Quaternary basalt southwest of Cox Peak. The fault may be a mountainward (eastern) splay of the West Robledo fault [2064]. No detailed studies have been made of the fault.

Date of compilation 02/16/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet El Paso

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the fault in New Mexico is from 1:125,000-scale map of Seager (1995 #975), but Seager and Mack (1994 #1015) mapped the fault zone at 1:24,000 scale. Only the portion of the fault with surficial expression is included on the map and in this discussion.

Geologic setting This poorly defined, mainly concealed northwest-trending range-bounding fault forms the western side of the southwest-tilled East Potrillo Mountain block (horst). It includes a dissected west-facing scarp on sediment of the Camp Rice Formation (Pliocene to Quaternary). Other strands of the fault zone form reverse fault-line scarps that separate lower Santa Fe Group sediment from piedmont-facies sediment of the Camp Rice Formation and are inferred (not proven) to cut basalt of the West Potrillo Mountains to the west of Mount Riley. The fault zone may be a mountainward (eastern) splay of the West Robledo fault [2064] . No detailed studies have been made of the fault.

Sense of movement N

Dip not reported
Comments: The fault zone is shown as being comprised of high-angle faults on cross sections of Seager and Mack (1994 #1015) and Seager (1995 #975).

Dip direction SW

Geomorphic expression Most of the faults in this relatively wide zone (as mapped by Seager and Mack, 1994 #1015) are buried by Quaternary deposits or basalts, but there is a short (5-km-long) fault scarp along the southwest margin of the fault zone and a few inferred scarps on basalt along the northwest part of the zone. Several of the faults form reverse fault-line scarps owing to more resistant rocks (Tertiary volcanics) on the downdropped (western) side of the faults. No detailed studies have been made of the fault scarps or their morphology.

Age of faulted deposits Quaternary units that are faulted include sediment of the upper part of the Camp Rice Formation (as young as early to middle? Pleistocene) and possibly some basalts of the West Potrillo Mountains (Seager, 1995 #975).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: The faulted deposits require Quaternary movement along at least one strand of the fault, whereas the other strands may have been active, but there is no surficial evidence of Quaternary movement on them.

Recurrence interval not reported

Slip-rate category unknown, probably <0.2 mm/yr
Comments: A low slip rate is inferred from the small apparent offset associated with scarp on sediment of the Camp Rice Formation and from rates of more conspicuous Quaternary faults in the region.

Length End to end (km): 35.9
Trace (km): 57.2
Comments: Fault continues into Mexico as MX-96 and -MX96b Lengths do not include these portions of the fault.

Average strike (azimuth) -34°±22°

Endpoints (lat. - long.) 31°54′50.41″N, 107°08′15.14″W
31°38′39.37″N, 106°55′42.09″W

References

#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.

#1015 Seager, W.R., and Mack, G.H., 1994, Geology of East Potrillo Mountains and vicinity, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 113, 28 p., 3 pls.

2072, Quebraditas fault zone

Structure Number 2072

Structure Name Quebraditas fault zone

Comments: This fault zone was named by Baltz and O'Neill (1986 #1714) for Las Quebraditas Valley, a northeast-trending strike valley that is formed by the Quebraditas fault zone. As mapped by Baltz and O'Neill (1986 #1714), the fault zone extends from the Sapello River on the south, north and northeast along the Quebraditas Valley to Rito Cebolla, a small stream that drains the Cebolla Valley.

Synopsis: Backsliding (extension) on this former Laramide reverse fault zone has resulted in a large continuous fault-line escarpment on Precambrian and Paleozoic rocks. Evidence for Quaternary movement is recorded by small isolated scarps (less than 5 percent of the faults length) on alluvial-fan deposits derived from the adjacent fault-line escarpment. Also, south of Rociada and Manuelitas Creek, a graben has formed by downdropping on several splays of the fault zone. East of the fault zone, Pliocene gravels (which formed El Valle pediment) are now uplifted as much as 190 m above stream level, indicating a long Quaternary record of deformation. No detailed studies have been conducted to refine the timing or amount of offset recorded by the isolated Quaternary scarps along the length of the fault zone.

Date of compilation 03/25/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County San Miguel; Mora

1° x 2° sheet Santa Fe

Province Basin and Range

Reliability of location Good

Comments: Trace from 1:24,000-scale geologic mapping by Baltz and O'Neill (1984 #1713) and O'Neill (1986 #1714), which was transferred to 1:250,000-scale topographic base map for digitization.

Geologic setting Backsliding (extension) on former Laramide reverse faults (*e.g.,* Quebraditas, Thunder Ranch, and Hermit Peak faults) has resulted in a large continuous fault-line escarpment on Precambrian and Paleozoic rocks (Baltz and O'Neill, 1986 #1714). The Quebraditas fault zone is the source of a prominent strike valley. Down-to-the-west movement on the fault zone has caused at offset on the base of the bedrock channels of the Sapello River and Rito Cebolla, thereby damning the backvalleys and causing substantial aggradation of the backvalleys and connecting strike valley. The timing of this offset is unknown, but gravels that rest on a Pliocene erosion surface (pediment) are now uplifted as much as 245 m (800 ft) above modern stream levels on the eastern side of the fault zone (Baltz and O'Neill, 1990 #1671).

Sense of movement N

Comments: Fault was created as a Laramide reverse fault, but was reactivated in Quaternary time as a normal fault (see Baltz and O'Neill, 1990 #1671).

Dip not reported
Comments: No dips are shown on map, but on cross section C of Baltz and O'Neill (1984 #1713) and cross sections B and D of Baltz and O'Neill (1986 #1714) the fault zone is shown as having a high- to moderate angle in the subsurface. With depth, they show the fault zone curving (less dip) and merging with thrusts faults of Laramide age.

Dip direction NW

Geomorphic expression Down-to-the-west Cenozoic movement on the fault zone has formed a large continuous fault-line escarpment on Precambrian and Paleozoic rocks, and small isolated scarps (less than 5 percent of length) on alluvial-fan deposits derived from the adjacent fault-line escarpment. However, in the area south of Rociada and Manuelitas Creek, a golf course was constructed on a Quaternary graben that has formed by downdropping on the several splays of the fault zone. These faults are mostly concealed, but they form subtle scarps on old and medial alluvial-fan deposits (Pleistocene). A water well in the Golf Course graben penetrated almost 300 ft (90 m) of Quaternary sediment (Baltz and O'Neill, 1990 #1671). The central part of the Sapello Valley is water logged and swampy, probably because of subsurface damming by young faults near the west end of Manuelitas Creek gap, a situation similar to that seen along the El Oro fault [2050] in the Mora Valley. No morphometric analyses of the isolated scarps or graben-bounding fault scarps has been made to better identify the most recent movement on the faults.

Age of faulted deposits Fault offsets locally derived alluvial-fan deposits of Pleistocene age. Baltz and O'Neill's (1984 #1713; 1986 #1714) units Qfm (middle? Quaternary) and Qfo (middle? to early Quaternary) are offset by the fault, whereas younger deposits (probable middle? to late Pleistocene) bury the trace of the fault. No detailed studies of soil development or radiometric dating have been conducted in order to refine the age of faulted and unfaulted deposits. However, the above age estimates are based on the compiler notes from mapping of Quaternary deposits in this and the adjacent quadrangles to the north (see Baltz and O'Neill, 1984 #1713). East of the fault zone along Manuelitas Creek, gravels that rest on a Pliocene erosion surface (El Valle pediment) are now uplifted as much as 190 m above modern stream level.

Detailed studies none

Timing of most recent paleoevent middle to late Quaternary (<750 ka)
Comments: Based on offset alluvial-fan deposits of probable middle to early Quaternary age, discontinuous (buried) nature of scarps, large offsets of subsurface channels of streams that cross the fault zone (see Baltz and O'Neill, 1984 #1713), and substantial uplift of Pliocene gravels east of the fault zone.

Recurrence interval Not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: The late Quaternary slip rate must be low (<0.2 mm/yr) based on the discontinuous nature and small size of scarps, whereas earlier (late Pliocene to early? Quaternary) slip may have occurred at a higher rate.

Length End to end (km): 14.7
Trace (km): 20.9

Average strike (azimuth) 040°±33°

Endpoints (lat. - long.) 35°53'54.45"N, 105°18'12.84"W
35°47'50.35"N, 105°24'31.44"W

References
#1713 Baltz, E., and O'Neill, J.M., 1984, Geologic map and cross sections of the Mora River area, Sangre de Cristo Mountains, Mora County, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1456, 2 sheets, scale 1:24,000.
#1714 Baltz, E., and O'Neill, J.M., 1986, Geologic map and cross sections of the Sapello River area, Sangre de Cristo Mountains, Mora and San Miguel Counties, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1575, 2 sheets, scale 1:24,000.
#1671 Baltz, E.H., and O'Neill, J.M., 1990, Third-day road log, from Angel Fire to Las Vegas, via Black Lake, Guadalupita, Mora, Rociada and Sapello, *in* Bauer, P.W., Lucas, S.G., Mawer, C.K., and McIntosh, W.C., eds., Tectonic development of the southern Sangre de Cristo Mountains, New Mexico: New Mexico Geological Society, 41st Field Conference, September 12-15, 1990, Guidebook, p. 67-92.

2073, Camel Mountain fault

Structure Number 2073

Structure Name Camel Mountain fault
Comments: This fault is named for Camel Mountain, (a small peak east of the fault) on the Luna/Dona Ana County line, just north of the International Boundary with Mexico (Las Cruces 1° x 2° quadrangle). The fault was first named in a field-trip guidebook (Anonymous, 1969 #1016; Reeves, 1969 #1017) although it was in reference to the southeastward trace of the fault in Chihuahua, Mexico. The fault extends about 30 km across a broad unnamed basin floor in southern New Mexico; Reeves (1969 #1017) extended the escarpment another 150 km southeastward into Chihuahua, Mexico. However, no indication was made as to which parts of the feature are of tectonic or lacustrine origin, or both. The southern extent of Reeve's trace is about 15 km north of Villa Ahumada, Mexico.

Synopsis: Little is known about this Quaternary fault other than it offsets Pliocene-Quaternary sediment of the Camp Rice Formation in New Mexico. An escarpment associated with the fault was visited on a 1969 field trip in Chihuahua, Mexico. Although the escarpment was considered to be a tectonic feature, that appears to have been partly formed by or at least accentuated by wave action along the shores of a late Pleistocene lake. No detailed studies or mapping have been performed.

Date of compilation 02/23/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico, Chihuahua (Mexico)

County Luna

1° x 2° sheet El Paso; Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the fault in New Mexico is from 1:125,000-scale map of Seager (1995 #975) Although Reeves (1969 #1017) extended it another 150 km southeastward into Chihuahua, Mexico, this trace is generalized and shown at a rather small scale.

Geologic setting This north-south to southeast-trending fault forms a gently uplifted bench that is underlain by basin-floor deposits of the Camp Rice Formation, which is largely undifferentiated and of Quaternary and Pliocene age in New Mexico. The entire trace of the fault is mapped as concealed beneath post-Camp Rice Formation sediment, most of which is probably of latest Pleistocene or Holocene age (see Seager, 1995 #975).

Sense of movement N

Dip not reported
Comments: The fault is shown as a high-angle structure on cross sections of Seager (1995 #975).

Dip direction W

Geomorphic expression No information is available about the surficial expression of the fault in New Mexico where it is mapped as everywhere concealed beneath post-Camp Rice Formation sediment of latest Pleistocene or Holocene age. However, down-to-the-west movement on the fault has produced a 30-m-high fault-line escarpment that bounds the western edge of a widespread bench (piedmont). The height of this escarpment probably represents the minimum amount of displacement in sediment of the Camp Rice Formation. In Chihuahua, Mexico, the fault forms a prominent escarpment that is considered to be a polygenetic feature (Reeves, 1969 #1017). At Stop 2 of Day 1 of a 1969 field trip (Anonymous, 1969 #1016), the escarpment was reported to be about 45-m high and it bounds the eastern edge of Laguna Tildio, a modern barrial (playa). Reeves (1969 #1017) argued that the Camel Mountain escarpment is in part due to Pleistocene faulting, the scarp having been accentuated by wave erosion at La Mota lake level. If this is true, then scarp morphology studies would be relatively meaningless in terms of the recency of movement along the fault.

Age of faulted deposits The fault offsets basin-floor deposits of the Camp Rice Formation (undifferentiated), which is Quaternary and Pliocene age according to mapping of Seager (1995 #975) to the north. However, deposits of middle or late Quaternary age may be offset in the shallow subsurface.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)

Recurrence interval not determined

Slip-rate category unknown, probably <0.2 mm/yr
Comments: A low slip rate is inferred from the relatively small apparent offset associated with the Quaternary (?) surface of the Camp Rice Formation and from rates of more conspicuous Quaternary faults in the region. Seager (1995 #975) states that about 30 m of Camp Rice sediment is exposed along the escarpment.

Length End to end (km): 47.0
Trace (km): 55.5
Comments: Fault continues into Mexico as MX-93. Lengths do not include this portion of the fault.

Average strike (azimuth) -13°±33°

Endpoints (lat. - long.) 32°03′34.97″N, 107°24′41.61″W
31°38′49.59″N, 107°17′42.96″W

References

#1016 Anonymous, 1969, First day road log from Ciudad Juarez to Nuevo Casas Grandes, via Sierra de Juarez, Sierra Boca Grande, Ascencion, and Janos, *in* Córdoba, D.A., Wengerd, S.A., and Shomaker, J., eds., Guidebook of the border region: New Mexico Geological Society, 20th Field Conference, October 23-25, 1969, Guidebook, p. 1-16.

#1017 Reeves, C.C., Jr., 1969, Pluvial Lake Palomas northwestern Chihuahua, Mexico, *in* Córdoba, D.A., Wengerd, S.A., and Shomaker, J., eds., Guidebook of the border region: New Mexico Geological Society, 20th Field Conference, October 23-25, 1969, Guidebook, p. 143-154.

#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.

2074, Unnamed fault north of Eagles Nest

Structure Number 2074

Structure Name Unnamed fault north of Eagles Nest
Comments: This fault is shown by Seager (1995 #975) as located about 8 km north-northwest of Eagles Nest, a small peak west of the West Potrillo Mountains.

Synopsis: Little is known about this Quaternary fault other than it is inferred to offset Pliocene-Quaternary sediment of the Camp Rice Formation in New Mexico. No detailed studies have been conducted of the fault or its surface expression.

Date of compilation 02/23/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Luna

1° x 2° sheet Las Cruces; El Paso

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the fault is from 1:125,000-scale map of Seager (1995 #975)

Geologic setting This north-south trending fault is inferred to offset Pliocene-Quaternary sediment of the Camp Rice Formation (see Seager, 1995 #975), which forms an extensive bench locally covered by eolian sand.

Sense of movement N
Comments: Suspected to be normal from sense of movement on other similarly oriented Quaternary faults in the region.

Dip not reported
Comments: Seager (1995 #975) does not show a sense of slip for this fault.

Dip direction not reported

Geomorphic expression No information is available about the surficial expression of the fault, however it must form at least a subtle scarp beneath eolian sand as indicated by Seager's (1995 #975) mapping.

Age of faulted deposits The fault offsets basin-floor deposits of the Camp Rice Formation (undifferentiated), which is of Quaternary and possible Pliocene age according to mapping of Seager (1995 #975). However, deposits of middle or late Quaternary age may be offset in the shallow subsurface.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)

Recurrence interval not determined

Slip-rate category unknown, probably <0.2 mm/yr
Comments: A low long-term slip rate is inferred from the small apparent offset associated with the Quaternary(?) surface of the Camp Rice Formation and from rates of more conspicuous Quaternary faults in the region.

Length End to end (km): 4.0
Trace (km): 4.3

Average strike (azimuth) -12°±19°

Endpoints (lat. - long.) 32°01′04.38″N, 107°22′53.56″W
31°58′56.28″N, 107°22′25.75″W

References

#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.

2075, West Florida Mountains fault

Structure Number 2075

Structure Name West Florida Mountains fault

Comments: The West Florida Mountains fault was named by Clemons (1984 #999) for its location along the western flank of the Florida Mountains. However, on a later structural index map of the area (Seager, 1995 #975), the name Treasure Mountain fault zone was extended from the north to include the aforementioned fault. We retain the original name for this compilation. Under this definition, the West Florida Mountains fault extends from about 1 km south of U.S. Interstate Highway 10, south across the piedmont apron of the Little Florida and Florida Mountains to the White Hills (South Peak 7.5-minute quadrangle, New Mexico).

Synopsis: This late Quaternary fault offsets piedmont-slope deposits that flank the western margin of the Florida Mountains. The scarps are small (<5 m high), but may reflect two episodes of movement. Studies of scarp morphology have been made along the central part of the fault, but no trenching or detailed mapping has been done.

Date of compilation 02/23/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Luna

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good

Comments: Generalized trace of the fault is from 1:125,000-scale map of Seager (1995 #975), with additional detail from 1:24,000-scale mapping of Clemons (1984 #999). In addition, Machette (unpubl. data, 1980) mapped the trace of the fault from aerial photographs.

Geologic setting This curving, but generally south-southwest trending, down-to-the-west fault offsets the piedmont slope that flanks the western margin of the Florida and Little Florida Mountains (Clemons, 1984 #999). Clemons (1984 #999) estimated that there may be 900-1,200 m of total vertical offset on the fault, most of which resulted from Miocene uplift and eastward tilting of the Florida and Little Florida Mountains. The fault may be a southward continuation of the Treasure Mountain fault (Cenozoic) as mapped by Seager (1995 #975).

Sense of movement N

Dip not reported

Comments: Clemons (1984 #999) showed the fault as being relatively high angle in cross section A.

Dip direction W

Geomorphic expression The fault forms conspicuous scarps on the piedmont slope that flanks the western margin of the Florida Mountains. The scarps are subtle yet conspicuous on aerial photographs owing to different types of vegetation (plant associations) on the upthrown and downdropped surfaces. Morphology studies (Machette, unpubl. data, 1980) indicate that the scarps within a kilometer of Florida Road (access road to Rock Hound State Park, northwest part of the Florida Mountains) are 3.2-

4.6 m high and have maximum scarp-slope angles of 2.3°-6.2°, whereas the adjacent piedmont commonly has a slope angle of 1.0-1.5°. These scarps are obviously old, but may reflect two faulting events because of the size of the scarps (>3 m) and the presence of compound slope angles. The morphology of the youngest elements of the scarp are almost identical to the Santa Rita scarps (ca. 100 ka in Pearthree and Calvo, 1987 #1023) of southeastern Arizona, whereas the morphometric data for total scarp height plot well below (older than) that of the Santa Rita scarps.

Age of faulted deposits The fault offsets piedmont-slope deposits (Membres Formation and younger equivalents) (Clemons, 1984 #999)) that flank the western margin of the Florida Mountains. Machette conducted a short reconnaissance of the fault in the summer of 1980. The soils that are offset along the largest scarps typically have a 75-100 cm thick stage III to stage IV calcareous B (Bk) horizon (Machette, unpubl. data, 1980). Similarly developed soils in southern New Mexico are commonly of middle Pleistocene age (Machette, 1985 #1267). The smallest (unprofiled) scarps are formed on deposits that have a 40-cm-thick reddish brown argillic B (Bt) horizon over a 30-cm-thick stage II calcareous B (Bk) horizon, which is probably of late middle (ca. 200 ka) to late Pleistocene (ca. 100 ka) age. Conversely, alluvium that may be latest Pleistocene to Holocene in age is not offset by the fault.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Clemons (1984 #999) stated that the fault remained active, at least intermittently, into the Pleistocene. The youngest unit (Qpa) he shows offset is of Pleistocene and/or Holocene age. However, as determined from unpublished soil and scarp morphology data (see above discussion), it appears that the fault scarps may be the result to two faulting events, the youngest of which occurred about 100 ka.

Recurrence interval not determined

Slip-rate category unknown; probably <0.2 mm/yr

Comments: The slip rate must be very low as evidenced by small scarps (2.3-4.6 m) on deposits of late(?) middle to middle Pleistocene age (estimated to be 100-200 ka) These scarps equate to vertical offsets of 2-4 m. There is no evidence that movement has occurred in latest Pleistocene or Holocene time (past 15 ka), to perhaps as long ago as 100 ka.

Length End to end (km): 19.8
Trace (km): 21.9

Average strike (azimuth) 014°±18°

Endpoints (lat. - long.) 32°14′36.49″N, 107°37′28.98″W
32°04′43.69″N, 107°42′20.56″W

References

#999 Clemons, R.E., 1984, Geology of Capitol Dome quadrangle, Luna County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 56, 1 sheet, scale 1:24,000.

#1267 Machette, M.N., 1985, Calcic soils of the southwestern United States, *in* Weide, D.L., ed., Soils and Quaternary geology of the southwestern United States: Geological Society of America Special Paper 203, p. 1-21.

#1023 Pearthree, P.A., and Calvo, S.S., 1987, The Santa Rita fault zone—Evidence for large magnitude earthquakes with very long recurrence intervals, Basin and Range province of southeastern Arizona: Bulletin of the Seismological Society of America, v. 77, p. 97-116.

#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.

2076, Unnamed faults north of Hermanas

Structure Number 2076

Structure Name Unnamed faults north of Hermanas
Comments: These faults are shown by Seager (1995 #975) as forming a b road zone on the northeast flank of the Cedar Mountains, about 7 km north-northeast of Hermanas, New Mexico.

Synopsis: Little is known about these faults other than they offset Pliocene to Quaternary deposits of the Mimbres Formation. No detailed studies have been conducted of the fault or its surface expression.

Date of compilation 02/26/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Luna

1° x 2° sheet El Paso

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the fault is from 1:125,000-scale map of Seager (1995 #975).

Geologic setting These faults lie along the southwestern margin of the Hermanas basin (Seager, 1995 #975) and northeast flank of the Cedar Mountains. They are primarily down to the northeast, toward the center of the basin.

Sense of movement N

Dip not reported
Comments: Although no dips are shown on the map of Seager (1995 #975), his cross section F shows the faults as having a high-angle dip.

Dip direction E
Comments: Seager (1995 #975) showed the faults dipping to the east into the Hermanas basin.

Geomorphic expression No information is available about the geomorphic expression of the faults other than they are presence at the surface. No detailed studies have been conducted of the faults or their surface expression.

Age of faulted deposits These faults offset deposits of Miocene fanglomerates and the Mimbres Formation (Pliocene to Pleistocene) according to mapping of Seager (1995 #975). The Mimbres is largely correlative with the Palomas and Camp Rice Formations to the east.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)

Comments:The faults are considered to be Quaternary in age because they are present at the surface and because the upper part of the Membres is Quaternary in age.

Recurrence interval not reported

Slip-ratecategory unknown; probably <0.2 mm/yr
Comments: A low slip rate is inferred from the small apparent offset associated with the Quaternary(?) surface of the Membres Formation and from rates of more conspicuous Quaternary faults in the region.

Length End to end (km): 4.7
Trace (km): 8.4

Average strike (azimuth) -16°±9°

Endpoints (lat. - long.) 31°55′10.41″N, 107°56′31.18″W
31°53′23.53″N, 107°54′22.75″W

References

#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.

2077, Unnamed faults and folds on La Mesa

Structure Number 2077

Structure Name Unnamed faults and folds on La Mesa
Comments: These unnamed faults and folds (monoclines) lie between the East Robledo fault [2063] and the West Robledo fault [2064] (Seager and others, 1987 #627; Seager, 1995 #975).

Synopsis: These faults and monoclines lie between the East and West Robledo faults, and thus occupy an intrahorst position. Most of the faults offset upper La Mesa (geomorphic) surface, which is of early Quaternary age. No detailed studies have been made of these faults or their morphology.

Date of compilation 02/27/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the fault and monoclines is from 1:125,000-scale maps of Seager and others (1987 #627) and Seager (1995 #975).

Geologic setting These north-northeast-trending faults and monoclines are between the East and West Robledo faults [2063, 2064, respectively] and thus occupy an intrahorst position. They deform sediment of the Camp Rice Formation and its constructional surface.

Sense of movement N

Dip not reported
Comments: These faults are probably high-angle structures sympathetic to the horst-bounding faults shown by Seager and others (1987 #627). However, no specific dip values are shown on their small-scale map.

Dip direction W; E

Geomorphic expression The faults and monoclines deform the constructional La Mesa surface (upper?). No detailed studies have been made of fault heights or scarp morphology.

Age of faulted deposits Faulted Quaternary units include the upper part of the Camp Rice Formation (early to middle ? Pleistocene) and the upper? La Mesa surface (constructional top of Camp Rice Formation) as shown on the maps of maps of Seager and others (1987 #627) and Seager (1995 #975). Upper La Mesa is probably a local, tectonically uplifted surface that is not regionally significant as a stratigraphic datum; however, it clearly pre-dates lower La Mesa (which is believed to have stabilized about 700-900 ka; (Mack and Seager, 1995 #1021). The presence of 1.2-Ma basalts on the upper La Mesa surface (Seager, 1995 #975) suggest it is of early Quaternary age. No measurements of fold amplitude or fault offset of La Mesa surface are published; however, topographic maps show little (<10 m) offset of La Mesa surface south of Interstate Highway 10.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing based on offset of upper La Mesa surface (>0.9-1.2 Ma). However, middle Pleistocene or younger faulting may have occurred.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on less than 10-m-high scarps on 1.2 Ma upper La Mesa surface.

Length not applicable
Comments: This zone includes several faults that have an end to end length of 24.0 km and a cumulative trace length of 39.0 km.

Average strike (azimuth) 013°±19°

Endpoints (lat. - long.) 32°17′27.37″N, 106°58′50.88″W
32°05′02.98″N, 107°03′20.13″W

References
#1021 Mack, G.H., and Seager, W.R., 1995, Transfer zones in the southern Rio Grande rift: Journal of the Geological Society, London, v. 152, p. 551-560.
#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.
#627 Seager, W.R., Hawley, J.W., Kottlowski, F.E., and Kelley, S.A., 1987, Geology of east half of Las Cruces and northeast El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 57, 3 sheets, scale 1:250,000.

2078, Ward Tank fault

Structure Number 2078

Structure Name Ward Tank fault
Comments: This fault was named by Seager and others (1975 #995) for Ward Tank, a small reservoir on the northwest side of the Cedar Hills (Sierra Alta 7.5-minute quadrangle). The fault extends from Rock Canyon (about 3 km northeast of Sierra Kemado), west and southwest of the Cedar Hills. According to mapping by Seager (1995 #975), the fault has surface offset to a point at least 2 km south of U.S. Interstate Highway 10 (due north of the Aden Hills). The northern end of the Ward Tank fault (mapped as the Sierra Kemado fault [2079]) splays northwestward. Seager (1995 #975) considered this splay as a segment of the Ward Tank, but in this database it is treated as a separate fault.

Synopsis: This Quaternary fault is the major boundary fault of the Sierra de las Uvas Range. It deforms Permian and Tertiary rocks as well as the upper (Quaternary) sediment of the Camp Rice Formation. Although much of the fault's movement probably occurred in the Tertiary, offset of Quaternary surfaces indicates reactivation of the fault. No detailed studies have been made of the fault's Quaternary history or its scarp morphology.

Date of compilation 02/27/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Although the trace of the fault is from 1:125,000-scale maps of Seager and others (1982 #626) and Seager (1995 #975), most of this information was generalized from 1:24,000-scale maps of Seager and others (1975 #995) and Clemons (1976 #1007).

Geologic setting This is the major boundary fault of the Sierra de las Uvas Range. It displaces Permian and Tertiary rocks and, for most of its length, places upper Santa Fe Group sediment against these older rocks. Movement on the Ward Tank fault is primarily responsible for uplift and northwesterly tilting of the Sierra de las Uvas block. Total stratigraphic separation on the fault appears to reach 610-760 m near the Rattlesnake Hills (Seager and others, 1975 #995).

Sense of movement N

Dip 65°-75° E
Comments: The fault 65°-75° according to Seager and others (1975 #995) and shown as a high-angle structure on cross sections by Seager and others (1975 #995) and Clemons (1976 #1007).

Dip direction E

Geomorphic expression For most of the fault's length, it places sediment of the Camp Rice Formation against older bedrock. However, at numerous locations along the central and northern parts of the fault, it offsets the Jornada I surface (middle Pleistocene), which is a local constructional piedmont surface of the Camp Rice Formation. Seager and others (1975 #995) stated that the Jornada I surface is deformed as evidenced by a continuous fresh(?) scarp about 3 m high between Horse Canyon and the Rattlesnake Hills. Along the southern part of the fault, Clemons (1976 #1007) mapped the trace as primarily buried, but it appears to control the course of local drainages. In later mapping, Seager (1995 #975) showed the fault as deforming the surface (La Mesa) of the Camp Rice Formation. No detailed studies have been made of the fault's scarp morphology.

Age of faulted deposits The fault offsets sediment of the upper part of the Camp Rice Formation (early to middle Pleistocene) and the Jornada I surface (middle Pleistocene). Younger (late Pleistocene) alluvial surfaces are not known to be offset by the Ward Tank fault. According to Seager and others (1975 #995) the Jornada I surface is deformed about 3 m.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on offset of Jornada I surface (middle Pleistocene). However, late Pleistocene faulting may have occurred on the basis of the young appearance of the fault scarps (see Seager and others, 1975 #995).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on 3-m-high scarp on the Jornada I surface (0.4-0.6 Ma).

Length End to end (km): 34.1
Trace (km): 36.8

Average strike (azimuth) 006°±16°

Endpoints (lat. - long.) 32°32′26.12″N, 107°03′15.02″W
32°14′05.64″N, 107°05′06.51″W

References

#1007 Clemons, R.E., 1976, Geology of east half Corralitos Ranch quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 36, 2 sheet, scale 1:24,000.

#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.

#995 Seager, W.R., Clemons, R.E., and Hawley, J.W., 1975, Geology of Sierra Alta quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 102, 56 p., 1 pl., scale 1:24,000.

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

2079, Sierra Kemado fault

Structure Number 2079

Structure Name Sierra Kemado fault

Comments: This fault was named by Seager and others (1975 #995) for Sierra Kemado, a small series of hills northwest of the Cedar Hills (Sierra Alta 7.5-minute quadrangle). The fault extends from Horse Canyon (about 2 km east of Sierra Kemado), where it splays from the Ward Tank fault [2078], north and northwest to Bignell Arroyo. Seager (1995 #975) considered the Sierra Kemado fault as a splay of the Ward Tank, but we treat it as a separate fault in this compilation.

Synopsis: This Quaternary fault deforms Tertiary rocks as well as the upper (Quaternary) part of the Camp Rice Formation. Although much of the fault's movement probably occurred in the Tertiary, offset of Quaternary surfaces indicates reactivation of the fault. No detailed studies have been made of the fault's Quaternary history or its scarp's morphology.

Date of compilation 02/27/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good

Comments: Trace of the fault is from 1:125,000-scale maps of Seager and others (1982 #626), which was generalized from the 1:24,000-scale map of Seager and others (1975 #995).

Geologic setting The fault places Tertiary rock against sediment of the Camp Rice Formation. Along at least half of the fault, the trace is entirely within the Camp Rice. The Sierra Kemado fault may be a northwestward extension (splay) of the Ward Tank fault [2078] (Seager and others, 1975 #995).

Sense of movement N

Dip 65° SW

Comments: The only dip recorded along the fault is 65°, and this is along a southwest dipping splay of the main fault. Along the northwest half of the fault, there are three separate strands, each of which are shown as high-angle on cross sections by Seager and others (1975 #995).

Dip direction NE; SW

Geomorphic expression From Rock Canyon north, the fault forms scarps on the Jornada I surface (middle Pleistocene), which is a local constructional piedmont surface of the Camp Rice Formation. North of Hersey Arroyo (Sierra Alta 7.5-minute quadrangle), the fault splits into two subparallel stands that form a local bedrock horst. In addition, there is a third strand southwest of the horst. All of these fault traces are characterized by small scarps on the Jornada I surface and by local control of ephemeral drainages. From inspection of 1:24,000-scale topographic maps, it appears that the scarps are associated with relatively minor offset (typically 5 m to <10 m) of the Jornada I surface. No detailed studies have been made of the fault's scarp morphology.

Age of faulted deposits The fault offsets sediment of the upper part of the Camp Rice Formation (early to middle Pleistocene) and the Jornada I surface (middle Pleistocene). Younger (late Pleistocene) alluvial surfaces are not known to be offset by the Ward Tank fault.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on offset of Jornada I surface (middle Pleistocene). However, late Pleistocene faulting may have occurred on the basis of the young appearance of the fault scarps (see Seager and others, 1975 #995).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on 5- to less than 10-m-high scarps on Jornada I surface (0.4-0.6 Ma).

Length End to end (km): 7.0
Trace (km): 14.7

Average strike (azimuth) -24°±24°

Endpoints (lat. - long.) 32°35'51.58"N, 107°05'12.43"W
32°32'26.17"N, 107°03'15.23"W

References

#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.
#995 Seager, W.R., Clemons, R.E., and Hawley, J.W., 1975, Geology of Sierra Alta quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 102, 56 p., 1 pl., scale 1:24,000.
#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

2080, Hackler Tank fault

Structure Number 2080

Structure Name Hackler Tank fault
Comments: This fault was named by Seager and others (1975 #995) for Hackler Tank, a small reservoir in the upper reach of Bignell Arroyo (Sierra Alta 7.5-minute quadrangle). The fault extends from Hersey Arroyo on the southeast (about 1 km north of Sierra Kemado), northwest along the northeast margin of the Quail Hills (Seager and others, 1975 #995), where it splits into two subparallel strands. The most northerly strand of the fault ends about 1 km north of Arroyo Angostura.

Synopsis: This Quaternary fault deforms Tertiary rocks as well as the upper (Quaternary) part of the Camp Rice Formation. Although much of the fault's movement probably occurred in the Tertiary, offset of Quaternary surfaces indicates reactivation of the fault. No detailed studies have been made of the fault's Quaternary history or the morphology of its scarps.

Date of compilation 02/27/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Trace of the fault is from 1:125,000-scale maps of Seager and others (1982 #626), which was generalized from the 1:24,000-scale map of Seager and others (1975 #995).

Geologic setting The Hackler Tank fault forms the northeastern edge of the Quail Hills, in part. Total stratigraphic separation may be only 60-100 m where the fault places Tertiary rock against sediment of the Camp Rice Formation, but along the northern part the trace is entirely within sediment of the Camp Rice Formation. From its geometry and age, it appears that the fault may be a northwestward en echelon extension of the Sierra Kemado [2079] and Ward Tank [2078] faults.

Sense of movement N

Dip 65° SW
Comments: The only dip recorded along the fault is 65°, and this is along a southwest dipping splay of the fault.

Dip direction NE; SW

Geomorphic expression The fault forms scarps on the Jornada I surface (middle Pleistocene), which is a local constructional piedmont surface of the Camp Rice Formation. North of Hersey Arroyo (Sierra Alta 7.5-minute quadrangle), the fault splits into two subparallel strands: the more northerly of these strands downwarps the Jornada I surface to the east (see fig. 13 in Seager and others, 1975 #995). No detailed studies have been made of the fault's scarp morphology.

Age of faulted deposits The fault offsets sediment of the upper part of the Camp Rice Formation (early to middle Pleistocene) and the Jornada I surface (middle Pleistocene) as much as 6 m. Younger (late Pleistocene) alluvial surfaces are not known to be offset by the Hackler Tank fault.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on offset of Jornada I surface (middle Pleistocene). However, late Pleistocene faulting may have occurred on the basis of the young appearance of the fault's scarps (see Seager and others, 1975 #995).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on 6-m-high scarps on Jornada I surface (0.4-0.6 Ma).

Length End to end (km): 8.7
Trace (km): 13.9

Average strike (azimuth) -29°±23°

Endpoints (lat. - long.) 32°38'03.97"N, 107°06'43.59"W
32°33'42.45"N, 107°04'33.20"W

References

#995 Seager, W.R., Clemons, R.E., and Hawley, J.W., 1975, Geology of Sierra Alta quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 102, 56 p., 1 pl., scale 1:24,000.

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

2081, Sierra de las Uvas fault zone

Structure Number 2081

Structure Name Sierra de las Uvas fault zone

Comments: This fault zone is named for the Sierra de las Uvas, a Tertiary uplift (dome) (see Clemons and Seager, 1973 #1003). The entire fault zone (as mapped by Seager and others, 1982 #626) extends along the northwest margin of the Sierra de las Uvas, from about 2 km west of the Luna/Dona Ana County line northeast to a point about due south of Placitas, New Mexico.

Synopsis: Little is known about the Quaternary history of this largely Tertiary normal fault. Detailed mapping along the fault zone reveals two short (<1 km) scarps on sediment of the Camp Rice Formation. A single scarp profile measured across one of the two fault strands by the compiler, suggests that the surface faulting may be as young as latest middle Pleistocene. No other detailed studies have been made of the scarps or the fault.

Date of compilation 02/28/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good

Comments: Generalized trace from 1:125,000-scale map of Seager and others (1982 #626), which was based on published (Clemons and Seager, 1973 #1003) and unpublished 1:24,000-scale mapping.

Geologic setting The Sierra de las Uvas fault zone bounds the northwest margin of a uplifted Tertiary dome of the same name. Late Tertiary movement on the fault zone has downdropped the northwest margin of this dome. The fault zone, as mapped by Clemons and others (1973 #1003), is about 0.5-1 km wide, and most strands of the zone are concealed beneath Quaternary cover or are within Tertiary volcanic rock. However, at least one basinward (northwest) strand has produced scarps on sediment of the Camp Rice Formation.

Sense of movement N

Dip not reported

Comments: The Quaternary and older fault strands of the zone are shown as high-angle structures on cross section D of Clemons and others (1973 #1003), but no specific dip values are shown on their map.

Dip direction NW

Geomorphic expression Most of the fault trace is concealed or in Tertiary rock, but short Quaternary scarps are present at two locations. These scarps are on the piedmont facies of the Camp Rice Formation and, although undated by Clemons, may deform the Jornada I surface as in the adjacent quadrangle (Seager and others, 1975 #995). A single scarp profile (M12-1, Machette, unpubl. data, 1980) was measured across the western end of the eastern scarp (Sec. 1, T. 19 S., R. 4 W.) as mapped by Clemons and others (1973 #1003). This profile yielded a scarp height of 0.5 m and a maximum slope angle of 3.0° (*i.e.*, very subdued). The scarp is formed on a gently (1.8-2.0°) north-sloping piedmont surface, so the scarp has a maximum slope angle of just 1° more than the piedmont. These data suggest that scarp has morphology more degraded than the 100-ka (estimated age) scarp of Santa Rita fault (Pearthree and Calvo, 1987 #1023). From this comparison, we suspect that the Sierra de las Uvas scarps were formed in late(?) middle Pleistocene (>130 ka) time rather than in the late Pleistocene (130-10 ka).

Age of faulted deposits The scarps are younger than sediment of the piedmont facies of the Camp Rice Formation, which in this area may be equivalent to the Jornada I surface. If so, the faulting must be younger than 700-900 ka Mack and Seager (1993 #1020), which is the time at which deposition of the Camp Rice Formation ceased. However, the Jornada I surface is a piedmont facies, and deposition of these sediment may have persisted longer, perhaps until about 400-600 ka.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: From the discussion of geomorphic expression, it appears the most recent faulting event is probably occurred in the late(?) middle Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: The small size (0.5 m) of the one measured scarp and the lack of continuity of the scarps along the entire zone suggest that the middle to late Quaternary slip rate across the fault zone is probably much less than 0.2 mm/yr.

Length	End to end (km):	18.0
	Cumulative (km):	22.7

Average strike (azimuth) 052°±32°

Endpoints (lat. - long.) 36°17′01.95″N, 106°19′06.70″W
36°04′51.02″N, 106°31′43.16″W

References

#1003 Clemons, R.E., and Seager, W.R., 1973, Geology of Souse Springs quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 100, 31 p., 1 pl., scale 1:24,000.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#1023 Pearthree, P.A., and Calvo, S.S., 1987, The Santa Rita fault zone—Evidence for large magnitude earthquakes with very long recurrence intervals, Basin and Range province of southeastern Arizona: Bulletin of the Seismological Society of America, v. 77, p. 97-116.

#995 Seager, W.R., Clemons, R.E., and Hawley, J.W., 1975, Geology of Sierra Alta quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 102, 56 p., 1 pl., scale 1:24,000.

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

2082, Unnamed faults south of Placitas Arroyo

Structure Number 2082

Structure Name Unnamed faults south of Placitas Arroyo
Comments: These unnamed east-trending faults were first shown by Clemons and others (1973 #1003). They are parallel to but basinward of the Sierra de las Uvas fault zone [2081]. Seager and others (1982 #626) showed the faults extending 5-6 km across the northern piedmont of the Sierra de las Uvas Mountains about 1-3 km south of Placitas Arroyo.

Synopsis: These faults form scarps on an erosional surface cut across sediment of the Camp Rice Formation and on a younger (late? Pleistocene) piedmont surface. They are parallel to and probably associated with the Sierra de las Uvas fault zone, which is several kilometers to the south. No detailed studies of the scarps have been made.

Date of compilation 02/28/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace from 1:125,000-scale map of Seager and others (1982 #626), but this was based largely on published (Clemons and Seager, 1973 #1003) and unpublished 1:24,000-scale mapping.

Geologic setting These east-west trending faults are parallel to but basinward of the Sierra de las Uvas fault zone [2081], which bounds the northwest margin of a uplifted Tertiary dome of the same name. This geometric relation as well as similar sense of slip and motion suggest that the unnamed faults are sympathetic to and associated with the Sierra de las Uvas fault zone.

Sense of movement N

Dip not reported
Comments: The fault strands (Quaternary and older) are parallel to and probably similar to faults of the Sierra de las Uvas zone [2081], which are shown as high-angle structures on cross section D of Clemons and others (1973 #1003). However, no specific dip values are shown on their map.

Dip direction N

Geomorphic expression Most of the fault traces are characterized by moderately large (10 m) scarps on the piedmont facies of the Camp Rice Formation (Jornada I surface?), and smaller scarps on a younger (middle to late Pleistocene) sequence of piedmont surfaces.

Age of faulted deposits The largest scarps are younger than the piedmont facies of the Camp Rice Formation, which in this area may be equivalent to the Jornada I surface. If so, the faulting must be younger than 700-900 ka Mack and others (1993 #1020), which is the time at which deposition of the Camp Rice Formation ceased. However, the Jornada I surface is a piedmont facies, and deposition of these sediments may have persisted longer, perhaps until about 400-600 ka. In addition, the small scarps are present on a younger sequence of piedmont surfaces (Qvo of Seager and others, 1982 #626) that probably correlate with the Tortugas alluvium (middle Pleistocene) and/or the Picacho alluvium (late Pleistocene) (see Seager and others, 1975 #995).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)

Comments: Based on offset of sediment of the upper part of the Camp Rice Formation. At least one of the faults was probably active in the early part of the late Pleistocene

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Although no scarp heights or times of faulting have been determined, the lack of continuity of the fault scarps and their apparent moderate (<10 m) to low height (several meters) as revealed from 1:24,000-scale topographic maps suggest that the middle to late Quaternary slip rate across the fault zone is probably much less than 0.2 mm/yr.

Length	End to end (km):	5.8
	Cumulative (km):	6.8

Average strike (azimuth) 083°±11°

Endpoints (lat. - long.) 32°36′47.71″N, 107°11′53.64″W
32°36′10.86″N, 107°15′31.52″W

References

#1003 Clemons, R.E., and Seager, W.R., 1973, Geology of Souse Springs quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 100, 31 p., 1 pl., scale 1:24,000.
#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.
#995 Seager, W.R., Clemons, R.E., and Hawley, J.W., 1975, Geology of Sierra Alta quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 102, 56 p., 1 pl., scale 1:24,000.
#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

2083, East Rincon Hills fault

Structure Number 2083

Structure Name East Rincon Hills fault
Comments: Named by Seager and Hawley (1973 #996) for the fault's location along the eastern margin of the Rincon Hills, northeast of Rincon, New Mexico. The mapped extent of the fault extends from U.S. Interstate Highway 25, where it was exposed in a road cut, north to the latitude of the Gramma (railroad) Siding, an important geologic locality that contains Quaternary volcanic ash.

Synopsis: Although no detailed studies have been made of this down-to-the east, north-trending fault, it is well mapped and known to be middle Pleistocene or younger. The fault forms scarps on sediment of the Camp Rice Formation, and puts these deposits in fault contact with Tertiary bedrock.

Date of compilation 02/29/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good

Comments: Generalized trace of the fault is from 1:125,000-scale map of Seager and others (1982 #626), which was based on 1:24,000-scale map of Seager and Hawley (1973 #996).

Geologic setting The fault comprises a 1/2-km-wide zone of short, overlapping faults that form the indistinct eastern margin of the Rincon Hills, which are comprised of a series of northwest-trending horsts and grabens that flank the southern end of the Caballo Mountains. The fault also forms the western margin of the Gramma graben, which is part of the Jornada del Muerto (a broad syncline).

Sense of movement N

Dip not reported
Comments: No dips are shown on the map of Seager and Hawley (1973 #996), but their cross sections show the fault as high angle.

Dip direction E

Geomorphic expression The fault forms dissected scarps on sediment of the Camp Rice Formation and, according to the map of Seager and Hawley (1973 #996), cuts alluvial surfaces formed by older alluvium (Qvo).

Age of faulted deposits The fault uplifted the Rincon surface and effectively isolated it from further fluvial deposition during early Pleistocene or late Pliocene time. Continued deposition of piedmont facies of the Camp Rice (Pleistocene) was primarily on the eastern (downthrown) side of the fault, thus the East Rincon Hills fault probably formed a significant slope in early Pleistocene time. Continued movement on the fault has displaced the Jornada I surface (top of piedmont facies of the Camp Rice Formation, middle Pleistocene) and younger local piedmont-slope alluvium, which correlates with either the Tortugas or Picacho alluvium (Seager and Hawley, 1973 #996).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: There is clear field evidence for displacement of Pliocene and early to middle Pleistocene sediment, and possible displacement of late Pleistocene sediment (Picacho alluvium).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No detailed studies have been made of the amount or timing of offset along the fault. In addition, because of syntectonic deposition along and across the fault during the Pleistocene, it is difficult to correlate units across the fault. Nevertheless, Seager and Hawley (1973 #996) stated that the East Rincon Hills fault probably offsets Camp Rice sediment 10-30 m (tens to as much as 100 ft). These data certainly support assigning the lowest slip-rate category to this fault.

Length	End to end (km):	7.0
	Cumulative (km):	7.9

Average strike (azimuth) 006°±20°

Endpoints (lat. - long.) 32°44′18.39″N, 107°3′00.36″W
32°40′30.83″N, 107°3′27.17″W

References

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

#996 Seager, W.R., and Hawley, J.W., 1973, Geology of Rincon quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 101, 42 p., 2 pls., scale 1:24,000.

2084, Blue Mountain fault

Structure Number 2084
Comments:

Structure Name Blue Mountain fault
Comments: Named by Elston (1957 #1031) for the fault's location along the northwest margin of Blue Mountain, about 5 km northwest of Dwyer (Faywood), New Mexico. The northern end of the fault is about 3 km west of Swartz, New Mexico (see Seager and others, 1982 #626). From here it extends south-southwest to Table Mountain (see Elston, 1957 #1031). Seager and others (1982 #626) showed the fault as concealed to as far southwest as City of Rocks State Park.

Synopsis: This northeast-striking, down-to-the northwest fault offsets Oligocene volcanic rocks along its northern part and Pleistocene alluvium along its southern part. Although no detailed studies have been made of the fault scarps or its Pleistocene history, the size of the scarps and general age limits of the associated alluvium imply multiple movements in the early and middle Pleistocene; the most recent faulting may have occurred as recently as the late Pleistocene although no detailed studies have been conducted to confirm this possibility.

Date of compilation 03/19/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Grant; Luna

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the fault is from 1:125,000-scale map of Seager and others (1982 #626). The fault was also shown on a much earlier 1:48,000-scale map by Elston (1957 #1031).

Geologic setting This northeast-trending fault downdrops Oligocene volcanic rocks to the west and offsets Quaternary sediment along its southern half. Elston (1957 #1031) considered the fault to be Neogene, but Seager and others (1982 #626) showed it as offsetting Pleistocene sediment. Elston (1957 #1031) reported the fault as having about 330 m of throw in Tertiary volcanic rocks south of Mimbres Peak.

Sense of movement N
Comments: Elston (1957 #1031) reported a rake of 80° NE for slickenlines on a bedrock exposure of the fault in San Jose Canyon, suggesting almost pure normal slip.

Dip 62° W
Comments: Elston (1957 #1031) measured this dip on a bedrock exposure of the fault in San Jose Canyon.

Dip direction NW

Geomorphic expression The fault forms a discontinuous strike valley in Oligocene rocks north of Blue Mountain and a prominent northwest-facing escarpment on Tertiary and Quaternary deposits south of Blue Mountain. Seager and others (1982 #626) showed the fault offsetting southeast- and southwest-sloping Quaternary surfaces (unit Qp1), and inspection of 1:24,000-scale topographic maps of the area (Table Mountain and Whitehouse Mountain 7.5-minute quadrangles) confirm the presence of a nearly continuous scarp on these surfaces. The scarp appears to be about 10-15 m high on the basis of projection and probable correlation of alluvial surfaces on both sides of the fault. In particular, down-to-the-northwest motion on the fault has formed a scarp that opposes the local geomorphic gradient, thereby deflecting drainages between Table Mountain and Blue Mountain. To the south, near City of Rocks

State Park, the fault forms a 13-m-high northwest-facing scarp that controls and may have been freshened by local drainage.

Age of faulted deposits Seager and others (1982 #626) showed the fault as offsetting undifferentiated Quaternary sediment of early to middle Pleistocene age. However, Seager (written commun., 1998) now believes that these deposits are more likely of early Pleistocene age and are correlative with the upper part of the Camp Rice Formation.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Maximum time of faulting is from age of deposits as shown by Seager and others (1982 #626). However, he now considers these deposits to only be as young as early Pleistocene. The size of the scarps (10-15 m) suggests multiple faulting events in the early to middle(?) Pleistocene, although additional movement could have occurred in the late Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on estimated 10-15 m of offset of 1.6 Ma (Quaternary) deposits.

Length	End to end (km):	14.9
	Cumulative (km):	14.8

Average strike (azimuth) 046°±15°

Endpoints (lat. - long.) 32°41′20.80″N, 107°52′23.56″W
32°35′37.36″N, 107°59′08.41″W

References
#1031 Elston, W.E., 1957, Geology and mineral resources of Dwyer quadrangle, Grant, Luna, and Sierra Counties, New Mexico: [New Mexico] Bureau of Mines and Mineral Resources Bulletin 38, 86 p., 4 pls.
#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

2085, Black Hills fault

Structure Number 2085

Structure Name Black Hills fault
Comments: Originally named the West Rincon Hills fault by Seager and Hawley (1973 #996) for its location along the west margin of the Rincon Hills. However, recent detailed mapping by Seager and Mack (in press #1258) and Seager and others (in press #1260) uses the name Black Hills because the fault is along the west margin of the Black Hills as shown on the most recent 1:24,000-scale topographic map. The Black Hills fault extends from its intersection with the eastern (pre-Quaternary) section of the Derry Hills fault [2086] south to about 2 km beyond Thurman Arroyo (Hatch 7.5-minute quadrangle). From here, Seager and others (1982 #626) and Seager and others (in press #1260) show the fault as concealed but projecting southeast to join an unnamed fold [2089] that trends southeast and south through the Rincon 7.5-minute quadrangle (Seager and Hawley, 1973 #996).

Synopsis: This down-to-the-west normal fault bounds uplifted Tertiary volcanic rocks of the Black Hills. It may be a southward splay of the Derry Hills fault [2086]. The fault forms minor scarps on Pliocene to early Quaternary basin-fill deposits, but does not appear to offset late Quaternary alluvium.

Date of compilation 08/16/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the fault is from 1:125,000-scale map of Seager and others (1982 #626), which was based on then unpublished 1:24,000-scale mapping by Seager and others (in press #1260) and Seager and Mack (in press #1259).

Geologic setting This down-to-the-west, south-trending normal fault bounds uplifted Tertiary volcanic rocks of the Black Hills. It may be a southward splay of the Derry Hills fault [2086] and appears to join an unnamed Quaternary syncline [2089] that trends southeast and south through the Rincon 7.5-minute quadrangle (Seager and Hawley, 1973 #996). The fault is one of several subparallel structures that bound the western margin of the Rincon and Black Hills.

Sense of movement N

Dip not reported

Dip direction W

Geomorphic expression The fault forms subdued and small (<5 m high?) scarps on surfaces formed by sediment of the Camp Rice Formation and larger scarps where sediment of the Camp Rice Formation is downdropped against Tertiary bedrock, thus indicating recurrent movement in the Pliocene to Pleistocene. No studies of scarp morphology or detailed mapping has been conducted to determine stratigraphic offset of Quaternary deposits.

Age of faulted deposits Sediment of the Camp Rice Formation (Pliocene to early Quaternary) is deformed along the trace of the fault. However, younger (late Quaternary) piedmont-slope deposits (Qvo) are not offset, limiting the youngest movement to early or middle(?) Quaternary time.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing based on deformation of Camp Rice Formation sediment. Late Quaternary piedmont-slope deposits do not appear to be faulted.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: The slip rate is most probably <0.2 mm/yr based on relatively small height of scarps on surfaces that could be as old as early Quaternary (1.6 Ma) and the lack of deformation of late Quaternary deposits.

Length (km) End to end (km): 8.2
Trace (km): 8.3

Average strike (azimuth) -21°±13°

Endpoints (lat. - long.) 32°46′39.98″N, 107°09′44.70″W
32°42′31.03″N, 107°07′59.24″W

References

#1259 Seager, W.R., in press, Geology of Alivio quadrangle, Sierra and Doña Ana Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 148, 2 pls., scale 1:24,000.

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.
#996 Seager, W.R., and Hawley, J.W., 1973, Geology of Rincon quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 101, 42 p., 2 pls., scale 1:24,000.
#1258 Seager, W.R., and Mack, G.H., in press, Geology of McLeod Tank quadrangle, Sierra and Dona Ana Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 77, 2 sheets, scale 1:24,000.
#1260 Seager, W.R., Mack, G.H., and W., H.J., in press, Geology of Hatch quadrangle, Dona Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 78, 2 sheets, scale 1:24,000.

2086, Derry Hills fault

Structure Number 2086

Structure Name Derry Hills fault
Comments Originally named by Kelley and Silver (1952 #1072) for the small town of Derry, New Mexico, which is on U.S. Highway 85, east of the Rio Grande and north of Hatch. However, Seager and Mack (in press #1258) now use the term Derry Hills fault because the fault bounds the southwest margin of these hills. The fault extends from about 3 km north-northeast of Derry (Seager and Mack, in press #1258), southeast to a point about 2.5 km northeast of Salem, New Mexico. Seager and others (1982 #626) included the Wolfer fault of Kelley and Silver (1952 #1072) as an eastward extension of the Derry Hills fault.

Synopsis: This west-trending normal fault bounds uplifted blocks of Paleozoic and Tertiary rocks (on the north) that are associated with the southern end of the Caballo Mountains block. The fault forms part of the eastern margin of the Palomas basin, a eastward-tilted sediment-filled half graben. The Derry Hills fault cuts Quaternary and Tertiary deposits of the Camp Rice Formation and a younger sequence of Quaternary piedmont-slope deposits related to the upper Camp Rice Formation. No detailed studies have been made of the fault's scarp morphology or its Quaternary history.

Date of compilation 04/16/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra; Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the fault is from 1:125,000-scale map of Seager and others (1982 #626), which was based on 1:24,000-scale maps of Seager and Mack (1991 #1263). Older maps of the fault, such as that of Kelley and Silver (1952 #1072), showed the fault as bounding only the Derry Hills.

Geologic setting This down-to-the-southwest normal fault bounds uplifted blocks of Paleozoic and Tertiary rocks that are associated with the southern Caballo Mountains block. The fault was probably initiated in the Miocene; it cuts Tertiary and Quaternary deposits of the Santa Fe Group and most facies of the Camp Rice Formation (Pliocene to Quaternary). At the fault's eastern end, it splits into two branches. The eastern branch (Wolfer fault of Kelley and Silver, 1952 #1072) places Paleozoic rock on the uplifted (northern) block against Tertiary sedimentary rock, but displays no evidence of Quaternary movement (Seager, oral commun., 1996). The southern branch displaces most facies of the

Camp Rice Formation including the fluvial facies and is considered herein as a separate fault, the Black Hills fault [2085]. Both the northern and southern ends of the fault are concealed beneath late Quaternary alluvium, and thus the fault may be considerably longer than shown on the map.

Sense of movement N
Comments: Shown as high-angle normal fault on cross-sections of Kelley and Silver (1952 #1072).

Dip Not reported

Dip direction SW

Geomorphic expression The Derry Hills fault forms a prominent topographic escarpment, most of which is a fault-line scarp on bedrock. This escarpment is most prominent where resistant Paleozoic rocks are preserved on the uplifted fault block, such is in the Derry Hills and Round Mountain. However, the fault forms a smaller scarp on Tertiary rocks and Quaternary sediment of the Camp Rice Formation. Conversely, the fault is buried by middle (?) to late Pleistocene alluvium at many localities. Although there have been no detailed studies of the height or morphology of the fault scarps, the scarps are clearly the result of numerous faulting events.

Age of faulted deposits Pliocene and Quaternary sediment of the Camp Rice Formation are offset by the fault. The fluvial facies and fanglomerate facies of the Camp Rice Formation are juxtaposed against Tertiary bedrock. The fluvial facies was being deposited until 700-900 k.y. (Mack and others, 1993 #1020) and thus may be of early Pleistocene age along the fault. Piedmont-slope deposits of middle(?) to late Pleistocene age are not offset according to detailed mapping of Seager and Mack (1991 #1263).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Early Pleistocene deposits are offset by repeated faulting events as evidence by scarps formed on sediment of the Camp Rice Formation. The youngest (piedmont gravel) unit in the Camp Rice is faulted, suggesting movement as young as 700-900 ka. No movement appears to have occurred in the late Pleistocene, but middle Pleistocene offset is possible.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip rates are inferred from the lack of late Pleistocene movement (<130 ka) and the apparent small size of scarps in deposits that are probably no younger than 700 ka.

Length	End to end (km):	8.2
	Cumulative (km):	8.7

Average strike (azimuth) -60°±21°

Endpoints (lat. - long.) 36°17′01.95″N, 106°19′06.70″W
36°04′51.02″N, 106°31′43.16″W

References

#1072 Kelley, V.C., and Silver, C., 1952, Geology of the Caballo Mountains: University of New Mexico Publications in Geology 4, 286 p., 9 pls.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

#1263 Seager, W.R., and Mack, G.H., 1991, Geology of Garfield quadrangle, Sierra and Doña Ana Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 128, 2 pls., scale 1:24,000.

#1258 Seager, W.R., and Mack, G.H., in press, Geology of McLeod Tank quadrangle, Sierra and Dona Ana Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 77, 2 sheets, scale 1:24,000.

2087, Red Hills fault

Structure Number 2087
Comments: Referred to as fault 10 in Machette (1987 #960).

Structure Name Red Hills fault
Comments: Named by Kelley and Silver (1952 #1072) for the Red Hills, a horst block southeast of Caballo Dam and southwest of the Caballo Mountains. The fault extends from Caballo Creek (about 3 km east of Caballo Dam) where it joins the Caballo fault [2088], southwest and south to a point about 4 km east of Derry, New Mexico, where it abuts the Derry Hills fault [2086].

Synopsis: This normal fault bounds Precambrian, Paleozoic, and Tertiary rocks that are uplifted in a north-trending horst, southeast of the Caballo Mountains block. The fault forms part of the eastern margin of the Palomas basin, a eastward-tilted sediment-filled half graben. The Red Hills fault joins the Caballo fault [2088] on the north and appears to abut the Derry Hills fault [2086] on the south. These three faults form the western, tectonically active margin of the Caballo uplift (Caballo Mountains, Red Hills, Derry Hills, Round Mountain, and Red House Mountain). Quaternary deposits of the Camp Rice Formation and middle to late Pleistocene piedmont-slope deposits are offset along almost the entire length of the Red Hills fault. However, no detailed studies have been made of scarp morphology or the faults Quaternary history.

Date of compilation 05/05/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Las Cruces

Province Basin and Range

Geologic setting This down-to-the-west normal fault bounds Precambrian, Paleozoic, and Tertiary rocks that are uplifted in a north-trending horst southeast of the Caballo Mountains block. The fault forms part of the eastern margin of the Palomas basin, a eastward-tilted sediment-filled half graben. The fault was probably initiated in the Miocene; it cuts Tertiary and Quaternary deposits of the Santa Fe Group, sediment of the Palomas Formation (largely equivalent to the Pliocene to Pleistocene Camp Rice Formation to the south), and locally derived piedmont-slope deposits of middle to late Quaternary age. The fault changes character at it's approximate mid-point: to the north, it places piedmont-slope deposits against bedrock and to the south the hangingwall is comprised mainly of sediment of the Palomas Formation. Also, this point marks a prominent southward bifurcation in the fault, with some strands trending southeast into Paleozoic bedrock. The point at which this change in character occurs may reflect long-term differences in slip rate, and may prove to be a fault segment boundary. However, no detailed studies have been made of the fault's scarp morphology or its Quaternary history to warrant such a segmentation model.

Number of sections 2
Comments: Sections based on the aforementioned character of fault (see geologic setting). Boundary placed in southwest corner of Sec. 4, T. 17 S., R. 4 W. (Garfield 7.5-minute quadrangle).

Length End to end (km): 13.8
Trace (km): 16.6

Average strike (azimuth) -8°±30°

Endpoints (lat. - long.) 32°55′23.51″N, 107°15′11.99″W
32°47′58.77″N, 107°14′22.00″W

2087a, northern section

Section number 2087a

Section name northern section
Comments: The section extends from Caballo Creek (about 3 km east of Caballo Dam) where it joins the Caballo fault [2088], southwest and south to a point about 2.5 km north of the mouth of Green Canyon (southwest corner of Sec. 4, T. 17 S., R. 4 W., Garfield 7.5-minute quadrangle). The southern boundary of the section is based on the geology of hangingwall deposits and footwall structure. Seager and others (1982 #626) showed primarily young piedmont-slope deposits against bedrock on this section.

Reliability of location Good
Comments: Generalized trace of the fault is from 1:125,000-scale map of Seager and others (1982 #626), which was based on 1:24,000-scale maps later published by Seager and Mack (1991 #1263). Older geologic maps do not show the Red Hills and Caballo faults joining to the north, although Kelley and Silver (1952 #1072) alluded to the possibility of such a connection.

Sense of movement N
Comments: Kelley and Silver (1952 #1072) considered the fault as normal.

Dip 67° W
Comments: Kelley and Silver (1952 #1072) show the fault as high-angle on their cross sections E and F, whereas Seager and others (1982 #626) show a single dip measurement of 67° near the south end of the section

Dip direction W

Geomorphic expression The Red Hills fault forms a prominent topographic escarpment, most of which is a fault-line escarpment formed on Precambrian and Paleozoic rocks exposed in the footwall block. However, according to Seager (oral commun., 1996) the fault forms small but prominent local scarps on late Pleistocene alluvium (unit Qvo of Seager and others, 1982 #626). Along the northern part of the section, the fault turns northeast and trends subparallel to drainages that it appears to control. Detailed mapping by Seager and Mack and by Machette (unpubl. mapping used in Machette, 1987 #960) shows discontinuous fault scarps between Cable Canyon (north end of section) and Apache Creek, at the north end of the Red Hills. No detailed studies have been made of the fault scarp morphology or its Quaternary history.

Age of faulted deposits Most facies of the Camp Rice Formation (Pliocene to early or middle(?) Pleistocene) are faulted against bedrock. Detailed mapping by Seager and Mack (1991 #1263) indicates that their unit Qvo (late Pleistocene piedmont-slope deposits) is displaced by the fault at a number of sites along this section of the fault.

Detailed studies none(1988 #991)(1991 #1263)

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Timing based on offset of unit Qvo of Seager and others (1982 #626) and presence of fresh-appearing scarps on bedrock at the northern end of the section.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Unit Qvo appears to have a scarp that is about 3-5 m high. The amount of offset in older sediment of the Camp Rice Formation cannot be determined because these deposits are only present on the hangingwall block of the fault. However, based on comparisons with the Caballo fault [2088]

and other associated faults in the region, this section of the Red Hills fault probably has a low slip rate (<0.2 mm/yr).

Length End to end (km): 7.6
Trace (km): 8.5

Average strike (azimuth) 004°±29°

Endpoints (lat. - long.) 32°55′23.51″N, 107°15′11.99″W
32°51′18.90″N, 107°15′32.40″W

2087b, southern section

Section number 2087b

Section name southern section
Comments: The section extends from the southwest corner of Sec. 4, T. 17 S., R. 4 W. (Garfield 7.5-minute quadrangle), at a point about 2.5 km north of the mouth of Green Canyon, south to a point about 4 km east of Derry, New Mexico, where it abuts the Derry Hills fault [2086]. The northern boundary of the section is based on the geology of hangingwall deposits and footwall structure. Seager and others (1982 #626) and Seager and Mack (1991 #1263) showed primarily older sediment of the Camp Rice Formation against bedrock on this section.

Reliability of location Good
Comments: Generalized trace of the fault is from 1:125,000-scale map of Seager and others (1982 #626), which was based on 1:24,000-scale maps later published by Seager and Mack (1991 #1263). The geologic map of Kelley and Silver (1952 #1072) shows the Red Hills fault extending south to a termination against the Wolfer fault [now referred to as the Derry Hills fault, 2087].

Sense of movement N
Comments: Kelley and Silver (1952 #1072).

Dip not reported
Comments: Kelley and Silver (1952 #1072) show the fault as high angle on cross sections E and F.

Dip direction W

Geomorphic expression The Red Hills fault forms a prominent west-facing topographic escarpment, most of which is a fault-line scarp on Paleozoic rocks exposed in the hangingwall block. Along this section, the fault trends south and has several splays that extend into bedrock of the footwall block. Only the most basinward (main) trace is known to be Quaternary. The fault places sediment of the Camp Rice Formation against Paleozoic bedrock, but further south it is entirely within bedrock. No detailed studies have been made of the faults scarp morphology or Quaternary history.

Age of faulted deposits Most facies of the Camp Rice Formation (Pliocene to early or middle(?) Pleistocene) are faulted against bedrock. Detailed mapping by Seager and Mack (1991 #1263) indicates that their unit Qvo (late Pleistocene piedmont-slope deposits) is not displaced by the fault.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on offset of sediment of the Camp Rice Formation and no offset of unit Qvo of Seager and others (1982 #626).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: The amount of offset in sediment of the Camp Rice Formation cannot be determined because these deposits are only present on the hangingwall block of the fault. However, based on comparisons with the Caballo fault [2088] and other associated faults in the region, this section of the Red Hills fault probably has a low slip rate (<0.2 mm/yr).

Length End to end (km): 6.4
Trace (km): 8.1

Average strike (azimuth) -20°±25°

Endpoints (lat. - long.) 32°51′19.13″N, 107°15′32.12″W
32°47′58.77″N, 107°14′22.00″W

References

#991 Foley, L.L., LaForge, R.C., and Piety, L.A., 1988, Seismotectonic study for Elephant Butte and Caballo Dams, Rio Grande Project, New Mexico: U.S. Bureau of Reclamation Seismotectonic Report 88-9, 60 p., 1 pl., scale 1:24,000.

#1072 Kelley, V.C., and Silver, C., 1952, Geology of the Caballo Mountains: University of New Mexico Publications in Geology 4, 286 p., 9 pls.

#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

#1263 Seager, W.R., and Mack, G.H., 1991, Geology of Garfield quadrangle, Sierra and Doña Ana Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 128, 2 pls., scale 1:24,000.

2088, Caballo fault

Structure Number 2088
Comments: Referred to as fault 9 in Machette (1987 #960) and fault 2 in Machette (1987 #847).

Structure Name Caballo fault
Comments: The fault is named for the Caballo (Spanish for horse) Mountains. The name appears to have been in common usage by the 1940's and is cited in Kelley and Silver (1952 #1072). However, we have been unable to document the first usage of this fault name. This description includes the Gordon fault, a mountainward fault associated with the Caballo according to Seager and Mack (in press #1257).

Synopsis: This down-to-the-west normal fault bounds the north-trending, east-tilted Caballo block, south of Truth or Consequences, New Mexico. The fault forms part of the eastern margin of the Palomas basin, a eastward-tilted, sediment-filled half graben. The fault probably began to uplift the Caballos in the Miocene, but uplift continued into the Pliocene and Quaternary. The geometry and general movement history of the fault suggest that it has four discrete sections: Holocene fault scarps are present on the Williamsburg (northwestern) and central sections of the Caballo fault. Deposits of the Palomas Formation (Pliocene-Pleistocene) and middle Pleistocene to Holocene piedmont-slope deposits are offset along the Williamsburg and central sections of the fault. The northern and southern sections appear to be of pre-Quaternary age, and thus are not included in the following discussion. About 35 topographic profiles have been measured on the Quaternary age sections to characterize the fault scarp morphology, and 2 exploratory trenches have been excavated to document the timing of fault movement.

Date of compilation 04/18/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Las Cruces; Tularosa

Province Basin and Range

Geologic setting This down-to-the-west normal fault bounds Precambrian, Paleozoic, and Tertiary rocks that are uplifted in the north-trending, east-tilted Caballo block. The fault forms part of the eastern margin of the Palomas basin, a eastward-tilted sediment-filled half graben. The Caballo fault abuts and truncates the Hot Springs fault [2100] on the north and joins the Red Hills fault [2087] on the south. Quaternary movement on the fault appears to have followed different paths than earlier in the Cenozoic. As a result, the active trace of the Caballo fault is concave to the west, rather than to the east as reflected in the shape of the Caballo Mountains. The Caballo, Hot Springs [2100], Red Hills [2087], and Derry Hills [2086] faults form the western, tectonically active margin of the Caballo uplift (Caballo Mountains, Red Hills, Derry Hills, Round Mountain, and Red House Mountain). Sediment of the Palomas Formation and middle Pleistocene to Holocene piedmont-slope deposits are offset along the northern and central sections of the Caballo fault indicating young movement, whereas the southern section appears to be of pre-Quaternary age.

Number of sections 4 (2 Quaternary)
Comments: Four sections are defined on the basis of geometry, timing of faulting, range-front morphology, and gaps in fault continuity. The Williamsburg (northwestern) and central sections clearly have repeated Pleistocene and Holocene movement, whereas the northern and southern sections do not appear to displace Quaternary deposits, at least as seen in reconnaissance studies. Therefore, only the two Quaternary-age sections [2088a, 2088b) are discussed herein.

Length End to end (km): 21.1
Trace (km): 27.6

Average strike (azimuth) -4°±24°

Endpoints (lat. - long.) 33°06′49.59″N, 107°15′58.50″W
32°55′23.45″N, 107°15′12.04″W

2088a, Williamsburg section

Section number 2088a

Section name Williamsburg (northwestern) section
Comments: Herein named the Williamsburg section after the Williamsburg fault (scarp), a 2-km-long scarp on piedmont-slope deposits south and east of the Rio Grande. Williamsburg is a small community on the north side of the Rio Grande, south of Truth or Consequences, New Mexico. Previously called the northern segment of the Caballo fault by Machette (1987 #960) and Foley and others (1988 #991), but this is confusing because there is a main-range bounding (northern) section of the Caballo fault that appears to be inactive (pre-Quaternary). The Williamsburg section of the fault extends from the Rio Grande south and southeast along the western margin of the northern Red Hills (see Kelley and Silver, 1952 #1072) where it truncates the southern end of the Hot Springs fault [2100]. To the south, the Williamsburg section joins the central (main) section of the Caballo fault just south of Red Creek. The Williamsburg section may extend northwest across the Rio Grande and join the Mud Springs fault [2101], as originally suggested by Kelley and Silver (1952 #1072).

Reliability of location Good
Comments: Trace of the fault is from detailed (1:24,000-scale) reconnaissance mapping by Machette (1987 #960) and Foley and others (1988 #991), and from 1:24,000-scale maps of Seager and Mack (in press #1257). The geologic map of Kelley and Silver (1952 #1072) does not show this section of the fault, but does project a concealed trace of the Mud Springs fault [2101] south across the Rio Grande to the approximate location of the Williamsburg fault scarp.

Sense of movement N

Comments: Kelley and Silver (1952 #1072) considered the fault as normal, but suggest that lateral drag of fabric within Precambrian rocks of the Caballo Range may reflect left-lateral movement on the fault. If such movement occurred, it may date from Cenozoic or older deformation.

Dip 65° W
Comments: Approximate dip of fault zone as measured in near-surface exposures along an arroyo that bisects the Williamsburg fault scarp (see fig. 2.7 in Foley and others, 1988 #991).

Dip direction W

Geomorphic expression This section of the fault is marked by a nearly continuous, 2-km-long fault scarp (Williamsburg fault scarp) that is formed on an extensive piedmont surface underlain by Tortugas(?) alluvium (Foley and others, 1988 #991), which is graded to a position 25-50 m above the Rio Grande. South of Sec. 9 (T. 13 S., R. 4 W., Williamsburg 7.5-minute quadrangle), the fault forms discontinuous scarps in an irregular pattern as they track around the west margin of the northern Red Hills. Much of the trace of the fault in this area is obscured by stream erosion. The fault places bedrock against sediment and the few remnant scarps that remain are the product of a long history of offset and stream erosion. Access is difficult in this area and the fault has not been mapped in detail south of the more prominent Williamsburg scarp.

At Red Canyon, the fault crosses alluvial terraces and seems to form two strands that define a minor horst. The easterly strand continues southeast toward the central section [2088b] of the Caballo fault, but the scarps are poorly preserved on high-level piedmont slope deposits. This portion of the fault provides a structural connection between the two active sections [2088a, 2088b]. The scarps appear to face northeast and southwest, and this change in downthrown direction may reflect a component of lateral slip, rather than the predominant normal slip component seen elsewhere. The northern section probably joins the central section at a point about 1 km south of Red Canyon (Palomas Gap Creek).

The Williamsburg scarps are 4.0-6.4 m high (3.5-6.2 m of surface offset) and there is a thick mantle of eolian sand that buries the lower part of the scarp in many places. This mantle of sand complicates interpretations of scarp morphology. Nevertheless, four scarp profiles measured by Foley and others (1988 #991) showed evidence of compound slopes and multiple faulting events. The youngest element of the scarps are about 2-3 m high and have maximum slope angles of 18-26°, which suggested an age of <5 ka.

Age of faulted deposits This section of the fault displaces sediment of the Camp Rice Formation, and piedmont-slope deposits associated with the Tortugas (150-250 ka) and Picacho (50-150 ka) alluviums according to Foley and others (1988 #991). In addition, Holocene colluvium and eolian sand are offset in a natural exposure across the Williamsburg scarp.

Detailed studies Site 2088a-1. Foley and others (1988 #991) excavated the southern wall of a natural stream-cut exposure across the Williamsburg scarp. This exposure revealed evidence for 3 or 4 surface-faulting events that produced a total of 5.0-5.5 m of offset in the past 150-250 k.y. The two older events yield a net offset of 2.5-3.0, and are recorded by faulted packages of gravel and loess, each of which is capped by moderately well developed calcic soil (in loess). Calculations of the amount of secondary carbonate in these soils yields soil-accumulation times of 140-150 k.y. each for a total of nearly 300 k.y., which exceeds the stated probable age of the alluvial surface. The next younger event(s) are evidenced by a package of fault-scarp colluvium that is intercalated with eolian sand. Uncertainties about the origin of these deposits led Foley and others (1988 #991) to suggest one Holocene faulting event of about 2.6 m offset, or two smaller offset events. If there were two events, they were most likely both in the Holocene because there is no discernible soil between the two fault-related deposits. The most recent event is known to be >1.6 ka on the basis of unfaulted charcoal collected from the exposure.

Timing of most recent paleoevent latest Quaternary (<15 ka)
Comments: The most recent event is considered to be <5 ka on the basis of scarp-morphology studies (Machette, 1987 #960) but >1.6 ka (uncorrected radiocarbon age, Foley and others, 1988 #991). A second Holocene event may have occurred, although the next older event is more than 100 ka.

Recurrence interval 75-150 k.y. (<150-300 ka)

Comments: Recurrence interval based on calculated duration of soil formation, which reflects tectonic stability between the faulting events. The soils have estimated accumulation times of 140-150 k.y. each for a total of nearly 300 k.y., which exceeds the stated probable age of the alluvial surface (150-250 ka). Elsewhere in New Mexico, the compiler (Machette) uses an estimate of 250±50 ka for the time of stablization of the Tortugas alluvium. If one assumes that the surface of the Tortugas alluvium stabilized as recently as 150 ka (as Foley suggested), then the average recurrence interval might be as little as 75 k.y. (2 events in 150 k.y.). Conversely, if the 250±50 ka age is more realistic, then the average recurrence interval might be as long as 150 k.y. (2 events in about 300 k.y.). There is a distinct possibility that two discrete surface-faulting events occurred in the Holocene, and thus there may be evidence for a clustering of faulting events on a time scale much less (*i.e.*, 5 k.y.) than that of reflected by the long term average. Similar evidence of clustering has been reported for the La Jencia [2109] and Organ Mountains [2052] faults.

Slip-rate category <0.2 mm/yr

Comments: Foley and others (1988 #991) calculated slip rates of 0.02-0.03 for the post-250 ka surfaces along the northern and central sections of the fault. Data from the natural exposure further north (5.0-5.5 m of net offset in the past 150-300 k.y.) suggest similar slip rates.

Length End to end (km): 8.3
Trace (km): 11.8

Average strike (azimuth) -18°±20°

Endpoints (lat. - long.) 33°06′49.59″N, 107°15′58.50″W
33°02′34.02″N, 107°14′21.79″W

2088b, *Central section*

Section number 2088b

Section name Central section

Comments: Named the central segment of the Caballo fault by Machette (1987 #960) and Foley and others (1988 #991); this is the only active section of the three main range-bounding sections along the Caballo Mountains. The Central section extends from its intersection with the Williamsburg section [2088a] south to Caballo Canyon, where it appears to merge with the Red Hills fault [2087] as originally suggested by Kelley and Silver (1952 #1072). The northern (inactive) section of the Caballo fault merges with the Hot Springs fault [2100] east of Truth or Consequences and joins the central section north of Palomas Gap Creek (Red Canyon). The central section includes the Gordon fault of Seager and Mack (in press #1257). To the south at Flordillo Canyon, the central section of the fault branches off from the southern (pre-Quaternary) section, which continues southeastward as the inactive range-bounding fault of the southern Caballo Mountains (see Seager and Mack, in press #1258, #1259).

Reliability of location Good

Comments: Trace of the fault is from detailed (1:24,000 scale) reconnaissance mapping by Machette (1987 #960) and Foley and others (1988 #991), and from 1:24,000-scale geologic maps of Seager and Mack (in press #1257). Seager and others (1982 #626) showed the generalized trace of the fault within the Las Cruces 1° x 2° quadrangle, which includes the southern half of this section. This generalized trace was based on unpublished mapping by Seager and Mack (see Seager and Mack, in press #1257). The geologic map of Kelley and Silver (1952 #1072) does not show the central section of the Caballo fault as joining the Red Hills fault [2087].

Sense of movement N

Comments: Kelley and Silver (1952 #1072) considered the fault as normal, but suggested that lateral drag of fabric within Precambrian rocks of the Caballo Range may reflect left-lateral movement on the fault. If such movement occurred, it may date from Cenozoic or older deformation.

Dip 80° W-90°

Comments: Approximate dip of fault zone as measured in exposures along an arroyo that cuts across the scarp about 1 km south of Granite Canyon (see fig. 2.9 in Foley and others, 1988 #991).

Dip direction W

Geomorphic expression This section of the fault is marked by nearly continuous west-facing scarps that are formed on locally derived sediment of the Camp Rice Formation, on younger piedmont-slope deposits that cut across the Camp Rice, and on alluvial terraces inset within these deposits. The scarps are 27-44 m high on the oldest Quaternary deposits (Palomas Formation, equivalent to fanglomerate facies of the Camp Rice Formation), and become progressively smaller on younger deposits, indicating a long history of recurrent movement on the fault. Scarps are well developed between Red Canyon and Ash Canyon, but access is difficult and only 5 scarp profiles have been measured in this area. The fault is easily accessed by road between Ash Canyon and Flordillo Canyon, where Machette (1987 #960) and Foley and others (1988 #991) measured 25 scarp profiles. Most of these profiles indicate the scarps are the product of multiple faulting events (scarp heights from 5-43 m).

Six of the profiles had young slope elements that may relate to a single faulting event or the most recent faulting event. The scarp-morphology data (see table 1 in Machette, 1987 #960) suggested that the most recent faulting event occurred during the past 5 ka. The youngest and steepest element of the scarps are 2.8-4 m high and have maximum slope angles of 16-22° (respectively). At the southern end of the section, young fault scarps turn southwestward (toward the Red Hills fault [2087]) and bifurcate from the main trend of the fault. The south to southeast continuation of the fault does not appear to have young scarps, and thus is designated as a different (southern) section.

Age of faulted deposits This section of the fault displaces sediment of the Palomas Formation, and piedmont-slope deposits associated with the Tortugas (150-250 ka) and Picacho (50-150 ka) alluvium, according to Foley and others (1988 #991). The compiler (Machette) prefers to use slightly different age calls of 250±50 ka for the Tortugas and 100±30 ka for the Picacho. The Cuchillo surface (top of the Palomas Formation) was assumed to be 500-600 k.y. However, Mack and others (1993 #1020) suggested that the Cuchillo surface is probably 700-900 ka. Finally, Foley and others (1988 #991) demonstrated that Holocene colluvium is offset in an exposure along an arroyo 1 km south of Granite Canyon.

Detailed studies Site 2088b-1. Foley and others (1988 #991) excavated the southern wall of an arroyo across the main-range bounding scarp about 1 km south of Granite Canyon (trench 2 of Foley and others, 1988 #991). This exposure revealed evidence for 2 surface-faulting events that produced a total of 3-4 m of offset in the past 50-150 k.y. Each event yielded a net offset of 1.5-2 m, as evidenced by the thickness of fault-generated scarp colluvium. The soil on the youngest (unfaulted) colluvium is poorly developed and appears to be similar to soils on the Fillmore alluvium (Holocene) near Las Cruces. Calculations of the amount of secondary carbonate in this young soil yields soil accumulation times of 5-7 k.y. There is no soil associated with the colluvium from the older faulting event, which suggests that it has been either removed or did not have time to form between the two faulting events.

Timing of most recent paleoevent latest Quaternary (<15 ka)

Comments: The most recent event is considered to be 4-5 ka on the basis of scarp morphology studies (Machette, 1987 #960), and the degree of soil development on unfaulted alluvium (Foley and others, 1988 #991).

Recurrence interval 45-75 k.y. (<700-900 ka)

Comments: The most recent recurrence interval could range from as little as several thousand years (*i.e.,* no soil between two young colluvial wedges) to as much as 150 k.y. (the oldest age for the alluvium that has been faulted twice). However, better estimates of the longer-term average recurrence interval are probably derived from the amount of offset associated with scarps on the older surfaces (>150 k.y.) Machette (1987 #960) suggested long-term (average) recurrence intervals of about 100 k.y. However, if one assumes that the 30-40 m of offset associated with the largest scarps occurred in 2-3 m increments, then there could have been 10-20 events in the past 700-900 k.y. These data yield average recurrence intervals of 45-75 k.y. for the middle and late Quaternary.

Slip-rate category <0.2 mm/yr

Comments: Machette (1987 #960) suggested slip rates of 0.02-0.03 mm/yr for the post-250 ka surfaces (5-8 m of offset), and 0.05-0.08 mm/yr for the constructional surface of the Palomas Formation based on an assumed age of 500-600 k.y. However, Mack and others (1993 #1020) suggested that age of the Cuchillo surface (top of the Palomas Formation) is probably more likely 700-900 ka, which would yield a slightly higher long-term slip rate.

Length	End to end (km):	13.3
	Cumulative (km):	15.8

Average strike (azimuth) 006°±19°

Endpoints (lat. - long.) 36°17′01.95″N, 106°19′06.70″W
36°04′51.02″N, 106°31′43.16″W

References

#991 Foley, L.L., LaForge, R.C., and Piety, L.A., 1988, Seismotectonic study for Elephant Butte and Caballo Dams, Rio Grande Project, New Mexico: U.S. Bureau of Reclamation Seismotectonic Report 88-9, 60 p., 1 pl., scale 1:24,000.

#1072 Kelley, V.C., and Silver, C., 1952, Geology of the Caballo Mountains: University of New Mexico Publications in Geology 4, 286 p., 9 pls.

#847 Machette, M.N., 1987, Preliminary assessment of paleoseismicity at White Sands Missile Range, southern New Mexico—Evidence for recency of faulting, fault segmentation, and repeat intervals for major earthquakes in the region: U.S. Geological Survey Open-File Report 87-444, 46 p.

#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

#1257 Seager, W.R., and Mack, G.H., in press, Geology of Caballo quadrangle, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 76, 1 sheet, scale 1:24,000.

#1258 Seager, W.R., and Mack, G.H., in press, Geology of McLeod Tank quadrangle, Sierra and Dona Ana Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 77, 2 sheets, scale 1:24,000.

2089, Unnamed fold northwest of Rincon

Structure Number 2089

Structure Name Unnamed fold northwest of Rincon

Comments: This unnamed fold is shown by Seager and Hawley (1973 #996) and by Seager and others (1982 #626) as extending parallel to but south of the southern margin of the Rincon and Black Hills, northwest of Rincon, New Mexico.

Synopsis: Little is known about the age of this fold. It is manifested at the surface as a southeast-trending syncline that deforms basin-fill deposits of the Pliocene to early or middle(?) Quaternary Camp Rice Formation, and thus is probably of Quaternary age.

Date of compilation 08/16/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Location taken from 1:125,000-scale mapping of Seager and others (1982 #626), which was based on 1:24,000-scale mapping of Seager and Hawley (1973 #996).

Geologic setting This east-west-trending syncline may reflect folding in response to uplift of the Rincon and Black Hills to the north. The fold deforms basin-fill deposits of the Pliocene to early or middle(?) Quaternary Camp Rice Formation. To the north, it merges with the Black Hills fault [2085], a down-to-the-west normal fault.

Sense of movement Down relative to limbs
Comments: Narrow, tight syncline.

Dip not reported
Comments: No values are mentioned for the limbs or axis of the syncline by Seager and Hawley (1973 #996). However, their map shows the syncline as having gentle dips in the Pliocene-Pleistocene sediment and as much as 20° dip in the underlying folded Tertiary rocks.

Dip direction N; S
Comments: Limbs of the syncline dip to the north and south as shown by Seager and Hawley (1973 #996).

Geomorphic expression The structure is expressed at the surface as a gentle fold that is elongate in the east-west direction. Constructional surfaces related to deposition of the Camp Rice Formation are deformed.

Age of faulted deposits Seager and Hawley (1973 #996) showed the fold developed in basin-fill deposits of the Camp Rice Formation, which is Pliocene to early or middle(?) Pleistocene. The structure deforms the surface of these deposits, and thus must postdate its stablization. However, younger piedmont-slope and stream deposits are not deformed according to their mapping.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing based on deformation of Camp Rice Formation sediment. Late Quaternary piedmont-slope deposits do not appear to be deformed.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: A low deformation rate inferred from the gentle dip of limbs and lack of deformation in late Quaternary deposits.

Length	End to end (km):	5.3
	Cumulative (km):	5.5

Average strike (azimuth) -48°±26°

Endpoints (lat. - long.) 32°42′00.92″N, 107°07′10.50″W
32°40′08.45″N, 107°04′38.88″W

References

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

#996 Seager, W.R., and Hawley, J.W., 1973, Geology of Rincon quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 101, 42 p., 2 pls., scale 1:24,000.

2090, Rimrock fault

Structure Number 2090
Comments: Fault number 7 of Machette and others (1986 #1033).

Structure Name Rimrock fault
Comments: Fault extends southeast across the Arizona/New Mexico boundary and is located about 8 km northeast of Duncan, Arizona.

Synopsis: Little is known about this northwest-southeast-trending basin-margin fault other than it offsets Pleistocene surficial deposits. Its scarps are as large as 13 m in height, which indicates multiple (recurrent) faulting events, the youngest of which may have occurred in the late Pleistocene.

Date of compilation 03/07/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico; Arizona

County Grant; NM; Greenlee, AZ

1° x 2° sheet Silver City

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:250,000-scale map of Machette and others (1986 #1033).

Geologic setting This fault is one of several Quaternary faults that mark the northeastern margin of the Duncan basin. All of the faults trend northwest and dip southwest; nearby Tertiary rocks are uplifted to the northwest. Regional geologic mapping by Drewes and others (1985 #1034) showed several short faults in this area, whereas Machette and others (1986 #1033) showed a longer trace for the fault.

Sense of movement N

Dip not reported

Dip direction SW

Geomorphic expression Machette and others (1986 #1033) reported that scarps along the fault are on topographically high, early to middle Pleistocene alluvial surfaces that form a broad dissected piedmont. The largest scarps are about 13 m high. A small asymmetric graben (not shown on map) is present on terrace alluvium inset into the higher surfaces. The antithetic (southwest) scarps that bound the graben are largely buried by Holocene alluvium. The scarps have not been studied carefully, but their overall morphology suggests a late Pleistocene age.

Age of faulted deposits The faulted high-level piedmont surface is underlain by early to middle Pleistocene alluvium, whereas the graben is formed on inset middle to late Pleistocene terrace deposits. The graben is buried in part by early to middle(?) Holocene alluvium.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)

Comments: Timing based on offset of middle to late Pleistocene deposits and morphology of scarps, which is suggestive of late Pleistocene offset.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Machette and others (1986 #1033) reported scarps as high as 13 m on early to middle Pleistocene piedmont surfaces. These scarps may relate to about 10-12 m of vertical offset in deposits that are probably on the order of 0.5-1.0 Ma. These data suggest a low long-term slip rate.

Length	End to end (km):	7.8
	Cumulative (km):	10.2

Average strike (azimuth) -25°±14°

Endpoints (lat. - long.) 32°48'39.95"N, 109°03'07.08"W
32°44'56.09"N, 109°00'41.57"W

References

#1034 Drewes, H., Houser, B.B., Hedlund, D.C., Richter, D.H., Thorman, C.H., and Finnell, T.L., 1985, Geologic map of the Silver City 1° x 2° quadrangle New Mexico and Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-1310-C, 1 sheet, scale 1:250,000.

#1033 Machette, M.N., Personius, S.F., Menges, C.M., and Pearthree, P.A., 1986, Map showing Quaternary and Pliocene faults in the Silver City 1° x 2° quadrangle and the Douglas 1° x 2° quadrangle, southeastern Arizona and southwestern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-C, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2091, Pearson Mesa faults

Structure Number 2091
Comments: Fault number 8 of Machette and others (1986 #1033).

Structure Name Pearson Mesa faults
Comments: These faults were mapped by Morrison (1965 #1042) but named by Machette and others (1986 #1033) for Pearson Mesa, a high-level geomorphic surface that slopes northwest about 3-7 km southeast of Franklin, Arizona. The faults displace this surface at a location about 15 km southeast of Duncan, Arizona

Synopsis: Little is known about these two intrabasin faults other than they offset the Pleistocene deposits that form Pearson Mesa. They are part of a larger set (mostly unconfirmed) that were mapped in 1965 by Roger Morrison. The two scarps included herein are as large as 5-6 m in height, which suggests they may be the result of two or more faulting events, the youngest of which may have occurred in the late Pleistocene.

Date of compilation 03/05/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Hidalgo

1° x 2° sheet Silver City

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:250,000-scale map of Machette and others (1986 #1033).

Geologic setting These two faults, which mark the southeastern margin of the Duncan basin, trend northeast and dip northwest. This trend is anomalous as most Quaternary faults in this region trend north to northwest. However, Drewes and others (1985 #1034) show several other faults (Pliocene to Pleistocene) to the south that have similar northeasterly trends.

Sense of movement N

Dip not reported

Dip direction NW

Geomorphic expression Morrison (1965 #1042) and Machette and others (1986 #1033) showed these scarps on Pearson Mesa, a topographically high, early to middle Pleistocene alluvial surface that forms a broad piedmont at the southeast margin of the Duncan basin. The scarps are about 5-6 m high but only 5 km long. Southeastward backtilting between two these subparallel scarps has reversed the northwest-sloping gradient of the mesa, thus forming a small playa between the faults. The scarps have not been studied carefully, but their subdued morphology suggests late Pleistocene (<130 ka), rather than younger (<30 ka) movement. Morrison (1965 #1042) mapped many more faults in the region, but these have not been confirmed as being of tectonic versus a more probable fluvial origin.

Age of faulted deposits According to Morrison (1965 #1042), Pearson Mesa is underlain by Kansan(?) alluvium, which would be of early middle Pleistocene age if his correlation with mid-Continent glacial stratigraphy is correct. However, no dating has been done that would confirm or deny this correlation, and no volcanic ashes are reported to be associated with Pearson Mesa or its underlying deposits.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Maximum timing based on offset of early(?) middle Pleistocene deposits (*i.e.*, 0.5-0.75 Ma), whereas the most recent faulting event is probably late Pleistocene (ca. 100 ka), rather than younger (<30 ka) as determined from the subdued morphology of the fault scarps.

Recurrence interval not reported

Slip-rate category unknown; probably<0.2 mm/yr
Comments: Machette and others (1986 #1033) reported scarps as high as 5-6 m on Pearson Mesa. These scarps may relate to about 5 m of vertical offset in deposits that may be on the order of 0.5-0.75 Ma. These age and offset values suggest extremely low long-term slip rates.

Length	End to end (km):	5.1
	Cumulative (km):	9.5

Average strike (azimuth) 035°±24°

Endpoints (lat. - long.) 32°38′37.99″N, 108°58′14.10″W
32°37′07.49″N, 109°00′58.18″W

References

#1034 Drewes, H., Houser, B.B., Hedlund, D.C., Richter, D.H., Thorman, C.H., and Finnell, T.L., 1985, Geologic map of the Silver City 1° x 2° quadrangle New Mexico and Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-1310-C, 1 sheet, scale 1:250,000.

#1033 Machette, M.N., Personius, S.F., Menges, C.M., and Pearthree, P.A., 1986, Map showing Quaternary and Pliocene faults in the Silver City 1° x 2° quadrangle and the Douglas 1° x 2° quadrangle, southeastern Arizona and southwestern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-C, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1042 Morrison, R.B., 1965, Geologic map of the Duncan and Canador Peak quadrangles Arizona and New Mexico: U.S. Geological Survey Miscellaneous Geologic Investigations I-442, 7 p. pamphlet, 1 sheet, scale 1:48,000.

2092, Washburn Ranch fault zone

Structure Number 2092
Comments: Fault number 9 of Machette and others (1986 #1033).

Structure Name Washburn Ranch fault zone
Comments: These faults were first mapped by Gillerman (1958 #1067), but were later named by Machette and others (1986 #1033) for Washburn Ranch, which is near the north end of the fault zone. The fault zone extends southeast about 15 km from near the latitude of Cowboy Pass to just south of New Mexico State Highway 9, west of Animas, New Mexico.

Synopsis: This zone of en echelon fault scarps bounds the western margin of the Animas Valley and east margin of the Pelloncilo Mountains, an elongate range that straddles the Arizona/New Mexico state boundary. The fault has fresh scarps that appear to be Holocene in age on the basis of their morphology. Some of the larger scarps appear to be compound (have definite slope elements) and are the result of a recent faulting event superposed on an older scarp.

Date of compilation 03/05/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Hidalgo

1° x 2° sheet Douglas, Silver City

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:250,000-scale map of Machette and others (1986 #1033), which was compiled at 1:24,000-scale from aerial photographs. Drewes and Thorman (1980 #1040) identified several additional scarps along the fault zone as part of 1:24,000-scale geologic mapping, whereas Drewes and others (1985 #1034) showed the generalized trace of the northern part of the fault on their 1:250,000-scale map.

Geologic setting This zone of south- to southwest-trending fault scarps bound the western margin of the Animas Valley and east margin of the Pelloncilo Mountains, an elongate range that crosses the Arizona/New Mexico state boundary. The scarps are on Quaternary surficial deposits, except near the southern end of the fault where the fault appears to offset part of the basalt of Animas Valley. These basalts were dated at 0.14-0.54 Ma almost 20 years ago by whole-rock K-Ar techniques (see table 1 in Machette and others, 1986 #1033), ages that now would be considered suspect.

Sense of movement N

Dip not reported

Dip direction E

Geomorphic expression Gillerman (1958 #1067) first noted the fault scarps and briefly described them as being incompletely buried by deposits along intermittent streams. Drewes and Thorman (1980 #1040) mapped several additional scarps along the fault but did not describe their geomorphic expression. Machette and others (1986 #1033) reported that the scarps are rather small, ranging from 0.5-5 m in height (this includes minor strands) in the area between Martin Draw (on the south) and a point about 1 km northeast of Grand Dad Well (Cotton City 7.5-minute quadrangle). On the basis of topographic profiling, they separated the data into two sets: those north of Martin Draw and those south of Martin Draw. The northern scarps are generally 2.6-4.8 m high and are morphologically younger than the Drum Mountains scarps of Utah (see fig. 9 in Machette and others, 1986 #1033), whereas the southern scarps are 2.2-4.0 m high and are morphologically similar to the Drum Mountains scarps (see fig. 8 in Machette and others, 1986 #1033). However, with out trenching or direct dating of the scarps, these differences do not justify separating the fault into sections or segments. At that time, the Drum Mountain scarps were considered to be about 5 ka. However, recent studies by Crone (1983 #552) indicate that the Drum Mountain scarps are probably early Holocene.

Age of faulted deposits Machette and others (1986 #1033) indicated that the scarps are formed on alluvial-fan deposits of middle to late Pleistocene and Holocene age. These age estimates were based on preservation of landforms, expression on aerial photographs, and brief glimpses of soils developed on the deposits. However, no detailed studies of the Quaternary alluvial sequence has been made in this area.

Detailed studies None

Timing of most recent paleoevent latest Quaternary (<15 ka)
Comments: Morphometric data from the Washburn Ranch scarps indicate that some of them are probably compound (more than one faulting event). The most recent faulting occurred no earlier than about 15 ka and is more likely to be early to middle Holocene in age (5-10 ka). These data support Gillerman's (1958 #1067) inference of Holocene faulting.

Recurrence interval 15-45 k.y. (<130 ka)
Comments: The scarps are present on middle to late Pleistocene and Holocene age deposits, and the larger scarps on older deposits may reflect two discrete faulting events. The compound scarps have poorly defined bevels, suggesting scarps from the penultimate faulting event were not greatly modified before the most recent event. Thus, Machette and others (1986 #1033) suspected that the penultimate event occurred in the late Pleistocene (*i.e.*, 130-30 ka), but the recurrence interval may be only 30-50 ka as reflected by the lack of pronounced bevels. If their inference is correct, the most recent recurrence interval might be somewhere between 15 k.y. (if events occurred at 15 and 30 ka) and 45 k.y. (if events occurred at 5 and 45 ka). However, any prior faulting event must have occurred at least 80-100 k.y. earlier as evidenced by to similar-size scarps on late and middle Pleistocene deposits.

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on small scarps (0.5-5.0 m) on late Pleistocene deposits.

Length	End to end (km):	12.0
	Cumulative (km):	17.9

Average strike (azimuth) -20°±20°

Endpoints (lat. - long.) 32°03′34.21″N, 108°56′24.36″W
31′57′32.00″N, 108°53′34.92″W

References

#552 Crone, A.J., 1983, Amount of displacement and estimated age of a Holocene surface faulting event, eastern Great Basin, Millard County, Utah, *in* Crone, A.J., ed., Paleoseismicity along the Wasatch Front and adjacent areas, central Utah: Utah Geological and Mineral Survey Special Studies 62, p. 49-55.

#1034 Drewes, H., Houser, B.B., Hedlund, D.C., Richter, D.H., Thorman, C.H., and Finnell, T.L., 1985, Geologic map of the Silver City 1° x 2° quadrangle New Mexico and Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-1310-C, 1 sheet, scale 1:250,000.

#1040 Drewes, H., and Thorman, C.H., 1980, Geologic map of the Cotton City quadrangle and the adjacent part of the Vanar quadrangle, Hidalgo County, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1221, 1 sheet, scale 1:24,000.

#1067 Gillerman, E., 1958, Geology of the central Peloncillo Mountains, Hidalgo County, New Mexico, and Cochise County, Arizona: [New Mexico] Bureau of Mines and Mineral Resources Bulletin 57, 152 p., 2 pls.

#1033 Machette, M.N., Personius, S.F., Menges, C.M., and Pearthree, P.A., 1986, Map showing Quaternary and Pliocene faults in the Silver City 1° x 2° quadrangle and the Douglas 1° x 2° quadrangle, southeastern Arizona and southwestern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-C, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2093, Animas Valley fault

Structure Number 2093
Comments: Fault number 10 of Machette and others (1986 #1033).

Structure Name Animas Valley fault
Comments: These faults were mentioned early by Reeder (1957 #1069) and Gillerman (1958 #1067), but were later mapped by Drewes and others (1985 #1034). Smith (1978 #1706) named the faults for the Animas Valley, which they border on the east. The faults extend from about 1 km north of Gore Canyon south to the latitude of Holtkamp Canyon, about 5 km northeast of Cotton City, New Mexico.

Synopsis: These faults bound the eastern margin of the Animas Valley and western piedmont of the Pyramid Mountains. The faults have small scarps that appear to be latest Pleistocene in age on the basis of their morphology. Most of the scarps are compound and have bevels near their crests, indicating they may be the result of multiple faulting events. No detailed studies have been made of the timing of fault movement or of the age of faulted materials.

Date of compilation 03/07/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Hidalgo

1° x 2° sheet Silver City

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:250,000-scale map of Machette and others (1986 #1033), which was compiled at 1:24,000-scale from aerial photographs. Thorman and Drewes (1978 #1039) mapped the northern end of the fault at 1:24,000 scale and Drewes and others (1985 #1034) showed the generalized trace of the entire fault on their 1:250,000-scale map. Fleischhauer and Stone (1982 #1274) showed some parts of the fault at 1:48,000 scale, along with late Pleistocene and Holocene shorelines of pluvial Lake Animas.

Geologic setting This south-trending fault forms a sinuous trace 1-5 km west of the Pyramid Mountains. The scarps bound the eastern margin of the Animas Valley and west margin of the southern part of the Pyramid Mountains. Hot springs along the southern end of the fault indicate locally high heat flow in the shallow subsurface; the area to the south (Lightening Dock Geothermal Resource area) has known geothermal potential.

Sense of movement N

Dip not reported

Dip direction W

Geomorphic expression Wells (in Elston and others, 1983 #1068) reported that the scarps have as much as 5 m of vertical relief. Machette and others (1986 #1033) measured topographic profiles across the scarps and found that they are commonly 2-3 m high and have maximum scarp-slope angles of 5°-10° (see fig. 10 in Machette and others, 1986 #1033). In addition, the larger scarps show clear evidence of being the result of two discrete faulting events (compound scarps), with pronounced bevels on the crest of the scarps. The younger element of the scarp height is 0.7 to <2 m high, and the resulting morphometric data plot between regression lines from the Drum Mountains (early Holocene, see Crone, 1983 #554) and the 15-ka Bonneville shoreline (Bucknam and Anderson, 1979 #332). These data led Machette and others (1986 #1033) to suggest that the most recent faulting event occurred in the latest Pleistocene.

Age of faulted deposits The scarps are formed on piedmont-slope deposits having "well developed" soil horizons (Wells in Elston and others, 1983 #1068). Machette and others (1986 #1033) indicated that the scarps are formed on alluvial-fan deposits of middle (?) to late Pleistocene age, and are buried by Holocene deposits. Likewise, Fleischhauer and Stone (1982 #1274) showed the fault cutting old fan alluvium (unit Qfo), which is of late to middle Pleistocene age. These age estimates were based on preservation of landforms, expression on aerial photographs, and soils developed on the deposits. However, no comprehensive studies of the Quaternary alluvial sequence has been made in this area.

Detailed studies none

Timing of most recent paleoevent latest Quaternary (<15 ka)
Comments: Morphometric data from the scarps indicate they probably formed between about 10-15 ka. These data support Wells' (in Elston and others, 1983 #1068) inference of late Pleistocene or Holocene faulting.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on small scarps (2-3 m) on late Pleistocene deposits.

Length End to end (km): 20.4
Trace (km): 22.3

Average strike (azimuth) 009°±21°

Endpoints (lat. - long.) 32°16′27.40″N, 108°48′55.74″W
32°05′26.82″N, 108°49′57.74″W

References

#332 Bucknam, R.C., and Anderson, R.E., 1979, Estimation of fault-scarp ages from a scarp-height—slope-angle relationship: Geology, v. 7, p. 11-14.

#554 Crone, A.J., ed., 1983, Paleoseismicity along the Wasatch front and adjacent areas, central Utah: Utah Geological and Mineral Survey Special Studies 62, 62 p.

#1034 Drewes, H., Houser, B.B., Hedlund, D.C., Richter, D.H., Thorman, C.H., and Finnell, T.L., 1985, Geologic map of the Silver City 1° x 2° quadrangle New Mexico and Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-1310-C, 1 sheet, scale 1:250,000.

#1068 Elston, W.E., Deal, E.G., and Logsdon, M.J., 1983, Geology and geothermal waters of Lightning Dock region, Animas Valley and Pyramid Mountains, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 177, 44 p., 2 pls.

#1274 Fleischhauer, H.L., Jr., and Stone, W.J., 1982, Quaternary geology of Lake Animas, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 174, 25 p., 1 pl., scale 1:48,000.

#1067 Gillerman, E., 1958, Geology of the central Peloncillo Mountains, Hidalgo County, New Mexico, and Cochise County, Arizona: [New Mexico] Bureau of Mines and Mineral Resources Bulletin 57, 152 p., 2 pls.

#1033 Machette, M.N., Personius, S.F., Menges, C.M., and Pearthree, P.A., 1986, Map showing Quaternary and Pliocene faults in the Silver City 1° x 2° quadrangle and the Douglas 1° x 2° quadrangle, southeastern Arizona and southwestern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-C, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1023 Pearthree, P.A., and Calvo, S.S., 1987, The Santa Rita fault zone—Evidence for large magnitude earthquakes with very long recurrence intervals, Basin and Range province of southeastern Arizona: Bulletin of the Seismological Society of America, v. 77, p. 97-116.

#1069 Reeder, H.O., 1957, Ground water in Animas Valley, Hidalgo County, New Mexico: New Mexico Engineer Technical Report 11, 101 p.

#1706 Smith, C., 1978, Geophysics, geology and geothermal leasing status of the Lightning Dock KGRA, Animas Valley, New Mexico, *in* Callender, J.F., Wilt, J.C., Clemons, R.E., and James, H.L., eds., Land of Cochise, southeastern Arizona: New Mexico Geological Society, 29th Field Conference, November 9-11, 1978, Guidebook, p. 343-348.

#1039 Thorman, C.H., and Drewes, H., 1978, Geologic map of the Gary and Lordsburg quadrangles, Hidalgo County, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1151, 1 sheet, scale 1:24,000.

2094, Gold Hill fault zone

Structure Number 2094
Comments: Fault number 11 of Machette and others (1986 #1033).

Structure Name Gold Hill fault (zone)
Comments: The fault zone was first mapped as largely concealed beneath alluvium by Hedlund (1978 #1043), but Machette and others (1986 #1033) mapped Quaternary scarps that are partly coincident with Hedlund's concealed trace. Machette and others (1986 #1033) applied the Gold Hill name to the fault, but in retrospect probably they should have applied a different name because the Gold Hill fault of Hedlund (1978 #1043) is entirely within Precambrian bedrock, just west of Gold Hill—a small but prominent peak and canyon east of the scarp at Cline Ranch. The fault zone is located about 20 km northeast of Lordsburg, New Mexico.

Synopsis: The Gold Hill fault zone is marked by discontinuous, en echelon southwest-facing scarps along the southwestern flank of a southern prong of the Big Burro Mountains. The scarps record evidence of multiple faulting events in the middle to late Pleistocene. Other than a few scarp profiles, no detailed studies have been made of the Quaternary history of the fault.

Date of compilation 03/15/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Hidalgo; Grant

1° x 2° sheet Silver City

Province Basin and Range

Geologic setting This fault is subparallel to Hedlund's (1978 #1043) Gold Hill fault zone, which is entirely within Precambrian bedrock. The Quaternary trace of the redefined Gold Hill fault zone is marked by discontinuous, en echelon southwest-facing scarps on piedmont-slope deposits along the southwestern flank of the Burro Mountains. Regional geologic mapping by Drewes and others (1985 #1034) showed the fault in a similar but less continuous manner than mapping by Machette and others (1986 #1033).

Number of sections 2
Comments: The northern section is herein defined as extending from Round Mountain on the north to Gold Hill Canyon on the south. The southern section, which is even more poorly studied, extends from Gold Hill Canyon (more basinward) southeast across the piedmont toward Ninetysix Ranch to within about 4 km west of Separ Road (Ninetysix Ranch 7.5-minute quadrangle, New Mexico).

Length End to end (km): 23.7
Trace (km): 29.4

Average strike (azimuth) -44°±30°

Endpoints (lat. - long.) 32°28′43.80″N, 108°34′47.95″W
32°18′50.48″N, 108°25′13.98″W

2094a, northern section

Section number 2094a

Section name northern section
Comments: The northern section is defined herein as extending from Round Mountain on the north to Gold Hill Canyon on the south.

Reliability of location Good
Comments: Trace from 1:250,000-scale map of Machette and others (1986 #1033), which was compiled at 1:24,000-scale from aerial photographs. Drewes and others (1985 #1034) showed the generalized trace of the entire fault on their 1:250,000-scale map. Hedlund's (1978 #1043) map shows the Quaternary fault trace as largely concealed (inferred) and was not used for the compilation.

Sense of movement N

Dip not reported

Dip direction SW

Geomorphic expression Scarps along the northern section are discontinuous but fairly large, where preserved. Near Round Mountain (and Hoodoo Canyon), Machette and others (1986 #1033) measured two scarps with heights of 6 m and 8.5 m on older alluvial fans. The larger scarp has two pronounced bevels on the upper surface suggesting that both it and the smaller scarp are probably a result of multiple faulting events (>2 and 2 events, respectively). This inference is also supported by the large height and surface offset (5.8 m and 2.9 m, respectively) for the small of the two scarps. Near the south end of the section, a very subdued scarp is preserved on an alluvial-fan deposit, whereas the fault appears to be buried by younger alluvium that forms inset fan-head terraces. The latter scarp has a height of about 2 m (offset of 0.6 m) and a maximum scarp-slope angle of 5° superposed on the 3° southwest slope of the fan. This small discordance in slope angles suggests a late Pleistocene (but not latest Pleistocene) age, such as recorded on the 100-ka Santa Rita fault scarp (see Pearthree and Calvo, 1987 #1023).

Age of faulted deposits The high-level piedmont surfaces on the northern part of the section are probably middle Pleistocene in age. Here, Machette found older alluvial fans that have strongly developed soils (thick Bt and K horizons) that are probably hundreds of thousands of years old (200-500 ka). The younger alluvial fans (faulted by a single event) have moderately developed soils (Bt and K horizons) and are probably of latest middle Pleistocene age (130-200 ka). The unfaulted fan-head terraces that are inset into the younger and older fans are probably latest Pleistocene to Holocene in age. These age estimates are based on soil development, degree of dissection, and landform preservation.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: The compiler suspects that the most recent event occurred in the late Pleistocene (but not latest Pleistocene), perhaps sometime about 100 ka. This estimate is based on offset of latest middle Pleistocene fan surfaces, subdued scarp morphology comparable to that of 100-ka scarps in Arizona (see Pearthree and Calvo, 1987 #1023), and discontinuous preservation of scarps.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on small scarps (3 m) on late Pleistocene deposits.

Length End to end (km): 10.2
Trace (km): 12.6

Average strike (azimuth) -27°±36°

Endpoints (lat. - long.) 32°28′43.80″N, 108°34′47.95″W
32°24′00.17″N, 108°31′29.67″W

2094b, southern section

Section number 2094b

Section name southern section
Comments: The southern section, which remains poorly studied, extends from Gold Hill Canyon southeast across the piedmont to a point about 4 km west of Separ Road (Ninetysix Ranch 7.5-minute quadrangle, New Mexico).

Reliability of location Good
Comments: Trace from 1:250,000-scale map of Machette and others (1986 #1033), which was compiled at 1:24,000-scale from inspection of topographic maps and from small scale (1:55,000) aerial photographs. Drewes and others (1985 #1034) showed the generalized trace of the entire fault on their 1:250,000-scale map. Hedlund's (1978 #1043) map showed the trace as largely concealed (inferred) and was not used in this compilation.

Sense of movement N

Dip not reported

Dip direction S

Geomorphic expression The fault forms subdued scarps that are discontinuous but that may control the position of some cross-fan streams such as at Jones Canyon. For the most part, the scarps are basinward of bedrock exposures, except at the southeastern end of the fault where the scarps extend within and among bedrock hills. The fault may be responsible for the 10° backtilt of old fan gravels (Qfo) shown by Hedlund (1978 #1043).

Age of faulted deposits Hedlund (1978 #1043) showed the piedmont deposits as Holocene and (or) Pleistocene. Most of the fan surfaces that have scarps developed on them are isolated above modern streams, dissected, and have mature landscape forms, suggesting a late to middle Pleistocene age. The older fan gravels (Qfo of Hedlund, 1978 #1043) are most probably early Pleistocene in age, although no definitive studies have been made of the surficial deposits in the area.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Based on inferences about the age of faulted deposits and the presence of recognizable scarps.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: A low slip-rate category is assigned based on lack of continuity of scarps, subdued morphology, and low slip rate estimated for northern (more active?) section [2094a].

Length End to end (km): 15.6
Trace (km): 16.8

Average strike (azimuth) -57°±14°

Endpoints (lat. - long.) 32°23′38.02″N, 108°33′27.03″W
32°18′50.48″N, 108°25′13.98″W

References

#1034 Drewes, H., Houser, B.B., Hedlund, D.C., Richter, D.H., Thorman, C.H., and Finnell, T.L., 1985, Geologic map of the Silver City 1° x 2° quadrangle New Mexico and Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-1310-C, 1 sheet, scale 1:250,000.

#1043 Hedlund, D.C., 1978, Geologic map of the Gold Hill quadrangle, Hidalgo and Grant Counties, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1035, 1 sheet, scale 1:24,000.

#1033 Machette, M.N., Personius, S.F., Menges, C.M., and Pearthree, P.A., 1986, Map showing Quaternary and Pliocene faults in the Silver City 1° x 2° quadrangle and the Douglas 1° x 2° quadrangle, southeastern Arizona and southwestern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-C, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1023 Pearthree, P.A., and Calvo, S.S., 1987, The Santa Rita fault zone—Evidence for large magnitude earthquakes with very long recurrence intervals, Basin and Range province of southeastern Arizona: Bulletin of the Seismological Society of America, v. 77, p. 97-116.

2095, Gray Ranch fault zone

Structure Number 2095
Comments: Fault number 20 of Machette and others (1986 #1033).

Structure Name Gray Ranch fault zone
Comments: Part of this fault zone was first mapped by Wrucke and Bromfield (1961 #1066), but it was more completely mapped and named by Machette and others (1986 #1033) for Gray [sic Grays] Ranch, which is near the fault zone (Animas Peak 15-minute quadrangle, New Mexico). Vincent and Krider (1997 #1193) produced detailed maps (1:24,000 scale) of the faults and geomorphic surfaces in the area. The fault zone extends from Tank Mountain, south to near the confluence of Indian Creek and Animas Creek. The southernmost part of the fault that parallels Animas Creek, as shown by Wrucke and Bromfield (1961 #1066), is not included because Vincent and Krider (1997 #1193) could find no evidence of Quaternary movement and because this part of the scarp may be entirely fluvial in origin. The mid-point of the fault is about 25 km south of Animas, New Mexico.

Synopsis: The Gray Ranch fault zone is marked by three en echelon, discontinuous, east-facing, south-trending scarps along the eastern flank of a south-central part of the Peloncillo Mountains. The scarps record evidence of multiple faulting events during or before the middle Pleistocene and at least one event in the late Pleistocene. No scarp morphology or trenching studies have been done along the fault.

Date of compilation 04/15/97

Compiler and affiliation Kirk R. Vincent, U.S. Geological Survey; Michael N. Machette, U.S. Geological Survey

State New Mexico

County Hidalgo

1° x 2° sheet Douglas

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:100,000-scale map compiled from 1:24,000-scale maps of Vincent and Krider (1997 #1193).

Geologic setting The Gray Ranch fault zone forms the eastern margin of the south-central part of the Peloncillo Mountains, and the western margin of the Animas Valley. Over much of it’s length, the Animas Valley consists of a full-graben, but in the southern part of the valley the bounding structures (*i.e.,* the east-dipping Gray Ranch fault zone [2095] and the west-dipping Gillespie Mountain fault [2096]) form a half-graben with a single west-dipping fault (Lang Canyon fault [2025]). The transition from full-graben to half-graben is located near the confluence of Animas and Indian Creeks, and is coincident with both a 6-km right step in the Animas range-front and a bedrock promontory that extends east into the valley from the Peloncillo Mountains. The southern end of Quaternary scarps on the Gray Ranch fault zone (and on the Gillespie Mountain fault) terminate at or near this transition zone. Uplift and dissection of the narrow pediment between the fault and the mountains implies that recurrent Quaternary movement occurred after an extensive period of tectonic quiescence during which the pediment was formed, perhaps in early Pleistocene time.

Sense of movement N

Dip not reported

Dip direction E

Geomorphic expression A set of three en echelon surficial traces define the general fault zone: an upper-piedmont trace, a middle-piedmont trace, and a lower-piedmont trace that extends north along the eastern side of Tank Mountain (Vincent and Krider, 1997 #1193). Each trace consists of continuous to discontinuous, east-facing, south-trending scarps. The 13-km-long upper-piedmont trace marks the boundary between rocks of the Peloncillo Mountains and surficial sediment of the basin. This is the main trace of the fault in that it has the most formidable escarpment and records the longest period of tectonism. It is expressed as a high escarpment, and at many locations the crest of that escarpment forms the edge of a narrow pediment. Locally, the scarp is formed on middle Pleistocene (*i.e.,* 500-750 ka) terrace sediment that covers the pediment and extends into the basin. South of Miner Canyon, a scarp with 17 m of surface offset formed on this material probably reflects multiple events. Younger terraces do not extend across the fault, so no data is available for the timing of the most recent event on that trace. The discontinuous middle-piedmont trace (with a preserved length of 6 km) is formed on middle Pleistocene alluvium (with scarps ≤ 3 m high), whereas late Pleistocene (ca. 100 ka) terraces cover the fault. The lower-piedmont trace (with a preserved length of 5 km) consists of a nearly continuous but subdued (mature) scarp (1-2 m high) formed on late Pleistocene (ca. 100 ka) fan remnants (and foot-slope deposits on the east side of Tank Mountain). This is the youngest faulted deposit in the zone but Holocene terraces cover the trace of this strand (Vincent and Krider, 1997 #1193). The conflicting histories of the three traces requires multiple faulting events with the most surface-faulting events occurring on the upper- (main) piedmont trace.

Age of faulted deposits Machette and others (1986 #1033) suggested that the scarps are formed on piedmont-slope deposits of probable early to middle Pleistocene age. Vincent and Krider (1997 #1193) concur with this assessment for the upper- and middle-piedmont traces, but their lower-piedmont trace (previously unmapped) clearly disrupts late Pleistocene deposits that are thought to be roughly 100 ka on the basis of soil development.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: From their inferences about the age of faulted deposits, Vincent and Krider (1997 #1193) concluded that the most recent movement was prior to Holocene but probably occurred in the late Pleistocene (*i.e.,* 30-130 ka).

Recurrence interval not reported

Slip-rate category unknown, probably <0.2 mm/yr

Comments: A low slip-rate category is assigned based on the amount of long term offset on all three traces. About 22 m of net cumulative vertical displacement is recorded by the three traces (17+3+2 m) over a period of record of 500 k.y. to 1 m.y.

Length End to end (km): 20.2
Cumulative (km): 27.5

Average strike (azimuth) -7°±18°

Endpoints (lat. - long.) 31°50′07.68″N, 108°48′57.54″W
31°39′18.58″N, 108°50′41.54″W

References

#1033 Machette, M.N., Personius, S.F., Menges, C.M., and Pearthree, P.A., 1986, Map showing Quaternary and Pliocene faults in the Silver City 1° x 2° quadrangle and the Douglas 1° x 2° quadrangle, southeastern Arizona and southwestern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-C, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1193 Vincent, K.R., and Krider, P.R., 1997, Geomorphic surface maps of the southern Animas Valley, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report OF-429, 12 sheets, scale 1:24,000.

#1066 Wrucke, C.T., and Bromfield, C.S., 1961, Reconnaissance geologic map of part of the southern Peloncillo Mountains Hidalgo County, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-160, 1 sheet, scale 1:62,500.

2096, Gillespie Mountain fault

Structure Number 2096
Comments: Fault number 21 of Machette and others (1986 #1033).

Structure Name Gillespie Mountain fault
Comments: This fault was first mapped by Zeller (1962 #1060), and later by Zeller and Alper (1965 #1253), Erb (1979 #1254), and Vincent and Krider (1997 #1193), but was named by Machette and others (1986 #1033) for Gillespie Mountain, a prominent peak in the Animas Mountains. The fault zone may extend from Animas Peak northward about 25 km. The mid-point of the fault is about 30 km south-southeast of Animas, New Mexico.

Synopsis: The Gillespie Mountain fault is marked by continuous west-facing, south-trending scarps along the western flank of the Animas Mountains. The larger scarps record evidence of multiple faulting events during or before the middle Pleistocene. Scarp morphology has been used to estimate the most recent faulting event as about 10 ka, although detailed geomorphic-surface mapping by Vincent and Krider (1997 #1193) suggests it might have last ruptured prior to the latest glacial (*i.e.,* >15 ka). No trenching has been done along the fault.

Date of compilation 04/10/97

Compiler and affiliation Kirk R. Vincent, U.S. Geological Survey; Michael N. Machette, U.S. Geological Survey

State New Mexico

County Hidalgo

1° x 2° sheet Douglas

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:100,000-scale map compiled from 1:24,000-scale maps of Vincent and Krider (1997 #1193). The 8-km-long trace north of Whitmire Pass is from 1:250,000-scale map of Machette and others (1986 #1033), which was compiled from 1:24,000-scale topographic maps and 1:50,000-scale aerial photographs.

Geologic setting The fault forms the western margin of the northern half of the Animas Mountains and the eastern margin of the Animas Valley. Over much of it's length, the valley consists of a full-graben, but in the southern part of the valley, the bounding structures (*i.e.,* the west-dipping Gillespie Mountain fault [2096] and the east-dipping Gray Ranch fault zone [2095]) form a half-graben with a single west-dipping fault (Lang Canyon fault [2025]). The transition from full-graben to half-graben is located near the confluence of Animas and Indian Creeks, and is coincident with both a 6-km right step in the Animas range-front and a bedrock promontory that extends east into the valley from the Peloncillo Mountains. The southern end of Quaternary scarps on the Gillespie Mountain fault (and on the Gray Ranch fault zone) terminate at or near this transition zone. Uplift and dissection of the narrow pediment between the fault and the mountains implies that recurrent Quaternary movement occurred after an extensive period of tectonic quiescence during which the pediment was formed, perhaps in early Pleistocene time.

Sense of movement N
Comments: Vincent and Krider (1997 #1193) observed slickensides at Cottonwood Creek trending N. 58° W. and plunging 59° W. (7 measurements) on exposed bedrock fault surfaces that strike about N. 40° E. and dip 60°-66° W.

Dip not reported

Dip direction W

Geomorphic expression A series of west-facing scarps mark the surficial trace of the fault zone. Along the northern part of the fault zone, Machette and others (1986 #1033) observed distinct 8- to 13-m-high scarps formed on piedmont-slope deposits of probable early middle Pleistocene age (*i.e.,* 500-750 ka). In the central part of the fault, smaller (1- 3-m-high) scarps are formed on alluvium thought to be on the order of 100 ka (Vincent and Krider, 1997), in addition to older and higher scarps that truncate narrow pediments. They could not find evidence of displacement of latest Pleistocene (*i.e.,* 20-50 ka) deposits, and Holocene terraces (<7 ka) (Krider, 1997 #1255) cover the fault. The southern part of the fault (south of Cottonwood Creek), which is inferred mostly from topography, splays into bedrock near Double Adobe Creek. It truncates a middle Pleistocene terrace (with ca. 13 m of throw) at the southern end of the trace near Indian Creek (Vincent and Krider, 1997 #1193). At that site neither late Pleistocene (ca. 100 ka) nor younger terraces are disrupted by faulting. South of Indian Creek the trace is lost in bedrock. Machette and others (1986 #1033) profiled the smaller (1- to 3-m-high) scarps found along the central portion of the trace. Their morphology (see fig. 12 in Machette and others, 1986 #1033) is similar or slightly less degraded (*i.e.,* fresher and younger) than the Drum Mountains scarps which Crone (1983 #552) indicates are probably early Holocene. Likewise, the small scarps of the Gillespie Mountain fault appear to be slightly younger than the 15-ka shoreline scarps of Lake Bonneville (Machette and others, 1986 #1033).

Age of faulted deposits Machette and others (1986 #1033) suggested that the large scarps are formed on piedmont-slope deposits of probable lower middle Pleistocene age (*i.e.,* 500-750 ka), whereas the small scarps are formed on upper Pleistocene deposits. Detailed mapping of Vincent and Krider (1997 #1193) showed that the late Pleistocene terraces (ca. 100 ka, based on soil development), although faulted along the central and northern parts of the Gillespie Mountain fault, are not disrupted at the southern end of the trace. They also reported that middle to late Holocene deposits cover the fault and are everywhere undisturbed.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Morphometric data from the 1-3 m high scarps indicate that they may have formed about 10 ka and are clearly younger than about 15 ka on the basis of comparison with the Bonneville shoreline in Utah. However, Vincent and Krider (1997 #1193) indicate that middle to late Holocene deposits cover the fault and are everywhere undisturbed, and deposits considered to be 20-50 ka are not demonstrably offset in the area where Machette and others (1986 #1033) profiled. As a result of this

apparent conflict, we use a conservative estimate that the northern two-thirds of the fault has ruptured in late Pleistocene time. The timing of movement along the southern part of the fault has not been documented other than to be middle Pleistocene (*i.e.*, 500-750 ka).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: A low slip-rate category is assigned based on 8- to 13-m-high scarps, which relate to about 6-10 m or vertical offset, on deposits are approximately 500-750 k. y. old.

Length	End to end (km):	21.6
	Cumulative (km):	27.1

Average strike (azimuth) 014°±26°

Endpoints (lat. - long.) 31°47′48.37″N, 108°44′14.22″W
31°36′26.57″N, 108°47′26.30″W

References

#552 Crone, A.J., 1983, Amount of displacement and estimated age of a Holocene surface faulting event, eastern Great Basin, Millard County, Utah, *in* Crone, A.J., ed., Paleoseismicity along the Wasatch Front and adjacent areas, central Utah: Utah Geological and Mineral Survey Special Studies 62, p. 49-55.

#1254 Erb, E.E., Jr., 1979, Petrologic and structural evolution of ash-flow tuff cauldrons and noncauldron-related volcanic rocks in the Animas and southern Peloncillo Mountains, Hidalgo County, New Mexico: Albuquerque, University of New Mexico, unpublished Ph.D. dissertation, 286 p.

#1255 Krider, P.R., 1997, Paleoclimate significance of late Quaternary lacustrine and alluvial stratigraphy, Animas Valley, New Mexico: Tucson, University of Arizona, unpublished M.S. thesis.

#1033 Machette, M.N., Personius, S.F., Menges, C.M., and Pearthree, P.A., 1986, Map showing Quaternary and Pliocene faults in the Silver City 1° x 2° quadrangle and the Douglas 1° x 2° quadrangle, southeastern Arizona and southwestern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-C, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1193 Vincent, K.R., and Krider, P.R., 1997, Geomorphic surface maps of the southern Animas Valley, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report OF-429, 12 sheets, scale 1:24,000.

#1060 Zeller, R.A., Jr., 1962, Reconnaissance geologic map of southern Animas Mountains: [New Mexico] Bureau of Mines and Mineral Resources Geologic Map 17, 1 sheet, scale 1:62,5000.

#1253 Zeller, R.A., Jr., and Alper, A.M., 1965, Geology of the Walnut Wells quadrangle, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 84, 105 p.

2097, Unnamed faults west of the Pyramid Mountains

Structure Number 2097

Structure Name Unnamed faults west of the Pyramid Mountains

Comments: These faults were mapped as separate structures by Wells (in Elston and others, 1983 #1068), Drewes and others (1985 #1034), and Machette and others (1986 #1033). Collectively, they extend discontinuously along the west margin of the Pyramid Mountains, from 2 km north of Jose Placencia Canyon south to the Threemile Hills.

Synopsis Little is known about this discontinuous series of faults that form the western margin of the Pyramid Mountains. The northern and southern ends have small scarps on Quaternary alluvium, whereas the central part is along bedrock; the scarps on alluvium appear to be late Pleistocene on the basis of their subdued morphology. The scarps may be associated with the Animas Valley fault [2093], which has a similar structural position, but it is to the west about 2-5 km. No detailed study has been made of the timing of fault movement or of the age of faulted materials.

Date of compilation 03/17/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Hidalgo

1° x 2° sheet Silver City

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:250,000-scale map of Machette and others (1986 #1033), which was compiled at 1:24,000-scale from aerial photographs. The southern part is shown in a slightly more mountainward (east) position by Drewes and others (1985 #1034).

Geologic setting This south-trending fault forms the western margin of the Pyramid Mountains. The fault has two short (ca. 3-km-long) piedmont scarps and a central range-bounding scarp. The fault may be part of a broad, but discontinuous system that bounds the eastern margin of the Animas Valley and, as such, may be associated with the Animas Valley fault [2093].

Sense of movement N

Dip not reported

Dip direction W

Geomorphic expression Machette and others (1986 #1033) included these piedmont slope scarp in a discussion of the Animas Valley fault [2093], although they are more subdued. These unnamed fault scarps west of the Pyramid Mountains are less than 5 m high as determined from the analysis of 1:24,000-scale topographic maps. No detailed profiles were measured by Machette and others (1986 #1033), but they concluded that the scarps are older than those to the west [2093] and may be of late Pleistocene age.

Age of faulted deposits The scarps are formed on piedmont-slope and alluvial-fan deposits mountainward (east) of the Animas Valley fault [2093]. No detailed studies have been made of the faulted deposits, but they are probably largely correlative with those downslope to the west. Machette and others (1986 #1033) indicated that the piedmont is underlain by alluvial-fan deposits of middle(?) to late Pleistocene age. These age estimates were based on preservation of landforms, expression on aerial photographs, and brief glimpses of soils developed on the deposits.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Timing is poorly controlled and based on correlation of deposits and inference about morphology of scarps.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: A low slip-rate category is assigned based on <5 m in height on deposits of middle (?) to late Pleistocene age (130 ka or older).

Length	End to end (km):	16.5
	Cumulative (km):	12.4

Average strike (azimuth) -3°±14°

Endpoints (lat. - long.) 32°11′26.22″N, 108°47′21.26″W
32°02′33.26″N, 108°48′18.81″W

References

#1034 Drewes, H., Houser, B.B., Hedlund, D.C., Richter, D.H., Thorman, C.H., and Finnell, T.L., 1985, Geologic map of the Silver City 1° x 2° quadrangle New Mexico and Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-1310-C, 1 sheet, scale 1:250,000.

#1068 Elston, W.E., Deal, E.G., and Logsdon, M.J., 1983, Geology and geothermal waters of Lightning Dock region, Animas Valley and Pyramid Mountains, Hidalgo County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 177, 44 p., 2 pls.

#1033 Machette, M.N., Personius, S.F., Menges, C.M., and Pearthree, P.A., 1986, Map showing Quaternary and Pliocene faults in the Silver City 1° x 2° quadrangle and the Douglas 1° x 2° quadrangle, southeastern Arizona and southwestern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-C, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2098, Foothills fault

Structure Number 2098

Structure Name Foothills fault

Comments: First mapped by Seager and others (1982 #626), the fault was later named by Seager and others (in press #1260) for exposures in the Hatch 7.5-minute quadrangle. The Foothills fault extends from its intersection with the Derry Hills fault [2086] south to a point about 3 km northeast of Salem (McLeod Tanks 7.5-minute quadrangle) where it is concealed beneath young alluvium.

Synopsis This northwest-trending normal fault places basin-fill sediment of the Camp Rice Formation (Upper Santa Fe Group) against Tertiary basin-fill sediment. It forms subdued and small (<5 m high?) scarps on surfaces formed by the Camp Rice Formation and larger scarps where sediment of the Camp Rice Formation is downdropped against older rocks. The youngest movement on the fault may have been in early or middle(?) Quaternary time.

Date of compilation 08/22/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good

Comments: Generalized trace of the fault is from 1:125,000-scale map of Seager and others (1982 #626), which was based on then unpublished 1:24,000-scale mapping by Seager and others (in press #1260) and Seager and Mack (in press #1258).

Geologic setting This northwest-trending down-to-the-west normal fault places basin-fill sediment of the Camp Rice Formation (Upper Santa Fe Group) against Tertiary basin-fill sediment (primarily Miocene, middle and lower parts of the Santa Fe Group). The fault forms the western margin of the Salem bench according to Seager and others (in press #1260).

Sense of movement N

Dip not reported

Comments: Shown as relatively high-angle fault (ca. 50-60°) on cross sections of Seager and Mack (in press #1258) and Seager and others (in press #1260).

Dip direction W

Geomorphic expression The fault forms subdued and small (<5 m high?) scarps on surfaces formed by sediment of the Camp Rice Formation and larger scarps where sediment of the Camp Rice Formation is downdropped against older rocks. No studies of scarp morphology or detailed mapping to determine stratigraphic offset of Quaternary deposits has been conducted.

Age of faulted deposits Sediment of the Camp Rice Formation (Pliocene to early or middle(?) Quaternary) is deformed along the trace of the fault. However, younger (late Quaternary) piedmont-slope deposits (Qvo) are not offset, limiting the youngest movement to early or middle(?) Quaternary time.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing based on deformation of Camp Rice Formation sediment. Late Quaternary piedmont-slope deposits do not appear to be offset.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: The slip rate is probably <0.2 mm/yr based on relatively small height of scarps on surfaces that could be as old as early Quaternary and the lack of deformation of late Quaternary deposits.

Length End to end (km): 7.1
Trace (km): 6.9

Average strike (azimuth) -18°±19°

Endpoints (lat. - long.) 32°46′43.33″N, 107°13′05.65″W
32°43′05.70″N, 107°11′34.93″W

References
#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.
#1258 Seager, W.R., and Mack, G.H., in press, Geology of McLeod Tank quadrangle, Sierra and Dona Ana Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 77, 2 sheets, scale 1:24,000.
#1260 Seager, W.R., Mack, G.H., and W., H.J., in press, Geology of Hatch quadrangle, Dona Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 78, 2 sheets, scale 1:24,000.

2099, Central fault

Structure Number 2099

Structure Name Central fault
Comments: The Central fault is shown by Seager and Hawley (1973 #996) and by Seager and others (1982 #626) as forming part of the southwestern margin of the Rincon Hills, northwest of Rincon, New Mexico. The faults name is derived from its central location between the East Rincon Hills fault [2083] and the West Rincon Hills fault [*i.e.,* Black Hills fault, 2085].

Synopsis: Little is known about the age of this fault. It has three strands that displace basin-fill deposits of the Pliocene to early or middle(?) Quaternary Camp Rice Formation. Late Quaternary piedmont-slope deposits are not offset; however, no detailed study of the history of the fault has been conducted.

Date of compilation 08/22/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Location taken from 1:125,000-scale mapping of Seager and others (1982 #626), which was based on 1:24,000-scale mapping of Seager and Hawley (1973 #996).

Geologic setting This generally southeast-trending fault system forms part of the southwest margin of the Rincon Hills. The fault put basin-fill deposits of the Pliocene to early or middle(?) Quaternary Camp Rice Formation against Tertiary rocks of the Rincon Hills uplift. At its southern end, the fault splays into three traces (compilers interpretation), one of which is entirely with basin-fill deposits of Camp Rice Formation and cuts a southeast-trending unnamed syncline [2098].

Sense of movement N

Dip not reported

Dip direction W

Geomorphic expression The fault system forms subdued and small (<5 m high?) scarps on surfaces formed by sediment of the Camp Rice Formation and larger scarps where sediment of the Camp Rice Formation is downdropped against Tertiary bedrock. No studies of scarp morphology or detailed mapping to determine stratigraphic offset of Quaternary deposits have been conducted.

Age of faulted deposits Seager and Hawley (1973 #996) showed the faults as developed on basin-fill deposits of the Camp Rice Formation, which is Pliocene to early or middle(?) Pleistocene. The structure deforms the surface of these deposits and thus must postdate its stablization. However, younger piedmont-slope and stream deposits are not deformed according to their mapping.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing based on deformation of Camp Rice Formation sediment. Late Quaternary piedmont-slope deposits do not appear to be faulted.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: The slip rate is probably <0.2 mm/yr based on relatively small height of scarps on surfaces that could be as old as early Quaternary and fault that do not deform late Quaternary deposits.

Length not applicable
Comments: This zone includes several faults that have an end to end length of 3.3 km and a cumulative trace length of 5.0 km.

Average strike (azimuth) -17°±32°

Endpoints (lat. - long.) 32°42'08.37"N, 107°05'48.57"W
32°40'37.49"N, 107°04'39.53"W

References

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

#996 Seager, W.R., and Hawley, J.W., 1973, Geology of Rincon quadrangle, Doña Ana County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 101, 42 p., 2 pls., scale 1:24,000.

2100, Hot Springs fault

Structure Number 2100
Comments: Referred to as fault 8 on fig. 1 in Machette (1987 #960).

Structure Name Hot Springs fault
Comments: First mapped in detail and named by Kelley and Silver (1952 #1072) for the town of Hot Springs, New Mexico, which is now known as Truth or Consequences. The fault extends from about 6 km north of Kettle Top Butte (Lozinsky, 1985 #1073) south to the Red Hills (Kelley and Silver, 1952 #1072), about 6 km south of Truth or Consequences.

Synopsis: This northeast-trending, down-to-the-west normal fault bounds Paleozoic and Cretaceous rocks in the north-trending, east-tilted Caballo block and further northeast forms part of the south-eastern margin of the Engle basin. Of special concern is the fault's proximity to Elephant Butte Dam. Although the fault is known to have Quaternary motion, detailed studies have not been able to decipher the faults history in any significant detail. The northern half of the fault now lies submerged beneath Elephant Butte Reservoir.

Date of compilation 10/02/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good

Comments: Trace of the central part of the fault is from detailed (1:25,000-scale) geologic mapping by Lozinsky (1985 #1073). The southern end is from 1:62,500-scale geologic mapping by Kelley and Silver (1952 #1072), whereas the northern end is from 1:24,000-scale geologic mapping by Warren (1978 #1079). This information was transferred to a 1:250,000-scale base map for digitization.

Geologic setting This northeast trending, down-to-the-west primarily normal fault bounds Paleozoic and Cretaceous rocks that are uplifted in the north-trending, east-tilted Caballo block. Northeast of Truth or Consequences, the fault forms part of the southeastern margin of the Engle basin, an eastward-tilted sediment-filled half graben (Lozinsky, 1985 #1073). Of special concern is the fault's location just 1.5 km northwest of the left abutment of the embankment dike of Elephant Butte Dam (see Foley and others, 1988 #991).

The Hot Springs fault forks into two splays at both its north and south ends. On the north, the Hot Springs fault (the western splay) ends in sediment of the Santa Fe Group whereas the eastern splay continues north as the Walnut Springs fault [2102] of Warren (1978 #1079). On the south end, the Hot Springs fault (the western splay) separates Paleozoic rock from Santa Fe Group sediment and terminates against the Williamsburg section of the Caballo fault [2088a]. The eastern splay (south of the Rio Grande) represents the northern, range-bounding portion of the Caballo fault [2088], which displays no evidence of Quaternary movement. These two southern splays form an intermediate-level structural element of the Caballo block. Collectively, the Caballo, Hot Springs [2100], and Walnut Springs [2102] faults form the western, tectonically active margins of the Caballo Mountains, Palomas and Engle basins, and Fra Cristobal Ranges (respectively). At least half of the trace of the Hot Springs fault lies buried beneath Elephant Butte Reservoir, east and northeast of Truth or Consequences.

Sense of movement N
Comments: Late Cenozoic motion is predominately normal and Lozinsky (1985 #1073) suggested that some of the apparent lateral offset across the fault zone noticed by Kelley and Silver (1952 #1072) may

be the result of right-lateral strike slip motion related to Laramide compression rather than Cenozoic extension.

Dip 78° NW
Comments: Lozinsky (1985 #1073) shows the fault as having a 78° dip and characterizes it as relatively high dip (70-80°) in his text and on his cross sections B and D.

Dip direction NW

Geomorphic expression No fault scarps have been found by Lozinsky (1985 #1073) on Quaternary surficial deposits younger than the Palomas Formation along the fault. However, along the southernmost and northernmost parts of the fault, it forms bedrock-cored escarpments. Along the northwest flank of the Caballo Mountains, these scarps are 50-150 m high where the fault juxtaposes Paleozoic rock and sediment of the Palomas Formation.

Age of faulted deposits Lozinsky (1985 #1073) mapped the fault as cutting the piedmont facies of the Palomas Formation (Pliocene to early or middle Pleistocene). In addition, the fault seems to have controlled the eastward margin of the ancestral Rio Grande during aggradation of the Engle basin. Along the southern part of the fault, south of Lozinsky's map area, Hawley and Seager (1978) mentioned that the fault offsets sediment of the upper part of the Santa Fe Group (Palomas Formation). Conversely, there appears to be no significant offset of 2.5 Ma basalts exposed on Rattlesnake Island in Elephant Butte Reservoir, but Machette (1987 #960) cited evidence from Warren (1978 #1079) that there is as much as 90 m offset in Quaternary basalts (probably late Pliocene, 2-3 Ma) farther north near Black Bluffs. Thus, it appears that a significant portion of the fault probably has stratigraphic evidence of at least early Pleistocene offset.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Early Pleistocene offset is suggested by offset of the piedmont facies of the Palomas Formation (Pliocene to early or middle Pleistocene). Middle Pleistocene movement cannot be ruled out because these age deposits are not preserved along the trace of the fault; however Lozinsky (1985 #1073) found no offset of late Quaternary surficial deposits along the fault. Foley and others (1988 #991) came to the same conclusion concerning a lack of late Quaternary movement on the fault.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Machette (1987 #960) cited evidence that 2-3 Ma basalts are offset as much as 90 m along the northern trace of the fault. These data yield a low long-term vertical slip rate.

Length	End to end (km):	28.4
	Cumulative (km):	34.2

Average strike (azimuth) 024°±23°

Endpoints (lat. - long.) 33°20′55.28″N, 107°08′33.20″W
33°06′52.96″N, 107°15′56.31″W

References

#991 Foley, L.L., LaForge, R.C., and Piety, L.A., 1988, Seismotectonic study for Elephant Butte and Caballo Dams, Rio Grande Project, New Mexico: U.S. Bureau of Reclamation Seismotectonic Report 88-9, 60 p., 1 pl., scale 1:24,000.

#1072 Kelley, V.C., and Silver, C., 1952, Geology of the Caballo Mountains: University of New Mexico Publications in Geology 4, 286 p., 9 pls.

#1073 Lozinsky, R.R., 1985, Geology and late Cenozoic history of the Elephant Butte area, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 187, 40 p., 2 pls.

#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.

#1079 Warren, R.G., 1978, Characterization of the lower crust-upper mantle of the Engle Basin, Rio Grande rift, from a petrochemical and field geologic study of basalts and their intrusions: Albuquerque, University of New Mexico, unpublished M.S. thesis, 156 p., 1 pl., scale 1:24,000.

2101, Mud Springs fault

Structure Number 2101
Comments: Referred to as fault 5 on fig. 1 in Machette (1987 #960)

Structure Name Mud Springs fault
Comments: Kelley and Silver (1952 #1072) suggested the presence of the Mud Springs fault and showed it as a concealed structure on their map of the Caballo Mountains and surrounding area. They named it for the Mud Springs Mountains, which are due west of Truth or Consequences, New Mexico. The fault extends from the Rio Grande on the south, northwest and north around the west margin of the Mud Springs Mountains and north across the Cuchillo Plain, northwest of Truth or Consequences. It may continue southeast across the Rio Grande and merge with the Williamsburg section of the Caballo fault [2088a] (Machette, 1987 #960).

Synopsis: Very little work has been done on the Mud Springs fault. It is a concave-to-the-east, down-to-the-west normal fault that uplifts the Mud Springs Mountains to the east and downdrops the Palomas basin to the west. To the north, the fault forms conspicuous scarps on the Cuchillo Plain, but the fault is concealed adjacent to the Mud Springs Mountains. The most recent movement on most of the fault is poorly documented, but the northern part of the fault has been active in the middle or late Quaternary.

Date of compilation 10/03/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping used to compile fig. 1 in Machette (1987 #960). The fault has also been shown (somewhat differently) on the 1:24,000-scale geologic map of the Cuchillo 7.5-minute quadrangle (Maxwell and Oakman, 1990 #1145).

Geologic setting The Mud Springs fault bounds the Mud Springs Mountains, a northeast-tilted block comprised mainly of Precambrian and Paleozoic rocks. It was considered to be the east-bounding fault of the Cuchillo Negro fault zone [2104] by Machette (1987 #960). Kelley and Silver (1952 #1072) were the first to speculate on the existence of this fault, and it was later mapped by Maxwell and Oakman (1990 #1145) and Machette (1987 #960). Most of the southern half of the fault is concealed beneath young alluvium in Mud Springs Arroyo and west of the Mud Spring Mountains, but the northern part of the fault forms scarps that oppose the regional east gradient of the Cuchillo Plain. Although somewhat conjectural, Lozinsky (1985 #1073) showed about 2,000 m of Tertiary down-to-the-west throw on the Mud Springs fault.

Sense of movement N

Dip not reported
Comments: Shown as a high-angle normal fault on cross sections of Lozinsky (1987 #1268).

Dip direction W

Geomorphic expression The fault trace is marked by 2- to 10-m high scarps that extend from Cuchillo Creek north to U.S. Interstate Highway 25, northwest of Truth or Consequences. These scarps mainly face west and have ponded or deflected local ephemeral streams. These scarps appear degraded (they have gentle slope angles), which led Machette (1987 #960) to infer a late middle Pleistocene age. However, no trenching of the fault scarps or detailed studies of the age of Quaternary deposits on the Cuchillo Plain have been conducted. Along the west side of the Mud Springs Mountains, the fault does not have a noticeable surface trace, but may control a prominent north-south alignment of small ephemeral streams (Machette, 1987 #960). South of Mud Mountain, the trace of the fault turns southeast (as shown by Kelley and Silver, 1952 #1072) and lies concealed beneath young alluvium of Mud Springs Canyon.

Age of faulted deposits No detailed studies of the age of Quaternary deposits along the fault have been conducted. However, the Cuchillo surface was considered to be middle Pleistocene by Lozinsky (1985 #1073) and Machette (1987 #960). More recent studies by Mack and others (1993 #1020) suggested that this constructional surface may be as old as 700-900 ka, thereby providing an older maximum limit on the deformation. Hawley and Seager (p. 87 in 1978 #1272) and Machette (1987 #960) mentioned the fault cutting sediment of the upper Santa Fe Group (Camp Rice Formation) in the lower part of Mud Springs Creek, as evidenced by gently tilted beds exposed in roadcuts along U.S. Interstate Highway 25.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Machette (1987 #960) suggested a late middle Pleistocene age for the fault scarps based on their subdued morphology.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Low slip-rate category assigned based on 2- to 10-m-high scarps on a surface that could be between 400 ka (Lozinsky, 1985 #1073) and 700-900 ka (Mack and others, 1993 #1020).

Length	End to end (km):	19.6
	Cumulative (km):	23.2

Average strike (azimuth) -1°±24°

Endpoints (lat. - long.) 33°18′12.72″N, 107°17′17.06″W
33°07′35.43″N, 107°17′15.96″W

References

#1272 Hawley, J.W., compiler, 1978, Guidebook to Rio Grande rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, 241 p., 1 pl., scale 1:1,000,00.

#1072 Kelley, V.C., and Silver, C., 1952, Geology of the Caballo Mountains: University of New Mexico Publications in Geology 4, 286 p., 9 pls.

#1268 Lozinsky, R.P., 1987, Cross section across the Jornada del Muerto, Engle, and northern Palomas Basins, south-central New Mexico: New Mexico Geology, v. 9, p. 55-57 and 63.

#1073 Lozinsky, R.R., 1985, Geology and late Cenozoic history of the Elephant Butte area, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 187, 40 p., 2 pls.

#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#1145 Maxwell, C.H., and Oakman, M.R., 1990, Geologic map of the Cuchillo quadrangle, Sierra County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1686, 1 sheet, scale 1:24,000.

2102, Walnut Springs fault

Structure Number 2102
Comments: Referred to as fault 7 on fig. 1 in Machette (1987 #960).

Structure Name Walnut Springs fault
Comments: Named by Warren (1978 #1079) for Walnut Springs, which is in Walnut Canyon below Red Gap in the southern part of the Fra Cristobal Mountains. The fault has also been called the Hot Springs fault by Thompson (1961 #1712) and the West Vein fault by Van Allen and Wilson (1984 #1266) in their discussion of fluorite deposits associated with the fault. Nelson (1986 #1176) compromised and called it the Walnut Canyon-West Vein fault. Machette (1987 #960) prefered Warren's original nomenclature because the Walnut Springs fault seems to have significantly more Cenozoic displacement than the Hot Springs fault. The fault extends from the northern end of the Fra Cristobal Mountains south to its intersection with the Hot Springs fault [2100] about 6 km north of Kettle Top Butte.

Synopsis: Little is known about the Quaternary history of this range-bounding fault that forms the west margin of the Fra Cristobal Mountains and eastern margin of the northern Engle basin. Although fault scarps are reported in the literature, none have been seen on aerial photographs or during aerial reconnaissance by the compiler. The prominent wall-like escarpment that cuts across the piedmont at the western front of the mountains is formed by silicified fault breccia in sediment of the upper Santa Fe Group, which suggest late Cenozoic movement on the fault. However, no studies have been conducted to discern the age and distribution of Quaternary deposits that overlie or are cut by this fault owing to limited access and property ownership.

Date of compilation 05/06/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra; Socorro

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Poor
Comments: Trace transferred from maps at various scales by Warren (1978 #1079), Thompson (1961 #1712), and Van Allen and Wilson (1984 #1266). These traces were supplemented by interpretation of aerial photographs. However, the trace is considered poorly controlled owing to the planimetric nature of the original source maps.

Geologic setting The Walnut Springs fault bounds the west margin of the Fra Cristobal Mountains and forms the eastern margin of the northern Engle basin for about 25 km. The most prominent expression of the fault is a wall-like escarpment formed by silicified fault breccia (Jacobs, 1956 #1711; Thompson, 1961 #1712; Van Allen and others, 1984 #1266; Nelson, 1986 #1176). This feature is well preserved along most of the proximal piedmont that borders the western front of the Fra Cristobal Mountains as illustrated in fig. 14 of Nelson (1986 #1176).

Sense of movement N
Comments:

Dip 65°-75° W
Comments: According to mapping of Nelson (1986 #1176).

Dip direction W

Geomorphic expression Although Nelson (1986 #1176) reported fault scarps on alluvial fans at the north end of the fault, none were observed along the western front of the Fra Cristobal Mountains on aerial photographs or during aerial reconnaissance by Machette (1987 #960) or Foley and others (1988 #991).

Age of faulted deposits From the dissected appearance of the piedmont, it appears that the alluvial fans are probably of middle and late Pleistocene age (Machette, 1987 #960). However, no studies have been conducted to discern the age and distribution of Quaternary deposits along this portion of the fault owing to limited access and property ownership.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Machette (1987 #960) considered the fault to be of possible early Pleistocene age whereas Foley and others (1988 #991) considered movement on the fault to be no younger than middle Pleistocene age. The more conservative estimate of Quaternary is used herein until specific studies are conducted on the Quaternary history of the Walnut Springs fault.

Recurrence interval not reported
Comments:

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on lack of bona fide scarps on deposits believed to be of middle and or late Pleistocene age.

Length	End to end (km):	20.8
	Cumulative (km):	21.2

Average strike (azimuth) 004°±12°

Endpoints (lat. - long.) 33°29′20.93″N, 107°06′04.72″W
33°18′07.19″N, 107°07′14.32″W

References

#991 Foley, L.L., LaForge, R.C., and Piety, L.A., 1988, Seismotectonic study for Elephant Butte and Caballo Dams, Rio Grande Project, New Mexico: U.S. Bureau of Reclamation Seismotectonic Report 88-9, 60 p., 1 pl., scale 1:24,000.
#1711 Jacobs, R.C., 1956, Geology of the central front of the Fra Cristobal Mountains: Albuquerque, University of New Mexico, unpublished M.S. thesis, 47 p.
#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.
#1176 Nelson, E.P., 1986, Geology of the Fra Cristobal Range, south-central New Mexico, *in* Clemons, R.E., King, W.E., and Mack, G.H., eds., Truth or Consequences region: New Mexico Geological Society, 37th Field Conference, October 16-18, 1986, Guidebook, p. 83-95.
#1712 Thompson, S., 1961, Geology of the southern part of the Fra Cristobal Range, Sierra County, New Mexico: Albuquerque, University of New Mexico, unpublished revision of M.S. thesis (1956), 89 p.
#1266 Van Allen, B.R., Wilson, J.L., and Hunter, J.C., 1984, Sunset Ridge fluorite deposit, Fra Cristobal Range, Sierra County, New Mexico: New Mexico Geology, v. 6, p. 1-5 and 12.
#1079 Warren, R.G., 1978, Characterization of the lower crust-upper mantle of the Engle Basin, Rio Grande rift, from a petrochemical and field geologic study of basalts and their intrusions: Albuquerque, University of New Mexico, unpublished M.S. thesis, 156 p., 1 pl., scale 1:24,000.

2103, Palomas Creek fault

Structure Number 2103
Comments: Referred to as fault 4 on fig. 1 in Machette (1987 #960).

Structure Name Palomas Creek fault

Comments: Machette (1987 #960) named this prominent fault for Palomas Creek, a major east-flowing tributary that enters the Rio Grande southwest of Truth or Consequences, New Mexico. The fault extends across the Cuchillo Plain from Palomas Creek on the north to Percha Creek on the south. Also included are numerous small subparallel scarps that lie to the southwest of the southern end of the main strand of the fault.

Synopsis The Palomas Creek fault has been studied on a reconnaissance basis and six topographic profiles have been collected for morphometric analysis. The fault forms down-to-the-east, north-trending intrabasin scarps that are preserved on the Cuchillo Plain, a high-level surface related to filling of the Palomas basin. The fault forms the southwest margin of the broader Cuchillo Negro fault zone [2104]. The most recent movement on the Palomas Creek fault is considered to be of late middle Pleistocene age (*i.e.,* 130-250 ka). However, no detailed study has been made of the age of Quaternary deposits within and adjacent to the fault zone.

Date of compilation 10/04/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping used to compile fig. 1 in Machette (1987 #960). Some of the faults are also shown in a generalized manner on the 1:100,000-scale map of Harrison (1993 #1226).

Geologic setting The Palomas Creek fault forms the southwestern part of the Cuchillo Negro fault zone [2104] about 16 km west of Truth or Consequences. The fault is the most mountainward (western) in this fault zone, which lies between the eastern margin of the Black Mountains and the Mud Spring Mountains and is within the Palomas basin, a east-tilted half graben (see Lozinsky, 1987 #1268). The fault displays unusual scissors-type motion, being down-to-the-east on the northern part and down-to-the-west on the southern part. This geometry is probably the geometric result of the two intersecting faults rather than the product of lateral movement.

Sense of movement N

Dip not reported
Comments: Shown diagramatically as high-angle faults on cross section in Lozinsky (1987 #1268).

Dip direction E; W

Geomorphic expression North of Palomas Creek the fault forms small, but continuous east-facing scarps on the Cuchillo surface. Machette (1987 #960) presented morphometric data from these fault scarps to argue that they are nearly in equilibrium with the surrounding piedmont. Six profiles were collected across these scarps to analysis their morphology. The scarps are 1.9-3.5 m high and have maximum scarp-slope angles of about 2°-4°, whereas the adjacent piedmont slope has an eastward slope of 0.75°-1.5° (see fig. 7 in Machette, 1987 #960). These scarps are more degraded than those of the 100-ka Santa Rita fault in southern Arizona, which led Machette to suggest that the fault scarps are probably of late-middle Pleistocene age (ca. 130-250? ka). No other studies (such as trenching) have been conducted along the Palomas Creek fault.

South of Palomas Creek, the scarp is less conspicuous where it crosses a dissected portion of the Cuchillo surface. From a point about 1.5 km south of Palomas Creek, south to Seco Creek, the fault forms a distinct west-facing scarp <5 m to almost 10 m high. The southern part of the fault forms west-facing scarps that oppose the gradient of the Cuchillo surface, and thus are quite apparent on aerial photographs and from the air. Also included for convenience are numerous small scarps that lie to the southwest of the southern end of the main strand of the fault are included with this fault. However, three additional discrete fault scarps farther south and east, beyond Seco Creek, are discussed as unnamed faults west of Caballo Reservoir [2105] in this compilation.

Age of faulted deposits The fault cuts the Palomas gravel (upper part of the Palomas Formation), which forms the constructional Cuchillo surface. This surface was considered to be middle Pleistocene (400-500 ka) by Lozinsky (1985 #1073) and Machette (1987 #960), but more recent studies by Mack and others (1993 #1020) suggested that this surface may be as old as 700-900 ka, thereby providing an older maximum limit on the deformation. However, no detailed mapping of Quaternary deposits along the fault or on the Cuchillo Plain have been conducted to help resolve the minimum age of the faulted deposits.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Machette (1987 #960) suggested a late middle Pleistocene age (ca. 130-250? ka) for the fault scarps based on their subdued morphology.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on fault scarps (<5-10 m high) formed on a surface that could be between 400 ka and 700-900 ka.

Length not applicable
Comments: This zone includes several faults that have an end to end length of 27.1 km and a cumulative trace length of 50.1 km.

Average strike (azimuth) 002°±20°

Endpoints (lat. - long.) 33°14′46.93″N, 107°24′59.88″W
33°00′13.43″N, 107°27′03.86″W

References

#1226 Harrison, R.W., Lozinsky, R.P., Eggleston, T.L., and McIntosh, W.C., 1993, Geologic map of the Truth or Consequences 30 x 60 minute quadrangle (1:100,000 scale): New Mexico Bureau of Mines and Mineral Resources Open-File Report 390, 19 p. pamphlet, 1 sheet, scale 1:100,000.

#1268 Lozinsky, R.P., 1987, Cross section across the Jornada del Muerto, Engle, and northern Palomas Basins, south-central New Mexico: New Mexico Geology, v. 9, p. 55-57 and 63.

#1073 Lozinsky, R.R., 1985, Geology and late Cenozoic history of the Elephant Butte area, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 187, 40 p., 2 pls.

#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

2104, Cuchillo Negro fault zone

Structure Number 2104
Comments: Referred to as faults labeled 3 on fig. 1 in Machette (1987 #960).

Structure Name Cuchillo Negro fault (zone)
Comments: Machette (1987 #960) named this long broad zone of faults for Cuchillo Negro Creek, a major east-flowing tributary that enters the Rio Grande just north of Truth or Consequences, New

Mexico. The fault zone extends across the Cuchillo Plain from the southern end of the San Mateo Mountains (north of Alamosa Creek), south to Palomas Creek.

Synopsis Very little work has been done on the Cuchillo Negro fault zone, although it forms conspicuous fault scarps on the Cuchillo Plain, northwest of Truth or Consequences. It is comprised of a 10- to 13-km-wide by 33- to 35-km-long zone of north-trending intrabasin fault scarps preserved on high-level surfaces related to late Cenozoic filling of the Marcial basin. The most recent movement on most of the faults in the zone is considered to be early late Pleistocene (100-130 ka) on the basis of fault scarp morphology. However, no detailed study has been made of the age of Quaternary deposits within and adjacent to the fault zone.

Date of compilation 10/04/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping used to compile fig. 1 in Machette (1987 #960). Some of the faults in this zone were shown on Maxwell and Oakman's (1990 #1145) 1:24,000-scale map of the Cuchillo 7.5-minute quadrangle and in a generalized manner on the 1:100,000-scale map of Harrison (1993 #1226).

Geologic setting The Cuchillo Negro fault zone is comprised primarily by north-trending, east- and west-dipping intrabasin normal faults in the central part of the Engle basin, northwest of Truth or Consequences. The fault zone is about 10- to 13-km wide and 33- to 35-km long. The margins of the fault zone are defined by the Palomas Creek fault [2103] on the southwest and the Mud Springs fault [2101] on the east.

Sense of movement N

Dip not reported
Comments: Shown diagramatically as high-angle faults on cross section in Lozinsky (1987 #1268).

Dip direction E; W

Geomorphic expression The fault forms small, but continuous primarily west-facing scarps that oppose the gradient of the Cuchillo surface, block drainages and form small ponds, and thus are quite apparent on aerial photographs and from the air. The scarps in this zone are topographically subdued and are generally less than 5 m high, with the exception of one prominent 10- to 15-m-high scarp in the central part of the zone (Machette, 1987 #960). The scarp morphology suggests that the youngest movement on these relatively small scarps probably dates from late-middle Pleistocene to perhaps late Pleistocene time.

Age of faulted deposits These faults cut the Palomas gravel (upper part of the Palomas Formation), which forms the constructional Cuchillo surface. This surface was considered to be middle Pleistocene (400-500 ka) by Lozinsky (1985 #1073) and Machette (1987 #960), but more recent studies by Mack and others (1993 #1020) suggests that this surface may be as old as 700-900 ka, thereby providing an older maximum limit on the deformation. However, no detailed mapping of Quaternary deposits along the fault or on the Cuchillo Plain have been conducted to help resolve the minimum age of faulted deposits.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)

Comments: Machette (1987 #960) suggested a late middle Pleistocene age (ca. 130-250? ka) to perhaps a late Pleistocene age for the fault scarps based on their subdued morphology. In retrospect, early late Pleistocene (100-130 ka) seems most likely for the time of most recent faulting.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on the presence of less than 5- to 15-m-high fault scarps on a surface that could be between 400 ka (Lozinsky, 1985 #1073) and 700-900 ka (Mack and others, 1993 #1020).

Length not applicable
Comments: This zone includes numerous faults that have an end to end length of 33.6 km and a cumulative trace length of 114.3 km.

Average strike (azimuth) 010°±14°

Endpoints (lat. - long.) 33°24′01.29″N, 107°19′21.94″W
33°05′57.13″N, 107°21′38.71″W

References
#1226 Harrison, R.W., Lozinsky, R.P., Eggleston, T.L., and McIntosh, W.C., 1993, Geologic map of the Truth or Consequences 30 x 60 minute quadrangle (1:100,000 scale): New Mexico Bureau of Mines and Mineral Resources Open-File Report 390, 19 p. pamphlet, 1 sheet, scale 1:100,000.
#1268 Lozinsky, R.P., 1987, Cross section across the Jornada del Muerto, Engle, and northern Palomas Basins, south-central New Mexico: New Mexico Geology, v. 9, p. 55-57 and 63.
#1073 Lozinsky, R.R., 1985, Geology and late Cenozoic history of the Elephant Butte area, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 187, 40 p., 2 pls.
#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.
#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.
#1145 Maxwell, C.H., and Oakman, M.R., 1990, Geologic map of the Cuchillo quadrangle, Sierra County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1686, 1 sheet, scale 1:24,000.

2105, Unnamed faults west of Caballo Reservoir

Structure Number 2105
Comments: Associated with fault 4 (but unlabeled as such) on fig. 1 in Machette (1987 #960).

Structure Name Unnamed faults west of Caballo Reservoir
Comments: Machette (1987 #960) mapped these unnamed faults and considered them as a probable extension of the Palomas Creek fault [2103]. The faults extend across the Cuchillo Plain from Palomas Creek on the north to Percha Creek on the south.

Synopsis: These faults form scarps similar to those of the Cuchillo Negro fault zone [2104] and Palomas Creek fault [2103], both of which are directly to the north. No detailed work has been done on their age, but they are probably coeval with the middle Pleistocene intrabasin faults in the Palomas and southern Engle basin, west of the Rio Grande.

Date of compilation 10/04/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping used to compile fig. 1 in Machette (1987 #960). Some of the faults are also shown on the northern margin of Seager and others' (1982 #626) 1:250,000-scale map and in a generalized manner on the 1:100,000-scale map of Harrison (1993 #1226).

Geologic setting These unnamed faults forms small scarps across the Cuchillo Plain. They lie close to but slightly east of the Palomas fault [2103], and may represent its southward continuation. They are intrabasin faults of the Palomas basin and, because most of the faults have down-to-the-west movement, they generally oppose the regional eastward gradient of the Cuchillo Plain.

Sense of movement N

Dip not reported

Dip direction W; E

Geomorphic expression These faults form small, mainly discontinuous east-facing scarps on the Cuchillo surface and shorter scarps of both east and west aspect. The most continuous of these faults extends southward across Seco Creek to the north bank of Percha Creek. No data on scarp morphology has been collected from these faults, although on aerial photographs they appear much like those of the intrabasin Cuchillo Negro fault zone.

Age of faulted deposits These faults cut the Palomas gravel (upper part of the Palomas Formation), which forms the constructional Cuchillo surface. This surface was considered to be middle Pleistocene (400-500 ka) by Lozinsky (1985 #1073) and Machette (1987 #960), but more recent studies by Mack and others (1993 #1020) suggests that this surface may be as old as 700-900 ka, thereby providing an older maximum limit on the deformation. However, no detailed mapping of Quaternary deposits along the fault or on the Cuchillo Plain have been conducted to help resolve the minimum age of faulted deposits.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing inferred from similarity with scarps of the Palomas Creek fault [2103], which Machette (1987 #960) suggested is of late middle Pleistocene age (ca. 130-250? ka) based on their subdued morphology.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on small scarps (<5-10 m high) on a surface that could be between 400 ka (Lozinsky, 1985 #1073) and 700-900 ka (Mack and others, 1993 #1020).

Length not applicable
Comments: This zone includes numerous faults that have an end to end length of 18.3 km and a cumulative trace length of 37.6 km.

Average strike (azimuth) -10°±21°

Endpoints (lat. - long.) 33°03'41.07"N, 107°23'23.96"W
32°54'10.88"N, 107°20'06.28"W

References
#1226 Harrison, R.W., Lozinsky, R.P., Eggleston, T.L., and McIntosh, W.C., 1993, Geologic map of the Truth or Consequences 30 x 60 minute quadrangle (1:100,000 scale): New Mexico Bureau of Mines and Mineral Resources Open-File Report 390, 19 p. pamphlet, 1 sheet, scale 1:100,000.

#1073 Lozinsky, R.R., 1985, Geology and late Cenozoic history of the Elephant Butte area, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 187, 40 p., 2 pls.
#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.
#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.
#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

2106, Unnamed faults west of Elephant Butte Reservoir

Structure Number 2106

Structure Name Unnamed faults west of Elephant Butte Reservoir
Comments: Machette (1987 #960) mapped these faults, but did not name them. The faults extend across the piedmont south of the San Mateo Mountains about 5-10 km west of Elephant Butte Reservoir.

Synopsis These north-trending intrabasin faults form scarps preserved on high-level surfaces related to filling of the Marcial basin. They have only been mapped as part of a regional reconnaissance, but their poorly preserved character suggests they might be of late middle to early late Pleistocene age (*i.e.*, 100-200 ka). However, no detailed study has been made of fault scarp morphology or the age of Quaternary deposits within and adjacent to the faults.

Date of compilation 10/04/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping used to compile fig. 1 in Machette (1987 #960). Some of the faults are also shown on in a generalized manner on the 1:100,000-scale map of Harrison (1993 #1226).

Geologic setting These unnamed intrabasin faults form small scarps across the piedmont that grades southeast from the San Mateo Mountains. They lie in the northern part of the Engle basin and are generally antithetic to the Walnut Springs fault [2102], which bounds the Fra Cristobal Mountains to the east.

Sense of movement N

Dip not reported

Dip direction E; W

Geomorphic expression These faults form small (commonly <5 m high), mainly discontinuous primarily east-facing scarps on the dissected Cuchillo surface. No data on scarp morphology has been collected from these faults, although on aerial photographs they appear much like those of the intrabasin Cuchillo Negro fault zone [2104] to the southwest.

Age of faulted deposits These faults cut the Palomas gravel (upper part of the Palomas Formation), which forms the constructional Cuchillo surface. This surface was considered to be middle Pleistocene (400-500 ka) by Lozinsky (1985 #1073) and Machette (1987 #960), but more recent studies by Mack and others (1993 #1020) suggested that this surface may be as old as 700-900 ka, thereby providing an older maximum limit on the deformation. However, no detailed mapping of Quaternary deposits along the fault or on the Cuchillo Plain have been conducted to help resolve the minimum age of faulted deposits.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing inferred from similarity with scarps of the Palomas Creek fault [2103], which Machette (1987 #960) suggested is of late middle Pleistocene age (ca. 130-250? ka) based on their subdued morphology.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on small scarps (<5-high) on a surface that could be between 400 ka (Lozinsky, 1985 #1073) and 700-900 ka (Mack and others, 1993 #1020).

Length not applicable
Comments: This zone includes several faults that have an end to end length of 15.8 km and a cumulative trace length of 8.8 km.

Average strike (azimuth) 019°±09°

Endpoints (lat. - long.) 33°26'30.08"N, 107°11'30.14"W
33°18'49.60"N, 107°15'55.05"W

References

#1226 Harrison, R.W., Lozinsky, R.P., Eggleston, T.L., and McIntosh, W.C., 1993, Geologic map of the Truth or Consequences 30 x 60 minute quadrangle (1:100,000 scale): New Mexico Bureau of Mines and Mineral Resources Open-File Report 390, 19 p. pamphlet, 1 sheet, scale 1:100,000.
#1073 Lozinsky, R.R., 1985, Geology and late Cenozoic history of the Elephant Butte area, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 187, 40 p., 2 pls.
#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.
#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

2107, Milligan Gulch fault zone

Structure Number 2107
Comments: Fault (zone) 2 in Machette (1987 #960).

Structure Name Milligan Gulch fault zone
Comments: Mapped and named by Machette (1987 #960) for Milligan Gulch, a prominent southeast-flowing ephemeral stream that enters the Rio Grande at the north end of Elephant Butte Reservoir. The fault zone extends from about 4 km north of Milligan Gulch south to Nogal Canyon, which also flows east from the southern San Mateo Mountains.

Synopsis: The Milligan Gulch fault zone is comprised of a 25-km-long series of diffuse north-trending intrabasin fault scarps preserved on high-level surfaces related to filling of the Marcial basin. The most recent movement on most faults in the zone is considered to be of late middle to early late Pleistocene age (*i.e.*, 100-200 ka). However, no detailed study has been made of fault scarp morphology or the age of Quaternary deposits within and adjacent to the fault zone.

Date of compilation 10/07/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping by Machette (1987 #960).

Geologic setting The Milligan Gulch fault zone is comprised of a 25-km-long group of diffuse north-trending intrabasin fault scarps in the west-central part of the San Marcial basin, northwest of the northern end of the Fra Cristobal Mountains and east of the southern part of the San Mateo Mountains. The southern and central parts of the zone are comprised mainly of down-to-the-east faults, whereas the northern part is comprised mainly of down-to-the-west faults. All of the faults have relatively minor displacement where they deform the highest (middle or early Pleistocene) surface related to Cenozoic filling of the Marcial basin.

Sense of movement N

Dip not reported

Dip direction E; W

Geomorphic expression These faults form small, fairly continuous east- and west-facing scarps that range from 1 km to 11 km in length. They were divided into two sets by Machette (1987 #960) on the basis of aspect: the scarps north of Milligan Gulch generally face west and the faults farther south generally face east. The west-facing scarps oppose the gradient of the piedmont slope on which they are formed, and thus are quite apparent on aerial photographs. Both sets of scarps are commonly less than 5 m high, and are generally mature (quite degraded) although no systematic study of their morphology has been conducted. Near the southern end of the zone, there are several fresher-appearing scarps formed on lower-level (late? Pleistocene) surfaces. The most prominent of these 'younger' scarps was named the Black Hill fault scarp by Machette (1987 #960), and thus it is discussed herein as a separate fault [2130].

Age of faulted deposits Most of the scarps in this fault zone are on high-level surfaces related to filling of the Marcial basin. To the south, these surfaces are generally correlative to the Cuchillo surface, which is underlain by the Palomas gravel (upper part of the Palomas Formation). This surface was considered to be middle Pleistocene (400-500 ka) by Lozinsky (1985 #1073) and Machette (1987 #960), but more recent studies by Mack and others (1993 #1020) suggested that the Cuchillo surface may be as old as 700-900 ka, thereby providing an older maximum limit on the deformation. The fresher appearing scarps at the southern end of the fault zone may be formed on alluvium of late (?) Pleistocene age. However, no detailed mapping of Quaternary deposits along this fault zone or in the Milligan Gulch area have been conducted to help resolve the minimum age of faulted deposits.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing based on degraded nature of fault scarps (Machette, 1987 #960). Collectively, the most recent movement on faults of the zone is considered to be late middle to early late Pleistocene age (*i.e.*, 100-200 ka). However, Machette (1987 #960) suggested that there may be late Pleistocene (30-130 ka) movement at the south end of the zone and on the Black Hill fault [2130], which forms the southwest margin of the Milligan Gulch fault zone.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on small scarps (<5 m high) on a surface that could be between 400 ka and 700-900 ka.

Length not applicable
Comments: This zone includes numerous faults that have an end to end length of 26.9 km and a cumulative trace length of 58.8 km.

Average strike (azimuth) 001°±16°

Endpoints (lat. - long.) 33°46′35.13″N, 107°07′03.97″W
33°32′02.55″N, 107°08′07.36″W

References

#1073 Lozinsky, R.R., 1985, Geology and late Cenozoic history of the Elephant Butte area, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 187, 40 p., 2 pls.
#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.
#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

2108, Socorro Canyon fault zone

Structure Number 2108
Comments: Referred to as fault 12 in Machette and McGimsey (1983 #1024).

Structure Name Socorro Canyon fault zone
Comments: Machette and McGimsey (1983 #1024) named this prominent fault (zone) after fault scarps exposed near Socorro Canyon, a major yet ephemeral east-trending stream canyon that enters the Rio Grande just south of Socorro, New Mexico. It was previously named the Socorro fault by Kelley (1954 #1222); as discussed herein it includes the MCA fault of Chamberlin and Eggleston (1996 #1224). The Socorro Canyon fault zone extends from San Lorenzo Canyon on the north (where it seems to merge with the Loma Peleda fault [2113], south to a point just east of U.S. Interstate Highway 25 about 2 km north of the highway exit to San Antonio, New Mexico.

Synopsis: The Socorro Canyon fault zone is comprised of two sections that bound the Socorro and Lemitar Mountains, west of Socorro. The northern section of the fault zone forms the eastern margin of the Socorro and northern Lemitar Mountains. In the intervening area between these two uplifted, backtilted ranges, the fault zone juxtaposes Pliocene and Miocene basin-fill sediment along the western margin of the topographically defined Socorro Basin. South of Socorro Canyon, the southern section of the fault zone strikes south and southeast across the piedmont, widening southward. This east-dipping normal fault zone parallels and influences the alluvial margin of the Rio Grande Valley in the Socorro Basin. Traces of the fault zone have been mapped at 1:24,000 scale, but no detailed studies have been made of the fault's movement history. At least one strand of the fault appears to be of latest Pleistocene to Holocene age based on the presence of a small (single-event) fault scarp on young alluvial deposits adjacent to Socorro Canyon.

Date of compilation 03/20/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey; Richard Chamberlin, New Mexico Bureau of Mines and Mineral Resources

State New Mexico

County Socorro

1° x 2° sheet Tularosa; Socorro

Province Basin and Range

Geologic setting The Socorro Canyon fault zone defines the eastern uplifted margin of the Socorro and northern Lemitar Mountains, which lie west of the Rio Grande valley. North of Socorro Canyon, east-dipping normal faults bound the Socorro and Lemitar Mountains, which were strongly uplifted and west-titled in late Oligocene to late Miocene time. These mountains are cored by Precambrian and Paleozoic rocks, but the Socorro Mountains are cut by the north wall of the Socorro Caldera, an Oligocene eruptive center that was the source of the 32 Ma Hells Mesa Tuff. About 3 km north of Socorro Canyon, the fault starts to splay (horsetail) southward into a distributed but subparallel series of intrabasin scarps on a variety of ages of piedmont-slope surfaces. Southward bifurcation of the Socorro Canyon fault zone is generally coincident with a transverse tilt-block domain boundary known as the Socorro accommodation zone (SAZ; previously called the Socorro transverse shear zone) (Chapin and others, 1978 #1240). The SAZ is coincident with an older crustal flaw that controlled emplacement of the ENE-trending Socorro-Magdalena caldera complex. The pattern of distributed Quaternary faulting may be the surficial expression of "hotter" (more plastic) middle crust associated with the geophysically defined Socorro magma body along the southern section of the Socorro Canyon fault zone. There is about 208 m of cumulative down-to-the-east displacement of a 4.0 Ma basalt that flowed across the fault zone in Socorro Canyon (Chamberlin and Harrison, 1996 #1225). Total Pliocene through Pleistocene displacement is probably not more than 300 m. Field relations around the 7.8-Ma rhyolitic lava dome (perlite deposit) near Socorro Canyon indicates that the fault zone did not exist prior to about 6 Ma. Larger offsets of Miocene and Oligocene strata (in the Socorro and Lemitar Mountains) predate the Socorro Canyon fault zone.

Number of sections 2
Comments: Although Chamberlin referred to segments of the fault, no definitive work has been done to substantiate such a scheme. The fault is herein divided into two sections on the basis of apparent recency of movement and surficial expression of faulting.

Length End to end (km): 48.6
Trace (km): 125.1

Average strike (azimuth) -14°±25°

Endpoints (lat. - long.) 34°15′03.35″N, 106°56′44.86″W
33°48′48.28″N, 106°54′30.58″W

2108a, northern section

Section number 2108a

Section name northern section
Comments: This section forms a mainly concealed and/or inferred trace that extends along the base of the Lemitar Mountains and northern part of the Socorro Mountains. The northern end is near San Lorenzo Arroyo. The southern end is located near Sedillo Springs, about 2 km north of Socorro Canyon.

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping by Machette used to compile fault map of Machette and McGimsey (1983 #1024), from Chamberlin's recent 1:24,000-scale mapping of the Socorro 7.5-minute quadrangle (unpublished, 1996), and from a 1:200,000-scale map of Socorro County (Osburn, 1984 #1238).

Sense of movement N

Dip not reported

Dip direction E

Geomorphic expression North of Socorro Canyon, the fault forms discontinuous and obscure east-facing scarps that are largely buried by colluvium shed from the mountains and by possible landslide debris. Near Nogal Canyon, the fault trends basinward and forms several anatomizing scarps, each of small height, but no scarp profiles have been measured along this part of the fault. There are two additional antithetic scarps preserved downslope (east) about 2-3 km. This broad zone of preserved scarps probably indicates the true width of the fault zone in the subsurface. Recognizable scarps of the Socorro Canyon fault end at Corkscrew Canyon (Puertocito de Canyoncitos del Lemitar), but the fault steps over to the northwest to form the relatively inactive eastern margin of the Lemitar Mountains. At the north end of these mountains, the through-going fault juxtaposes Plio-Pleistocene sediment of the Sierra Ladrones Formation with the Miocene Popotosa Formation.

Age of faulted deposits The fault zone cuts middle to early Quaternary surficial deposits. The only prominent scarps along this section are preserved on high-level piedmont slopes between Nogal Canyon and Canoncito del Puertocito de Lemitar, and no scarps are known to be formed on deposits or surfaces as young as late Pleistocene age. Along the Lemitar Mountains, the fault juxtaposes Plio-Pleistocene sediment of the Sierra Ladrones Formation with the Miocene Popotosa Formation (both comprising the Santa Fe Group). However, no dating of deposits along the fault have been conducted to help resolve the minimum age of faulted deposits.

Detailed studies none

Timing of most recent paleoevent middle to late Quaternary (<750 ka)
Comments: Machette and McGimsey's (1983 #1024) comments about the time of movement apply to the southern section of the fault, not the northern one. They did not study any of the scarps on this section of the fault. Thus, the timing of movement is only controlled by the age of deposits on which the scarps are preserved.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Little offset/age data exist for these faults. However, as mapped by Chamberlin (unpublished data, 1996), the scarps near Nogal Canyon barely affect the gradient of the faulted piedmont slope (20-ft, 6-m contour interval). Thus, there is probably <5-7 m (15-20 ft) of offset across single strands of the fault. These high-level surfaces are at least middle or possibly early(?) Quaternary in age, thus suggesting a very low average slip rate.

Length End to end (km): 22.5
Trace (km): 37.0

Average strike (azimuth) -4°±28°

Endpoints (lat. - long.) 34°15'03.35"N, 106°56'44.86"W
34°02'51.85"N, 106°56'19.45"W

2108b, southern section

Section number 2109b

Section name southern section
Comments: The southern section forms mainly continuous fault scarps that extend along the southern part of the Socorro Mountains and across the piedmont slope that flanks the eastern margin of the Chupadera Mountains. The northern end of the section is at Sedillo Springs, whereas the southern end is at a point just east of Interstate Highway 25 about 2 km north of the exit to San Antonio, New Mexico.

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping by Machette used to compile fault map of Machette and McGimsey (1983 #1024), and from Chamberlin's recent 1:24,000-scale mapping of the

Socorro (unpublished, 1996) and Luis Lopez 7.5-minute quadrangles (Chamberlin and Eggleston, 1996 #1224).

Sense of movement N

Dip not reported

Dip direction E; W

Geomorphic expression South of Socorro Canyon, the fault zone forms a southward-widening distributed zone of subparallel scarps (7-km wide) on a variety of ages of piedmont-slope surfaces. There are several discontinuous east- to southeast-trending scarps that strike away from the main trace of the fault zone at the section boundary; these scarps may be following preexisting faults associated with the Socorro caldera in the subsurface. Not all the scarps are present on the same-age landforms, suggesting that some strands of the fault may be more or less active than others. On the south bank of Socorro Canyon the fault forms scarps that appear to represent the most recent and penultimate faulting events on the main (active) strand of the fault zone. The morphology of these scarps, and others to the south, have been analyzed by Machette and McGimsey (1983 #1024). They suggested that most of the scarps along the fault zone are the result of multiple faulting events. For example, scarps on uppermost Pleistocene terrace and piedmont slope surfaces are 0.7-1.0 m high (single event), those on upper Pleistocene surfaces are commonly 2-3 m high (two? events), and those on early Pleistocene surfaces are as much as 25 m high (many events). The youngest scarps have morphometric relations that are comparable with the Drum Mountains scarps of Utah, which are probably of early Holocene age (Crone, 1983 #552).

Age of faulted deposits The fault zone cuts a 4.0-Ma basalt flow at the mouth of Socorro Canyon, and a wide variety of Quaternary surficial deposits, the youngest of which are generally of late Pleistocene age. The most spectacular scarps are formed on the old, high-level Las Canas surface of McGrath and Hawley (1987 #1239). This surface is offset 21-24 m by the main trace of the fault zone south of Socorro Canyon (Chamberlin and Harrison, 1996 #1225); this surface is now considered to be early Pleistocene in age (ca. 800±100 ka) based on a tentative correlation with the lower La Mesas surface in Las Cruces area, which Mack and others (1993 #1020) dated as older than 0.73 Ma and younger than 0.9 Ma. However, no dating of deposits along the fault have been conducted to help resolve the minimum age of faulted deposits.

Detailed studies Site 2108-1. A single trench was excavated across a 3-4 m high scarp at the mouth of Socorro Canyon about 40 m north of U.S. Highway 60 in the early 1980's, but the trench was never adequately mapped or sampled to decipher the fault's movement history. In the winter of 1997-98, Bruce Harrison (New Mexico Tech, Socorro, New Mexico) refreshed the main trench and dug a second trench across the aforementioned small scarp. No information about the new trenching had been released at the time of this compilation.

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Machette and McGimsey (1983 #1024) suggested a late Pleistocene age (ca. 10-130 ka) for the fault scarps based on their subdued morphology. However, some scarps, such as the 0.7-1.0 m high (single-event?) scarp on an uppermost Pleistocene terrace of Socorro Canyon, may have been formed in the early(?) Holocene (*i.e.*, near 10 ka). Other scarps in the zone could be pre-late Pleistocene, but the general presence of well preserved scarps argues for late Pleistocene movement over most of the fault zone.

Recurrence interval not reported

Slip-rate category <0.2 mm/yr
Comments: Little offset/age data exist for these faults. However, Machette and McGimsey (1983 #1024) cited 2-3 m offset of upper Pleistocene terrace deposits. Stratigraphic and geomorphic relations indicate that most of these-size scarps are the result of two movements, the most recent of which may be 5-15 ka. If one assumes that the 2-3 m of offset observed at Socorro Canyon formed over the entire

late Pleistocene (130-10 ka), then the slip rate on this individual fault strand is no less than 0.02-0.03 mm/yr (2-3 m in <120 k.y.). If the penultimate event occurred later in the late Pleistocene (*i.e.*, 50 ka), then slip rates may be as high as 0.05-0.08 mm/yr (2-3 m in 40 k.y.).
Chamberlin's current estimate of the long-term slip rate across the main strand of the fault zone is 28±8 m/Ma (0.028 mm/yr), or about 3/4th of the previously published slip rate of 39±9 m/Ma (Chamberlin and Harrison, 1996 #1225), easily within the range mentioned above. The cumulative Plio-Pleistocene slip rate across the entire fault zone south of Socorro Canyon could however, be twice (0.06 mm/y) as much as that observed on the main fault trace. The modern rate of deformation (possibly as a result of draping rather than brittle failure) across the fault zone is about 0.4-0.5 mm/y, as determined from geodetic data. Reilinger and others (1980 #1237), who measured elevation changes along the now abandoned rail line from Socorro to Magdalena, showed an abrupt ca. 20 mm-high uplift zone (block edge) near the mouth of Socorro Canyon. This leveling anomaly probably represents aseismic warping along the fault zone between 1934 and 1978. This amount of uplift (strain accumulation) would be equivalent to forming the youngest 0.3-0.6 m high scarp once every 7-14 k.y. or the 2-3 m high scarp every 70 k.y. Although active, the Quaternary history of the fault zone is one of relatively slow slip interrupted by surface faulting.

Length End to end (km): 26.1
Trace (km): 88.2

Average strike (azimuth) -19°±23°

Endpoints (lat. - long.) 34°02′51.85″N, 106°56′19.45″W
33°48′48.28″N, 106°54′30.58″W

References

#1224 Chamberlin, R.M., and Eggleston, T.L., 1996, Geologic map of the Luis Lopez 7.5 minute quadrangle, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 421, 2 sheet, scale 1:24,000.

#1225 Chamberlin, R.M., and Harrison, B., 1996, Pliocene and Pleistocene displacement history of the Socorro Canyon fault, central Rio Grande rift, New Mexico [abs]: New Mexico Geology, v. 18, p. 45.

#1240 Chapin, C.E., Chamberlin, R.M., Osburn, G.R., White, D.W., and Sanford, A.R., 1978, Exploration framework of the Socorro geothermal area, New Mexico, *in* Chapin, C.E., Elston, W.E., and James, H.L., eds., Field guide to selected cauldrons and mining districts of the Datil-Mogollon volcanic field New Mexico: New Mexico Geological Society Special Publication 7, p. 114-129.

#552 Crone, A.J., 1983, Amount of displacement and estimated age of a Holocene surface faulting event, eastern Great Basin, Millard County, Utah, *in* Crone, A.J., ed., Paleoseismicity along the Wasatch Front and adjacent areas, central Utah: Utah Geological and Mineral Survey Special Studies 62, p. 49-55.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#1239 McGrath, D.B., and Hawley, J.W., 1987, Geomorphic evolution and soil-geomorphic relationships in the Socorro area, central New Mexico, *in* McLemore, V.T., and Bowie, M.R., eds., Guidebook to the Socorro area, New Mexico: New Mexico Bureau of Mines and Mineral Resources, 24th Annual Meeting of the Clay Minerals Society and 36th Annual Clay Minerals Conference, Guidebook, p. 55-67.

#1238 Osburn, G.R., compiler, 1984, Geology of Socorro County: New Mexico Bureau of Mines and Mineral Resources Open-File Report 238, 13 p. pamphlet, 1 sheet, scale 1:200,000.

#1237 Reilinger, R., Oliver, J., Brown, L., Sanford, A., and Balazs, E., 1980, New measurements of crustal doming over the Socorro magma body, New Mexico: Geology, v. 8, p. 291-295.

2109, La Jencia fault

Structure Number 2109
Comments: Referred to as fault 11 in Machette and McGimsey (1983 #1024).

Structure Name La Jencia fault
Comments: First recognized as a young range-bounding fault by Kirk Bryan in 1933 (cited on p. 73 in Loughlin and Koschmann, 1942 #1273), it was shown in a general manner and named the Magdalena fault by Kelley (1954 #1222). It was not mapped in detail until the late 1970's (see Machette, 1978 #1223). Machette (see citations in Machette and McGimsey, 1983 #1024) renamed it for La Jencia Creek, a stream that drains La Jencia basin, the northern part of the Magdalena Mountains, and the southern part of the Bear Mountains, northwest of Socorro. The fault extends south from a point about 2 km south of Bear Springs Canyon (Sec. 20, T. 1 S., R. 3 W.) and crosses U.S. Highway 60 about 7 km east of Magdalena. The fault can be traced south along the mountain front and associated piedmont to Six Mile Canyon.

Synopsis: The La Jencia fault is one of a dozen or so faults in the Rio Grande rift that have been investigated in detail. The fault's trace was mapped in detail, more than 50 scarp profiles have been measured to document offset and scarp morphology, and four trenches were excavated in the late 1970's to help document the fault's chronology. No radiometric dating was performed, but detailed analyses of soil development were used to estimate times of movement and suggest a segmentation scheme for the fault. New dating techniques such as AMS radiocarbon or thermoluminescence could be used to refine the fault's chronology.

Date of compilation 02/03/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Socorro

Province Basin and Range

Geologic setting The La Jencia fault (Machette, 1986 #1220) bounds the eastern margin of the strongly uplifted (west-titled) Magdalena Mountains and the more subdued Bear Mountains (to the north). Both ranges have embayed range-fronts, suggesting a lack of significant Quaternary faulting. However, the La Jencia fault forms the tectonic margin between the mountains to the west and the Cenozoic La Jencia basin to the east. The basin probably has a half-graben geometry, with the eastern part formed by west-dipping rocks of the Socorro and Lemitar Mountains. The Magdalena Mountains are comprised of Precambrian rocks, with an overlying (eroded) section of Paleozoic sedimentary rocks and locally derived Tertiary volcanic rocks. The Bear Mountains are of similar composition, but are not so strongly uplifted. Late Cenozoic uplift across the La Jencia fault probably exceeds 1,000 m, and may be as much as 1,500 m locally (Machette, 1988 #1221).

Number of sections 2
Comments: This 34-km-long fault was previously divided into 6 segments on the basis of apparent timing of movement. However, these segments are rather short (3-8 km long) and probably do not reflect truly independent rupture segments. Therefore, for descriptive purposes, the segments are com-

bined into two sections herein strictly on a geometric basis, the northern section trending north and northeast from U.S. Highway 60 and the southern section trending southeast and south from U.S. Highway 60.

Length End to end (km): 31.5
Trace (km): 45.0

Average strike (azimuth) -19°±29°

Endpoints (lat. - long.) 34°15′46.85″N, 107°09′57.95″W
34°00′01.51″N, 107°02′03.00″W

2109a, northern section

Section number 2109a

Section name northern section
Comments: Includes segments D, E, and F of Machette (1988 #1221).

Reliability of location Good
Comments: Trace from 1:48,000-scale geologic mapping by Machette (1988 #1221). Other maps show the fault at scales of 1:187,500 (Kelley, 1954 #1222) to 1:250,000 (Machette and McGimsey, 1983 #1024).

Sense of movement N
Comments: From trenching, Machette (1988 #1221) inferred primarily normal dip-slip movement at the surface.

Dip not reported
Comments: Machette (1988 #1221) showed typical dip angles of 70°-90°, all within 3-4 m of the surface.

Dip direction E

Geomorphic expression The fault forms prominent, yet subdued east-facing scarps on alluvial piedmont slopes of the Bear Mountains and northern Magdalena Mountains. The scarps are commonly 3 m to as much as 6 m high, and generally decrease in height to the north. Machette (1988 #1221) measured four scarp profiles near the south end of the section of the fault (segment D) and his plots of maximum scarp-slope angle against scarp height suggested that the scarp was substantially older (ca. 40 ka) than those south of U.S. Highway 60. The scarps north of La Jencia Creek (segment E) are formed on piedmont-slope deposits that are buried beneath a 1-3 m thick cover of Holocene and older eolian sand. These scarps are unsuitable from morphologic analysis. Farther north, scarps along segment F are 1-2 m high and have maximum slope angles of only 2°-4° more than the piedmont. These highly degraded scarps, combined with results from a trench across segment E (see description of site 2109-1), suggested much older movement, perhaps at about 150 ka.

Age of faulted deposits The piedmont slope that is faulted along this section is believed by Machette (1988 #1221) to be primarily of latest middle Pleistocene age (*i.e.,* 150 ka) on the basis of detailed field and laboratory analyses of soil development. However, no numerical dates were obtained from deposits exposed along the fault. Machette's studies (1988 #1221) were performed before dating techniques, such AMS dating of carbon and thermoluminescence dating of eolian sediment, were being applied to paleoseismic studies. Younger alluvial deposits, inset into the piedmont, and eolian sands overlying the piedmont are faulted along the southern portion of the section (segments D and E).

Detailed studies Machette (1988 #1221) published a detailed study of the fault that was based on a comprehensive analysis of scarp morphology, soil development, and trenching of four sites. On this section of the fault, he trenched two sites. The northern site (2109a-1) is on segment E, whereas the southern site (2109a-2) is on segment D.
Site 2109a-1. This trench yielded evidence for three(?) faulting events, the youngest two of which occurred <3 ka and about 3 ka. The youngest event may not be truly tectonic, but instead may reflect

local slumping of materials (compilers assertion). These time estimates are based on soil development and were not calibrated against similar-age dated deposits, thus they may be in error by as much as 100 percent (compilers assertion). The two younger events resulted in about 4.5 m of offset of Holocene eolian sands and older deposits. The penultimate event, estimated to be about 150 ka (probably ±50 ka, compilers assertion), resulted in about 1.5 m of offset of middle Pleistocene alluvial and eolian deposits. The resultant time interval between these two phases of activity is a minimum of nearly 100 ka.

Site 2109a-2. This trench yielded evidence for two discrete faulting events, the youngest of which occurred about at 33 ka (28-40 ka) and the older at about 150 ka. These time estimates are based on the development of moderately to strongly developed soils but calibrated against soils on similar-age deposits; they may be in error by as much as 50 percent (compilers assertion). The younger event displaced a 300-ka soil (middle Pleistocene) 3.6-3.8 m and warped it an additional 1.25 m. The penultimate event, estimated to have occurred at about 150 ka, resulted in 1-2 m high scarp that was almost completely obliterated (degraded) by the time of the most recent event. The resultant time interval between these two phases of activity is roughly 100 ka, considering the lack of error limits on the 150 ka event.

Timing of most recent late Quaternary (<130 ka)

Comments: Timing determined from analysis of scarp morphology, trenching investigations, and detailed analyses of soil development on faulted and unfaulted deposits (Machette, 1988 #1221). Estimated time for the most recent paleoevent ranges from 28-40 ka on segment D (southern part of section) to roughly 3 ka on segment E (central part of section), and about 150 ka on segment F (northern part of section). Scarps along segment E may have been formed at the same time as some of those on the southern section (segment A). Nevertheless, the northern section is considered to have been active in the late Quaternary (<130 ka). The penultimate event is estimated to be about 150 ka on all parts of the section.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Low slip-rate category assigned based on assuming 5 m of displacement occurred in the late Pleistocene.

Length End to end (km): 14.0
Trace (km): 18.3

Average strike (azimuth) 005°±24°

Endpoints (lat. - long.) 34°15′46.85″N, 107°09′57.95″W
34°08′11.65″N, 107°10′51.63″W

2109b, southern section

Section number 2109b

Section name southern section

Comments: Includes segments A, B, and C of Machette (1988 #1221).

Reliability of location Good

Comments: Trace from 1:48,000-scale geologic mapping by Machette (1988 #1221). Other maps show the fault at scales of 1:187,500 (Kelley, 1954 #1222) to 1:250,000 (Machette and McGimsey, 1983 #1024).

Sense of movement N

Comments: From trenching, Machette (1988 #1221) inferred primarily normal dip-slip movement at the surface.

Dip not reported

Comments: Machette (1988 #1221) showed typical dip angles of 70-90°, all within 3-4 m of the surface.

Dip direction NE

Geomorphic expression The fault forms prominent east- and northeast-facing scarps on alluvial fans and piedmont slopes of the Magdalena Mountains. The scarps are as little as 1 m to as much as 6.5 m high, and generally decrease in height south of Water Canyon. Machette (1988 #1221) measured almost 50 scarp profiles along this section of the fault, and separated it into three segments (A, B, and C). His plots of maximum scarp-slope angle against scarp height suggested that the scarps were all <15 ka, considerably younger than those just to the north of U.S. Highway 60. The scarps between the highway and Water Canyon (segments B and C) are formed on moderately sloping proximal piedmont-slope deposits close to the range front, whereas those south of Water Canyon (segment A) are as much as 2-3 km east of the range front and are formed on gently sloping medial piedmont-slope deposits.

Age of faulted deposits Machette (1988 #1221) suggested that most of the faulted proximal piedmont slope along segments B and C is of middle Pleistocene age (*i.e.*, 130-750 ka) on the basis of detailed field and laboratory analyses of soil development. Conversely, most of the medial piedmont slope that is faulted along segment A is believed to be of late to latest Pleistocene age (*i.e.,* 10-130 ka) on the basis of detailed analyses of soil development. However, no numerical ages were obtained from deposits exposed along the fault. Machette's studies (1988 #1221) were performed before dating techniques, such AMS dating of carbon and thermoluminescence dating of eolian sediment, were being applied to paleoseismic studies. Younger alluvial deposits, inset into the piedmont are faulted as much as older surficial units, suggesting that the scarps are primarily the result of a single surface-faulting event, rather than multiple events as seen on the northern section of the fault.

Detailed studies Machette (1988 #1221) published a detailed study of the fault that was based on a comprehensive analysis of scarp morphology, soil development, and trenching of four sites. On this section of the fault, he trenched two sites. The northern site (2109b-1) is on segment B, whereas the southern site (2109b-2) is on segment A. No trenches were excavated on segment C owing to restricted access.

Site 2109b-1. This trench yielded evidence for two faulting events, the youngest of which occurred at about 15 ka (±5 ka in the compilers judgment) and the older at least 500 ka. These time estimates are based on the development of moderately to strongly developed soils that were calibrated against soils on against similar-age deposits; these age estimates may be in error by as much as 50 percent (compilers assertion). The younger event displaces a 500-ka soil (middle Pleistocene) about 5 m. The penultimate event, estimated to have occurred somewhat before 500 ka, resulted in <2 m of offset that was completely obliterated by continued deposition of piedmont-slope deposits at the site.

Site 2109b-2. This trench yielded evidence for a single faulting event that occurred about at 5-6 ka (middle Holocene). This time estimate is based on the faulted piedmont having weakly developed soils, which were calibrated against soils on similar-age deposits in southern New Mexico; they may be in error by as much as 50 percent (compilers assertion). This young event offset alluvial deposits about 2.2 m in the trench, but adjacent scarps range from 0.7-2.6 m in height. There is no geologic evidence for a penultimate event at the site.

Timing of most recent paleoevent latest Quaternary (<15 ka)
Comments: Timing determined from analysis of scarp morphology, trenching investigations, and detailed analyses of soil development on faulted and unfaulted deposits (Machette, 1988 #1221). Estimated times for the most recent paleoevent range from 5-6 ka on segment A (southern part of section) to 15 ka on segments B and C (central and northern part of section).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on the long, assumed recurrence interval of 500 k.y.

Length End to end (km): 20.2
Trace (km): 26.6

Average strike (azimuth) -36°±19°

Endpoints (lat. - long.) 34°08′11.65″N, 107°10′51.63″W
34°00′01.51″N, 107°02′03.00″W

References

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1273 Loughlin, G.F., and Koschmann, A.H., 1942, Geology and ore deposits of the Magdalena mining district, New Mexico: U.S. Geological Survey Professional Paper 200, 168 p., 5 pls.

#1223 Machette, M.N., compiler, 1978, Preliminary geologic map of the Socorro 1° by 2° quadrangle, central New Mexico: U.S. Geological Survey Open-File Report 78-607, 1 sheet, scale 1:250,000.

#1220 Machette, M.N., 1986, History of Quaternary offset and paleoseismicity along the La Jencia fault, central Rio Grande rift, New Mexico: Bulletin of the Seismological Society of America, v. 76, p. 259-272.

#1221 Machette, M.N., 1988, Quaternary movement along the La Jencia fault, central New Mexico: U.S. Geological Survey Professional Paper 1440, 82 p., 2 pls.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2110, West Joyita fault zone

Structure Number 2110

Structure Name West Joyita fault zone

Comments: The West Joyita fault zone (West La Joya fault of Machette and McGimsey, 1983 #1024) extends along the west flank of the Joyita Hills, and forms the eastern margin of the Socorro constriction. The fault was first mapped and named by Wilpolt and others (1946 #1424) and Wilpolt and Wanek (1951 #1425) during oil and gas investigations in the Albuquerque-Belen basin. Subsequent detailed mapping has been conducted along parts of the fault zone (Beck, 1993 #1284; Cather, 1996 #1290).

Synopsis: The West Joyita fault zone forms the eastern margin of the Rio Grande rift in the narrow part of the rift known as the Socorro constriction. Faulting along the West Joyita fault zone appears to be much less active than along the Ladron and Lemitar Mountains on the western margin of the Socorro constriction. In most places the fault zone is poorly expressed, except northwest of San Acacia, on the west flank of the northernmost Joyita Hills, where the fault offsets upper Santa Fe Group Sierra Ladrones Formation against Paleozoic rocks. South of the latitude of San Acacia, to about 5 km south of U.S. highway 380, the fault zone is comprised of a series of poorly expressed right-and left-stepping en echelon normal faults. The West Joyita fault zone is buried along most of its length by middle Pleistocene and younger rocks but offsets early Pleistocene Sierra Ladrones Formation more than 150 m near its northern end.

Date of compilation 09/10/96

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Socorro and Tularosa

Province Basin and Range

Reliability of location Good

Comments: Fault traces are from Wilpolt and others (1946 #1424), Wilpolt and Wanek (1951 #1425), and Cather (1996 #1290).

Geologic setting The West Joyita fault zone forms the eastern margin of Rio Grande rift in the Socorro constriction.

Sense of movement N

Dip 41°-80° W
Comments: Dip data are from Cather (1996 #1290), along the southern end of the West Joyita fault zone.

Dip direction W

Geomorphic expression The West Joyita fault is poorly expressed, and is buried along much of its length by middle Pleistocene and younger deposits.

Age of faulted deposits The West Joyita fault zone offsets sediments of the Sierra Ladrones Formation along much of its length. These sediments contain reworked deposits of Bandelier pumice in the San Antonio quadrangle near the southern end of the fault zone, and thus in places must be less than 1.6 Ma (S.M. Cather, unpublished mapping, 1996). Cather (1996 #1290) describes apparent segmented behavior along a section of the fault in the Loma de las Cañas 7.5 minute quadrangle. Here the Coyote fault (one strand of the West Joyita fault zone) is buried by the upper Sierra Ladrones Formation in the middle of the quadrangle near Arroyo de la Presilla, but offset the upper aggradational surface of the Sierra Ladrones Formation (Las Cañas surface of McGrath and Hawley, 1987 #1239) in the southern part of the quadrangle near Arroyo de las Cañas.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing is based on the youngest deposits offset by the West Joyita fault zone, the early Pleistocene Sierra Ladrones Formation.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Slip rate data are estimated from offset estimates of Machette and McGimsey (1983 #1024).

Length End to end (km): 48.0
Trace (km): 53.7

Average strike (azimuth) -10°±24°

Endpoints (lat. - long.) 34°18′14.11″N, 106°50′28.48″W
33°52′34.07″N, 106°45′32.23″W

References

#1284 Beck, W.C., 1993, Structural evolution of the Joyita Hills, Socorro County, New Mexico: Socorro, New Mexico Institute of Mining and Technology, unpublished Ph.D thesis, 187 p.

#1290 Cather, S.M., 1996, Geologic maps of the upper Cenozoic deposits of the Loma de las Cañas and Mesa del Yeso 7.5-minute quadrangles, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 417, 32 p. pamphlet, 2 sheets, scale 1:24,000.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1239 McGrath, D.B., and Hawley, J.W., 1987, Geomorphic evolution and soil-geomorphic relationships in the Socorro area, central New Mexico, *in* McLemore, V.T., and Bowie, M.R., eds., Guidebook to the Socorro area, New Mexico: New Mexico Bureau of Mines and Mineral Resources, 24th Annual Meeting of the Clay Minerals Society and 36th Annual Clay Minerals Conference, Guidebook, p. 55-67.

#1424 Wilpolt, R.H., Bates, R.L., MacAlpin, A.J., and Vorbe, G., 1946, Geologic map and stratigraphic sections of Paleozoic rocks of Joyita Hills, Los Piños Mountains, and northern Chupadera Mesa, Valencia, Torrance, and Socorro Counties, New Mexico: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 61, 1 sheet, scale 1:63,360.

#1425 Wilpolt, R.H., and Wanek, A.A., 1951, Geology of the region from Socorro and San Antonio east of Chupadera Mesa, Socorro County, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-121, 2 sheets, scale 1:63,360.

2111, Cliff fault

Structure Number 2111

Structure Name Cliff fault
Comments: The Cliff fault was first mapped by Denny (1941 #1293), but he did not show offset in surficial deposits. Machette (1978 #1400; 1982 #1401) and Machette and McGimsey (1983 #1024) remapped and named the Cliff fault for the Cliff triangulation station, where the fault is particularly well exposed.

Synopsis: The Cliff fault offsets the piedmont facies of the Sierra Ladrones Formation and two older terrace deposits of the Rio Salado. Offset relations with these terraces indicate that the age of last movement is bracketed between the approximately 120 ka age of unfaulted terraces and the approximately 140,000 ka age of the youngest faulted terraces.

Date of compilation 08/30/96

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: Fault trace is from Machette (1978 #1400) and Machette and McGimsey (1983 #1024).

Geologic setting The Cliff fault is located in an intrabasin setting, antithetic to the main rift-margin faults (Loma Pelada [2113] and Loma Blanca [2112] faults) in this part of the Albuquerque-Belen basin.

Sense of movement N

Dip 60° W
Comments: Dip measurement is from Machette (1978 #1400).

Dip direction W

Geomorphic expression The Cliff fault is well expressed in Sierra Ladrones Formation sediments.

Age of faulted deposits The Cliff fault offsets early Pleistocene sediments of the Sierra Ladrones Formation, and late middle Pleistocene alluvial terrace deposits of the Rio Salado (Machette, 1978 #1400; 1978 #1433; Machette and McGimsey, 1983 #1024). Machette (1978 #1433) used pedogenic calcium carbonate contents to estimate ages of 140-220 ka for the offset terrace sediments.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Offset relations and quantitative soils studies of alluvial terrace deposits of the Rio Salado indicate that the age of last movement is bracketed between the approximately 120 ka soil age of the

oldest unfaulted terrace, and the approximately 140 ka soil age of the youngest faulted terrace (Machette, 1978 #1433; Machette and McGimsey, 1983 #1024).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on fault scarp data of Machette (1978 #1433) and Machette and McGimsey (1983 #1024) that indicates offset of 6 m in the last 140 ka.

Length End to end (km): 19.3
Trace (km): 19.5

Average strike (azimuth) -2°±8°

Endpoints (lat. - long.) 34°24′12.30″N, 106°53′40.83″W
34°13′44.92″N, 106°53′12.52″W

References

#1293 Denny, C.S., 1941, Quaternary geology of the San Acacia area, New Mexico: Journal of Geology, v. 49, p. 225-260.

#1400 Machette, M.N., 1978, Geologic map of the San Acacia quadrangle, Socorro County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1415, 1 sheet, scale 1:24,000.

#1433 Machette, M.N., 1978, Late Cenozoic geology of the San Acacia-Bernardo area, *in* Hawley, J.W., ed., Guidebook to Rio Grande rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 135-137.

#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2112, Loma Blanca fault

Structure Number 2112

Structure Name Loma Blanca fault
Comments: The Loma Blanca fault is sub-parallel to and basinward (east) of the Loma Pelada fault [2113]. Parts of the Loma Blanca fault were mapped by Kelley (1954 #1222; 1977 #1106), but the fault was mapped in detail and named by Machette (1978 #1400). Machette (1982 #1401) and Machette and McGimsey (1983 #1024) conducted fault scarp studies in several places along the Loma Blanca fault.

Synopsis: The Loma Blanca fault offsets sediments of the Sierra Ladrones Formation and middle to upper Pleistocene alluvium. Along the central part of the fault, terrace gravels (~120 ka) of the Rio Salado are offset about5 m. At the north end of the Loma Blanca fault, late Pleistocene alluvium is offset 0.5-7 m and middle Pleistocene alluvium is offset 5-10 m. These relations indicate recurrent Quaternary movements. In a 5 km long stretch between Arroyo Canthe and the Rio Salado, the Loma Blanca fault is marked by a 2- to 5-m-wide calcium carbonate and manganese cemented clastic dike.

Date of compilation 08/30/96

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: The fault trace is from Machette (1978 #1400) and Machette and McGimsey (1983 #1024).

Geologic setting The Loma Blanca fault is located on the piedmont slope flanking the eastern side of the Ladron Mountains. It is an intrabasin normal fault, synthetic to the Loma Pelada fault [2113], which forms the active margin of the Rio Grande rift in this area.

Sense of movement N

Dip not reported

Dip direction E

Geomorphic expression The Loma Blanca fault is well expressed as a clastic dike in its central part and by fault scarps in surficial deposits north of Rio Salado (Machette, 1978 #1400; Machette and McGimsey, 1983 #1024).

Age of faulted deposits The Loma Blanca fault offsets alluvial deposits of middle and late Pleistocene age north of Rio Salado (Machette, 1978 #1433; Machette and McGimsey, 1983 #1024).

Detailed studies No detailed fault studies have been conducted, but Machette (1982 #1401) and Machette and McGimsey (1983 #1024) conducted reconnaissance fault scarp studies in several locations along the Loma Blanca fault. They measured or estimated offsets of 2-10 m on late Pleistocene alluvial deposits and 5-22 m on middle Pleistocene alluvial deposits.

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Kelley (1977 #1106, fig. 23) described the scarps at the north end of the Loma Blanca fault as late Holocene in age, but scarp morphology data of Machette (1982 #1401) and Machette and McGimsey (1983 #1024) indicate that the most recent movement on the fault occurred much older than 15 ka.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on fault scarp data from Machette (1982 #1401) and Machette and McGimsey (1983 #1024) that indicates offsets of 2-7 m in late Pleistocene (10-150 ka) alluvium.

Length End to end (km): 22.7
Trace (km): 30.6

Average strike (azimuth) -1°±17°

Endpoints (lat. - long.) 34°26′41.11″N, 106°56′55.85″W
34°14′23.96″N, 106°56′06.16″W

References

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.
#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.
#1400 Machette, M.N., 1978, Geologic map of the San Acacia quadrangle, Socorro County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1415, 1 sheet, scale 1:24,000.
#1433 Machette, M.N., 1978, Late Cenozoic geology of the San Acacia-Bernardo area, *in* Hawley, J.W., ed., Guidebook to Rio Grande rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Circular 163, p. 135-137.
#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology

and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.
#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2113, Loma Pelada fault

Structure Number 2113

Structure Name Loma Pelada fault
Comments: The Loma Pelada fault is the southern extension of the Coyote Springs fault [2114], and extends roughly north south along the eastern flank of the Ladron and northern Lemitar Mountains (Machette, 1982 #1401; Machette and McGimsey, 1983 #1024). The fault was originally mapped and named by Denny (1940 #1292) for Loma Pelada, a series of low foothills now known as the Sierra Ladrones. A fault in the same position was named the Pelado fault by Kelley (1977 #1106), but most maps continue the use of Loma Pelada fault (Machette, 1978 #1400; Machette and McGimsey, 1983 #1024). Machette (1978 #1400) and Machette and McGimsey (1983 #1024) in places interchange “Peleda” and “Pelada”; but we retain the original spelling of “Pelada” from Denny (1940 #1292). The active trace of the fault extends from Cañada Vivorosa on the south to 3 km north of Cañada Colorado on the north (1978 #1223; Machette, 1978 #1400). A few kilometers west of the Loma Pelada fault, faults with inferred Quaternary movement have been mapped along the eastern flank of the Ladrones Mountains (Nobel, 1950 #1410; Black, 1964 #1286; Haederle, 1966 #1300; Nimick, 1986 #1409). No unequivocal evidence, such as offset alluvial deposits, has been described along these faults, so the active margin of the Rio Grande rift in this area may have stepped basinward to the Loma Pelada fault.

Synopsis The Loma Pelada fault offsets Upper Santa Fe Group Sierra Ladrones Formation sediments along much of its length, and also offsets Quaternary alluvium at its northern end. Offsets of 13 m in late Pleistocene alluvium and 35 m in middle(?) Pleistocene alluvium have been measured near Cañada Colorado, indicating that the Loma Pelada fault has undergone recurrent movements in the middle and late Pleistocene.

Date of compilation 08/29/96

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: Fault traces are from Machette (1978 #1223; 1978 #1400) and Machette and McGimsey (1983 #1024).

Geologic setting The Loma Pelada fault forms the active western margin of the Rio Grande rift along the eastern flank of the Ladron and northern Lemitar Mountains.

Sense of movement N

Dip 60°-80° E
Comments: Dip measurements are from Machette (1978 #1400).

Dip direction E

Geomorphic expression The Loma Pelada fault is well expressed as fault scarps and offsets in lower Pleistocene Sierra Ladrones Formation basin-fill deposits. Machette (1978 #1223; 1978 #1400) and Machette and McGimsey (1983 #1024) estimated surface displacements of 13 m in late Pleistocene deposits and 35 m in middle(?) Pleistocene deposits.

Age of faulted deposits Machette (1978 #1223; 1978 #1400) and Machette and McGimsey (1983 #1024) mapped fault scarps in alluvial fan deposits of middle(?) and late Pleistocene age.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: Machette and McGimsey (1983 #1024) mapped fault scarps in late Pleistocene deposits along the Loma Pelada fault.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on 13-m offset of late Pleistocene deposits (130 ka). (data from Machette and McGimsey, 1983 #1024)

Length End to end (km): 24.3
Trace (km): 40.2

Average strike (azimuth) -8°±21°

Endpoints (lat. - long.) 34°26'25.99"N, 106°59'12.86"W
34°13'37.76"N, 106°55'39.42"W

References

#1286 Black, B.A., 1964, The geology of the northern and eastern parts of the Ladron Mountains, Socorro County, New Mexico: Albuquerque, University of New Mexico, unpublished M.S. thesis, 117 p., 1 pl., scale 1:31,250.

#1292 Denny, C.S., 1940, Tertiary geology of the San Acacia area, New Mexico: Journal of Geology, v. 48, p. 73-106.

#1300 Haederle, W.F., 1966, Structure and metamorphism in the southern Sierra Ladrones, Socorro County, New Mexico: Socorro, New Mexico Institute of Mining Technology, unpublished , 56 p., 2 pls.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1223 Machette, M.N., compiler, 1978, Preliminary geologic map of the Socorro 1° by 2° quadrangle, central New Mexico: U.S. Geological Survey Open-File Report 78-607, 1 sheet, scale 1:250,000.

#1400 Machette, M.N., 1978, Geologic map of the San Acacia quadrangle, Socorro County, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1415, 1 sheet, scale 1:24,000.

#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1409 Nimick, K.G., 1986, Geology and structural evolution of the east flank of the Ladron Mountains, Socorro County, New Mexico: Albuquerque, University of New Mexico, unpublished M.S. thesis, 98 p., 3 pl., scale 1:12,000.

#1410 Nobel, E.A., 1950, Geology of the southern Ladron Mountains, Socorro County, New Mexico: Albuquerque, University of New Mexico, unpublished M.S. thesis, 72 p.

2114, Coyote Springs fault

Structure Number 2114

Structure Name Coyote Springs fault
Comments: Originally named the Coyote fault by Kelley (1977 #1106), this fault was renamed the Coyote Springs fault by Machette (1982 #1401) and Machette and McGimsey (1983 #1024), after Coyote Spring, which is located near the southwest corner of the Comanche Ranch 7.5 minute quadrangle. The fault extends from the southern end of the Santa Fe fault [2123] to the northern end of the Loma Pelada fault [2113] along the northeastern margin of the Ladron Mountains.

Synopsis: The Coyote Springs fault (and the Santa Fe [2123] and Loma Pelada [2113] faults to the north and south, respectively) form the active southwestern margin of the Rio Grande rift. Offsets of 12-15 m in lower and middle Pleistocene deposits and 1-3 m in upper Pleistocene deposits indicate recurrent Quaternary movement along the Coyote Springs fault. At its southern end, clear evidence of Quaternary faulting dies out at Mariano Draw, and at its northern end, fault scarps dies out about 5 km north of Arroyo Monte Largo.

Date of compilation 08/29/96

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Valencia; Socorro

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: Fault traces from Machette and McGimsey (1983 #1024).

Geologic setting The Coyote Springs fault forms the active southwestern margin of the Albuquerque-Belen basin in the Rio Grande rift, with the abandonment of the Comanche fault to the west (Kelley, 1977 #1106). Recent seismic reflection studies support Kelley's assumption that a shallow shelf or bench (Monte Largo bench) underlies the area between the Coyote Springs and Comanche faults (Russell and Snelson, 1994 #1186).

Sense of movement N

Dip 15°-17° E
Comments: Subsurface (at 5 km depth) dip data are from seismic reflection data of Russell and Snelson (1994 #1186).

Dip direction E

Geomorphic expression Prominent, intermittent fault scarps in surficial deposits mark the central part of the Coyote Springs fault trace. The youngest scarps are found at the southern end of the Coyote Springs fault. Machette (1982) and Machette and McGimsey (1983 #1024) measured offsets of 12-15 m in lower and middle Pleistocene deposits, and 1-3 m in upper Pleistocene deposits.

Age of faulted deposits The Coyote Springs fault offsets alluvial fan deposits of early and middle Pleistocene age along its northern part, and middle and late Pleistocene age along its southern part (Machette and McGimsey, 1983 #1024).

Detailed studies none

Timing of most recent paleoevent latest Quaternary (<15 ka).
Comments: Fault scarp morphology studies by Machette and McGimsey (1983 #1024) indicate possible latest Pleistocene or early Holocene movement on the southern part of the Coyote Springs fault north of Mariano Draw.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on fault scarp data from Machette (1982 #1401) and Machette and McGimsey (1983 #1024) that indicates offsets of 1-3 m in late Pleistocene (10-150 ka) alluvium.

Length End to end (km): 16.9
Trace (km): 30.5

Average strike (azimuth) -22°±27°

Endpoints (lat. - long.) 34°37′10.38″N, 107°06′28.97″W
34°29′02.13″N, 107°01′24.28″W

References

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1186 Russell, L.R., and Snelson, S., 1994, Structure and tectonics of the Albuquerque basin segment of the Rio Grande rift—Insights from reflection seismic data, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 83-112.

2115, Unnamed intrabasin faults west of the Rio Puerco

Structure Number 2115

Structure Name Unnamed intrabasin faults west of the Rio Puerco
Comments: This group of structures consists of numerous short, generally isolated, north-trending faults within the Albuquerque-Belen basin west of the Rio Puerco mapped by Machette (1982 #1401), Machette and McGimsey (1983 #1024), and Love and Young (1983 #1723). Some of these faults were previously mapped and named by Kelley (1977 #1106).

Synopsis: These unnamed faults are mostly expressed as short fault scarps in deposits of the upper Santa Fe Group Sierra Ladrones Formation; some have offsets of 3-20 m in middle Pleistocene alluvium. Most faults are partly to nearly completely covered by eolian sand.

Date of compilation 09/24/96

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Socorro; Valencia

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: Fault traces from Machette and McGimsey (1983 #1024).

Geologic setting These faults dip to the east and west, and form a broad zone within the active part of the Albuquerque basin.

Sense of movement N

Dip not reported

Dip direction E; W

Geomorphic expression These faults are marked by subdued, intermittently exposed, mostly sand covered scarps within the basin. Machette and McGimsey (1983 #1024) measured offsets of 3-20 m in middle Pleistocene alluvium.

Age of faulted deposits These faults offset lower Pleistocene sediments of the upper Santa Fe Group Sierra Ladrones Formation, and early and middle Pleistocene alluvium (Machette, 1978 #1223; Machette and McGimsey, 1983 #1024).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: No deposits younger than middle Pleistocene alluvium have been shown to be offset by these faults, but offsets of 3-20 m measured by Machette and McGimsey (1983 #1024) indicate a recurrent history of movement that in some cases probably extended into the late Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on offsets of 3-20 m of middle Pleistocene (150-750 ka) alluvium (Machette and McGimsey, 1983 #1024).

Length (km) not applicable
Comments: This zone includes numerous faults that have an end to end length of 22.5 km and a cumulative trace length of 91.1 km.

Average strike (azimuth) -7°±14°

Endpoints (lat. - long.) 34°41′32.27″N, 106°58′53.23″W
34°29′23.41″N, 106°57′51.56″W

References

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1723 Love, D.W., and Young, J.D., 1983, Progress report on the late Cenozoic geologic evolution of the lower Rio Puerco, *in* Chapin, C.E., and Callender, J.F., eds., Socorro region II: New Mexico Geological Society, 34th Field Conference, October 13-15, 1983, Guidebook, p. 277-284.

#1223 Machette, M.N., compiler, 1978, Preliminary geologic map of the Socorro 1° by 2° quadrangle, central New Mexico: U.S. Geological Survey Open-File Report 78-607, 1 sheet, scale 1:250,000.

#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2116, Sabinal fault

Structure Number 2116

Structure Name Sabinal fault
Comments: The Sabinal fault was first recognized by Denny (1941 #1293) and later remapped by Kelley (1977 #1106), Machette (1982 #1401), and Machette and McGimsey (1983 #1024); the latter named the fault for exposures near the Sabinal triangulation station located in the Abeytas 7.5 minute quadrangle. The Sabinal fault extends from the latitude of Sabinal to the latitude of Belen, along the western edge of the Llano de Albuquerque, and is one of numerous faults that offset the Llano de Albuquerque in the central Albuquerque-Belen basin.

Synopsis:

Date of compilation 09/09/96

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Socorro; Valencia

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: The fault trace is from Machette and McGimsey (1983 #1024).

Geologic setting The Sabinal fault is one of numerous intrabasin faults that offset the Llano de Albuquerque in the central part of the Albuquerque-Belen basin.

Sense of movement N

Dip not reported

Dip direction W

Geomorphic expression The Sabinal fault is well expressed as a large fault scarp (6-27m) cutting the Llano de Albuquerque (Machette and McGimsey, 1983 #1024).

Age of faulted deposits The Sabinal fault offsets well developed calcic soils that underlie the early Pleistocene(?) Llano de Albuquerque.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: No deposits younger than the early Pleistocene(?) Llano de Albuquerque have been shown to be offset by the Sabinal fault, but offsets up to 27 m measured by Machette and McGimsey (1983 #1024) indicate a long recurrent history of movement that probably extends into the late Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on offsets of 5-27 m of the early Pleistocene (~1 Ma?) Llano de Albuquerque (Machette and McGimsey, 1983 #1024).

Length End to end (km): 19.6
Trace (km): 19.8

Average strike (azimuth) -10°±8°

Endpoints (lat. - long.) 34°38′47.48″N, 106°51′21.46″W
34°28′20.70″N, 106°49′12.15″W

References
#1293 Denny, C.S., 1941, Quaternary geology of the San Acacia area, New Mexico: Journal of Geology, v. 49, p. 225-260.
#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.
#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.
#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2117, Unnamed faults on the Llano de Manzano

Structure Number 2117

Structure Name Unnamed faults on the Llano de Manzano
Comments: These structures include several northeast-trending faults on the Llano de Manzano in the southeastern part of the Albuquerque-Belen basin mapped by Machette and McGimsey (1983 #1024).

Synopsis: These unnamed faults are mostly marked by scarps offsetting the early Pleistocene Llano de Manzano. Two fault trends are apparent in this group of structures. In the southeastern corner of the basin, two en echelon, northeast-trending faults offset the Llano de Manzano 5-20 m and may represent the active rift margin between the West Joyita fault [2010] to the south and the Hubbell Spring fault [2120] to the north. Further north, a cluster of faults offset the Llano de Manzano 5-20 m about 8 km east-southeast of Belen. These faults may fill the gap between the Hubbell Springs fault and the two possible rift margin faults to the south, although this cluster of faults lies 6-10 km westward of the southern end of the Hubbell Spring fault.

Date of compilation 09/24/96

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Socorro; Valencia

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: Fault traces are from Machette and McGimsey (1983 #1024).

Geologic setting Most of these faults are intrabasin structures, but the southernmost faults in this group may form the active margin of the Rio Grande rift in the southeastern part of the Albuquerque basin.

Sense of movement N

Dip not reported

Dip direction E; W

Geomorphic expression The traces of these faults are marked by subdued, intermittently preserved fault scarps that are mostly covered by eolian sand. Machette and McGimsey (1983 #1024) estimate offsets of 50-20 m of the Llano de Manzano along these faults.

Age of faulted deposits Machette (1978 #1223) and Machette and McGimsey (1983 #1024) map these faults in surficial deposits of early and middle Pleistocene age.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Machette and McGimsey (1983 #1024) estimated that the latest events on these faults are no older than the middle Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on offsets of 5-20 m of the early Pleistocene (~1 Ma) Llano de Manzano (Machette and McGimsey, 1983 #1024)r.

Length not applicable
Comments: This zone includes several faults that have an end to end length of 68.0 km and a cumulative trace length of 96.5 km.

Average strike (azimuth) 019°±19°

Endpoints (lat. - long.) 34°43′23.34″N, 106°31′49.11″W
34°10′25.38″N, 106°51′30.02″W

References
#1223 Machette, M.N., compiler, 1978, Preliminary geologic map of the Socorro 1° by 2° quadrangle, central New Mexico: U.S. Geological Survey Open-File Report 78-607, 1 sheet, scale 1:250,000.
#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2118, Los Piños fault

Structure Number 2118

Structure Name Los Piños fault

Comments: The Los Piños fault forms the eastern margin of the Rio Grande rift in the southeastern part of the Albuquerque basin. This area was originally mapped by Wilpolt and others (1946 #1424), and subsequently by Kelley (1954 #1222; 1977 #1106), Myers and others (1981 #1407) in the Becker quadrangle, and Myers and others (1986 #1408) in the Becker SW and Cerro Montoso quadrangles. On most maps, the Los Piños fault is shown as a continuous southern extension of the Manzano fault [2119], which occupies a similar geomorphic position to the north (Machette, 1982 #1401; Machette and McGimsey, 1983 #1024).

Synopsis: The Los Piños fault extends along the steep west flank of the Los Piños Mountains, from near Palo Duro Canyon north to the vicinity of Goat Draw and U.S. Highway 60. No published geologic maps show offsets of Quaternary deposits along the trace of the Los Piños fault, but small scarps may be present in middle (?) Pleistocene alluvium just south of Bootleg Canyon. A landslide mapped just south of Bootleg Canyon may also be faulted, but otherwise little evidence of faulting is preserved in alluvial deposits along the western front of the Los Piños Mountains. The ages of alluvium along the mountain front are unknown, but are probably no older than middle Pleistocene, so any evidence of fault movement in the early Pleistocene is probably buried.

Date of compilation 08/15/96

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Poor
Comments: Published maps show fault dotted along most of its length; fault trace from Machette and McGimsey (1983 #1024).

Geologic setting The Los Piños fault forms the eastern margin of the Rio Grande rift in the southeastern part of the Albuquerque-Belen basin. However, more recent fault activity appears to have shifted westward to faults that cut the Llano de Manzano, east of the Rio Grande. A shallow bedrock bench underlies much of the valley floor between the Los Piños fault and the more active faults to the west.

Sense of movement N

Dip not reported

Dip direction NW

Geomorphic expression In places, a steep mountain front marks the trace of the Los Piños fault, but little or no evidence of scarps in Quaternary deposits is found along most of the fault.

Age of faulted deposits No published geologic maps show offsets of Quaternary deposits along the trace of the Los Piños fault, but Machette and McGimsey (1983 #1024) describe a minor scarp in middle(?) Pleistocene alluvium just south of Bootleg Canyon. A landslide mapped just south of Bootleg Canyon (Kelley, 1977 #1106; Myers and others, 1986 #1408), may also be faulted, but otherwise little evidence of faulting is preserved in alluvial deposits along the front of the Los Piños Mountains. The ages of alluvium along the mountain front are unknown, but are probably no older than middle Pleistocene, so any evidence of fault movement in the early Pleistocene is probably buried.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Estimate based on mapping of Machette and McGimsey (1983 #1024).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No detailed studies of fault offset or age of offset deposits are available; slip rate estimate based on lack of prominent fault scarps and low rates of slip on other faults in this part of the Rio Grande rift.

Length End to end (km): 18.4
Trace (km): 18.8

Average strike (azimuth) 032°±12°

Endpoints (lat. - long.) 34°25′55.45″N, 106°32′06.41″W
34°17′28.67″N, 106°38′27.02″W

References
#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1407 Myers, D.A., McKay, E.J., and Sharps, J.A., 1981, Geologic map of the Becker quadrangle, Valencia and Socorro Counties, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-1556, 1 sheet, scale 1:24,000.

#1408 Myers, D.A., Sharps, J.A., and McKay, E.J., 1986, Geologic map of the Becker SW and Cerro Montoso quadrangles, Socorro County, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1567, 1 sheet, scale 1:24,000.

#1424 Wilpolt, R.H., Bates, R.L., MacAlpin, A.J., and Vorbe, G., 1946, Geologic map and stratigraphic sections of Paleozoic rocks of Joyita Hills, Los Piños Mountains, and northern Chupadera Mesa, Valencia, Torrance, and Socorro Counties, New Mexico: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 61, 1 sheet, scale 1:63,360.

2119, Manzano fault

Structure Number 2119

Structure Name Manzano fault

Comments: The Manzano fault was named after the Manzano Mountains, which form a steep escarpment along the eastern edge of the central Albuquerque-Belen basin. Most maps show the Manzano fault as a northern continuation of the Los Piños fault [2118], from near U.S. Highway 60 northward about 55 km along the steep eastern flank of the Manzano Mountains, to near the mouth of Hell Canyon at the Bernalillo/Valencia County line (Read and others, 1944 #1416; Reiche, 1949 #1417; Kelley, 1954 #1222; Myers and McKay, 1970 #1406; Baltz, 1976 #1431; 1977 #1106; Machette, 1982 #1401; Machette and McGimsey, 1983 #1024; Karlstrom and others, 1997 #1768). Karlstrom and others (1997 #1768) named the northernmost section of the fault the "Manzanita fault", but to reduce confusion, the name "Manzano fault" is retained herein for the entire structure.

Synopsis: The Manzano fault forms the eastern margin of the Rio Grande rift in the central part of the Albuquerque-Belen basin. The fault is usually mapped as a buried trace; no published geologic maps show offsets of late or middle Pleistocene deposits along the trace of the Manzano fault. However, the Manzano fault must control the steep west-facing front of the Manzano Mountains and thus may have undergone early Pleistocene or Pliocene movement. Intermittent fault scarps on alluvial fan deposits may be present along a 12-km-long, north-trending section of the fault between Ojito Canyon and Cañon del Trigo.

Date of compilation 03/10/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Bernalillo; Socorro; Torrance; Valencia

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Poor

Comments: Published maps show the fault as dotted (buried) along most of its length.

Geologic setting The Manzano fault forms part of the eastern margin of the Rio Grande rift and the Albuquerque-Belen basin.

Sense of movement N

Dip not reported

Dip direction W

Geomorphic expression In most places, the fault is marked by a steep mountain front; no evidence of fault scarps in Quaternary deposits has been documented in the literature, but fault scarps are visible on air photographs and on the ground (J.W. Hawley, oral commun., 1997) between Ojito Canyon and Cañon del Trigo. Recent unpublished mapping in the Bosque Peak quadrangle (S.D. Connell, written commun., 1997) also shows evidence of prominent fault scarps in this area.

Age of faulted deposits The ages of faulted deposits are unknown; deposits are probably lower Pleistocene along most of the fault (Machette and McGimsey, 1983 #1024), and middle(?) Pleistocene between Ojito Canyon and Cañon del Trigo.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Timing estimates based on the geomorphology of the western flank of the Manzano Mountains suggest an early Pleistocene age for the most recent paleoevent (Machette and McGimsey, 1983 #1024), but the recent discovery of prominent fault scarps between Ojito Canyon and Cañon del Trigo (S.D. Connell, written commun., 1997) suggest a middle or late Pleistocene age.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No detailed studies of fault offset or age of offset deposits are available; slip rate estimates are based on lack of prominent fault scarps and low rates of slip on other faults in this part of the Rio Grande rift.

Length End to end (km): 54.1
Trace (km): 57.6

Average strike (azimuth) 008°±25°

Endpoints (lat. - long.) 34°54′56.07″N, 106°26′37.26″W
34°26′00.52″N, 106°31′59.36″W

References

#1431 Baltz, E.H., 1976, Seismotectonic analysis of the central Rio Grande rift, New Mexico—A progress report on geologic investigations: U.S. Geological Survey Administrative Report, 93 p., 2 pls.

#1768 Karlstrom, K.E., Chamberlin, R.M., Connell, S.D., Brown, C., Nyman, M., Cavin, W.J., Parchman, M.A., Cook, C., and Sterling, J., 1997, Geology of the Mount Washington 7.5-minute quadrangle, Bernalillo and Valencia Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map OF-DM 8, 31 p. pamphlet, 1 sheet, scale 1:24,000.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1406 Myers, D.A., and McKay, E.J., 1970, Geologic map of the Mount Washington quadrangle, Bernalillo and Valencia Counties, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-886, 1 sheet, scale 1:24,000.

#1416 Read, C.B., Wilpolt, R.H., Andrews, D.A., Summerson, C.H., and Wood, G.H., 1944, Geologic map and stratigraphic sections of Permian and Pennsylvanian rocks of parts of San Miguel, Santa Fe,

Sandoval, Bernalillo, Torrance, and Valencia Counties, north-central New Mexico: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 21, 1 sheet, scale 1:190,080.
#1417 Reiche, P., 1949, Geology of the Manzanita and North Manzano Mountains, New Mexico: Geological Society of America Bulletin, v. 60, p. 1183-1212.

2120, Hubbell Spring fault

Structure Number 2120

Structure Name Hubbell Spring fault
Comments: The Hubbell Spring fault was originally mapped and named the Ojuelos fault by Read and others (1944 #1416). Numerous other investigators have used the names "Ojuelos fault", "Ojuelos-Hubbell Springs fault", and "Hubbell Spring (or Springs) fault" interchangeably for this structure (Reiche, 1949 #1417; Kelley, 1954 #1222; Stark, 1956 #1419; Titus, 1963 #1421; Baltz, 1976 #1431; Kelley, 1977 #1106). The namesake for the fault is Hubbell Spring, a prominent spring that flows from the fault zone near its northern end, so the name "Hubbell Spring fault", as used in more recent publications (Machette, 1982 #1401; Machette and McGimsey, 1983 #1024; GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430; Love and others, 1996 #1762) is retained herein. A northwest-trending splay fault (Sanchez fault of Karlstrom and others, 1997 #1768) south of Hubbell Spring may connect the Hubbell Spring fault to the Manzano fault [2119]. The Sanchez fault may offset early Pleistocene deposits south of the Hubbell Bench (Love and others, 1996 #1762; Karlstrom and others, 1997 #1768; S.D. Connell, pers. commun., 1997).

Synopsis: The active trace of the Hubbell Spring fault forms the western edge of a prominent intrabasin topographic bench, the Hubbell bench, which lies 5-11 km east of the steep escarpment at the foot of the Manzano Mountains. The active trace merges with and offsets the Tijeras-Cañoncito fault system [2033] at the Travertine Hills on Sandia National Laboratory at its northern end, and extends southward to about the latitude of Belen. Fault traces are marked by 4-to 30-m-high scarps in deposits ranging in age from early to late Pleistocene. The Hubbell Spring fault has been recurrently active throughout the Quaternary, and shows evidence of movement in the late Pleistocene. It may be one of the more active faults in the Albuquerque basin.

Date of compilation 05/19/98

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Valencia

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: Fault traces are from Machette and McGimsey (1983 #1024), GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430), and Love and others (1996 #1762).

Geologic setting The active trace of the Hubbell Spring fault forms the western edge of the Hubbell bench, which lies east of the steep escarpment at the foot of the Manzano Mountains. The Hubbell Spring fault marks the active margin of the Rio Grande rift in this part of the Albuquerque-Belen basin.

Sense of movement N

Dip 50°-75° W
Comments: Dip measurements are from shallow fault exposures at the Hubbell Spring trench site (S.F. Personius, unpublished data, 1997).

Dip direction W

Geomorphic expression The Hubbell Spring fault is well expressed as fault scarps and aligned springs along the western margin of the Hubbell bench.

Age of faulted deposits The Hubbell Spring fault offsets alluvial deposits of early, middle (Love and others, 1996 #1762), and late Pleistocene (Machette and McGimsey, 1983 #1024; GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430) age along much of its length.

Detailed studies A trench investigation conducted in 1997 by the compiler is the first detailed investigation on the Hubbell Spring fault.

Hubbell Spring trench (site 2120-1). A 60 m long trench and two soil test pits were excavated across a 7-m-high scarp near the northern end of the Hubbell Spring fault in the fall of 1997 (Personius, 1998 #1779). The trench exposed two west-dipping fault zones and an intervening 16-m-wide horse block broken by numerous small displacement east- and west-dipping faults. Well sorted sands of the lower Pleistocene upper Santa Fe Group are overlain by middle Pleistocene alluvial fan deposits in the upthrown block; three wedges or sheets of mixed eolian sand and minor colluvium overlie the fan deposits in the downthrown blocks. The number of sand wedges (3) and net vertical offset of the alluvial fan deposits across the fault zone (~4.7 m) suggest three post-alluvial fan surface-faulting events, with average vertical offsets of ~1.6 m. Several pending thermoluminescence (TL) and uranium-series ages should aid in the determination of the timing of the last two or three surface ruptures on the Hubbell Spring fault at this site.

Timing of most recent paleoevent late Quaternary (<130 ka)

Comments: Although early workers speculated that the fresh scarps found along the trace of the Hubbell Spring fault were formed in the Holocene, more recent work on fault scarp morphology (Machette, 1982 #1401; Machette and McGimsey, 1983 #1024), surficial geologic mapping (GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430), and preliminary soils data from the Hubbell Spring trench indicate that the most recent movement on the Hubbell Spring fault occurred in the late Pleistocene.

Recurrence interval not reported

Comments: No detailed estimated of recurrence intervals have been published, but preliminary soils data from the Hubbell Spring trench (Personius, 1998 #1779) indicate that recurrence intervals between the last three events may be several tens of thousands of years or longer.

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Low slip-rate category assigned based on fault scarp data from Machette and McGimsey (1983 #1024) that indicate offsets of 2-11 m in late Pleistocene (10-150 ka) deposits.

Length End to end (km): 42.6
Trace (km): 99.3

Average strike (azimuth) 003°±33°

Endpoints (lat. - long.) 34°59′52.61″N, 106°30′31.73″W
34°36′57.62″N, 106°33′47.05″W

References

#1431 Baltz, E.H., 1976, Seismotectonic analysis of the central Rio Grande rift, New Mexico—A progress report on geologic investigations: U.S. Geological Survey Administrative Report, 93 p., 2 pls.

#1430 GRAM Incorporated, and William Lettis & Associates Incorporated, 1995, Conceptual geologic model of the Sandia National Laboratories and Kirtland Air Force Base: Technical report to Sandia National Laboratories, Albuquerque, New Mexico, December 1995, 15 pls.

#1768 Karlstrom, K.E., Chamberlin, R.M., Connell, S.D., Brown, C., Nyman, M., Cavin, W.J., Parchman, M.A., Cook, C., and Sterling, J., 1997, Geology of the Mount Washington 7.5-minute quadrangle, Bernalillo and Valencia Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map OF-DM 8, 31 p. pamphlet, 1 sheet, scale 1:24,000.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.
#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.
#1762 Love, D.W., Hitchcock, C., Thomas, E., Kelson, K., Van Hart, D., Cather, S., Chamberlin, R., Anderson, O., Hawley, J., Gillentine, J., White, W., Noler, J., Sawyer, T., Nyman, M., and Harrison, B., 1996, Geology of the Hubbell Spring 7.5-min quadrangle, Bernalillo and Sandoval [Valencia] Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map OF-DM 5, 7 p. pamphlet, 1 sheet, scale 1:24,000.
#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.
#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.
#1779 Personius, S.F., 1998, Preliminary paleoseismic analysis of a trench across the Hubbell Spring fault near Albuquerque, New Mexico, *in* Slate, J.L., ed., U.S. Geological Survey Middle Rio Grande basin study—Proceedings of the Second Annual Workshop, Albuquerque, New Mexico, February 10-11, 1998: U.S. Geological Survey Open-File Report 98-337, p. 91.
#1416 Read, C.B., Wilpolt, R.H., Andrews, D.A., Summerson, C.H., and Wood, G.H., 1944, Geologic map and stratigraphic sections of Permian and Pennsylvanian rocks of parts of San Miguel, Santa Fe, Sandoval, Bernalillo, Torrance, and Valencia Counties, north-central New Mexico: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 21, 1 sheet, scale 1:190,080.
#1417 Reiche, P., 1949, Geology of the Manzanita and North Manzano Mountains, New Mexico: Geological Society of America Bulletin, v. 60, p. 1183-1212.
#1419 Stark, J.T., 1956, Geology of the south Manzano Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 34, 46 p., 1 pl., scale 1:48,000.
#1421 Titus, F.B., Jr., 1963, Geology and ground-water conditions in eastern Valencia County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Ground-Water Report 7, 113 p., 2 pls., scale 1:125,000.

2121, Intrabasin faults on the Llano de Albuquerque

Structure Number 2121

Structure Name Intrabasin faults on the Llano de Albuquerque
Comments: This group of north-trending normal faults form a series of horsts and grabens on the Llano de Albuquerque, west of Albuquerque. The thick cover of eolian sand that covers most of the Llano de Albuquerque explains why faults of varying orientations have been mapped in this area (Kelley, 1977 #1106; Kelley and Kudo, 1978 #1307; Machette, 1982 #1401; Machette and McGimsey, 1983 #1024; Hawley and Haase, 1992 #1304; Wong and others, 1995 #1155; Hawley and Whitworth, 1996 #1303). Named faults include several strands of the West Mesa and Cat Mesa fault zones (Wong and others, 1995 #1155; Hawley and Whitworth, 1996 #1303) and the Atrisco fault (Hawley and Haase, 1992 #1304); however, we have abandoned these specific fault names until more detailed mapping and fault studies are conducted.

Synopsis: These faults are mostly expressed as short fault scarps that offset the early Pleistocene(?) Llano de Albuquerque geomorphic surface. Most of these intrabasin faults are partly to nearly completely covered by eolian sand, but on air photographs, these features are marked by linear scarps, aligned drainages, and in some cases aligned ephemeral ponds. Displacements on most of these faults are unknown, but a few have scarp heights of 3-12 m. Some of these faults may be related to volcanic activity, such as those associated with the Wind Mesa and Los Lunas volcanic centers.

Date of compilation 05/19/98

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Bernalillo; Valencia

1° x 2° sheet Albuquerque; Socorro

Province Basin and Range

Reliability of location Poor
Comments: Most fault traces on the Socorro 1° x 2° sheet are from Machette and McGimsey (1983 #1024), with supplemental mapping from Maldonado and Atencio (1998 #1777) and geophysical data from Grauch and Millegan (1998 #1721) and U.S. Geological Survey and SIAL Geosciences Inc. (1997 #1722). Most fault traces on the Albuquerque 1° x 2° sheet are from air photo reconnaissance by the compiler, (S.F. Personius, unpublished data, 1997), supplemented with geophysical data. The area is blanketed by thick sequences of eolian sand, so most fault strands are subdued and others may be obscured.

Geologic setting This group of intrabasin faults forms a broad zone within the Albuquerque basin of the Rio Grande rift.

Sense of movement N

Dip not reported

Dip direction E; W

Geomorphic expression These faults are marked by subdued, intermittently exposed, mostly sand covered scarps on the Llano de Albuquerque. East of El Rincon, these structures form an anastomosing group of horsts and grabens that are marked by linear scarps, aligned drainages, and aligned ephemeral ponds. Some of the down-to-the-west faults have linear ponds along their bases, apparently caused by damming of the prevailing east-southeast-flowing drainages. Machette and McGimsey (1983 #1024) have measured offsets of 3-12 m of the Llano de Albuquerque on some of these faults in the Socorro 1° x 2° sheet.

Age of faulted deposits These faults offset the early Pleistocene(?) Llano de Albuquerque.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Some of these faults offset the early Pleistocene(?) Llano de Albuquerque at least 12 meters (Machette and McGimsey, 1983 #1024); these data indicate a recurrent history of faulting that in some cases probably extended at least into the middle Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on offsets of 3-12 m of the early Pleistocene (~1 Ma) Llano de Albuquerque (Machette and McGimsey, 1983 #1024).

Length not applicable
Comments: This zone includes several faults that have an end to end length of 101.3 km and a cumulative trace length of 307.5 km.

Average strike (azimuth) 002°±18°

Endpoints (lat. - long.) 35°13′04.85″N, 106°51′33.28″W
34°18′17.00″N, 106°59′45.07″W

References
#1721 Grauch, V.J.S., and Millegan, P.S., 1998, Mapping intrabasinal faults from high-resolution aeromagnetic data: The Leading Edge, v. 17, p. 53-55.
#1304 Hawley, J.W., and Haase, C.S., compilers, 1992, Hydrogeologic framework of the northern Albuquerque basin: New Mexico Bureau of Mines and Mineral Resources Open-File Report 387, 1 pl., scale 1:100,000.
#1303 Hawley, J.W., and Whitworth, T.M., compilers, 1996, Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modeling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 402-D.
#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.
#1307 Kelley, V.C., and Kudo, A.M., 1978, Volcanoes and related basalts of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 156, 29 p., 2 pls.
#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.
#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.
#1777 Maldonado, F., and Atencio, A., 1998, Preliminary geologic map of the Wind Mesa quadrangle, Bernalillo County, New Mexico: U.S. Geological Survey Open-File Report 97-740, 1 sheet, scale 1:24000.
#1722 U.S. Geological Survey, and SIAL Geosciences Inc., 1997, Description of digital aeromagnetic data collected north and west of Albuquerque, New Mexico: U.S. Geological Survey Open-File Report 97-286, 40 p.
#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2122, Cat Mesa fault

Structure Number 2122

Structure Name Cat Mesa fault

Comments: The Cat Mesa fault was originally mapped by Kelley (1954 #1222; 1977 #1106) and in more detail by Kelley and Kudo (1978 #1307). Minor modifications were made by Machette (1978 #1223; 1982 #1401), Machette and McGimsey (1983 #1024), and Maldonado and Atencio (1998 #1778).

Synopsis: The active trace of the Cat Mesa fault extends from t New Mexico State Highway 6, west of Los Lunas, northward along the eastern edge of Cat Mesa. At about its midpoint, the Cat Mesa fault splits into two north-trending splays that offset Upper Santa Fe Group sediments and die out near the western edge of the Llano de Albuquerque. The Cat Mesa fault offsets the late Pliocene Cat Mesa basalt flow, which is exposed by the Cat Mesa fault along the eastern edge of Cat Mesa. The Cat Mesa basalt flow is interbedded with the upper part of the upper Santa Fe Group Sierra Ladrones Formation, 6-10 m below the Llano de Albuquerque, and is offset about 30 m near the middle of the fault. Early and middle Pleistocene deposits are offset about 17 m across the two fault strands near the northern end of the fault zone. The Cat Mesa fault lies to the west of and does not cut the late Pleistocene basalts of the Cat Hills, but the Cat Mesa basalt flow may have originated from the fault and dike system that fed the younger Cat Hills basalt field.

Date of compilation 05/19/1998

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Bernalillo; Valencia

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: Fault traces from Kelley and Kudo (1978 #1307), Machette and McGimsey (1983 #1024), and recent mapping in the Dalies NW 7.5 minute quadrangle (Maldonado and Atencio, 1998 #1778).

Geologic setting The Cat Mesa fault is an intrabasin fault near the western margin of the central Albuquerque-Belen basin. The Cat Mesa fault lies to the west of and does not cut the late Pleistocene basalts of the Cat Hills, but Kelley and Kudo (1978 #1307, fig. 20) infer that the Cat Mesa basalt flow underlies and probably originated from the fault and dike system that fed the younger Cat Hills basalt field. Thus, the fault may be related to volcanic activity in the vicinity of the Cat Hills volcanic field.

Sense of movement N

Dip Not reported

Dip direction E

Geomorphic expression The Cat Mesa fault is well expressed where the resistant Cat Mesa basalt flow is exposed in the fault zone. Elsewhere, the fault strands are marked by broad swales on the Llano de Albuquerque. Machette and McGimsey (1983 #1024) estimated that the Cat Mesa basalt flow is offset about 30 m near the middle of the fault. They also estimated a total of 17 m of offset in early and middle Pleistocene deposits across the two fault strands near the northern end of the fault zone.

Age of faulted deposits The Cat Mesa fault offsets the Cat Mesa basalt flow, which has been recently dated at 3±0.1 Ma (Maldonado and Atencio, 1998 #1778). The Cat Mesa basalt flow is interbedded with the upper part of the upper Santa Fe Group Sierra Ladrones Formation (Machette, 1978 #1223), 6-10 m below the Llano de Albuquerque (Kelley and Kudo, 1978 #1307). The two fault strands near the northern end of the fault zone offset the early Pleistocene(?) Llano de Albuquerque (Machette and McGimsey, 1983 #1024).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Machette and McGimsey (1983 #1024) document offsets of the early Pleistocene(?) Llano de Albuquerque. They also speculate that if the Cat Mesa fault is related to structures controlling the basalts of the Cat Hills volcanic field, then there may be late Pleistocene movement on the Cat Mesa fault.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No detailed studies of fault offset are available. Low slip-rate category assigned based on evidence that the 3 Ma Cat Mesa basalt is offset about 30 m (Machette and McGimsey, 1983 #1024).

Length End to end (km): 20.0
Trace (km): 39.2

Average strike (azimuth) 001°±16°

Endpoints (lat. - long.) 34°57′46.81″N, 106°54′36.54″W
34°46′58.99″N, 106°55′41.47″W

References
#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.
#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.
#1307 Kelley, V.C., and Kudo, A.M., 1978, Volcanoes and related basalts of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 156, 29 p., 2 pls.
#1223 Machette, M.N., compiler, 1978, Preliminary geologic map of the Socorro 1° by 2° quadrangle, central New Mexico: U.S. Geological Survey Open-File Report 78-607, 1 sheet, scale 1:250,000.
#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.
#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.
#1778 Maldonado, F., and Atencio, A., 1998, Preliminary geologic map of the Dalies northwest quadrangle, Bernalillo County, New Mexico: U.S. Geological Survey Open-File Report 97-741, 1 sheet, scale 1:24000.

2123, Santa Fe fault

Structure Number 2123

Structure Name Santa Fe fault

Comments: The Santa Fe fault forms part of the western margin of the Rio Grande rift and the Albuquerque basin (Machette, 1982 #1401; Machette and McGimsey, 1983 #1024). The structure was originally named the Carrizo fault by Wright (1946 #1427), was later renamed the Santa Fe fault by Kelley and Wood (1946 #1379), and was included on subsequent compilations (Kelley, 1954 #1222; Kelley, 1977 #1106). The Santa Fe fault offsets Pliocene to early Pleistocene (Lozinsky and Tedford, 1991 #1399) Sierra Ladrones Formation down-to-the-east against older rocks (Machette and McGimsey, 1983 #1024).

Synopsis: The Santa Fe fault forms the western margin of the Rio Grande rift in the central Albuquerque-Belen basin. The fault has been active in the early Pleistocene, based on offset of upper Santa Fe Group (Sierra Ladrones Formation) sediments. Other indirect evidence of Quaternary offset includes differences in the elevation of the Ortiz surface across the fault trace and the geometry of spring deposits found along the fault. No scarps in surficial deposits have been observed along the trace of the Santa Fe fault.

Date of compilation 08/28/96

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Valencia

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Poor
Comments: No scarps in surficial deposits have been observed, so fault is dashed along most of its trace on published maps. Fault trace is from Machette and McGimsey (1983 #1024).

Geologic setting The Santa Fe fault forms the western margin of the Rio Grande rift and the Albuquerque basin; this structure separates the rift from the eastern edge of the Colorado Plateau.

Sense of movement N

Dip 45°-80° E
Comments: Dip data are from Wright (1946 #1427), Callender and Zilinski, (1976 #1289); and Russell and Snelson (1994 #1186).

Dip direction E

Geomorphic expression No scarps have been mapped in surficial deposits along the Santa Fe fault, but the fault forms a bedrock escarpment along the northern half of its trace.

Age of faulted deposits The Santa Fe fault offsets Pliocene to early Pleistocene (Lozinsky and Tedford, 1991 #1399) Sierra Ladrones Formation down-to-the-east against older rocks (Machette and McGimsey, 1983 #1024). Other indirect evidence of Quaternary offset includes differences in the elevation of the Ortiz surface across the fault trace (Kelley and others, 1976 #1380; Kelley, 1977 #1106, p. 28) and the geometry of spring deposits found along the fault (Callender and Zilinski, 1976 #1289).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing estimate is based on offset of Plio-Pleistocene Sierra Ladrones Formation sediments (Machette and McGimsey, 1983 #1024).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/y
Comments: No detailed studies of fault offset or age of offset deposits are available. However, low slip-rate category assigned based on about 30 m offset of basalt dated at 3.7 Ma (Bachman and Mehnert, 1978 #1265) at the mouth of Arroyo Comanche (Kelley, 1977 #1106).(Bachman and Mehnert, 1978 #1265)

Length End to end (km): 29.6
Trace (km): 30.3

Average strike (azimuth) 004°±13°

Endpoints (lat. - long.) 34°54′04.36″N, 107°04′56.32″W
34°38′05.01″N, 107°06′14.77″W

References

#1265 Bachman, G.O., and Mehnert, H.H., 1978, New K-Ar dates and the late Pliocene to Holocene geomorphic history of the central Rio Grande region, New Mexico: Geological Society of America Bulletin, v. 89, p. 283-292.

#1289 Callender, J.F., and Zilinski, R.E., Jr., 1976, Kinematics of Tertiary and Quaternary deformation along the eastern edge of the Lucero uplift, central New Mexico, *in* Woodward, L.A., and Northrop, S.A., eds., Tectonics and mineral resources of southwestern North America: New Mexico Geological Society Special Publication 6, p. 53-61.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1379 Kelley, V.C., and Wood, G.H., Jr., 1946, Geology of the Lucero uplift, Valencia, Socorro, and Bernalillo Counties, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map 47, 1 sheet, scale 1:63,360.

#1380 Kelley, V.C., Woodward, L.A., Kudo, A.M., and Callender, J.F., 1976, Guidebook to Albuquerque basin of the Rio Grande rift, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 153, 31 p.

#1399 Lozinsky, R.P., and Tedford, R.H., 1991, Geology and paleontology of the Santa Fe Group, southwestern Albuquerque basin, Valencia County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 132, 35 p., 3 pls., scale 1:24,000.
#1401 Machette, M.N., 1982, Quaternary and Pliocene faults in the La Jencia and southern part of the Albuquerque-Belen basins, New Mexico—Evidence of fault history from fault-scarp morphology and Quaternary geology, *in* Grambling, J.A., and Wells, S.G., eds., Albuquerque Country II: New Mexico Geological Society, 33rd Field Conference, November 4-6, 1982, Guidebook, p. 161-169.
#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.
#1186 Russell, L.R., and Snelson, S., 1994, Structure and tectonics of the Albuquerque basin segment of the Rio Grande rift—Insights from reflection seismic data, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 83-112.
#1427 Wright, H.E., Jr., 1946, Tertiary and Quaternary geology of the lower Rio Puerco area, New Mexico: Geological Society of America Bulletin, v. 57, p. 383-456.

2124, Unnamed faults west of Mountainair

Structure Number 2124

Structure Name Unnamed faults west of Mountainair
Comments: These fault scarps were first mapped by Machette and McGimsey (1983 #1024) on the basis of aerial photo interpretation. They extend discontinuously to the southwest across the piedmont slope on the east margin of the Manzano Mountains from Arroyo de Manzano (on the north) to a point about 2 km south of Canon Barranco (on the south). They are located about 10 km west-northwest of Mountainair, New Mexico.

Synopsis: Little is known about these faults on the eastern margin of the Manzano Mountains. They were mapped on the basis of aerial photography and map interpretation, and form obvious northwest-facing scarps on piedmont-slope deposits of middle(?) Pleistocene age. No scarp profiles have been measured, and the age of the piedmont-slope deposits is not well established.

Date of compilation 04/28/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: Trace from interpretation of aerial photography (about 1:60,000 scale), which Machette and McGimsey (1983 #1024) compiled at 1:250,000-scale for the fault map of Socorro 1° x 2° quadrangle.

Geologic setting These down-to-the-northwest normal faults are parallel to the general trend of young faults within the modern physiographic expression of the Rio Grande rift and are, thus, probably related to regional east-west extension. They do not appear to cause substantial offset of the underlying Permian bedrock (Abo and Yeso Formations) according to the mapping of Machette (1978 #1223).

Sense of movement N

Dip not reported

Dip direction NW

Geomorphic expression These faults form northwest-facing scarps on piedmont-slope deposits. The scarps oppose the regional topographic gradient (to the southeast) of the piedmont and thus block or deflect stream drainages. They appear to have subdued morphology on aerial photography, but no detailed studies have been made of their morphology. Machette and McGimsey (1983 #1024) estimated that these scarps range from 3-8 m in displacement.

Age of faulted deposits No detailed study or mapping of the faulted deposits have been conducted, but Machette and McGimsey (1983 #1024) inferred that the scarps are formed on piedmont-slope deposits of middle to possible late Pleistocene age. These inferences were made of the basis of unpublished mapping and aerial photo interpretation for the Socorro 1° x 2° quadrangle (Machette, 1978 #1223; Machette and McGimsey, 1983 #1024).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Based on presence of scarps on deposits of middle Pleistocene age and scarps on deposits of possible late Pleistocene age (Machette and McGimsey, 1983 #1024).

Recurrence interval not reported

Slip-rate category unknown; <0.2 mm/yr
Comments: Low slip-rate category assigned based on scarp morphology data of Machette and McGimsey (1983 #1024) that suggest 3 m of displacement for the scarps on possible late Pleistocene deposits and 8 m of displacement for the scarps on middle Pleistocene deposits.

Length End to end (km): 14.2
Trace (km): 20.7

Average strike (azimuth) 024°±11°

Endpoints (lat. - long.) 34°38′06.77″N, 106°17′20.75″W
34°30′57.67″N, 106°20′43.59″W

References

#1223 Machette, M.N., compiler, 1978, Preliminary geologic map of the Socorro 1° by 2° quadrangle, central New Mexico: U.S. Geological Survey Open-File Report 78-607, 1 sheet, scale 1:250,000.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2125, VLA faults

Structure Number 2125

Structure Name VLA faults
Comments: First mapped by Machette and McGimsey (1983 #1024), these faults were later named by Menges and others (1984 #1269) for the VLA (Very Large Array) Radiotelescope, which occupies the central portion of the San Agustin Plains, southeast of Datil, New Mexico. The faults extend from the margin of the ancient lake basin (Pleistocene Lake San Agustin) south to the northwest margin of the San Mateo Mountains.

Synopsis: These north-trending faults form subdued small to prominent-large (40-m-high) scarps on piedmont slopes that border the northern and northwestern margin of the San Mateo Mountains. The most recent movement on the faults is suspected to be about 100 ka on the basis of analyses of scarp morphology and offset of a piedmont-slope deposit of late(?) Quaternary age. No trenching studies of the Quaternary deposits along the fault have been conducted.

Date of compilation 05/08/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Socorro; Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished mapping of Machette used to compile the 1:250,000-scale fault map of Socorro 1° x 2° quadrangle by Machette and McGimsey (1983 #1024) and from the 1:100,000-scale geologic map of Socorro County (Osburn, 1984 #1238), which was modified from aerial photo and map interpretation by the compiler. Digitized from compilation at 1:100,000 scale.

Geologic setting These north-trending faults extend from the northwest margin of the San Mateo Mountains to near the margin of Lake San Agustin, an ancient (late Pleistocene) pluvial lake that occupied the central portion of the San Agustin Plains, southeast of Datil, New Mexico. Little is known about the structural setting of the faults, nor the origin of the northeast-trending, upper portion of the San Agustin Plains.

Sense of movement N

Dip not reported

Dip direction W; E

Geomorphic expression Forms subdued small to prominent-large (40-m-high) scarps on piedmont slopes that border the northern and northwestern margin of the San Mateo Mountains. Machette and McGimsey (1983 #1024) reported scarp heights (estimated from topographic maps) of 10-40 m. Menges and others (1984 #1269) made a more detailed study of the scarps using standard scarp-profiling techniques. The scarps are mainly west- and east-facing, but there are a few north- and south-facing scarps at the northern end of the faults.

Age of faulted deposits Machette and McGimsey (1983 #1024) reported scarps on middle to early Pleistocene piedmont-slope deposits. The scarps are generally not found on late Pleistocene deposits, with the exception of a single small (<5 m) scarp. McFadden and others (1994 #1670) conducted soil, tectonic and climatic-geomorphic investigations of the San Agustin Plans area and reported that Q1(>500 ka) deposits are offset 20-30 m, and Q2 deposits (>75-100 ka) are offset 2-5 m. Q3 (latest Pleistocene, <30? ka) and younger Holocene surfaces do not appear to be disturbed by the faults.

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: This timing is suggested by the presence of large (10-30 m high) scarps on middle Pleistocene deposits and smaller (2-5 m) scarps on suspected late Pleistocene deposits. Menges and others (1984 #1269) reported that movement on the westernmost of the faults (fault 17) is about 100 ka. This estimate is based on analysis of scarp morphology. McFadden and others (1994 #1670) concluded that the VLA faults most recently ruptured in the late Pleistocene, but clearly before 10,000 ka.

Recurrence interval 100 k.y.
Comments: Menges and others (1984 #1269) reported a recurrence interval of about 100 k.y. for the westernmost of the faults (fault 17), and a most recent event of about 100 ka. This estimate is based on an assumption of 2-6 m slip per event, 20-30 m high scarps, and thus 5-10 events during and since the middle Pleistocene (<750 ka). The actual range of acceptable recurrence intervals is 75-150 k.y. Conversely, McFadden and others (see p. 14 1994 #1670) reported an average recurrence interval of 10 k.y., but this appears to be a typographical error (sic 100 k.y.).

Slip-rate category unknown; probably<0.2 mm/yr

Comments: Low slip-rate category assigned based on Menges and other's (1984 #1269) report of 20- to 30-m-high scarps formed during and since the middle Pleistocene.

Length not applicable

Comments: This zone includes several faults that have an end to end length of 14.6 km and a cumulative trace length of 54.5 km.

Average strike (azimuth) 008°±26°

Endpoints (lat. - long.) 34°04'08.65"N, 107°38'11.56"W
33°56'18.56"N, 107°36'57.06"W

References

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1670 McFadden, L.D., Lozinsky, R.R., Menges, C.M., Miller, J.R., and Ritter, J., 1994, Soil, tectonic and climatic geomorphologic investigations in the San Agustin Plains area, NM, *in* Chamberlin, R.M., Kues, B.S., Cather, S.M., Barker, J.M., and McIntosh, W.C., eds., Mogollon slope, west-central New Mexico and east-central Arizona: New Mexico Geological Society, 45th Field Conference, September 28-October 1, 1994, Guidebook, p. 12-14.

#1269 Menges, C.M., Kawaguchi, G.H., Lozinsky, R.P., and McFadden, L.D., 1984, Rates and amounts of Quaternary faulting on the VLA fault scarp, northeastern San Agustin Plains, New Mexico: Geological Society of America Abstracts with Programs, v. 16, no. 4, p. 248.

#1238 Osburn, G.R., compiler, 1984, Geology of Socorro County: New Mexico Bureau of Mines and Mineral Resources Open-File Report 238, 13 p. pamphlet, 1 sheet, scale 1:200,000.

2126, Unnamed faults northeast of Datil

Structure Number 2126

Structure Name Unnamed faults northeast of Datil

Comments: These fault scarps were first mapped by Lopez and Bornhorst (1979 #1739) and later confirmed by Machette and McGimsey (1983 #1024) on the basis of aerial photo interpretation. They extend discontinuously to the southwest across the piedmont slope on the southeast margin of the Datil Mountains to a point about 5 km northeast of Datil, New Mexico.

Synopsis: Little is known about these faults which form the eastern margin of the Datil Mountains. They were mapped on the basis of aerial photography and map interpretation, and form east- and southeast-facing scarps on piedmont-slope deposits of middle(?) Pleistocene age. No scarp profiles have been measured and the age of the piedmont-slope deposits is not well established.

Date of compilation 04/28/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good

Comments: Trace from mapping of Lopez and Bornhorst (1979 #1739), which Machette used to compile the 1:250,000-scale fault map of Socorro 1° x 2° quadrangle (Machette and McGimsey, 1983 #1024). Also shown on 1:100,000-scale geologic map of Socorro County (Osburn, 1984 #1238).

Geologic setting These down-to-the-east normal faults are parallel to the margin of the San Agustin Plains, which might be controlled by earlier (Tertiary) rifting.

Sense of movement N

Dip not reported

Dip direction E; SE

Geomorphic expression These faults form a main southeast-facing scarp and a subsidiary east-facing scarp (splay) on piedmont-slope deposits. The scarps compliment the regional gradient (to the southeast) of the piedmont and thus do not block drainages. They appear subdued on aerial photography, but no detailed studies have been made of their morphology. Machette and McGimsey (1983 #1024) estimated as much as 5 m of displacement for these scarps.

Age of faulted deposits No detailed study or mapping of the faulted deposits have been conducted, but Machette and McGimsey (1983 #1024) inferred that the scarps are formed on piedmont-slope deposits of middle Pleistocene age. These inferences were made of the basis of unpublished mapping and aerial photo interpretation for the Socorro 1° x 2° quadrangle (Machette, 1978 #1223; Machette and McGimsey, 1983 #1024).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Based on presence of scarps on deposits of middle Pleistocene age.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on data presented by Machette and McGimsey (1983 #1024) who estimated <5 m of displacement for the scarps on middle Pleistocene deposits.

Length End to end (km): 21.4
Trace (km): 30.1

Average strike (azimuth) 024°±16°

Endpoints (lat. - long.) 34°16’32.06”N, 107°41’32.22”W
34°05’24.97”N, 107°45’30.96”W

References

#1739 Lopez, D.A., and Bornhorst, T.J., 1979, Geologic map of the Datil area, Catron County, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1098, 1 sheet, scale 1:50,000.

#1223 Machette, M.N., compiler, 1978, Preliminary geologic map of the Socorro 1° by 2° quadrangle, central New Mexico: U.S. Geological Survey Open-File Report 78-607, 1 sheet, scale 1:250,000.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1238 Osburn, G.R., compiler, 1984, Geology of Socorro County: New Mexico Bureau of Mines and Mineral Resources Open-File Report 238, 13 p. pamphlet, 1 sheet, scale 1:200,000.

2127, Unnamed faults at North Lake

Structure Number 2127

Structure Name Unnamed faults at North Lake
Comments: These fault scarps were first mapped by Machette and McGimsey (1983 #1024) on the basis of aerial photo interpretation. They trend to the southeast and bound both sides of North Lake on the northern margin of the San Agustin Plains, about 20 km northeast of Datil, New Mexico.

Synopsis: Little is known about these faults on the northern margin of the San Agustin Plains. They were mapped on the basis of aerial photography and map interpretation and appear to form northeast- and southwest-facing scarps on piedmont-slope deposits of suspected Quaternary age. No scarp profiles have been measured and the age of the piedmont-slope deposits is not well established.

Date of compilation 02/13/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished mapping of Machette used to compile the 1:250,000-scale fault map of Socorro 1° x 2° quadrangle by Machette and McGimsey (1983 #1024). Also shown on 1:100,000-scale geologic map of Socorro County (Osburn, 1984 #1238).

Geologic setting These two closely spaced southeast-trending faults oppose the regional structural grain (northeast-trending), which is probably controlled by earlier (Tertiary) rifting.

Sense of movement N

Dip not reported

Dip direction NE; SW

Geomorphic expression These faults control the position of North Lake, a small ephemeral lake. The larger of the scarps faces northeast and blocks local drainages, hence the lake. The faults appear subdued on aerial photography, but no detailed studies have been made of their morphology. Machette and McGimsey (1983 #1024) estimated about 6 m of displacement for the southwestern (larger) of the two scarps.

Age of faulted deposits No detailed study or mapping of the faulted deposits have been conducted. Although Machette and McGimsey (1983 #1024) did not indicate the age of the faulted deposits, they probably are middle Pleistocene or younger (compiler's assertion). This inference is made of the basis of unpublished mapping and aerial photo interpretation for the Socorro 1° x 2° quadrangle (Machette, 1978 #1223; Machette and McGimsey, 1983 #1024).

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Based on presence of scarps on deposits inferred to be of middle Pleistocene or younger age.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Precise slip rates can not be calculated from the meager data that exists for these faults. However, they probably are <0.2 mm/yr based on slip rates calculated for other young faults in the region.

Length End to end (km): 5.9
Trace (km): 8.6

Average strike (azimuth) -48°±10°

Endpoints (lat. - long.) 34°16'12.88"N, 107°39'54.37"W
34°14'24.52"N, 107°36'43.87"W

References
#1223 Machette, M.N., compiler, 1978, Preliminary geologic map of the Socorro 1° by 2° quadrangle, central New Mexico: U.S. Geological Survey Open-File Report 78-607, 1 sheet, scale 1:250,000.
#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.
#1238 Osburn, G.R., compiler, 1984, Geology of Socorro County: New Mexico Bureau of Mines and Mineral Resources Open-File Report 238, 13 p. pamphlet, 1 sheet, scale 1:200,000.

2128, Coyote fault

Structure Number 2128

Structure Name Coyote fault
Comments: The Coyote fault was first mapped and named by Reiche (1949 #1417), and later appeared on compilations by Kelley (1954 #1222; 1977 #1106). Parts of the Coyote fault also appear on more detailed mapping of Myers and McKay (1970 #1406), GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430) and Karlstrom and others (1997 #1768).

Synopsis: The Coyote fault forms part of the western range front of the Manzanita Mountains. The fault is truncated on the north by the Tijeras-Cañoncito fault system [2033], and appears to die out to the south, where active control of the range front along the western margin of the Manzanita and Manzano Mountains steps eastward to the Manzano fault. Evidence of Quaternary movement along the Coyote fault is equivocal; the fault may cut a Quaternary terrace near Coyote Springs, and tonal and vegetation lineaments in middle to late Pleistocene alluvial fan deposits mark the projected trace of the Coyote fault south of Coyote Springs. One or more strands of the Coyote fault are exposed in Precambrian and Paleozoic bedrock south of the Sandia National Laboratories boundary.

Date of compilation 03/17/97

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Bernalillo

1° x 2° sheet Albuquerque; Socorro

Province Basin and Range

Reliability of location Poor
Comments: The fault trace is well located where exposed in bedrock (Reiche, 1949 #1417; Myers and McKay, 1970 #1406), but much of the trace is projected across alluvial fan deposits where fault location is poor (GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430; Karlstrom and others, 1997 #1768).

Geologic setting The Coyote fault forms part of the western margin of the Manzanita Mountains. This fault is one of several faults (Los Pinos [2118], Manzano [2119], Sandia [2037], and Rincon [2036]) that form the eastern margin of the Rio Grande rift and the Albuquerque basin.

Sense of movement N

Dip 55°-77° W
Comments: Dip measurements in bedrock are from Reiche (1949 #1417) and Myers and McKay (1970 #1406).

Dip direction W

Geomorphic expression The Coyote fault forms part of the western margin of the Manzanita Mountains, but this range front is deeply embayed, which implies a lack of persistent late Quaternary faulting. The trace of the Coyote fault may be marked by tonal contrasts and vegetation lineaments in middle to late Pleistocene alluvial fan deposits (GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430).

Age of faulted deposits Ages of deposits offset by the Coyote fault are poorly known. Myers and McKay (1970 #1406) map a Quaternary terrace deposit faulted against Pennsylvanian sedimentary rocks southwest of Coyote Springs GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430, p. 2-25) found no conclusive evidence that this Quaternary deposit was faulted, but they mapped tonal and vegetation lineaments in middle to late Pleistocene alluvial fan deposits and show the fault buried by late Pleistocene fan deposits. Karlstrom and others (1997 #1768) show the Coyote fault trace buried by middle and late Pleistocene alluvial-fan deposits.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Event timing is based on surficial geologic mapping of GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430). They observed that the youngest event probably occurred after the deposition of middle and late Pleistocene alluvial fan deposits (their unit Pf4.lm), and before the deposition of late Pleistocene alluvial fan deposits (their unit Pf5.lm).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No detailed studies of fault offset or age of offset deposits are available; the slip rate estimate is based on lack of prominent fault scarps and low rates of slip on other faults in this part of the Rio Grande rift.

Length End to end (km): 10.6
Trace (km): 13.6

Average strike (azimuth) 003°±43°

Endpoints (lat. - long.) 35°01′35.22″N, 106°27′31.78″W
34°55′51.03″N, 106°27′50.42″W

References

#1430 GRAM Incorporated, and William Lettis & Associates Incorporated, 1995, Conceptual geologic model of the Sandia National Laboratories and Kirtland Air Force Base: Technical report to Sandia National Laboratories, Albuquerque, New Mexico, December 1995, 15 pls.

#1768 Karlstrom, K.E., Chamberlin, R.M., Connell, S.D., Brown, C., Nyman, M., Cavin, W.J., Parchman, M.A., Cook, C., and Sterling, J., 1997, Geology of the Mount Washington 7.5-minute quadrangle, Bernalillo and Valencia Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map OF-DM 8, 31 p. pamphlet, 1 sheet, scale 1:24,000.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1406 Myers, D.A., and McKay, E.J., 1970, Geologic map of the Mount Washington quadrangle, Bernalillo and Valencia Counties, New Mexico: U.S. Geological Survey Geologic Quadrangle Map GQ-886, 1 sheet, scale 1:24,000.

#1417 Reiche, P., 1949, Geology of the Manzanita and North Manzano Mountains, New Mexico: Geological Society of America Bulletin, v. 60, p. 1183-1212.

2129, Cedar Lake and Antelope faults

Structure Number 2129

Structure Name Cedar Lake and Antelope faults
Comments: The Cedar Lake and Antelope faults were named by Mack and Seager (in press #1262). Cedar Lake is an ephemeral lake (playa) located about 6 km north of Engle, New Mexico. The Cedar Lake fault extends from a point about 2 km northwest of Cedar Lake, south-southeast to the eastern margin of the Engle 7.5-minute quadrangle. The Antelope fault extends from a point about 4 km north-northeast of Engle, south-southeast to the eastern margin of the Engle 7.5-minute quadrangle. The origin of the Antelope fault's name is unknown. Both faults probably extend further to the southeast (east of 107°), but no fault mapping is available for that area.

Synopsis: These two faults are largely inferred; their existence is based primarily on physiographic evidence and similarity with the Engle fault [2060] to the west. The faults form subtle scarps on Quaternary deposits and are associated with tectonically induced physiography, such as backtilted Quaternary surfaces and a playa lake. No specialized studies have been conducted along the fault.

Date of compilation 05/07/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Traces of the faults are shown on 1:24,000-scale map of Mack and Seager (in press #1262).

Geologic setting The south- to southeast-trending Cedar Lake and Antelope faults are down-to-the-east intrabasin faults that are similar to the Engle fault [2060] to the west. The faults are interpreted by Mack and Seager (in press #1262) to separate three asymmetric ridges, which are thought to represent fault-tilted blocks. These faults are considered to be part of a larger system that includes the Jornada Draw [2056] and Engle [2060] faults.

Sense of movement N
Comments: Interpreted as normal faults from tilting of the Cuchillo surface and formation of questa-like ridges (see Mack and Seager, in press #1262).

Dip not reported

Dip direction E
Comments: Shown as high-angle faults on cross sections of Mack and Seager (in press #1262).

Geomorphic expression These faults tilt the Cuchillo surface, which is underlain by gravels of the Palomas Formation. The southwestern dipping surfaces (slopes of 1°-3°) are thought to be hanging-wall dip slopes related to movement on the two faults, as well as the Engle fault [2060] to the southwest. The surficial expression of the scarps is subtle, and they are probably less than 10 m high in most places, although this amount may include substantial deposition on the footslope of the scarps.

Age of faulted deposits The faults displace Pliocene to early Pleistocene basin-fill deposits of the Palomas Formation, and the 700-900 ka (Mack and others, 1993 #1020) constructional Cuchillo surface. There is no evidence that late Pleistocene and Holocene deposits are disturbed by the fault.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Mack and Seager (in press #1262) indicated that the piedmont scarps are clearly younger than the Cuchillo surface (900-700 ka in Mack and others, 1993 #1020). Because deformation is only documented for the Cuchillo surface, the most recent faulting event is herein considered to be <750 ka.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Mack and Seager (in press #1262) do not report any amounts of Quaternary offset associated with the faults. However, their surficial expression is relatively minor (generally <10 m).

Length End to end (km): 6.4
Trace (km): 6.7

Average strike (azimuth) -35°±8°

Endpoints (lat. - long.) 33°14′09.68″N, 107°01′23.57″W
33°10′55.15″N, 106°59′59.79″W

References

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#1262 Mack, G.H., and Seager, W.R., in press, Geology of Engle quadrangle, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 79, 2 sheets, scale 1:24,000.

2130, Black Hill fault

Structure Number 2130
Comments: Included with fault zone 3 in Machette (1987 #960).

Structure Name Black Hill fault
Comments: Mapped and named by Machette (1987 #960), but previously included with the Milligan Gulch fault zone [2107]. The fault is named for Black Hill, a small bedrock hill just east of U.S. Highway 85, about 4 km north of Nogal Canyon, which trends east from the southern San Mateo Mountains. The fault extends from Bottle Hill on the north to about 1 km south of Nogal Canyon on the south (Black Hill 7.5 -minute quadrangle).

Synopsis: The Black Hill fault forms fairly continuous, but isolated fault scarps that trend south and southeast in the southern part of the San Marcial basin, south of the Milligan Gulch fault zone. The fault forms a southward, left-stepping pattern of singular scarps preserved on high-level surfaces related to filling of the San Marcial basin. The most recent movement on the faults in the zone is considered to be of early late Pleistocene age (*i.e.*, <130 ka) based on studies of fault scarp morphology. However, there have been no studies of the age of Quaternary deposits within and adjacent to the fault.

Date of compilation 10/10/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping by Machette (1987 #960).

Geologic setting The Black Hill fault forms intrabasin scarps that are east of the southern San Mateo Mountains. However, at Black Hill the fault probably lies within several hundred meters of bedrock, and as such may represent an ancient basin-margin fault; the margin is now greatly dissected and has retreated to the west.

Sense of movement N

Dip not reported

Dip direction NE

Geomorphic expression The Black Hill fault has fresher-appearing scarps than those of the Milligan Gulch fault zone [2107]. The Black Hill scarps are east facing and have a maximum scarp-slope angle of 6° on a piedmont of 1-2° east slope. The single profile measured by Machette (1987 #960) suggested that the fault scarp is morphologically similar to scarps of the Santa Rita fault in eastern Arizona, which Pearthree and Calvo (1987 #1023) considered to be about 100 ka.

Age of faulted deposits Machette (1987 #960) indicated that the 4.3-m high scarp that he profiled is on middle Pleistocene surface, although he gave no indication of the criteria for estimating the age of the faulted deposits. This age call was made on the basis of the degree of dissection and surface morphology of the piedmont-slope deposits, and from glimpses of the soils preserved along the margins of the dissected surfaces (compiler's remarks, 1998).

Detailed studies none

Timing of most recent paleoevent late Quaternary (<130 ka)
Comments: The Black Hill fault probably formed the observed scarp in the early late Pleistocene (ca. 100 ka), rather than more recent time (<30 ka) (Machette, 1987 #960).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: These fault scarps are small (<5 m high) and are formed on a surface that is probably more than 130 ka. This old datum and small amount of maximum offset indicated low long-term slip rate).

Length End to end (km): 14.4
Trace (km): 21.1

Average strike (azimuth) 002°±21°

Endpoints (lat. - long.) 33°37′56.45″N, 107°12′43.33″W
33°30′21.08″N, 107°10′43.53″W

References

#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.

#1023 Pearthree, P.A., and Calvo, S.S., 1987, The Santa Rita fault zone—Evidence for large magnitude earthquakes with very long recurrence intervals, Basin and Range province of southeastern Arizona: Bulletin of the Seismological Society of America, v. 77, p. 97-116.

2131, Unnamed faults along San Mateo Mountains

Structure Number 2131

Structure Name Unnamed faults along San Mateo Mountains
Comments: Mapped but not named during reconnaissance investigations for a study of regional Quaternary and late Pliocene faults (Machette, 1987 #960). The faults extend from 2 km southwest of Big Rosa Canyon, south past the Melton Ranch at North Canyon (Tenmile Hill 7.5-minute quadrangle) to Cuero Canyon (Steel Hill 7.5-minute quadrangle) along the eastern margin of the San Mateo

Mountains. Also includes a short subparallel fault trace to the west of the northern part of the main fault trace.

Synopsis: These unnamed faults are about 2-3 km inboard of the eastern margin of the San Mateo Mountains at its southern part and form two piedmont scarps along its northern part. Both faults have anomalous down-to-the-west motion, which opposes the regional (*i.e.,* basin-range) pattern of uplifted ranges and downdropped basins. However, this information was gleaned from aerial photographs and topographic maps; only the northern part has been field checked. No detailed study has been made of fault-scarp morphology or the age of Quaternary deposits within and adjacent to the fault zone.

Date of compilation 02/13/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Traces from 1:24,000-scale map of Ferguson {, 1988 #1227} and unpublished 1:24,000-scale mapping by Machette (1987 #960). Digitized from 1:100,000-scale compilation.

Geologic setting This rather long, unnamed fault lies 2-3 km inboard of the eastern margin of the San Mateo Mountains. It, and a subparallel strand west of the northern part, have down-to-the-west motion that opposes the regional pattern of uplifted ranges and downdropped basins. The fault forms saddles and anomalous strike valleys within bedrock, and west-facing scarps on old piedmont-slope deposits. About two-thirds of the mapped trace is within bedrock, giving little significant indication of the recency of faulting.

Sense of movement N

Dip not reported

Dip direction W

Geomorphic expression These faults form small, discontinuous west-facing scarps on piedmont surfaces graded to the San Marcial basin between Big Rosa Canyon on the north and North Canyon on the south. The west-facing scarps oppose the gradient of the piedmont slope on which they are formed, and thus are quite apparent on aerial photographs. Ferguson (1988 #1227) noted that the scarps just north of the Melton Ranch are as much as 8 m high, but become progressively smaller toward the northern of the fault. No detailed study has been made of fault-scarp morphology nor have the scarps within bedrock been field checked.

Age of faulted deposits Machette's (unpubl., 1981) notes indicate that the west-facing scarps are formed on old piedmont-slope deposits, which are probably middle Pleistocene in age. Ferguson (1988 #1227) mapped these deposits as the Palomas Formation, which is considered to be of Pliocene to Pleistocene age. The constructional surface of the Palomas Formation is probably of middle to early Pleistocene age. Ferguson also noted that there are anomalous clayey deposits in the Palomas Formation that are exposed on the south bank of North Canyon, just west of the scarp near the Melton Ranch. These deposits probably represent temporary damming of the drainage of North Canyon as a result of down-to-the-west movement on the main strand of the fault. No detailed mapping of Quaternary deposits along this fault zone have been conducted to help further resolve the age of faulted deposits.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)

Comments: Timing based on degraded nature of fault scarps (Machette, 1987 #960) as they appear on aerial photographs and from inferred age of the constructional surface of the Palomas Formation.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on the inference that the 8-m-high scarp noted by Ferguson (1988 #1227) as the maximum size of scarp (and offset) formed on the Palomas Formation, and an age of 700-900 ka for the surface (see Mack and others, 1993 #1020).

Length End to end (km): 41.1
Trace (km): 44.4

Average strike (azimuth) 000°±19°

Endpoints (lat. - long.) 33°48′17.27″N, 107°17′35.16″W
33°26′10.75″N, 107°15′00.77″W

References

#1227 Ferguson, C.A., 1988, Geology of the Tenmile Hill 7.5′ quadrangle, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 283, 21 p., 2 pls.

#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

2132, Unnamed faults west of Bosque del Apache

Structure Number 2132

Structure Name Unnamed faults west of Bosque del Apache

Comments: Machette (1987 #960) mapped these faults as part of a regional study but did not name them. The faults extend across the piedmont slope south and east of the Chuperado Mountains and west of the Bosque del Apache National Wildlife Refuge.

Synopsis: These north-trending intrabasin fault scarps are preserved on high-level surfaces related to filling of the San Marcial basin. Although they have only been mapped as part of a regional reconnaissance, the presence of scarps on unconsolidated surficial materials suggests a Quaternary age. However, no detailed study has been made of their scarp morphology or the age of Quaternary deposits within and adjacent to the fault zone.

Date of compilation 10/10/96

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Socorro

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping by Machette transferred to 100,000-scale base map.

Geologic setting These unnamed primarily down-to-the-southeast intrabasin faults forms small scarps across the piedmont that grades south and east from the Chupadera Mountains. They lie in the northwestern part of the San Marcial basin.

Sense of movement N

Dip not reported

Dip direction SE; NW

Geomorphic expression These faults form small (commonly <5-m-high), mainly discontinuous primarily east-facing scarps on the more stable (undissected) parts of the piedmont slope. No data on scarp morphology has been collected from these faults, although on aerial photographs they appear much like those of the intrabasin Milligan Gulch fault zone [2107] further southwest.

Age of faulted deposits These faults cut older, piedmont-slope surfaces of unknown but probable Quaternary age. However, no detailed mapping of Quaternary deposits along the fault have been conducted to help resolve the age of the faulted deposits.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing inferred from presence of fault scarps on unconsolidated surficial materials.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Based on small size of scarps and slip rates determined for similar intrabasin faults in the region.

Length End to end (km): 4.4
Trace (km): 8.3

Average strike (azimuth) 053°±15°

Endpoints (lat. - long.) 33°47′46.99″N, 106°54′50.50″W
33°46′04.05″N, 106°56′47.06″W

References

#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.

2133, Fra Cristobal fault zone

Structure Number 2133
Comments: Associated with fault 6 on fig. 1 in Machette (1987 #960).

Structure Name Fra Cristobal fault zone
Comments: Main fault named by Nelson (1986 #1176) for the Fra Cristobal Range. The fault zone extends along the eastern margin of the Fra Cristobal Range and appears to be an inactive, but an associated basinward splay at its northern end is Quaternary.

Synopsis: Little is known about this range-bounding fault zone that forms the east margin of the Fra Cristobal Range. Although there is a fairly steep (bedrock) escarpment along the range front, there is no published evidence of Quaternary faulting along the suspected trace of the fault. At the southern end of the fault, basalts of suspected late Pliocene age are not offset. However, at the northern end of the range, an associated basinward splay forms an inconspicuous fault scarp of probable late(?) to middle Pleistocene age. No studies have been conducted to discern the age and distribution of Quaternary deposits that overlie either of these fault sowing to limited access and property ownership.

Date of compilation 04/28/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra; Socorro

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good

Geologic setting The Fra Cristobal fault bounds the east margin of the Fra Cristobal Range (an east-titled horst block) and forms the western margin of the Jornada del Muerto basin (a gentle Cenozoic syncline). Most of the structural complexity in the Fra Cristobal range is of Laramide age (Nelson, 1986 #1176). The fault is expressed as a steep mountain-front escarpment and as a basinward splay that forms a scarp on alluvium.

Sense of movement N

Dip not reported
Comments: High-angle according to Nelson (1986 #1176).

Dip direction E

Geomorphic expression No evidence of fault scarps or deformed Quaternary deposits are reported by Thompson (1961 #1712) or Nelson (1986 #1176). However, aerial photo reconnaissance by Machette (1987 #960) reported an conspicuous fault scarp on alluvium at the northeast margin of the Fra Cristobal Range.

Age of faulted deposits From the dissected appearance of the piedmont, it appears that the alluvial fans that are offset by the basinward splay are probably of middle and late(?) Pleistocene age (Machette, 1987 #960). However, no studies have been conducted to discern the age and distribution of Quaternary deposits along this scarp or the main range-front fault owing to limited access and property ownership. At the southern end of the fault, basalts of suspected late Pliocene age are not offset by the fault (Nelson, 1986 #1176).

Detailed studies none

Timing of most recent paleoevent middle to late Quaternary (<750 ka)
Comments: Machette (1987 #960) considered the main range-front fault to be primarily of Pliocene age and it is shown as a concealed Quaternary fault herein, whereas the basinward fault scarp is of possible late(?) to middle Pleistocene age.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on lack of bona fide scarps on deposits along the range-front fault and on inconspicuous (*i.e.,* small <5 m) scarps along the basinward strand of the fault zone.

Length End to end (km): 21.8
Trace (km): 25.2

Average strike (azimuth) 000°±12°

Endpoints (lat. - long.) 33°29′07.27″N, 107°03′45.86″W
33°17′21.08″N, 107°04′47.41″W

References

#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.

#1176 Nelson, E.P., 1986, Geology of the Fra Cristobal Range, south-central New Mexico, *in* Clemons, R.E., King, W.E., and Mack, G.H., eds., Truth or Consequences region: New Mexico Geological Society, 37th Field Conference, October 16-18, 1986, Guidebook, p. 83-95.

#1712 Thompson, S., 1961, Geology of the southern part of the Fra Cristobal Range, Sierra County, New Mexico: Albuquerque, University of New Mexico, unpublished revision of M.S. thesis (1956), 89 p.

2134, Unnamed faults on the Cuchillo Plain

Structure Number 2134
Comments:

Structure Name Unnamed faults on the Cuchillo Plain
Comments: These unnamed faults form the western margin of the Palomas basin and the eastern margin of the Sierra Cuchillo. Machette (1987 #960) showed them as rather discontinuous fault scarps west of the Palomas Creek fault zone [2103], which in turn is west of Truth or Consequences, New Mexico. The unnamed faults extend across the head of the Cuchillo Plain from Palomas Creek on the north to King Arroyo on the south, where the most continuous trace joins the Palomas Creek fault zone [2103].

Synopsis: These unnamed north-trending faults form the western margin of the Palomas basin and the eastern margin of the Sierra Cuchillo. They extend across the head of the Cuchillo Plain and the most continuous trace joins the Palomas Creek fault zone [2103]. The faults are primarily down-to-the-east. No detailed study has been made of the age of Quaternary deposits within and adjacent to the fault zone.

Date of compilation 04/28/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sierra

1° x 2° sheet Tularosa

Province Basin and Range

Reliability of location Good
Comments: Trace from unpublished 1:24,000-scale mapping by Machette used to compile figure 1 in Machette (1987 #960). Digitized from compilation on 100,000-scale base map.

Geologic setting These faults form the western structural margin of the Palomas basin and the eastern margin of the Sierra Cuchillo. The faults are predominately down-to-the-west and do not appear to have significant structural throw; they may reflect bending at the western margin of an east-tilted half graben (Palomas basin).

Sense of movement N

Dip not reported

Dip direction E; W

Geomorphic expression Machette (1987 #960) showed these down-to-the-east faults has having rather discontinuous fault scarps west of the Palomas Creek fault zone [2103]. The scarps, which were recognized from aerial photo interpretation, are primarily east-facing on the east- to south-east sloping

Cuchillo Plain. No one has characterized the scarps in terms of their height or morphology; however, most scarps recognized from aerial photographs are at least a meter high.

Age of faulted deposits The faults cut dissected basin-fill sediment (the Palomas Formation) and the Palomas gravel (upper part of the Palomas Formation), which forms the constructional Cuchillo surface. This surface was considered to be middle Pleistocene (400-500 ka) by Lozinsky (1985 #1073) and Machette (1987 #960), but more recent studies by Mack and others (1993 #1020) suggested that this surface may be as old as 700-900 ka, thereby providing an older maximum limit on the deformation. However, no detailed mapping of Quaternary deposits along the fault or on the Cuchillo Plain have been conducted to help resolve the minimum age of faulted deposits.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 M)

Comments:
Timing based on presence of recognizable scarps on the Cuchillo surface, which could be as young as middle Pleistocene (400-500 ka) or as old as early Pleistocene (700-900 ka).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on small size of scarps and slip rates determined for similar intrabasin faults in the region.

Length (km) not applicable
Comments: This zone includes several faults that have an end to end length of 15.5 km and a cumulative trace length of 39.4 km.

Average strike (azimuth) -8°±15°

Endpoints (lat. - long.) 33°12′46.02″N, 107°28′20.28″W
33°04′33.24″N, 107°26′14.04″W

References

#1073 Lozinsky, R.R., 1985, Geology and late Cenozoic history of the Elephant Butte area, Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 187, 40 p., 2 pls.
#960 Machette, M.N., 1987, Preliminary assessment of Quaternary faulting near Truth or Consequences, New Mexico: U.S. Geological Survey Open-File Report 87-652, 40 p.
#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

2135, McCormick Ranch faults

Structure Number 2135

Structure Name McCormick Ranch faults
Comments: The McCormick Ranch faults consist of several north- to northeast-trending normal faults that lie directly west of Sandia National Laboratories. The two prominent structures that form this graben are the down-to-the-east West McCormick Ranch fault and the down-to-the-west East McCormick Ranch fault. The East McCormick Ranch fault was first mapped by Kelley (1977 #1106), and the West McCormick Ranch fault was first mapped by Machette and McGimsey (1983 #1024). GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430) named these structures after the nearby McCormick Ranch, and mapped several other faults that form smaller horst and graben blocks in the area. Numerous fault-related ridges and swales mapped by Love and others (1996 #1762; in press #1761) in the area are included in this compilation.

Synopsis: Several north- to northeast-trending faults offset upper Santa Fe Group sediments and the Llano de Manzano, an early Pleistocene geomorphic surface, southwest of McCormick Ranch. These faults are marked by linear scarps and accompanying depressions that extend as far south as Hells Canyon Wash and as far west as the western margin of the Llano de Manzano. The faults form a series of horst and graben blocks that are partly buried by eolian sand.

Date of compilation 05/20/98

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Bernalillo

1° x 2° sheet Socorro

Province Basin and Range

Reliability of location Good
Comments: Fault traces are from Machette and McGimsey (1983 #1024), GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430), Love and others (1996 #1762; in press #1761), and airphoto reconnaissance by the compiler (S.F. Personius, unpublished data, 1997-1998.

Geologic setting The McCormick Ranch faults are intrabasin normal faults in the Albuquerque basin of the Rio Grande rift.

Sense of movement N

Dip Not reported

Dip direction E and W

Geomorphic expression Faults are marked by topographic scarps and accompanying linear depressions on the Llano de Manzano, an early Pleistocene geomorphic surface. They form a series of horst and graben blocks that are partly buried by eolian sand. Machette and McGimsey (1983 #1024) estimated offsets of 5-20 m across the West McCormick Ranch fault, and GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430) measured scarp heights of 10 m across several McCormick Ranch faults.

Age of faulted deposits The McCormick Ranch faults offset upper Santa Fe Group sediments that contain clasts of upper Bandelier Tuff from the Jemez Mountains (Love and others, 1996 #1762; Love and others, in press #1761), so the faulted deposits are younger than 1.2 Ma. The stable geomorphic surface formed on these deposits, locally known as the Llano de Manzano, has a stage IV carbonate horizon developed in it (Love and others, 1996 #1762; Love and others, in press #1761), suggesting that this surface is also early Pleistocene in age.

Detailed studies none

Timing of most recent paleoevent middle and late Quaternary (<750 ka)
Comments: Machette and McGimsey (1983 #1024) estimated that the latest event on the West McCormick Ranch fault is no older than the middle Pleistocene. Offsets of 10-20 m measured on some of these faults (Machette and McGimsey, 1983 #1024; GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430) suggest recurrent movements that probably extended into at least the middle Pleistocene.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on upper Santa Fe Group sediments (ca. 1.2 Ma) offset 5-20 m (Machette and McGimsey, 1983 #1024; GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430).

(1983 #1024)(1995 #1430)**Length** (km) not applicable
Comments: This zone includes several faults that have an end to end length of 12.9 km and a cumulative trace length of 67.1 km.

Average strike (azimuth) 006°±29°

Endpoints (lat. - long.) 34°59'26.77"N, 106°37'27.01"W
34°52'38.29"N, 106°39'22.56"W

References

#1430 GRAM Incorporated, and William Lettis & Associates Incorporated, 1995, Conceptual geologic model of the Sandia National Laboratories and Kirtland Air Force Base: Technical report to Sandia National Laboratories, Albuquerque, New Mexico, December 1995, 15 pls.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1762 Love, D.W., Hitchcock, C., Thomas, E., Kelson, K., Van Hart, D., Cather, S., Chamberlin, R., Anderson, O., Hawley, J., Gillentine, J., White, W., Noler, J., Sawyer, T., Nyman, M., and Harrison, B., 1996, Geology of the Hubbell Spring 7.5-min quadrangle, Bernalillo and Sandoval [Valencia] Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map OF-DM 5, 7 p. pamphlet, 1 sheet, scale 1:24,000.

#1761 Love, D.W., Jones, G., White, W., Hawley, J., McIntosh, W., Kudo, A., Gibson, A., and Abeita, N., in press, Preliminary geologic map of Isleta quadrangle: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map OF-DM 13, 4 p. pamphlet, 1 sheet, scale 1:24,000.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.

2136, Hickman fault

Structure Number 2136

Structure Name Hickman fault
Comments: The recognized Quaternary trace of this fault extends from Freeland Arroyo on the north to Newton Draw on the south (Tres Lagunas 7.5-minute quadrangle). The central part of the Quaternary rupture is located about 6 km north of Tres Lagunas and 15 km north of Pie Town, small communities in western New Mexico.

Synopsis: This north- to northeast-trending fault forms an apparent scarp on unconsolidated Quaternary deposits and may control the course of Newton Draw, a north-flowing ephemeral drainage. The Hickman fault, which has proven Neogene movement, extends considerably farther to the south-southwest and to the north, where it offsets basaltic dikes of late Oligocene age (28-29 Ma). No field studies have been conducted to verify the presence of faulted sediment.

Date of compilation 04/25/97

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Catron

1° x 2° sheet Saint Johns

Province Basin and Range

Reliability of location Good
Comments: Trace transferred from 1:50,000-scale (approximate) aerial photographs to 1:100,000-scale topographic map of the Quemado 1/2° x 2° quadrangle. Tertiary to Quaternary fault trace as shown

by Chamberlin and others (1994 #1256) is much longer and is based on mapping of Cretaceous to Tertiary rocks.

Geologic setting The Hickman fault is a Neogene normal fault that seems to have been a right-lateral reverse fault during the Laramide. The fault parallels the regional structural grain, which is one of mostly NNE-trending high-angle normal faults of Neogene age and gently SSE-dipping middle Tertiary strata (Chamberlin and others, 1994 #1256). The normal faulting is generally considered to represent backsliding (extension) on Laramide compressional fault zones.

Sense of movement N
Comments: Chamberlin and others (1994 #1256) considered the Hickman fault to be high-angle dip-slip normal fault, but it appears to have been a right-lateral (dextral) reverse fault in Laramide time. They estimated 275-366 m (1000-1200 ft) of Neogene displacement where the Hickman fault crosses the Lehew dike (28-29 Ma), but only about 90 m (300) feet of post 5-Ma (Pliocene to Pleistocene) throw on the fault about 30 km to the southwest.

Dip not reported
Comments: Chamberlin and others (1994 #1256) reported the Hickman fault as high-angle dip-slip normal fault.

Dip direction W
Comments: Inferred from fault scarp which is west facing.

Geomorphic expression Fault forms apparent, but small scarp on unconsolidated Quaternary sediment. The northern several kilometers are obscure (buried by eolian sand?), but the central part is quite apparent on aerial photographs. The southern half of the trace, which is shown as concealed on the map, appears to control the course of Newton Draw, a north-flowing ephemeral drainage. No fault-specific field studies have been to confirm Quaternary movement on this structure.

Age of faulted deposits Quaternary (<1.6 Ma)
Comments: Chamberlin and others (1994 #1256) showed unconsolidated upper Quaternary alluvium and middle to upper Quaternary (older) alluvium along the suspected trace of the fault. Elsewhere, Paleogene sedimentary rocks and the late Oligocene Lehew dike are the youngest units that are shown as cut by the Hickman fault (Chamberlin and others, 1994 #1256).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing poorly controlled. Based on presence of scarp on unconsolidated Quaternary sediment, which Chamberlin and others (1994 #1256) map as upper Quaternary.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Length End to end (km): 9.0
Trace (km): 13.4

Average strike (azimuth) 022°±16°

Endpoints (lat. - long.) 34°28′46.04″N, 108°04′41.53″W
34°24′10.85″N, 108°06′39.15″W

References

#1256 Chamberlin, R.M., Cather, S.M., Anderson, O.J., and Jones, G.E., 1994, Reconnaissance geologic map of the Quemado 30 x 60 minute quadrangle, Catron County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 406, 29 p. pamphlet, 1 sheet, scale 1:100,000.

2137, Unnamed fault east of Mangas

Structure Number 2137

Structure Name Unnamed fault east of Mangas
Comments: The recognized Quaternary trace of this short fault (ca. 1 km long) was mapped by Chamberlin and others (1994 #1256). It extends southeast from Cottonwood Draw, and seems to represent reactivation of an older Tertiary fault that extends much farther northwest and southeast.

Synopsis: This short Quaternary fault trace seems to represent minor reactivation of an older northwest-trending Tertiary fault that connects the Mangas (pre-Quaternary) fault on the west with the pre-Quaternary trace of the Hickman fault [2136] on the east. The fault forms a scarp of unknown height on Pliocene to early Pleistocene gravels.

Date of compilation 03/23/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Catron

1° x 2° sheet Saint Johns

Province Basin and Range

Reliability of location Good
Comments: Trace from geologic map of the Quemado 1/2° x 2° quadrangle by Chamberlin and others (1994 #1256).

Geologic setting This northwest-trending primarily Tertiary fault connects the Mangas (pre-Quaternary) fault on the west with the pre-Quaternary trace of the Hickman fault [2136] on the east (Chamberlin and others, 1994 #1256). It is one of several north- to northwest-trending faults that connect a wide belt of northeast-trending faults of Neogene age.

Sense of movement N
Comments: Shown as a normal fault by Chamberlin and others (1994 #1256).

Dip not reported

Dip direction sW
Comments: As shown by Chamberlin and others (1994 #1256) and inferred from fault scarp which is west facing.

Geomorphic expression Fault forms a suspect (not confirmed) west-facing scarp on locally derived basin-fill sediment (mainly gravel). No information has been published about the size or morphology of the scarp.

Age of faulted deposits Chamberlin and others (1994 #1256) showed the fault as offsetting the Quemado Formation, a Pliocene to lower Pleistocene unit that is widespread but locally derived from sources in western New Mexico. The deposits are primarily unconsolidated to poorly consolidated gravels.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing poorly controlled. Based on presence of scarp on deposits of possible early Quaternary age (Chamberlin and others, 1994 #1256).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: Low slip-rate category assigned based on inferred small size of scarps and slip rates determined for similar faults in the region.

Length End to end (km): 2.9
Trace (km): 3.0

Average strike (azimuth) -25°±12°

Endpoints (lat. - long.) 34°10′32.70″N, 108°17′02.72″W
34°09′05.82″N, 108°16′15.48″W

References

#1256 Chamberlin, R.M., Cather, S.M., Anderson, O.J., and Jones, G.E., 1994, Reconnaissance geologic map of the Quemado 30 x 60 minute quadrangle, Catron County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 406, 29 p. pamphlet, 1 sheet, scale 1:100,000.

2138, Red Hill faults

Structure Number 2138

Structure Name Red Hill faults
Comments: This set of faults are named for Red Hill, a small knoll located about 15 km east of the New Mexico/Arizona state boundary along U.S. Highway 60. The Quaternary traces of these faults were mapped by Chamberlin and others (1994 #1256). From U.S. Highway 60, they extend as a 1-km-wide zone of three faults south-southwest for a distance of about 15 km.

Synopsis: This series of subparallel Quaternary faults trend south-southwest across Quaternary, Pliocene, and Miocene basalt flows. At the north end, the faults displace basalt flows that are early Quaternary in age, thus confirming that a portion (of all) of the fault traces have Quaternary movement. No information exists about the fault chronology, nor have detailed studies been made to better define the most recent movement along the faults.

Date of compilation 04/17/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Catron

1° x 2° sheet Saint Johns

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:100,000-scale geologic map of the Quemado 30 x 60 minute sheet by Chamberlin and others (1994 #1256).

Geologic setting This north-northwest-trending set of faults cuts early Quaternary to late Pliocene basalts and basin fill deposits (Quemado Formation) and late Miocene basalt flows south of Cimarron Mesa, a high plateau that is formed by late Miocene basalt flows (Chamberlin and others, 1994 #1256). These faults are part of a larger system of faults that strike northeast in the region. They are parallel to subparallel to the trend of upper Miocene eruptive centers (cones, vents, etc.) (Chamberlin and others, 1994 #1256).

Sense of movement N
Comments: Chamberlin and others (1994 #1256)

Dip not reported

Dip direction SE; NW

Comments: Predominantly east-dipping as shown by Chamberlin and others (1994 #1256) and inferred from main (longest) fault scarp, which is east-facing.

Geomorphic expression Fault forms scarps of unknown (but not large) size, primarily on basalt. Also forms scarps that separate basin-fill deposits from basalts. No information has been published about the size or morphology of the scarps.

Age of faulted deposits Chamberlin and others (1994 #1256) showed the fault as offsetting the basalts and sediment of the Quemado Formation, a Pliocene to lower Pleistocene unit that is widespread but locally derived from sources in western New Mexico. The basin-fill deposits are primarily unconsolidated to poorly consolidated gravels. Chamberlin showed the youngest faulted basalts as having K-Ar ages of about 2.5 Ma (late Pliocene) to 0.86 Ma (early Pleistocene). Younger basaltic tephra deposits (Qbt) of 70-210 ka age are not mapped as being offset by the Red Hill faults (Chamberlin and others, 1994 #1256).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing poorly controlled. Based on presence of scarp on deposits of possible early Quaternary age (Chamberlin and others, 1994 #1256).

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip-rate category assigned based on inferred small size of scarps and slip rates determined for similar faults in the region.

Length End to end (km): 14.9
Trace (km): 19.5

Average strike (azimuth) 024°±12°

Endpoints (lat. - long.) 34°13′25.55″N, 108°49′35.19″W
34°05′52.29″N, 108°52′51.69″W

References

#1256 Chamberlin, R.M., Cather, S.M., Anderson, O.J., and Jones, G.E., 1994, Reconnaissance geologic map of the Quemado 30 x 60 minute quadrangle, Catron County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 406, 29 p. pamphlet, 1 sheet, scale 1:100,000.

2139, Unnamed fault west of Hatch

Structure Number 2139

Structure Name Unnamed fault west of Hatch
Comments: This unnamed northwest-trending fault is shown by Seager and others (1982 #626). It are parallel to but west of the western margin of the Rio Grande valley. The middle of the fault is located about 6 km west of Hatch, New Mexico.

Synopsis: This down-to-the-southwest fault forms scarps (of unknown height) on the constructional surface formed by ancient fluvial (river) deposits of the Camp Rice Formation. The fault juxtaposes the fluvial deposits against Miocene syntectonic basin-fill deposits of the Rio Grande rift. No detailed studies of the scarps have been made.

Date of compilation 07/16/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet Las Cruces

Province Basin and Range

Reliability of location Good
Comments: Generalized trace from 1:125,000-scale map of Seager and others (1982 #626).

Geologic setting This down-to-the-southwest fault juxtaposes upper Pliocene to early Quaternary fluvial deposits of the Camp Rice Formation against Miocene syntectonic basin-fill deposits of the Rio Grande rift. Towards its north end, its surface trace is entirely with early Quaternary fluvial deposits.

Sense of movement N

Dip not reported
Comments: The fault is probably a high-angle structure, similar to others shown on cross section D of Clemons and others (1973 #1003). However, no specific dip values are shown on Seager and others (1982 #626) map.

Dip direction SW

Geomorphic expression This down-to-the-southwest fault forms scarps (of unknown height) on the constructional surface formed by ancient fluvial (river) deposits of the Camp Rice Formation. No detailed studies of the scarps have been made.

Age of faulted deposits The fault forms scarps on the constructional surface formed by ancient fluvial (river) deposits of the Camp Rice Formation. Mack and others (1993 #1020) have shown that, along the Rio Grande, this surface was stabilized between 700-900 ka. Thus, the fluvial deposits are probably of early Pleistocene age.

Detailed studies none

Timing of most recent paleoevent Quaternary (<750 ka)
Comments: Based on offset of early Pleistocene(?) fluvial sediment of the upper part of the Camp Rice Formation.

Recurrence interval not determined

Slip-rate category unknown, probably <0.2 mm/yr
Comments: Although no scarp heights or times of faulting have been determined, the lack of continuity of the fault scarps and their apparent moderate (<10 m) to low height (several meters) as revealed from 1:24,000-scale topographic maps suggest that the Quaternary slip rate across the fault is probably much less than 0.2 mm/yr

Length End to end (km): 4.8
Trace (km): 4.5

Average strike (azimuth) -58°±16°

Endpoints (lat. - long.) 32°40'37.48"N, 107°14'44.52"W
32°39'13.65"N, 107°12'07.35"W

References

#1003 Clemons, R.E., and Seager, W.R., 1973, Geology of Souse Springs quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 100, 31 p., 1 pl., scale 1:24,000.

#1020 Mack, G.H., Salyards, S.L., and James, W.C., 1993, Magnetostratigraphy of the Plio-Pleistocene Camp Rice and Palomas formations in the Rio Grande rift of southern New Mexico: American Journal of Science, v. 293, p. 49-77.

#626 Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwest part of Las Cruces 1° x 2° sheet, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 53, 3 sheets, scale 1:250,000.

2140, Cebollita Mesa fault

Structure Number 2140

Structure Name Cebollita Mesa fault
Comments: This Quaternary fault was named by Levish and others (1992 #1715) for Cebollita Mesa, a Pliocene basalt covered mesa located about 8 km east and northeast of the fault. The fault was first shown by Machette (1978 #1223) on the geologic map of the Socorro 1° x 2° quadrangle, but was omitted by Machette and McGimsey (1983 #1024) in their later fault compilation. Maxwell (1986 #1720) made the first detailed map showing the fault, whereas Levish (1992 #1715) characterized its late Quaternary history as part of a dam hazards study. The fault is mapped for about 13 km across the toe slope of dissected Cretaceous bedrock hills. It extends from the north side of Bonine Canyon on the south, north past Head Windmill and New Mexico State Highway 117. About 1 km north of the highway, the fault disappears beneath a young basalt flow.

Synopsis: The Cebollita Mesa fault has seemingly young (<15 ka) movement, which is anomalous in the sense that their are few mapped Quaternary faults in this region, and in the Colorado Plateaus Province in general. However, field studies have shown that the fault has been recurrently active in the late Quaternary. Single-event scarps on the fault are about 2-2.5 m high, whereas older (late? Pleistocene) alluvium has compound (multiple-event) scarps as much as 8 m high. No dating has been conducted to refine the timing of last movement, slip rate, or recurrence interval for this down-to-the-west normal fault.

Date of compilation 03/26/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Valencia

1° x 2° sheet Socorro

Province Colorado Plateaus

Reliability of location Good
Comments: Trace from geologic map (scale ca. 1:100,000) of Levish and others (1992 #1715), which was based on aerial photography, field mapping and modified from 1:62,500-scale mapping of Maxwell (1986 #1720). Trace recompiled on 1:250,000-scale topographic base and digitized.

Geologic setting The fault offsets the toe slope of dissected Cretaceous bedrock hills west of Cebollita Mesa. To the north, the fault disappears beneath a late Holocene basalt flow, but may continue further as suggested by as much as 300 m of down-to-the-west displacement on two normal faults imaged by shallow seismic-reflection profiling (Kelly and Reynolds, 1989 #1738). The Cebollita Mesa fault is sub-parallel to (but west of) similarly oriented normal faults that Maxwell (1986 #1720) maps as cutting Pliocene basalts of Cebollita Mesa.

Sense of movement N
Comments: As mapped by Maxwell (1986 #1720) and seen in natural exposures by Levish and others (1992 #1715).

Dip not reported
Comments: Although not mentioned by Levish and others (1992 #1715), the faults exposed in natural exposure have high-angle (near vertical) dips near the surface (Dan Levish, oral commun., 1988).

Dip direction W
Comments: Inferred from west-facing normal-dip fault scarps and as seen in natural exposures by Levish and others (1992 #1715).

Geomorphic expression The fault forms a north-trending, left-stepping series of three en echelon scarps. Levish and others (1992 #1715) measured four scarp profiles: one (P-1) on the northern strand and three (P-2 to P-4) on the southern half of the southern strand. These profiles document single-event scarps of about 2.2-2.5 m height (1.9-2.0 m surface offset) and compound (multiple-event) scarps of about 6.0-8.5 m height (5.2-7.5 m surface offset). All four of the profiled scarps have modest maximum scarp-slope angles of 10°-16°, but they are formed on relatively fine-grained easily eroded sediment. Levish and others' (1992 #1715) analysis of this data suggested that the younger scarps are late Pleistocene to Holocene in age, whereas as the larger scarps have morphology indicative of late Pleistocene movement. The compiler's evaluation of the scarp data suggests that the morphometric data from the younger scarps (P-3 and P-4) are similar to the Drum Mountains scarps (early Holocene) and the Bonneville shoreline (15 ka). Conversely, the compound scarps have nearly identical maximum scarp-slope angles as the single-event scarps, suggesting that the steepness of all the scarps is controlled by the younger (<15 ka) event.

Age of faulted deposits Maxwell (1986 #1720) mapped the faults as offsetting fine-grained Quaternary alluvium derived from Cretaceous sedimentary rock to the east. The smaller scarps are formed on alluvium of the lowest fluvial terrace, whereas the compound scarps are on alluvium that forms the next higher fluvial terrace. These deposits are likely to be latest or late Pleistocene in age (<130 ka). Levish and others (1992 #1715) reported that the scarps are locally muted (buried) by eolian sand. No studies or detailed mapping have been conducted to refine the age of the Quaternary sediment that are offset by the fault. To the north of New Mexico State Highway 117, the fault disappears beneath the McCartys basalt flow, which is estimated to be of latest Holocene age (400-1,200 yrs old) {see \Levish, 1992 #1715; Maxwell ,1986 # 1720}.

Detailed studies none

Timing of most recent paleoevent latest Pleistocene (<15 ka).
Comments: Timing deciphered from compiler's evaluation of Levish and others' (1992 #1715) scarp-morphology data. This estimate is consistent with the continuity of the scarps, and expression on the lowest of the fluvial terraces of local streams that cross the scarps.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: It appears that the slip rate probably falls in the <0.2 mm/yr category because the 1.9-2.0 m of offset from the most recent event was the result of strain accumulation over 15-120 k.y.

Length End to end (km): 13.3
Trace (km): 15.0

Average strike (azimuth) 003°±18°

Endpoints (lat. - long.) 34°43'47.45"N, 107°58'44.39"W
34°36'34.41"N, 107°58'44.77"W

References

#1738 Kelly, T.E., and Reynolds, C.B., 1989, Structural geology of the Malpais Valley, San Rafael, New Mexico, *in* Anderson, O.J., Lucas, S.G., Love, D.W., and Cather, S.M., eds., Southern Colorado Plateau: New Mexico Geological Society, 40th Field Conference, September 28-October 1, 1989, Guidebook, p. 119-121.

#1715 Levish, D.R., Vetter, U.R., Ake, J.P., and Piety, L.A., 1992, Seismotectonic study for Black Rock Dam, Bureau of Indian Affairs, Pueblo of Zuni, New Mexico: Bureau of Reclamation Seismotectonic Report 92-3, 62 p.

#1223 Machette, M.N., compiler, 1978, Preliminary geologic map of the Socorro 1° by 2° quadrangle, central New Mexico: U.S. Geological Survey Open-File Report 78-607, 1 sheet, scale 1:250,000.

#1024 Machette, M.N., and McGimsey, R.G., 1983, Map of Quaternary and Pliocene faults in the Socorro and western part of the Fort Sumner 1° x 2° quadrangles, central New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-A, 12 p. pamphlet, 1 sheet, scale 1:250,000.
#1720 Maxwell, C.H., 1986, Geologic map of El Malpais Lava Field and surrounding areas, Cibola [Valencia] County, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1595, 1 sheet, scale 1:62,500.

2141, Hachita Valley fault

Structure Number 2141
Comments:

Structure Name Hachita Valley fault
Comments: The Hachita Valley fault was named by Lawton and Harrigan (in press #1745) for its location along the western margin of Hachita Valley, southwest of Hachita, New Mexico. The fault extends along virtually the entire length of the Little Hachet Mountains (Hachita Peak 7.5-minute quadrangle) from at least as far north as New Mexico State Highway 9 south to a point about 1.5 km north of Hatchet Gap on New Mexico State Highway 81.

Synopsis: This Quaternary fault offsets piedmont-slope deposits that flank the eastern margin of the Little Hachet Mountains. The scarps are rather small (<6 m high), but may reflect two episodes of movement. No studies of scarp morphology have been made along the fault, nor has trenching or detailed mapping has been done.

Date of compilation 04/22/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey; Tim F. Lawton, New Mexico State University; William R. Seager, New Mexico State University

State New Mexico

County Hidalgo; Grant

1° x 2° sheet Douglas

Province Basin and Range

Reliability of location Good
Comments: Generalized trace of the central part of the fault is from geologic sketch map (fig. 1; ca. 1:24,000-scale) of Lawton and Harrigan (in press #1745), with additional mapping of northern and southern ends from unpublished aerial photoreconnaissance compiled at 1:100,000 scale by Lawton (written commun., 1998).

Geologic setting This slightly undulating, north-south-trending, down-to-the-east fault offsets proximal piedmont-slope deposits that flank the eastern margin of the Little Hatchet Mountain and forms part of the western margin of the Hachita Valley (Lawton and Harrington, in press #1745). The Little Hachet Mountains (which includes Hachita Peak) are a west-tilted block of mainly Jurassic rock that contains a NE-dipping Laramide thrust. The northern part of the mountains contain Cretaceous and early Tertiary rocks that are downdropped to the N and NE along the Copper Dick fault (Lawton and Harrington, in press #1745). The Hachita Valley fault cuts across these uplifted rocks to form a typical basin-and-range structure.

Sense of movement N

Dip not reported
Comments: High angle in shallow subsurface inferred from other Quaternary normal faults in this part of the southern Basin and Range province. However, east of Granite Pass (NW 1/4 Sec. 2, T. 30 S., R. 16 W.) the fault is crossed by a seismic-reflection profile that shows the fault to flatten with depth

and have a listric geometry (unpublished data of Kate Miller, UTEP). Thus, at seismogenic depths the fault might dip at moderate rather than high angle.

Dip direction E

Geomorphic expression The fault forms conspicuous, semi-continuous scarps as much as 6 m high on proximal piedmont slope-deposits that flank the eastern margin of the Little Hachet Mountains (Lawton and Harrington, in press #1745). The scarps are quite degraded according to Lawton (W.R. Seager, written commun., 1998), which suggests that they are older than 30 ka or possibly pre-late Pleistocene (>130 ka) in age. However, no scarp profiles have been measured to help document the age of the most recent or penultimate(?) faulting events.

Age of faulted deposits The fault offsets piedmont-slope deposits that have well developed calcic soils with stage IV calcareous B (Bk) horizons. Similarly developed soils in southern New Mexico are commonly of middle or early Pleistocene age (Machette, 1985 #1267). The piedmont-slope deposits probably correlate with the upper part of the Camp Rice and Palomas Formations, and thus would be Pleistocene in age. Holocene sediment (in channels and young fans) does not appear to be displace by the fault.

Detailed studies none

Timing of most recent paleoevent middle to late Quaternary (<750 ka)
Comments: Timing based on offset of soil on piedmont-slope deposits, which are early to possibly middle Pleistocene in age (based on correlation).

Recurrence interval not determined

Slip-rate category unknown, probably <0.2 mm/yr

Comments: The slip rate must be very low as evidenced by small scarps (<6 m) on deposits of middle(?) to early Pleistocene age. The degraded nature of the scarps suggests that they are pre-latest Pleistocene, and possibly pre-late Pleistocene in age.

Length End to end (km): 22.5
Trace (km): 22.7

Average strike (azimuth) 004°±10°

Endpoints (lat. - long.) 31°56′24.35″N, 108°24′38.31″W
31°44′16.58″N, 108°25′31.92″W

References

#1745 Lawton, T.F., and Harrington, P.J., in press, Jurassic Broken Jug Formation—Redefinition of lower part of Bisbee Group, Little Hatchet Mountains, Hidalgo County, New Mexico: New Mexico Geology, v. 20, no. 3.

#1267 Machette, M.N., 1985, Calcic soils of the southwestern United States, *in* Weide, D.L., ed., Soils and Quaternary geology of the southwestern United States: Geological Society of America Special Paper 203, p. 1-21.

2142, Faults near Cochiti Pueblo

Structure Number 2142

Structure Name Faults near Cochiti Pueblo
Comments: Numerous north-northwest trending normal faults are mapped near Cochiti Pueblo in the northwestern part of the Santo Domingo basin. Some of these faults are included in early compilations and regional mapping (Kelley, 1954 #1222; Smith and others, 1970 #1125; Kelley, 1977 #1106; Wong and others, 1995 #1155), but recent 1:24,000-scale mapping in the region has better defined the structural geology in this area (Smith and Kuhle, 1998 #1770; 1998 #1771). From west to east, named faults

in this area include: Borrego, Peralta, Camada, Sile, Domingo, and Cochiti faults (Smith and Kuhle, 1998 #1772).

Synopsis: Numerous north-northwest trending faults in the Santo Domingo basin near Cochiti Pueblo form a broad, low-relief accommodation zone between the eastward tilted Albuquerque basin to the south and the westward tilted Española basin to the north. Most of these faults offset the Bandelier Tuff and thus have been active since the early Pleistocene. Younger movements may be demonstrated by offset of middle Pleistocene terraces, but no fault scarps have been reported.

Date of compilation 05/20/98

Compiler and affiliation Stephen F. Personius, U.S. Geological Survey

State New Mexico

County Sandoval

1° x 2° sheet Albuquerque

Province Basin and Range

Reliability of location Good
Comments: Fault traces are from Smith and Kuhle (1998 #1770; 1998 #1771) and S.A. Minor (written commun., 1998) at a scale of 1:24,000, supplemented by mapping of Smith and others (1970 #1125) and Kelley (1977 #1106) at scales of 1:125,000 and 1:190,000, respectively.

Geologic setting Faults in the Santo Domingo basin of the Rio Grande rift near Cochiti Pueblo form a broad, low-relief accommodation zone between the eastward tilted Albuquerque basin to the south and the westward tilted Española basin to the north (Cather, 1992 #1773; Smith and Kuhle, 1998 #1772). This interpretation differs from some interpretations which imply the presence of a discrete northeast trending Santa Ana accommodation zone across this region (Chapin and Cather, 1994 #1180, fig. 2; May and Russell, 1994 #1775, fig. 3; Hawley and Whitworth, 1996 #1303, plate 2). The Cochiti fault lies in an area of complex structural geology between the Pajarito [2008] and La Bajada [2032] faults, and the Domingo fault may be a splay of the San Francisco fault [2031] (Smith and Kuhle, 1998 #1772).

Sense of movement N

Dip 47°-86°; most 60°-75°
Comments: Fault dip data are from S.A. Minor (written commun., 1998).

Dip direction E and W

Geomorphic expression Faults near Cochiti Pueblo are discontinuously exposed in Miocene to lower Pleistocene sediments of the Santa Fe Group, and in places offset the lower Pleistocene Bandelier Tuff (Smith and Kuhle, 1998 #1770; 1998 #1771); no fault scarps in surficial deposits have been reported.

Age of faulted deposits Most of these faults offset the lower Pleistocene Bandelier Tuff (Smith and Kuhle, 1998 #1770; Smith and Kuhle, 1998 #1771); several faults may offset middle Pleistocene terraces (Smith and Kuhle, 1996 #1774).

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Most of these faults offset the Bandelier Tuff, and thus have been active since the early Pleistocene. Younger movements may be demonstrated by offset of middle Pleistocene terraces (Smith and Kuhle, 1996 #1774), but no fault scarps have been reported.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr

Comments: No slip rates have been published, but reported offsets of 50-200 m of the lower Pleistocene Bandelier Tuff (Smith and Kuhle, 1996 #1774; Smith and Kuhle, 1998 #1772) across some of these faults indicate low long term slip rates.

Length (km) not applicable

Comments: This zone includes numerous faults that have an end to end length of 32.2 km and a cumulative trace length of 104.4 km.

Average strike (azimuth) -15°±18°

Endpoints (lat. - long.) 35°41′51.40″N, 106°20′48.93″W
35°24′59.56″N, 106°26′10.74″W

References

#1773 Cather, S.M., 1992, Suggested revisions to the Tertiary tectonic history of north-central New Mexico, *in* Lucas, S.G., Kues, B.S., Williamson, T.E., and Hunt, A.P., eds., San Juan basin IV: New Mexico Geological Society, 43rd Field Conference, September 30-October 3, 1992, Guidebook, p. 109-122.

#1180 Chapin, C.E., and Cather, S.M., 1994, Tectonic setting of the axial basins of the northern and central Rio Grande rift, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 5-25.

#1303 Hawley, J.W., and Whitworth, T.M., compilers, 1996, Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modeling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Report 402-D.

#1222 Kelley, V.C., 1954, Tectonic map of a part of the upper Rio Grande area, New Mexico: U.S. Geological Survey Oil and Gas Investigations Map OM-157, 1 sheet, scale 1:190,080.

#1106 Kelley, V.C., 1977, Geology of Albuquerque basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p., 2 pls.

#1775 May, S.J., and Russell, L.R., 1994, Thickness of the syn-rift Santa Fe Group in the Albuquerque basin and its relation to structural style, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 113-123.

#1774 Smith, G.A., and Kuhle, A.J., 1996, Inter-relationship of late Cenozoic tectonism, sedimentation, and volcanism, northern Santo Domingo basin, Rio Grande rift, New Mexico: Geological Society of America Abstracts with Programs, v. 28, no. 7, p. A-515.

#1770 Smith, G.A., and Kuhle, A.J., 1998, Geologic map of the Santo Domingo Pueblo quadrangle, Sandoval County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map OF-DM 15, 1 sheet, scale 1:24,000.

#1771 Smith, G.A., and Kuhle, A.J., 1998, Geologic map of the Santo Domingo Southwest quadrangle, Sandoval County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map OF-DM 26, 1 sheet, scale 1:24,000.

#1772 Smith, G.A., and Kuhle, A.J., 1998, Hydrostratigraphic implications of new geological mapping in the Santo Domingo basin, New Mexico: New Mexico Geology, v. 20, p. 21-27.

#1125 Smith, R.L., Bailey, R.A., and Ross, C.S., 1970, Geologic map of the Jemez Mountains, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-571, 1 sheet, scale 1:125,000.

#1155 Wong, I., Kelson, K., Olig, S., Kolbe, T., Hemphill-Haley, M., Bott, J., Green, R., Kanakari, H., Sawyer, J., Silva, W., Stark, C., Haraden, C., Fenton, C., Unruh, J., Gardner, J., Reneau, S., and House, L., 1995, Seismic hazards evaluation of the Los Alamos National Laboratory: Technical report to Los Alamos National Laboratory, Las Alamos, New Mexico, February 24, 1995, 3 volumes, 12 pls., 16 appen.

2143, Unnamed faults of Jemez Mountains

Structure Number 2143

Structure Name Unnamed faults of Jemez Mountains
Comments: This system of faults were mapped by Smith and others (1970 #1125) during a regional geologic reconnaissance of the Jemez Mountains. Although the faults are unnamed, they are closely associated with two Quaternary-age calderas (explosive volcanic edifaces) that form the core of the mountains. The most easterly of the faults is located about 6-10 km west of Los Alamos, New Mexico.

Synopsis: The faults that are characterized herein represent the structural walls of Quaternary calderas, possible collapse features (gravitationally driven slumps) that are on the margins of the calderas, and intracaldera faults that are associated with volcanic domes constructed during resurgence of the caldera floors. The caldera-wall structures have demonstrable Quaternary movement along faults that penetrate into the crust, but the other features may be more of a surficial nature. No detailed paleoseismic studies have been conducted on any of these faults, although much detailed research has concentrated on the timing, petrography, geochemistry, and volcanic processes involved in the caldera eruptions.

Date of compilation 07/27/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Sandoval; Los Alamos; Rio Arriba

1° x 2° sheet Albuquerque; Aztec

Province Southern Rocky Mountains

Geologic setting These faults represent the structural walls of Quaternary calderas [2143a, 2143b], possible collapse features (gravitationally driven slumps) that are on the margins of the calderas [2143c], and intracaldera faults [2143d] that are associated with volcanic domes constructed during resurgence of the caldera floors. Much of the geologic setting briefly described herein is abstracted from a classic article on the Bandelier Tuff (Smith and Bailey, 1966 #2069) and excellent geologic map of the Jemez Mountains that were completed nearly thirty years ago (Smith and others, 1970 #1125) . Two calderas—the Valles and Toleda—form the central, core of the Jemez Mountains. The calderas are roughly circular and have a ring-fracture zone that is largely buried by moat (intracaldera) sediment and intruded by post-eruptive volcanic domes related to resurgence of the calderas. Eruption of the Toleda caldera created the Otowi member of the Bandelier Tuff (Smith and others, 1970 #1125) at about 1.6 Ma (Izett and Obradovich, 1994 #1305). This is the more easterly of the two calderas and only the northeastern half is preserved. It is about 9 km in diameter, and its eastern margin is located only about 6-10 km from Los Alamos, New Mexico. Eruption of the younger Valles caldera created the Tshirege member of the Bandelier Tuff (Smith and others, 1970 #1125) at about 1.2 Ma (Izett and Obradovich, 1994 #1305). It is a larger caldera, being roughly 13-17 km in diameter and overlapping the older Toledo caldera on the east. The outflow facies of these two massive eruptions formed welded to unwelded ash-flow tuffs in and around the calderas, but the more distant airfall ash component is found in fluvial and lacustrine beds throughout N. Mex. and farther downwind in western Texas and adjacent states.

Number of sections 4
Comments: These unnamed faults are divided into four sections for ease of description. Faults of the first two sections [2143a, 2143b] are associated with the Valles and Toledo calderas (respectively), whereas faults of the third section [2145c] are associated with inward collapse of the caldera walls. The fourth section [2143d] includes intracaldera faults that are associated with volcanic domes constructed during resurgence of the Valles caldera.

Length (km)   not applicable
Comments: This system of faults has an end to end length of 24.0 km and a cumulative trace length of 224.3 km.

Average strike (azimuth) -41°±86°

Endpoints (lat. - long.) 35°59′42.97″N, 106°24′35.63″W
35°52′42.01″N, 106°37′58.49″W

2143a, Unnamed faults of the Valles caldera

Section number 2143a

Section name Unnamed faults of the Valles caldera
Comments: These faults form the ring-fracture zone of the Valles caldera.

Reliability of location Good
Comments: Digitized trace from 1:125,000-scale map of Jemez Mountains by Smith and others (1970 #1125). Although shown as a single concealed (dotted) fault on the map, the structure is more realistically shown as a 1-2 km wide zone of parallel circular faults on cross section B of Smith and others (1970 #1125).

Sense of movement N

Dip not reported
Comments: Shown, somewhat schematically, by Smith and others (1970 #1125) as dipping about 75° on cross-section B.

Dip direction not applicable
Comments: These faults dip toward the center of the Valles caldera and form a ring-like (circular) pattern. As such, they dip in all directions of the compass.

Geomorphic expression These faults form the structural wall of a collapsed volcanic edifice (the Valles caldera). The resultant escarpments are formed on the Bandelier Tuff and underlying late Tertiary volcanic rocks. There are no scarps mapped in the post-eruptive sedimentary moat fill, although collapse of the caldera margins may have continued later into the Quaternary.

Age of faulted deposits These faults displace the Bandelier Tuff, specifically the Tshirege member of the Bandelier Tuff (Smith and others, 1970 #1125), which has been dated at about 1.2 Ma (Izett and Obradovich, 1994 #1305). Volcanic domes (Quaternary Valles Rhyolite) have been emplaced along the ring-fracture zone after the eruption, but they do not appear to be disturbed by later movement on the faults comprising the ring-fracture zone.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Movement probably is mainly at 1.2 Ma during eruption of the Tshirege member of the Bandelier Tuff (Smith and others, 1970 #1125).

Recurrence interval not reported

Slip Rate unknown; probably <0.2 mm/yr

Length (km)   not applicable
Comments: This zone includes several faults that have an end to end length of 16.7 km and a cumulative trace length of 46.7 km.

Average strike (azimuth) -90°±101°

Endpoints (lat. - long.) 35°53′56.42″N, 106°27′4.95″W
35°53′48.84″N, 106°38′11.56″W

2143b, Unnamed faults of the Toledo caldera

Section number 2143b

Section name Unnamed faults of the Toledo caldera
Comments: These faults form the ring-fracture zone of the Toledo caldera.

Reliability of location Good

Comments: Digitized trace from 1:125,000-scale map of Jemez Mountains by Smith and others (1970 #1125). Although shown as a single concealed fault on the map, the structure is more realistically a 1-2 km wide zone of parallel faults as shown for the adjacent Valles caldera on cross section B of Smith and others (1970 #1125).

Sense of movement N

Dip not reported
Comments: Probably high-angle as shown for the adjacent Valles caldera by Smith and others (1970 #1125) on cross-section B.

Dip direction not applicable
Comments: These faults dip toward the center of the Toledo caldera and form a circular (ring-like) pattern. As such, they dip in all directions of the compass.

Geomorphic expression These faults for the structural wall of a collapsed volcanic edifice (caldera). The resultant escarpments are formed in the Bandelier Tuff and underlying late Tertiary volcanic rocks. There are no scarps mapped in the post-eruptive sedimentary moat fill, although collapse of the caldera margins may have continued later into the Quaternary.

Age of faulted deposits These faults displace the Bandelier Tuff, specifically the Otowi member of the Bandelier Tuff (Smith and others, 1970 #1125), which has been dated at about 1.6 Ma (Izett and Obradovich, 1994 #1305). Volcanic domes (Cerro Rubio Quartz Latite and Cerro Toledo Rhyolite, Quaternary) have been emplaced along the ring-fracture zone and within the caldera, but they do not appear to be disturbed by later movement on the faults.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Movement probably is mainly at 1.6 Ma during eruption of the Otowi member of the Bandelier Tuff (Smith and others, 1970 #1125).

Recurrence interval not reported

Slip Rate unknown; probably <0.2 mm/yr

Length (km) not applicable
Comments: This zone includes several faults that have an end to end length of 10.9 km and a cumulative trace length of 25.0 km.

Average strike (azimuth) -47°±77°

Endpoints (lat. - long.) 36°00′04.09″N, 106°26′02.58″W
35°54′12.21″N, 106°26′58.87″W

2143c, Unnamed faults along the Valles and Toledo caldera walls

Section number 2143c

Section name Unnamed faults along the Valles and Toledo caldera walls
Comments: These faults form semicircular patterns with down-to-the-center movement suggestive of collapse of the walls of the Valles and Toledo calderas.

Reliability of location Good

Comments: Digitized trace from 1:125,000-scale map of Jemez Mountains by Smith and others (1970 #1125).

Sense of movement N

Comments: These faults are probably associated with minor collapse along the margins of both of these calderas. Smith and others (1970 #1125) show them as all having a normal sense of displacement.

Dip not reported

Comments: Their curvilinear form and association with ring-fracture faults of the calderas [2143a, 2143b] suggest that they may be of moderate to low angle. However, Smith and others (1970 #1125) did not show any dip angles on their maps.

Dip direction not applicable

Comments: These faults dip toward the centers of the calderas. They are roughly hemispherical in form, and resemble large landslides.

Geomorphic expression These faults from scarps of unknown height and displacement in consolidated sediment and rock (the Bandelier Tuff and underlying late Tertiary volcanic rock). No studies have been made of the size or morphology of the scarps.

Age of faulted deposits These faults displace both members of the Bandelier Tuff (1.2-1.4 Ma) and older volcanic rocks (late Tertiary or early Quaternary) of the Jemes Mountains.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)

Comments: Movement probably is mainly at 1.2-1.4 Ma during eruptions of the Valles and Toledo calderas (Smith and others, 1970 #1125).

Recurrence interval not reported

Slip Rate unknown; probably <0.2 mm/yr

Length (km) not applicable

Comments: This zone includes several faults that have an end to end length of 20.3 km and a cumulative trace length of 57.5 km.

Average strike (azimuth) -37°±74°

Endpoints (lat. - long.) 36°00′50.67″N, 106°35′36.82″W
35°54′08.76″N, 106°24′57.10″W

2143d, Unnamed faults related to resurgent dome of the Valles caldera

Section number 2143d

Section name Unnamed faults related to resurgent dome of the Valles caldera

Reliability of location Good

Comments: Trace from 1:125,000-scale map of Jemez Mountains by Smith and others (1970 #1125).

Sense of movement N

Comments: These intracaldera faults are associated with volcanic domes constructed during resurgence of the Valles caldera. Smith and others (1970 #1125) show them as all having a normal sense of displacement.

Dip not reported

Dip direction not applicable

Comments: These faults dip in all directions of the compass, although the more continuous ones appear to have a preferred northeasterly orientation.

Geomorphic expression These faults from scarps of unknown height and displacement on rhyolitic domes (the Valles Rhyolite) and ash-flow tuff (Bandelier Tuff) that form the core of the resurgent dome of the Valles caldera. No studies have been made of the size or morphology of the scarps.

Age of faulted deposits The faults cut Quaternary volcanic rocks (Valles Rhyolite and Bandelier Tuff) that are 1.6 Ma and younger.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Movement is certainly younger than 1.6 Ma (age of the Otowi member of the Bandelier Tuff).

Recurrence interval not reported

Slip Rate unknown; probably <0.2 mm/yr

Length (km) not applicable
Comments: This zone includes numerous faults that have an end to end length of 11.3 km and a cumulative trace length of 95.2 km.

Average strike (azimuth) -17°±82°

Endpoints (lat. - long.) 35°55′23.03″N, 106°30′17.99″W
35°51′59.73″N, 106°36′34.84″W

References

#1305 Izett, G.A., and Obradovich, J.D., 1994, $^{40}Ar/^{39}Ar$ age constraints for the Jaramillo Normal Subchron and Matuyama-Brunhes geomagnetic boundary: Journal of Geophysical Research, v. 99, no. B2, p. 2925-2934.
#2069 Smith, R.L., and Bailey, R.A., 1966, The Bandelier Tuff; a study of ash-flow eruption cycles from zoned magma chambers: Bulletin Volcanologique, v. 29, p. 83-104.
#1125 Smith, R.L., Bailey, R.A., and Ross, C.S., 1970, Geologic map of the Jemez Mountains, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-571, 1 sheet, scale 1:125,000.

0000S, Continental Divide fault (suspect)

Structure Number 0000S
Comments: Fault is unnumbered owing to its suspect origin.

Structure Name Continental Divide fault
Comments: This suspect fault extends about 9 km along the Continental Divide from just north of New Mexico State Highway 36 to near Penasco Lakes. Although unnamed by Anderson (1986 #1281), who first mapped it, Levish and others (1992 #1715) named it for its proximity to the Continental Divide.

Synopsis: Little is known about this northeast-trending suspect fault; it reportedly forms a low, but prominent scarp on Quaternary basalts of the North Plains lava field. The trend of the feature is parallel to a string of eruptive basalt cones that occupy the center of the field, which suggests that movement on the fault may be controlled by volcanism and deeper-seated crustal structures. No detailed studies have been conducted to determine the timing of movement or amount of offset of the basalt. Some authors have suggested that the scarp may be the result of volcanic processes, but its association with a mapped bedrock fault supports an interpretation of a tectonic origin.

Date of compilation 07/27/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Valencia

1° x 2° sheet Saint Johns

Province Basin and Range

Reliability of location Good
Comments: Trace from 1:100,000-scale geologic map of the Fence Lake 1/2° x 2° quadrangle compiled by Anderson (1986 #1281).

Geologic setting This northeast-trending feature appears to offset the southern part of the North Plains lava field and is parallel to eruptive basalt cones that occupy the center of the field. These cones mark the southwestern trace of the Jemez lineament (also called Springer-Raton lineament), which is one of many northeast-trending crustal structures that control the location of young volcanism within and outside of the northern Rio Grande rift in New Mexico. The southern end of the feature is mapped as cutting the Miocene(?) Fence Lake Formation {(Anderson, 1986 #1281). If this association is not a spatial coincidence, it would support a tectonic origin..

Sense of movement N
Comments: As reported by Anderson (1986 #1281).

Dip Not reported

Dip direction SE
Comments: Inferred from escarpment which faces southeast.

Geomorphic expression Fault forms a scarp of 2-3 m height (Orin Anderson, written commun., 1997) on basalts of the North Plains lava field. Levish and others (1992 #1715) argued that the scalloped appearance of the escarpment suggests it is a volcanic flow margin and not a fault.

Age of faulted deposits This feature appears to offset Quaternary basalts according to Anderson (1986 #1281). The Jaralosa Draw lobe (flow), which extends west from the North Plains lava field, has been dated at about 1.4±0.3 Ma (see Campbell, 1989 #1276). The central part of the lava field, where this fault exists, may be younger than 1.4 Ma on the basis of the seemingly young appearance of cinder cones, such as at Chimney Hill. In support of this observation, Levish and others (1992 #1715) cited an unpublished (in 1992) date of 670-700 ka for the basalt on which the escarpment is mapped.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: Timing poorly controlled. Based on presence of scarp on Quaternary basalt.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: Low slip rate estimated from presence of scarp of 2-3 m height (Orin Anderson, written commun., 1997) on Quaternary age basalt.

References

#1281 Anderson, O.J., compiler, 1986, Geologic map of Fence Lake, New Mexico 1:100,000 metric sheet: New Mexico Bureau of Mines and Mineral Resources Open-File Report 220, 4 p. pamphlet, 4 sheets, scale 1:100,000.

#1276 Campbell, F., 1989, Geology and coal resources of Fence Lake 1:50,000 quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 62, 2 sheets, scale 1:50,000.

#1715 Levish, D.R., Vetter, U.R., Ake, J.P., and Piety, L.A., 1992, Seismotectonic study for Black Rock Dam, Bureau of Indian Affairs, Pueblo of Zuni, New Mexico: Bureau of Reclamation Seismotectonic Report 92-3, 62 p.

0000S, Unnamed fault of Bonita Canyon (suspect)

Structure Number 0000S

Structure Name Unnamed fault of Bonita Canyon (suspect)
Comments: This suspect fault was first mapped by Maxwell (1986 #1720). Levish and others (1992 #1715), as part a regional reconnaissance for a dam-hazards study, characterized it a non-tectonic feature related to volcanic processes. Levish and others (1992 #1715) referred to it as one of the faults in the Zuni-Bandera volcanic field. This fault forms a north-trending scarp(?) across the Twin Craters and El Calderon lava flows south of Bonita Canyon. The scarp is located at the south end of Cerritos de Jaspe (a prominent, west-facing ridge), which is just east of Bonita Canyon.

Synopsis: This suspect fault is mapped on older (Quaternary) basalt flows of El Malpais lava field. The fault may represent reactivation of a bedrock fault that is concealed in Bonita Canyon, but which must juxtapose Precambrian rock on the west against Paleozoic rock on the east. However, similar mapped features within El Malpais lava field are considered by Levish and others (1992 #1715) to be related to volcanic processes. No detailed studies of the fault has been conducted to confirm its origin or document the amount of vertical displacement that may be associated with it. Thus, the feature is herein considered to be of suspect origin

Date of compilation 04/07/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Valencia

1° x 2° sheet Socorro

Province Colorado Plateaus

Reliability of location Good
Comments: Trace shown on 1:62,500-scale geologic map of Maxwell (1986 #1720).

Geologic setting The fault is in Quaternary (undifferentiated) basalt flows according to the mapping of Maxwell (1986 #1720). It trends north on the basalts, and northwest up Bonita Canyon where it juxtaposes Precambrian rock on the west against Paleozoic rock on the east.

Sense of movement not reported
Comments: Although not reported, mapping by Maxwell (1986 #1720) indicates that Paleozoic bedrock is downdropped on the eastern side of the fault relative to Precambrian bedrock along a northern (concealed) extension of the fault. Conversely, where the fault crossed the El Calderon flow it appears to form a west-facing scarp.

Dip not reported

Dip direction not reported

Geomorphic expression The faults forms a 2-km-long north-trending scarp(?) on basaltic lava flows (Maxwell, 1986 #1720). Levish and others (1992 #1715) suggested that the fault is related to volcanic processes and is not of tectonic origin. No measurements of any vertical displacement have been made across the fault to confirm the amount or direction of possible movement.

Age of faulted deposits Maxwell (1986 #1720) mapped the fault as offsetting the Twin Craters lava flow, which is shown as a Quaternary basalt. In addition, just south of New Mexico State Highway 53 the fault is mapped as crossing a small tongue of El Calderon flow, which is older than the Twin Craters. Neither of these basalt flows were dated at the time Maxwell's (1986 #1720) map was published.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)

Comments: The fault features are present on two different-aged Quaternary basalt flows.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No measurement of offset across the fault has been reported. If the scarps(?) are formed on an early Quaternary age landscape, the recurrence interval for accumulating stress prior to the most recent faulting (suspect) event could be 750 k.y. or more. Thus, it seems reasonable that slip rates associated with these suspect faults would be very low (<0.2 mm/yr).

References
#1715 Levish, D.R., Vetter, U.R., Ake, J.P., and Piety, L.A., 1992, Seismotectonic study for Black Rock Dam, Bureau of Indian Affairs, Pueblo of Zuni, New Mexico: Bureau of Reclamation Seismotectonic Report 92-3, 62 p.
#1720 Maxwell, C.H., 1986, Geologic map of El Malpais Lava Field and surrounding areas, Cibola [Valencia] County, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1595, 1 sheet, scale 1:62,500.

0000S, Unnamed faults of El Malpais lava field (suspect)

Structure Number 0000S

Structure Name Unnamed faults of El Malpais lava field (suspect)
Comments: These faults were first mapped by Maxwell (1986 #1720); additional structures were mapped to the west by Baldridge and others (1989 #1741). Levish and others (1992 #1715), as part a regional reconnaissance for a dam-hazards study, characterized them as non-tectonic features related to volcanic processes. Levish and others (1992 #1715) referred to the features as faults in the Zuni-Bandera volcanic field. The faults form four groups on El Malpais lava field. The southern group trends north across the North Plains, and the main (longest) feature is named La Rendija (Spanish, The Crack). The southern extent of these faults is unknown, but Maxwell (1986 #1720) suggested that they extend several miles (>3 km) south of his mapped area (south of 34° 40′ S.). The western group, as mapped by Baldridge and others (see fig. 5 1989 #1741) is comprised of about a dozen short northeast-trending faults located in th southern part of North Plains, mainly north of New Mexico State Highways 36 and 177. The northern group is comprised of two short north-northeast trending faults located about 3 km south and southwest of Hoya de Cibola (Maxwell, 1986 #1720). The northeastern group is comprised of four short faults that trend north to northeast; they are located about 5 km southeast of Cerro Encierro.

Synopsis: These four groups of suspect faults form numerous fissures and cracks on early Quaternary basalt flows of El Malpais lava field. They may include pressure ridges and collapsed lava tubes that give the expression of tectonic activity, but could be related to volcanic processes. Thus, the features are considered to be of suspect origin. No detailed studies of the features have been conducted to confirm their origin or document the amount of vertical displacement that may be associated with them.

Date of compilation 04/10/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Valencia

1° x 2° sheet St. Johns

Province Colorado Plateaus

Reliability of location Good

Comments: Fault traces are shown on 1:62,500-scale geologic map of Maxwell (1986 #1720) and small-scale geologic map of Baldridge and others (1989 #1741). Extensions of the fault features south of Maxwell's mapping are shown on 1:100,000-scale geologic map of Anderson (1986 #1281).

Geologic setting The fault features are present on Quaternary (undifferentiated) basalt flows according to the mapping of Maxwell (1986 #1720). They trend north and northeast and may be related to extension (E-W) or to the NE-trending Jemez lineament. Levish and others (1992 #1715) characterized the faults as non-tectonic features related to volcanic processes.

Sense of movement N
Comments: As mapped by Maxwell (1986 #1720), although the features are mainly fissures that may not correspond to vertical displacement.

Dip not reported

Dip direction W; NW; E
Comments: Inferred from aspect of normal-dip fault scarps(?) shown by Maxwell (1986 #1720) and Baldridge and others (1989 #1741).

Geomorphic expression The faults form short north- and northeast-trending en echelon scarps (?), fissures and open crevices in lava flows (Maxwell, 1986 #1720). Levish and others (1992 #1715) suggested that the faults are really numerous fissures, cracks, pressure ridges, and collapsed lava tubes that give the expression of tectonic activity, but are in fact related to volcanic processes.

Age of faulted deposits Maxwell (1986 #1720) mapped the faults as offsetting Quaternary basalts that have reported K-Ar ages of 0.788 Ma near Cerro Bandera, and 1.38 Ma several miles west of the mapped area. These dates suggest that the older (undifferentiated) basalts flows (Qb) are mainly early Quaternary.

Detailed studies none

Timing of most recent paleoevent Quaternary (<1.6 Ma)
Comments: The fault features are present on basalts flows (Qb) of early Quaternary age. However, Maxwell (1986 #1720) suggested that the southern group of features (La Rendija) are Holocene in age because the crevices lack alluvial fill, thus indicating a very young age for the formation of the features. In addition, he suggested that numerous small fault scarps (?) in unconsolidated alluvium at the eastern edge of North Plains are also very young.

Recurrence interval not reported

Slip-rate category unknown; probably <0.2 mm/yr
Comments: No measurement of offset across the features have been reported. If the features are really faults of Holocene age (Maxwell, 1986 #1720) and have substantial (>10 m) of offset, then they could have a slip rate that exceeds 0.2 mm/yr. However, the features are formed on an early Quaternary age landscape, thus the recurrence interval for accumulating stress prior to the most recent faulting (suspect) event could be 750 k.y. or more. Thus, it seems reasonable that slip rates associated with these suspect faults would be very low (<0.2 mm/yr).

References
#1281 Anderson, O.J., compiler, 1986, Geologic map of Fence Lake, New Mexico 1:100,000 metric sheet: New Mexico Bureau of Mines and Mineral Resources Open-File Report 220, 4 p. pamphlet, 4 sheets, scale 1:100,000.

#1741 Baldridge, W.S., Perry, F.V., Vaniman, D.T., Nealey, L.D., Leavy, B.D., Laughlin, A.W., Kyle, P., Bartov, Y., Steinitz, G., and Gladney, E.S., 1989, Excursion 8A—Magmatism associated with lithospheric extension—Middle to late Cenozoic magmatism of the southeastern Colorado Plateau and central Rio Grande rift, New Mexico and Arizona, *in* Chapin, C.E., and Zidek, J., eds., Field excursions to volcanic terranes in the Western United States, v. I, Southern Rocky Mountain region: New Mexico Bureau of Mines and Mineral Resources Memoir 46, p. 187-202.

#1715 Levish, D.R., Vetter, U.R., Ake, J.P., and Piety, L.A., 1992, Seismotectonic study for Black Rock Dam, Bureau of Indian Affairs, Pueblo of Zuni, New Mexico: Bureau of Reclamation Seismotectonic Report 92-3, 62 p.
#1720 Maxwell, C.H., 1986, Geologic map of El Malpais Lava Field and surrounding areas, Cibola [Valencia] County, New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1595, 1 sheet, scale 1:62,500.

0000D, Barrera fault (discounted)

Structure Number 0000D

Structure Name Barrera fault
Comments: Named by Kelley (1971 #992) during a regional study of bedrock geology of southeastern New Mexico. Origin of name unknown; suspected fault extends about 25 km along base of the Capitan reef (bedrock) escarpment, due south of Carlsbad Caverns National Park.

Reason for exclusion: On aerial photographs Kelley (1971 #992) noted the sharp linear change in vegetation along the basal slope of the Capitan reef escarpment. However, Hayes and Bachman (1979 #1375) reexamined the localities where Kelly has described surface faults and concluded that the steep dips observed along the escarpment were due to original sedimentary dip. The linear pattern noted by Kelly appears to reflect the long and poorly understood process of reef-front exhumation that has probably been taking place episodically since earliest Triassic time (Adams and others, 1993 #1669).

Date of compilation 03/15/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Eddy

1° x 2° sheet Carlsbad

Province Great Plains

References
#1669 Adams, J.W., Hawley, J.W., Pray, L.C., and Love, D.W., 1993, Second-day road log, from Carlsbad to Whites City, Guadalupe Mountains National Park, Salt Flat, Washington Ranch and return to Carlsbad, *in* Love, D.W., Hawley, J.W., Kues, B.S., Adams, J.W., Austin, G.S., and Barker, J.M., eds., Carlsbad region, New Mexico and West Texas: New Mexico Geological Society, 44th Field Conference, October 6-9, 1993, Guidebook, p. 43-47.
#1375 Hayes, P.T., and Bachman, G.O., 1979, Examination and reevaluation of evidence for the Barrera fault, Guadalupe Mountains, New Mexico: U.S. Geological Survey Open-File Report 79-1520, 11 p.
#992 Kelley, V.C., 1971, Geology of the Pecos country, southeastern New Mexico: [New Mexico] Bureau of Mines and Mineral Resources Memoir 24, 75 p., 7 pls.

0000D, Carlsbad fault (discounted)

Structure Number 0000D

Structure Name Carlsbad fault
Comments: Probably named by Kelley (1971 #992) during a regional study of bedrock geology of southeastern New Mexico. Origin of name is unknown, but is most likely named for the fault's proximity to Carlsbad, New Mexico. The fault extends from about 2 miles north of the entrance to Dark Canyon for 5 miles northeasterly toward Carlsbad (Kelley, 1971 #992).

Reason for exclusion: On aerial photographs, Kelley (fig. 24, 1971 #992) and Kelley and Singletary (fig. 2, 1971 #1749) noted a sharp vegetation lineament in bedrock near the mouth of Sheep Canyon (Draw), southwest of Carlsbad, New Mexico. The fault downdrops rocks of the Salado Formation (Permian) against the Tansill Formation (Permian). Although Kelley and Singletary (1971 #992) infer young (*i.e.*, Quaternary) movement from the contact (fig. 1) and the striking appearance of the lineament (fig. 2), we are not aware of any stratigraphic evidence that supports Quaternary movement. Until further studies are conducted on the surface trace of the Carlsbad fault, it is herein characterized as a discounted fault.

Date of compilation 04/29/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Eddy

1° x 2° sheet Carlsbad

Province Great Plains

References

#992 Kelley, V.C., 1971, Geology of the Pecos country, southeastern New Mexico: [New Mexico] Bureau of Mines and Mineral Resources Memoir 24, 75 p., 7 pls.

#1749 Kelley, V.C., and Singletary, C.E., 1971, Road log of a route in the Carlsbad to Roswell area (Third Day), *in* Kelley, V.C., ed. Stratigraphy and structure of the Pecos country, southeastern New Mexico: West Texas and Roswell Geological Societies Publication 71-58, October 27-29, 1971, Guidebook, p. 31-34.

0000D, Dan Valley fault zone (discounted)

Structure Number 0000D

Structure Name Dan Valley fault zone
Comments: Origin of name unknown, but probably named after local geographic feature (Dan Valley).

Reason for exclusion: The Dan Valley fault zone was evaluated by Levish and others (1992 #1715) as part of a dam hazards study. It was considered as a possible Quaternary seismic source on the basis of its depiction on published geologic maps. These maps show Quaternary gravels in fault contact with Precambrian rocks and the solid-line fault contacts imply Quaternary movement. At many places along the mapped contact, there is a bedrock escarpment. An alternate explanation is that the contact is depositional and that the escarpment is a fault-line scarp or cliff that is parallel or subparallel to the fault trace and thus results from differential erosion.

Levish and others (1992 #1715) cited Chamberlin as concluding that the Dan Valley and associated faults are Laramide in age, and also concludes that there is no evidence for late Tertiary extension of these faults in association with the uplift of the adjacent Zuni Mountains. Levish and others' field investigations and study of 1:80,000- and 1:24,000-scale aerial photographs did not yield evidence consistent with Quaternary displacement along the Dan Valley fault (see p. 33 in Levish and others, 1992 #1715), and thus the fault is discounted herein as a Quaternary structure.

Date of compilation 04/10/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Valencia

1° x 2° sheet Gallup

Province Colorado Plateaus

References

#1715 Levish, D.R., Vetter, U.R., Ake, J.P., and Piety, L.A., 1992, Seismotectonic study for Black Rock Dam, Bureau of Indian Affairs, Pueblo of Zuni, New Mexico: Bureau of Reclamation Seismotectonic Report 92-3, 62 p.

0000D, Jaralaso Draw fault (discounted)

Structure Number 0000D

Structure Name Jaralaso Draw fault (discounted)

Comments: These faults are shown as in alluvial valleys and along the southern margin of the Jaralaso Draw lobe of the North Plains lava field (also known as the Malpais or Zuni-Bandera field) on a regional compilation by Campbell (1989 #1276). The scarps in alluvial valleys are north and south of Santa Rita Mesa, whereas the scarps on alluvium and on basalt are located along the north side of Jaralosa Draw and Jaralosa Canyon (north of Santa Rita Mesa), south and southwest of Atarque, New Mexico, in the northwestern part of the state. Levish and others (1992 #1715) named them as part of a dam hazards study

Reason for exclusion: Campbell's map (1989 #1276) shows the subject faults by dashed and solid in areas that are underlain by Pleistocene alluvium that is seemly young (occupying lowest topographic position and alluvial stream channels). No dotted faults are shown on the map. As a result of conversations with Orin Anderson (New Mexico Bureau of Mines and Mineral Resources), who compiled the adjacent map (Anderson, 1987 #1275) and the new geologic map of the State, these faults are inappropriately depicted and should have been mapped as concealed faults. They are based on bedrock mapping, not detailed Quaternary mapping.

In addition, some of the faults mapped as displacing Pleistocene basalt appear to be more reasonably interpreted as a combination of terrace risers, landslides, and/or the margin of a basalt flow (Levish and others, 1992 #1715). Levish and others (1992 #1715) came to these conclusions based on aerial reconnaissance, field investigation, and aerial photographic analysis. The faults along Jaralosa Canyon include some concealed faults in addition to faults that displace the surface of the 1.4-Ma Jaralosa Draw lobe of the North Plains lava field (see Campbell, 1989 #1276). However, all of these faults are located along the southern margin of the flow, suggesting that they are gravitational features related to lateral (southward) spreading of the unbuttressed margin of the flow. Further studies are need to document if any Quaternary movement has occurred on any of the concealed faults.

Date of compilation 04/14/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Valencia

1° x 2° sheet St. Johns

Province Colorado Plateaus

References

#1275 Anderson, O.J., 1987, Geology and coal resources of Atarque Lake 1:50,000 quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 61, 2 sheets, scale 1:50,000.

#1276 Campbell, F., 1989, Geology and coal resources of Fence Lake 1:50,000 quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 62, 2 sheets, scale 1:50,000.

#1715 Levish, D.R., Vetter, U.R., Ake, J.P., and Piety, L.A., 1992, Seismotectonic study for Black Rock Dam, Bureau of Indian Affairs, Pueblo of Zuni, New Mexico: Bureau of Reclamation Seismotectonic Report 92-3, 62 p.

0000D, Malpais fault (discounted)

Structure Number 0000D

Structure Name Malpais fault

Comments: This fault is named for Malpais, a locality just north of the International Boundary with Mexico (Las Cruces 1° x 2° quadrangle). As mapped by Seager (1995 #975), the inferred trace of the fault extends for about 18 km along the west side of the West Potrillo Mountains from just east of Eagle Nest south into Mexico, crossing the border just east of Camel Mountain.

Reason for exclusion: Little is known about this north-trending fault. It was inferred to have a surficial trace in Quaternary basalt on the basis of mapping by Seager (1995 #975). However, Seager suggests deleting the fault as a demonstrable Quaternary structure (W.R. Seager, written comm., 1998). He says that the fault has no surface indication—it does not cut basalt. However, its presence in the subsurface is indicated by a steep gravity gradient, which presumably marks the fault at the edge of an early (Tertiary) rift basin. No detailed studies or mapping have been performed.

Date of compilation 04/10/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Dona Ana

1° x 2° sheet El Paso

Province Basin and Range

References
#975 Seager, W.R., 1995, Geology of southwest quarter of Las Cruces and northwest El Paso 1° x 2° sheets, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 60, 5 sheets, scale 1:125,000.

0000D, Mangas fault (discounted)

Structure Number 0000D
Comments: Fault number 112 of Machette and others (1986 #1033).

Structure Name Mangas fault
Comments: Named after the Mangas Valley, a graben-like feature that extends northwest trending from the Continental Divide (about 2 km southwest of Tyrone, New Mexico). The name Mangas probably was first applied to this fault by Gillerman (1964 #1743).

Reason for exclusion: This fault is shown on various maps as cutting Quaternary-Tertiary basin-fill deposits (see Gillerman, 1964 #1743; Drewes and others, 1985 #1034). Paige (1922 #1744) mentioned that faults in the Tyrone area (probably the Mangas fault) place Quaternary sediment against bedrock, but Machette and others (1986 #1033) found that Pleistocene alluvium, which unconformably overlies the Gila Conglomerate (Pleistocene(?) to Miocene) in the area of Tyrone, New Mexico., is not displaced by the fault. This same relation was shown on detailed maps of the area by Hedlund (1978 #1746; 1978 #1747). Locally, the Gila has been down-faulted and rotated against Precambrian to Tertiary bedrock along the Mangas fault (see Drewes and others, 1985 #1034), resulting in a prominent fault-line scarp that may have been rejuvenated by entrenchment of the Mangas River. Near the northwest end of the

Little Burro Mountains, Pliocene(?) basalt that is interbedded with the Gila Conglomerate appears to have been offset little (or not at all) where it straddles the Mangas fault. From this evidence, Machette and others (1986 #1033) concluded that the Mangas fault may have been active in the Pliocene, but not necessarily in the Quaternary. Further studies are need to document if any Quaternary movement has occurred on the Mangas fault.

Date of compilation 04/21/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Grant

1° x 2° sheet Silver City

Province Basin and Range

References

#1034 Drewes, H., Houser, B.B., Hedlund, D.C., Richter, D.H., Thorman, C.H., and Finnell, T.L., 1985, Geologic map of the Silver City 1° x 2° quadrangle New Mexico and Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-1310-C, 1 sheet, scale 1:250,000.

#1743 Gillerman, E., 1964, Mineral deposits of western Grant County, New Mexico: [New Mexico] State Bureau of Mines and Mineral Resources Bulletin 83, 213 p., 11 pls.

#1746 Hedlund, D.C., 1978, Geologic map of the Wind Mountain quadrangle, Grant County, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1031, 1 sheet, scale 1:24,000.

#1747 Hedlund, D.C., 1978, Geologic map of the Tyrone quadrangle, Grant County, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1037, 1 sheet, scale 1:24,000.

#1033 Machette, M.N., Personius, S.F., Menges, C.M., and Pearthree, P.A., 1986, Map showing Quaternary and Pliocene faults in the Silver City 1° x 2° quadrangle and the Douglas 1° x 2° quadrangle, southeastern Arizona and southwestern New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1465-C, 12 p. pamphlet, 1 sheet, scale 1:250,000.

#1744 Paige, S., 1922, Copper deposits of the Tyrone District, New Mexico: U.S. Geological Survey Professional Paper 122, 53 p., 6 pls.

0000D, Moreno Hill fault (discounted)

Structure Number 0000D

Structure Name Moreno Hill fault

Comments: Campbell (1989 #1276) showed a 16-km-long, north-south-trending fault south of Moreno Hill, for which it is named.

Reason for exclusion: Campbell's map (1989 #1276) shows the Moreno Hill fault with a solid contact in Quaternary units, although the maps from which Campbell compiled (see Levish and others, 1992 #1715) showed the structures as inferred (concealed) from stratigraphic offset in adjacent Cretaceous rocks. According to Levish and others (1992 #1715), the contacts were probably inadvertently modified to definite fault contacts, which from map presentation only imply Quaternary activity. Their field investigations and aerial photo interpretations did not reveal any evidence of Quaternary activity along this post-Cretaceous fault. Therefore, the Moreno Hill fault is herein considered to be of probable pre-Quaternary age (*i.e.,* discounted as a Quaternary fault).

Date of compilation 04/16/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Catron, Valencia

1° x 2° sheet St. Johns

Province Colorado Plateaus

References

#1276 Campbell, F., 1989, Geology and coal resources of Fence Lake 1:50,000 quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 62, 2 sheets, scale 1:50,000.

#1715 Levish, D.R., Vetter, U.R., Ake, J.P., and Piety, L.A., 1992, Seismotectonic study for Black Rock Dam, Bureau of Indian Affairs, Pueblo of Zuni, New Mexico: Bureau of Reclamation Seismotectonic Report 92-3, 62 p.

0000D, Nutria monocline (discounted)

Structure Number 0000D

Structure Name Nutria monocline

Comments: Origin of name unknown, but probably named after small town of Upper Nutria.

Reason for exclusion: The Nutria Monocline was evaluated by Levish and others (1992 #1715) as part of a dam hazards study. It was considered as a possible Quaternary seismic source on the basis of inferences by previous workers (see p. 34 in Levish and others, 1992 #1715) that an erosional surface covered with upper Tertiary, and possibly Quaternary, deposits had been deformed by uplift of the Zuni Mountains, south of Gallup, New Mexico.

Most of the evidence cited by Levish and others (1992 #1715) for movement on the Nutria monocline would be the result of uplift of the Zuni Mountains. The uplift is inferred from geomorphic considerations, such as stream gradients and amounts of local and regional stream downcutting. More importantly, the cover deposits (inferred to be upper Tertiary, and possibly Quaternary) are know known to be comprised entirely of the upper Tertiary Bidahochi Formation (late Miocene and Pliocene). Levish and others (1992 #1715) concluded that formation of the Nutria Monocline and associated Zuni uplift occurred in late Tertiary time, not in the Pleistocene, and that downcutting and terrace formation attributed to localized upwarping is actually of regional extent related to Neogene uplift of the Colorado Plateaus Province and incision of the Colorado River and its tributaries, including the Little Colorado. Thus, the Nutria Monocline (and Zuni Uplift) are considered as discounted features for this database.

Date of compilation 04/15/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County McKinley

1° x 2° sheet Gallup

Province Colorado Plateaus

References

#1715 Levish, D.R., Vetter, U.R., Ake, J.P., and Piety, L.A., 1992, Seismotectonic study for Black Rock Dam, Bureau of Indian Affairs, Pueblo of Zuni, New Mexico: Bureau of Reclamation Seismotectonic Report 92-3, 62 p.

0000D, Vaughn fault (discounted)

Structure Number 0000D

Structure Name Vaughn fault (discounted)

Comments: This fault was mapped and named by Kelley (1972 #2004). It forms a 25-mile (40-km) long north-trending, west-facing escarpment (bedrock ridge) that extends from Mesa Leon on the north, south to 5 km north of the Guadalupe-Lincoln County line, passing about 1 km west of Vaughn, New Mexico near its central point.

Reason for exclusion: This fault was mapped as part of a regional geologic study of the Fort Sumner 1° x 2° sheet, but little is known about its age or Quaternary history of movement. It lies east of the accepted boundaries of the present Rio Grande rift and is within the Great Plains Province. The fault may offset gravels of the Ogallala Group (Miocene) according to Kelly's map (1972 #2004), but no Quaternary movement is documented. Most of the fault's trace is mapped as concealed, except for a 6-km-long portion west and southwest of Vaughn. The escarpment impounds Quaternary sediment to the west, and blocks local drainages. Although the fault has a fairly linear trace, John Hawley (oral commun., 1998) suspects that the structure is the result of dissolution of salt (or other soluble materials) in the subsurface, and thus may not be a deep-seated (tectonic) feature that is associated with earthquakes.

Date of compilation 07/28/98

Compiler and affiliation Michael N. Machette, U.S. Geological Survey

State New Mexico

County Guadalupe

1° x 2° sheet Fort Sumner

Province Great Plains

References

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