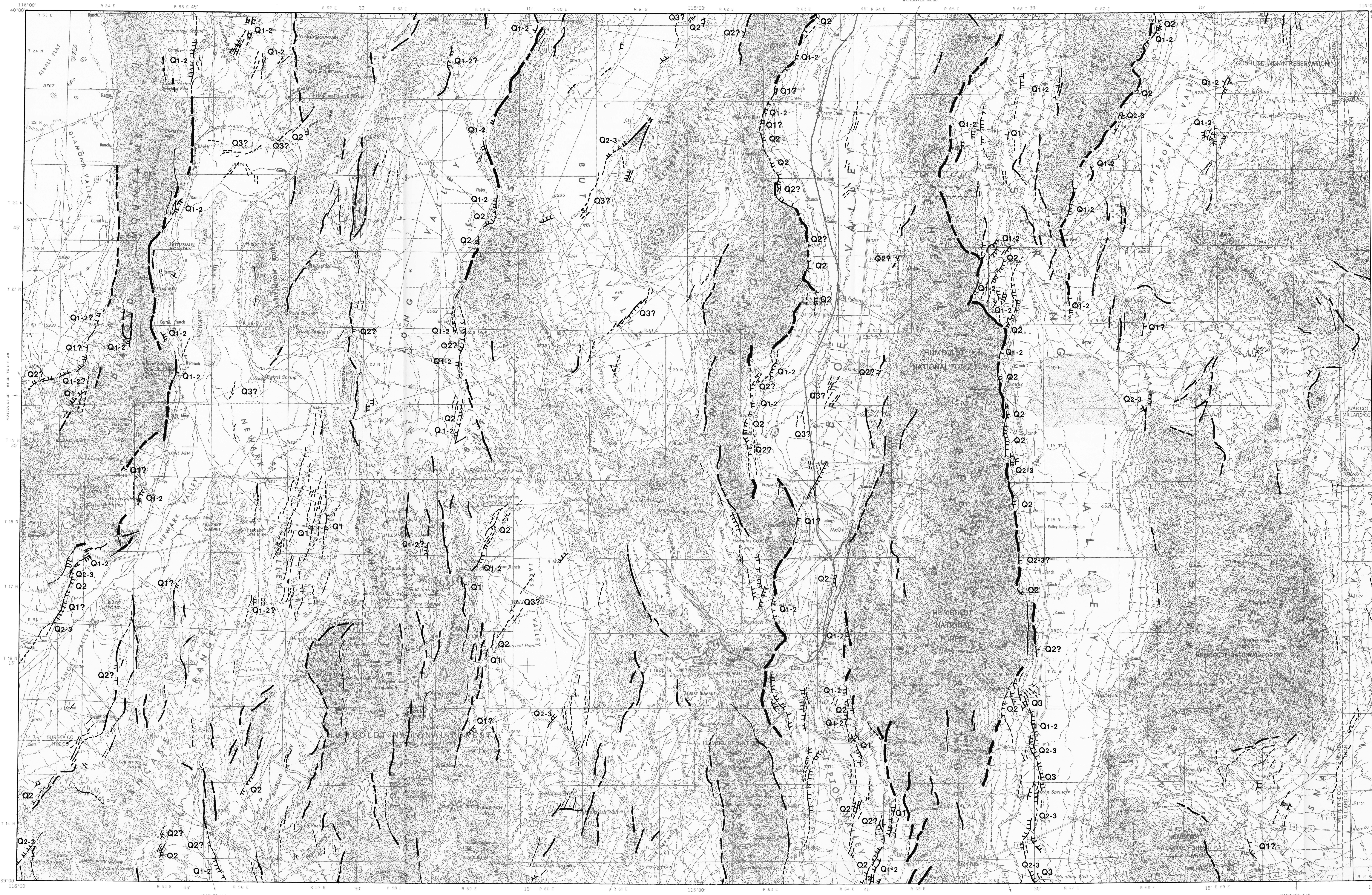

Base from U.S. Geological Survey, 1957
Revised 1971
Transverse Mercator projection

SCALE 1:250 000

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

APPROXIMATE MEAN DECLINATION, 1981

QUADRANGLE LOCATION

Mapped in 1988-90 by J.C. Dohrenwend and B.A. Schell
Edited by C.L. Ostergren; prepared by Lori Moore
Manuscript approved for publication June 28, 1991

RECONNAISSANCE PHOTOGEOLOGIC MAP OF YOUNG FAULTS IN THE ELY 1° BY 2° QUADRANGLE, NEVADA AND UTAH

By
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1991

INTRODUCTION

The State of Nevada occupies most of the central and western parts of the Great Basin, the largest tectonically active region within the Basin and Range geomorphic province of North America. The topography of this region is typified by generally north-northwest- to northeast-trending, subparallel mountain ranges separated by alluvial basins of similar plan form and orientation. This classic Basin and Range physiography is the product of at least two phases of middle to late Cenozoic extensional faulting (Zoback and others, 1981; Eaton, 1982; Stewart, 1983), and most of the basins and ranges of the region are at least partly bounded by late Cenozoic faults. The earlier phase of extension was marked by widespread shallow detachment faulting that began at approximately 35 Ma and locally continued into the time of the later phase (Eaton, 1982; Stewart, 1983). The later phase, which was dominated by high-angle, more deeply penetrating block faulting, may have begun locally at about 17 Ma and continues episodically to the present time (Christiansen and McKee, 1978; Eaton, 1982). This map, one of a series of 1° by 2° quadrangle maps showing young faults in Nevada, provides a generalized picture of the late Tertiary and Quaternary faulting that is associated with the latter extensional phase. These young faults are a primary determinant of the present configuration of ranges and basins within the quadrangle.

MAPPING PROCEDURE

Young faults are herein defined as those faults that have undergone latest Tertiary and (or) Quaternary movement. These faults are commonly marked by a variety of diagnostic constructional landforms and other surficial phenomena that can be readily identified and mapped on aerial photographs. These features include (1) scarps on latest Tertiary and (or) Quaternary surficial deposits, volcanic strata, or geomorphic surfaces (either erosional or depositional); (2) prominent alignments of linear drainageways, ridges and swales, active springs and (or) spring deposits, and linear discontinuities of structure, rock type, and vegetation; and (3) abrupt, steeply sloping range fronts with basal scarps, faceted spurs, 'wineglass valleys,' and elongate drainage basins with narrow valley floors (Thornbury, 1969; Bull, 1977; Bull and McFadden, 1977; Wallace, 1977, 1978).

National High Altitude Program (NHAP), 1:58,000-nominal-scale, color-infrared photography was used for photogeologic interpretation. This mapping was transferred directly to 1/2° by 1° topographic quadrangle maps that were enlarged to the scale of the photographs. These maps were reduced and compiled at 1:250,000 scale. This compilation was then compared with previous mapping of young faults within the quadrangle (Ertec Western, Inc., 1981; see fig. 1) and significant differences between maps were resolved. Because the previous mapping was based on photogeologic analysis of 1:24,000-scale color aerial photography and extensive field verification, more young faults were identified by this mapping than by the present reconnaissance study. Many of these additional faults are located on distal piedmonts and basin flats and most are included on our map.

Following comparison and resolution with previous mapping, the final 1:250,000-scale compilation was digitized using a GTCO digitizing board connected to a Macintosh II minicomputer. The resulting vector file was converted to raster format (cell size = 200 m by 200 m) and analyzed to determine the approximate length and average orientation of each fault segment. These data are summarized in table 1 and figure 2.

General ages of surficial deposits and erosion surfaces cut by young faults were estimated using a variety of photogeologic and geomorphic criteria (table 2). These age estimates provide a general indication of the approximate timing of young faulting throughout the quadrangle. However, it should be emphasized that these data do not necessarily reflect the age of most recent rupture along any particular fault segment. Rather, they provide only very general (and commonly somewhat biased) age constraints on this surface faulting. Age estimates based on photogeologic analysis of surficial deposits and erosion surfaces are, at best, both tentative and imprecise. Moreover, the distribution of these deposits and surfaces is inherently biased by geomorphic process and environment. For example, in those areas of the Great Basin where range uplift rates are low to moderate, remnants of older geomorphic surfaces tend to be concentrated in proximal piedmont areas, whereas younger surficial deposits tend to accumulate on distal piedmonts and basin flats. Consequently, young faults located in intrabasin areas are more likely to offset younger surface deposits then are faults located along range fronts or in proximal piedmont areas. Therefore, inferences based on these data regarding the temporal distribution of young fault activity should be used with caution.

In addition to the limitations imposed by map and photo scales, one other factor also significantly constrains the resolution of the present map. The photography used in this analysis, which was acquired under high sun-angle conditions, is not well suited for the discrimination and mapping of subtle topographic features. Consequently, reexamination of any of the fault systems shown on this map using larger scale and (or) lower sun-angle aerial photography would very likely reveal a substantial number of additional young fault segments.

PATTERNS OF LATEST TERTIARY AND QUATERNARY FAULTING

Several factors significantly influence the preservation of fault-related landforms and, therefore, the apparent distribution of young faults as indicated by the distribution of these landforms can be significantly biased. These factors include (1) composition, induration, and structural integrity of the rock or sediment type(s) underlying fault scarps; (2) local geomorphic environment of the scarp or other fault-related landforms; (3) regional climatic conditions and paleoclimatic variations; and (4) magnitude and recurrence of fault movement (Wallace, 1977; Bucknam and Anderson, 1979; Nash, 1980, 1984; Hanks and others, 1984; Mayer, 1984; Pierce and Colman, 1986; Machette, 1986, 1988, 1989). Therefore, the distribution of young faults shown on this map provides, at best, only an approximate and somewhat biased picture of late Tertiary and Quaternary faulting within the quadrangle. Specifically, faults having a long history of recurrent movement, juxtaposing bedrock and alluvium, or cutting upper Cenozoic lava flows and (or) welded ash-flow tuffs tend to be overrepresented whereas faults of pre-late Pleistocene age cutting unconsolidated surficial deposits and having either short histories of recurrent movement or long recurrence intervals tend to be underrepresented. Scarps developed on volcanic rocks may be preserved for periods of as much as 10 m.y. By comparison, scarps on the fluvially active parts of piedmont surfaces would likely be completely destroyed within a few thousand years at most, and even on inactive piedmont surfaces, fault scarps on unconsolidated alluvial fill are significantly rounded within 10,000 years (Wallace, 1977), and low scarps would be sufficiently degraded to be unrecognizable on standard aerial photography within a few hundred thousand years (Wallace, 1977; Hanks and others, 1984; Machette, 1989).

Young faults are distributed more or less uniformly across most of the Ely 1° by 2° quadrangle although they are conspicuously less abundant along the east margin of the map area (east of Spring and Antelope Valleys). Average young fault densities range between 0.09 and 0.11 km/km^2 and fault trace orientations are concentrated within 20° to 30° of north-south (table 1, fig. 2). Major fault zones showing evidence of late Pleistocene and (or) Holocene displacement define most range fronts within the western 80 percent of the quadrangle. These major faults have predominantly northerly trends that contrast with the more northeasterly orientations of major fault zones in adjacent quadrangles to the west. This change in orientation is part of a general gradual change at this latitude across the Great Basin.

Major faults along the east sides of the Egan and Schell Creek Ranges extend almost continuously across the entire quadrangle from north to south. These faults, ranging from 130 to 160 km long, are among the longest faults in the Great Basin. Another nearly continuous zone of young faulting is present along the west side of the Butte Mountains and appears to continue southward along the east side of Moorman Ridge in the eastern part of the White Pine Range. However, this zone is composed of two separate systems, the former is downdropped to the west and the latter downdropped to the east. In the extreme southwest corner of the quadrangle, the predominant orientation of young faulting changes to a more northeasterly trend along the east side of the Diamond Mountains and the west side of the Pancake Range.

Holocene faulting is widely scattered across the quadrangle. Generally, faulting of this age can only be interpreted with confidence in the central parts of the intermontane basins which are occupied by modern playa and latest Pleistocene pluvial lake deposits. Small clusters of short, small-displacement faults and lineaments are present in Newark, Jakes, Butte, Steptoe and Spring Valleys. In addition, faulting in southern Spring Valley includes a major fault with a large multiple-displacement scarp as high as 20 m. The latest displacement along this fault cuts latest Pleistocene pluvial lake shorelines and, therefore, probably represents a major Holocene earthquake event. Many of the lineaments in these central basin areas may represent cracks and fissures formed by seismically induced liquefaction and lateral spreading (Schell, 1985, 1987). It is noteworthy that most of these minor Holocene features have northeasterly orientations in contrast to the more northerly trends of the major range-bounding fault zones.

REFERENCES CITED

Bucknam, R.C., and Anderson, E., 1979, Estimation of fault-scarp ages from a scarp-height--slope-angle relationship: Geology, v. 7, p. 11-14.

Bull, W.B., 1977, Tectonic geomorphology of the Mojave Desert, California: U.S. Geological Survey, Office of Earthquakes, Volcanoes, and Engineering, Contract Report 14-08-001-G-394, Menlo Park, Calif., 188 p.

Bull, W.B., and McFadden, L.D., 1977, Tectonic geomorphology north and south of the Garlock fault, California, *in* Doehring, D.C., ed., Geomorphology in arid regions: Proceedings 8th Annual Geomorphology Symposium, State University of New York, Binghamton, p. 115-137.

Christiansen, R.L., and McKee, E.H., 1978, Late Cenozoic volcanic and tectonic evolution of the Great basin and Columbia intermontane basin: Geological Society of America Memoir 152, p. 283-311.

Eaton, G.P., 1982, The Basin and Range Province: Origin and tectonic significance: Annual Reviews Earth and Planetary Science, v. 10, p. 409-440.

Ertec Western, Inc., 1981, Faults and lineaments in the MX siting region, Nevada and Utah: unpublished report prepared for the Department of the U.S. Air Force, Norton A.F.B., California, 77 p., 11 maps, scale 1:250,000.

Hanks, T.C., Bucknam, R.C., Lajoie, K.R., and Wallace, R.E., 1984, Modification of wave-cut and faulting-controlled landforms: Journal of Geophysical Research, v. 89 (B7), p. 5771-5790.

Machette, M. N., 1986, History of Quaternary offset and paleoseismicity along the La Jencia fault, central Rio Grande rift, New Mexico: Seismology Society of America Bulletin, v. 76, p. 259-272.

______ 1988, Quaternary movement along the La Jencia fault, central New Mexico: U. S. Geological Survey Professional Paper 1440, 81 p.

______ 1989, Slope-morphometric dating, *in* Forman, S.L., ed., Dating methods applicable to Quaternary geologic studies in the western United States: Utah Geological and Mineral Survey Miscellaneous Publication 89-7, p. 30-42.

Mayer, L., 1984, Dating Quaternary fault scarps formed in alluvium using morphological parameters: Quaternary Research, v. 22, p. 300-313.

Nash, D.B., 1980, Morphological dating of degraded normal fault scarps: Journal of Geology, v. 88, p. 353-360.

______ 1984, Morphologic dating of fluvial terrace scarps and fault scarps near West Yellowstone, Montana: Geological Society of America Bulletin, v. 95, p. 1413-1424.

Pierce, K.L., and Colman, S.M., 1986, Effect of height and orientation (microclimate) on geomorphic degradation rates and processes, late-glacial terrace scarps in central Idaho: Geological Society of America Bulletin, v. 97, p. 869-885.

Schell, B.A., 1985, Earthquake-induced ground failures in basin-fill alluvium, Idaho, Utah and Nevada: Geological Society of America Abstracts with Programs, v. 17, p. 263-264.

______ 1987, Lineaments in the Basin and Range Province, western U.S.: Geological Society of America Abstracts with Programs, v. 19, p. 832.

Slemmons, D.B., 1957, Geological effects of the Dixie Valley-Fairview Peak, Nevada, earthquakes of December 16, 1954: Seismological Society of America Bulletin, v. 47, p. 353-375.

Stewart, J.H., 1983, Cenozoic structure and tectonics of the northern Basin and Range Province, California, Nevada and Utah, *in* The role of heat in the development of energy and mineral resources in the northern Basin and Range Province: Geothermal Resources Council, Special Report 13, p. 25-40.

Thenhaus, P.C., and Barnhard, T.P., 1989, Regional termination and segmentation of Quaternary fault belts in the Great Basin, Nevada and Utah: Bulletin of the Seismological Society of America, v. 79, p. 1426-1438.

Thornbury, W.D., 1969, Principles of Geomorphology: John Wiley & Sons, Inc., New York, 594 p.

Wallace, R.E., 1977, Profiles and ages of young fault scarps, north-central Nevada: Geological Society of America Bulletin, v. 88, p. 1267-1281.

______, 1978, Geometry and rates of change of fault-generated range fronts, north-central Nevada: U.S. Geological Survey Journal of Research, v. 6, p. 637-650.

______, 1979, Map of young fault scarps related to earthquakes in north central Nevada: U.S. Geological Survey Open File Report 79-1554, scale 1:125,000.

Zoback, M.L., Anderson, R.E., and Thompson, G.A., 1981, Cainozoic evolution of the state of stress and style of tectonism of the Basin and Range Province of the western United States, *in* Vine, F.T., and Smith, A.D., eds., Extensional tectonics associated with convergent plate boundaries: The Royal Society, London, p. 189-216.

Fault scarps on Quaternary surficial deposits or Quaternary erosional surfaces--Scarps on Quaternary deposits or Quaternary erosion surfaces other than those displacements associated with known historic earthquakes. Hachures indicate downslope direction of scarp. Symbol indicates approximate age of offset surficial deposit or erosion surface:

- Q3 — Holocene (0-10 ka)
- Q2-3 — Latest Pleistocene and (or) Holocene (0-30 ka)
- Q2 — Late Pleistocene (10-130 ka)
- Q1-2 — Early to middle and (or) late Pleistocene (0.01-1.5 Ma)
- Q1 — Early to middle Pleistocene (0.13-1.5 Ma)

Photogeologic and geomorphic criteria used to estimate ages are summarized in table 2

Fault-related lineaments on Quaternary surficial deposits or on Quaternary erosion surfaces--Alignments, in Quaternary surficial deposits or across Quaternary erosional surfaces, of one or more of the following features: linear reaches of stream channels, linear stream valleys, shallow linear swales, springs, vegetation discontinuities. Commonly associated with fault scarps on Quaternary deposits and (or) erosional surfaces. Age designations as above

Major range-front faults--Faults bounding tectonically active fronts of major mountain ranges. These range fronts are characterized by: fault juxtaposition of Quaternary alluvium against bedrock, fault scarps and lineaments on surficial deposits along or immediately adjacent to range front, a general absence of pediments, abrupt piedmont-hillslope transitions, steep bedrock slopes, faceted spurs, wineglass valleys, and subparallel systems of high-gradient, narrow, steep-sided canyons orthogonal to range front. Only mapped in areas along range front where fault scarps and (or) lineaments on Quaternary surficial deposits or on Quaternary erosion surfaces are absent

Faults juxtoposing Quaternary alluvium against bedrock (other than major range-front faults)--Morphologically similar to major range-front faults except that associated fault systems are significantly less extensive and fault scarps are substantially lower, shorter, and less continuous. Solid lines indicate locations where fault scarps are abrupt and well-defined; long dashes indicate locations where scarps are less well defined

Faults forming scarps and (or) prominent topographic lineaments on Tertiary volcanic or sedimentary rocks--These scarps have morphologies ranging from partly rounded and moderately dissected to undissected. Topographic lineaments are composed of alignments of one or more of the following landforms: abrupt scarps, linear hillside ridges, benches and trenches, linear reaches of stream channels and small stream valleys, ridge-crest saddles and cols, linear depressions and small closed basins. Many of these faults form closely spaced groups in areas underlain by Tertiary ash-flow tuffs and lava flows

Table 1. *Characteristics of young faults in the Ely 1° by 2° quadrangle*
[See figure 1 for area boundaries]

Orientation	West: Length (km)	West: Percent	East: Length (km)	East: Percent
90.0 to 80°	- - -	- - -	3.6	0.4
79.9 to 70°	9.8	1.0	8.0	0.9
69.9 to 60°	4.4	0.4	2.2	0.3
59.9 to 50°	5.4	0.5	- - -	- - -
49.9 to 40°	44.6	4.4	14.6	1.7
39.9 to 30°	49.4	4.9	42.6	5.0
29.9 to 20°	125.6	12.5	82.4	9.7
19.9 to 10°	227.8	22.6	127.6	15.0
09.9 to 0.0°	232.6	23.1	173.8	20.5
359.9 to 350°	218.4	21.7	218.2	25.7
349.9 to 340°	71.6	7.1	58.8	6.9
339.9 to 330°	9.0	0.9	78.6	9.3
329.9 to 320°	3.0	0.3	16.2	1.9
319.9 to 310°	- - -	- - -	3.4	0.4
309.9 to 300°	- - -	- - -	4.4	0.5
299.9 to 290°	4.0	0.4	10.0	1.2
289.9 to 280°	- - -	- - -	3.6	0.4
279.9 to 270°	2.6	0.3	- - -	- - -
Total (km)	1008.2	100.0	848.0	100.0
Area (km2)	9300	- - -	9750	- - -
Density (km/km2)	0.108	- - -	0.087	- - -
Number	201	- - -	168	- - -
Density (no./km2)	0.022	- - -	0.017	- - -
Mean length (km)	5.0	- - -	5.0	- - -

Table 2. *General photogeologic and geomorphic criteria used to estimate general ages of piedmont surfaces*

Map unit	Age	Depth of dissection	Drainage net morphology	Interfluve morphology	Geomorphic relations	Typical geomorphic environments	General field criteria
Unit Q3	Holocene (0 to 10 ka)	Shallow to none; generally <3 m	Predominantly radial from fan apex; channels typically poorly to moderately well defined	Typically poorly defined; bar and swale micro-topography common on most surfaces	Surfaces cut pluvial shorelines and (or) late Pleistocene glacial moraines	Distal piedmont surfaces; channels and terraces in proximal areas; (proximal surfaces along some highly active range fronts)	Unweathered to slightly weathered; very weak to weak soil development
Unit Q2	Late Pleistocene (10 to 130 ka)	Shallow to moderate; typically 2-6 m	Predominantly distributary; however, some channels head on piedmont; well-defined channels	Typically well defined; surfaces broad and flat with abrupt margins	Surfaces overlain by pluvial shorelines and (or) latest Pleistocene glacial moraines	Proximal to distal piedmont surfaces; some inset terraces	Weakly to moderately well developed soils; interlocking stone pavements
Unit Q1	Early to middle Pleistocene (0.13 to 1.5 Ma)	Moderate to deep; commonly >10 m	Predominantly subparallel; well-defined channels	Well defined; older interfluve surfaces (ballenas) commonly narrow and irregular	Surfaces overlain by pluvial shorelines and (or) latest Pleistocene glacial moraines	Generally confined to intermediate and proximal piedmont areas	Moderately to very well developed soils; interlocking to highly degraded stone pavements

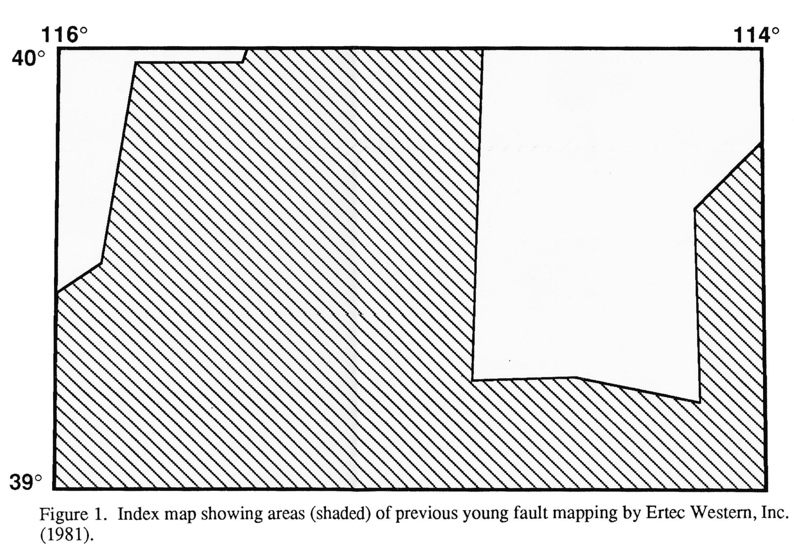

Figure 1. Index map showing areas (shaded) of previous young fault mapping by Ertec Western, Inc. (1981).

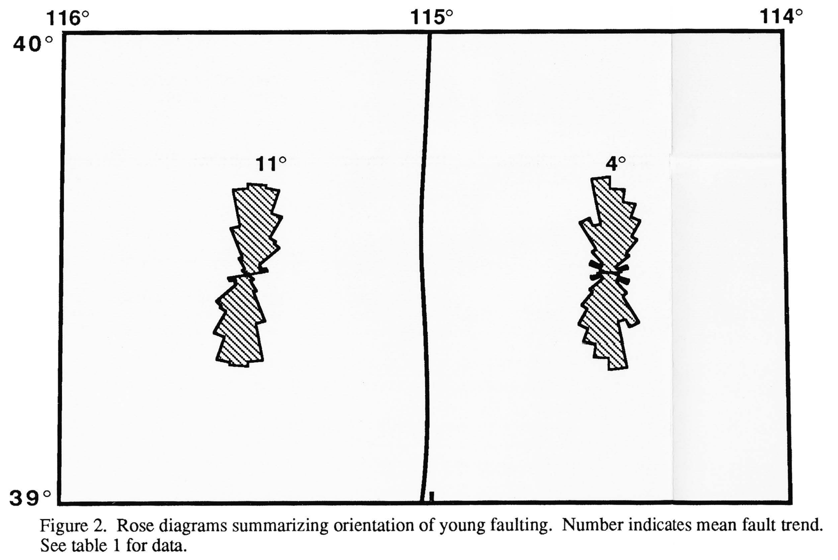

Figure 2. Rose diagrams summarizing orientation of young faulting. Number indicates mean fault trend. See table 1 for data.

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