Base from U.S. Geological Survey, 1956
Transverse Mercator projection

APPROXIMATE MEAN DECLINATION, 1992

SCALE 1:250 000

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

Mapped in 1988-90 by J.C. Dohrenwend, B.A. Schell, and M.A. McKittrick
Edited by C.L. Ostergren; prepared by M.E. Coveau
Manuscript approved for publication June 28, 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).

NASA U-2, 1:115,000 to 1:124,000 scale, color infrared transparencies and National High Altitude Program (NHAP), 1:58,000 nominal-scale, color infrared photography were 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 surface 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).

The Goldfield 1° by 2° quadrangle extends across the Walker Lane Belt of the western Great Basin. The Walker Lane belt, a complex zone of strike-slip displacement from 80 to 150 km wide, extends northwestward from the eastern Mojave Desert for approximately 700 km along the western margin of the Great Basin. This complex neotectonic zone is made up of several major structural blocks, each of which has acted more or less independently of adjacent blocks during late Cenozoic Basin and Range extension (Carr, 1984; Stewart, 1987; Dohrenwend, 1987). In the southwestern part of the quadrangle, the predominantly strike-slip northern Death Valley-Fish Lake Valley fault zone marks the boundary between the Inyo-Mono and Goldfield blocks of the Walker Lane Belt. The central part of the quadrangle contains four physiographically (and neotectonically) distinct areas within the Goldfield block, and the eastern part of the quadrangle lies across the transitional boundary between the Walker Lane belt and the central and southeast Great Basin (Dohrenwend, 1987). Consequently, the density and orientation of young faulting vary substantially from one area of the quadrangle to another (Table 1 and Fig.2).

Throughout the southern half of the quadrangle, from the Pliocene Saline Range in the Inyo-Mono block of the Walker Lane belt to the late Miocene Pahute Mesa and Belted Range in the southeast Great Basin, large swarms of short, bifurcating to crosscutting, normal faults cut extensive areas of late Tertiary volcanic rocks. Young fault densities in these areas range from 0.09 to 0.20 km/km². These faults display little evidence of Quaternary activity and probably are mostly synvolcanic in origin. To the north, major range-bounding fault zones form the dominant mode of young faulting in the northwestern part of the quadrangle (along the west flanks of the Silver Peak Range, Clayton Ridge, and the Montezuma Range and the east flank of the Weepah Hills in the northwest Goldfield block). Similar range-bounding fault zones exist in the northeastern part of the quadrangle (along the Kawich, Reveille, and Belted Ranges). These areas of conspicuous Quaternary fault movement (with young fault densities of 0.04 to 0.08 km/km²) are separated by a largely inactive region, nearly 80 km across, of low ranges and extensive pediments. This inactive region, which includes the Cactus Range, Goldfield and Monitor Hills, and intervening basins, is almost entirely devoid of young faults and bears a strong geomorphic resemblence to areas of the eastern Mojave Desert.

All of the major range-bounding fault systems within the quadrangle display evidence of Quaternary activity. Several lesser range-front systems and four areas of extensive intrabasinal faulting (Clayton Valley, Stonewall Flat, Yucca Flat, and northern Death Valley) also display evidence of Pleistocene movement. However, only one area of likely Holocene (0-10 ka) activity (along the northwest margin of Stonewall Flat) was identified by this photogeologic reconnaissance. This apparent lack of Holocene faulting is probably due to the limited resolution of the small-scale NASA U-2 photography that was used to map the western 80 percent of the quadrangle.

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.

Carr, W.J., 1984, Regional structural setting of Yucca Mountain, southwestern Nevada, and late Cenozoic rates of tectonic activity in part of the southwestern Great basin, Nevada and California: U.S. Geological Survey Open-File Report OFR-84-854, 109 p.

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.

Dohrenwend, J.C., 1987, Morphometric comparison of tectonically defined areas with the west-central Basin and Range, California and Nevada:
U.S. Geological Survey Open-File Report OFR 87-83, 26 p.

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: Bulletin Seismology Society of America, 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.

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.

______ 1987, Tectonics of the Walker Lane belt, western Great Basin: Mesozoic and Cenozoic deformation in a zone of shear, *in* W.G. Ernst, ed., Metamorphism and crustal evolution of the western United States, Rubey Volume VII: Englewood Cliffs, N. J., Prentice-Hall, Inc., p. 683-713.

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.

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.

EXPLANATION

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 Goldfield 1° by 2° quadrangle*
[See figure 1 for area boundaries]

	Northeast		Southeast		Northwest		Southwest(NV)		Southwest(CA)	
Orientation	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent	Length (km)	Percent
90.0 to 80°	---	---	---	---	11.0	3.3	63.0	24.2	---	---
79.9 to 70°	---	---	5.8	1.2	---	---	22.6	8.7	---	---
69.9 to 60°	2.6	1.1	---	---	2.8	0.9	33.2	12.7	---	---
59.9 to 50°	---	---	5.2	1.1	18.8	5.7	8.2	3.1	---	---
49.9 to 40°	3.6	1.6	9.2	1.9	40.0	12.2	36.4	14.0	16.2	3.6
39.9 to 30°	3.4	1.5	17.0	3.5	24.8	7.5	12.0	4.6	15.6	3.5
29.9 to 20°	8.8	3.8	28.2	5.8	32.8	10.0	14.6	5.6	80.2	17.7
19.9 to 10°	49.0	21.4	108.8	22.3	92.2	28.1	6.2	2.4	121.0	26.8
09.9 to 0.0°	37.0	16.2	201.4	41.2	54.6	16.6	9.4	3.6	42.4	9.4
359.9 to 350°	47.4	20.7	82.6	16.9	15.6	4.7	2.6	1.0	15.4	3.4
349.9 to 340°	34.4	15.0	16.2	3.3	17.6	5.4	17.0	6.5	22.6	5.0
339.9 to 330°	31.0	13.6	---	---	10.8	3.3	---	---	12.4	2.7
329.9 to 320°	3.4	1.5	10.8	2.2	---	---	---	---	42.8	9.5
319.9 to 310°	4.2	1.8	---	---	2.0	0.6	9.2	3.5	40.2	8.9
309.9 to 300°	---	---	---	---	---	---	---	---	38.2	8.5
299.9 to 290°	3.8	1.7	---	---	5.6	1.7	---	---	5.0	1.1
289.9 to 280°	---	---	---	---	---	---	10.8	4.1	---	---
279.9 to 270°	---	---	3.2	0.7	---	---	15.6	6.0	---	---
Total (km)	228.6	100.0	488.4	100.0	328.6	100.0	260.8	100.0	452.0	100.0
Area (km2)	5570	---	4620	---	4370	---	2760	---	2260	---
Density (km/km2)	0.041	---	0.106	---	0.075	---	0.094	---	0.200	---
Number	47	---	93	---	58	---	58	---	93	---
Density (no./km2)	0.008	---	0.020	---	0.013	---	0.021	---	0.041	---
Mean length (km)	4.9	---	5.3	---	5.7	---	4.5	---	4.9	---

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 shore-lines 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

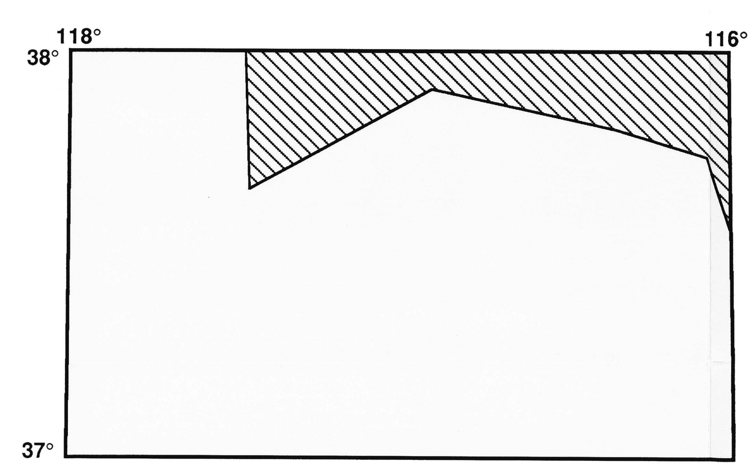

Figure 1. Index map showing areas (shaded) of previous young fault mapping by Ertec Western, Inc. (1981).

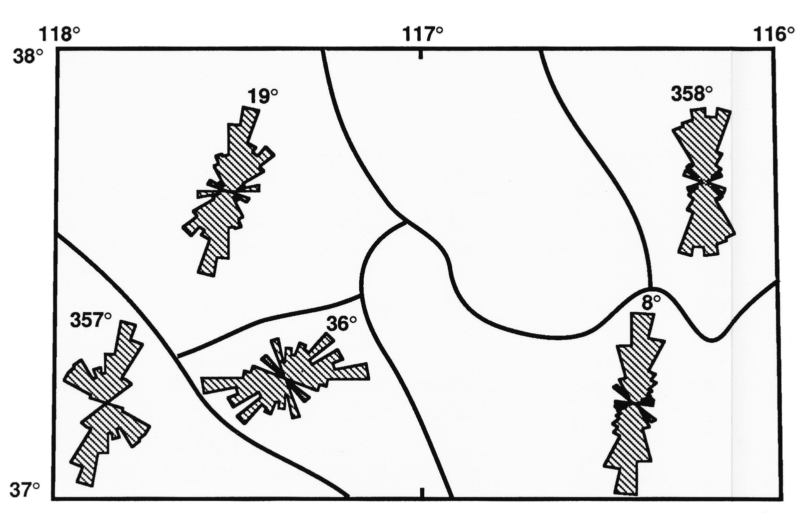

Figure 2. Rose diagrams summarizing orientation of young faulting. Number indicates mean fault trend. See table 1 for data.

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

By
John C. Dohrenwend, Bruce A. Schell, Mary Anne McKittrick, and Barry C. Moring
1992

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1992

For sale by U.S. Geological Survey, Map Distribution,
Box 25286, Federal Center, Denver, CO 80225