FAULT EVALUATION REPORT FER-159

Owens Valley and White Mountains Frontal Fault Zones

Big Pine area, Inyo County

by

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INTRODUCTION

Potentially active faults located in northern Inyo County evaluated in this FER comprise the Owens Valley fault zone and a segment of the White Mountains frontal fault zone (figure 1). Segments of the Owens Valley fault zone were zoned for special studies in 1976. The Big Pine study area is located in the northeast 1/4 of the Big Pine 15-minute quandrangle. These faults are evaluated as part of a statewide effort to evaluate faults for recency of activity. Those faults determined to be sufficiently active and well defined are zoned by the State Geologist as directed by the Alquist-Priolo Special Studies Zones Act (Hart, 1980).

SUMMARY OF AVAILABLE DATA

The Big Pine study area is characterized by Basin and Range style normal faulting. Topography in the study area ranges from the relatively flat flood plain of the Owens River to moderately steep slopes along the eastern front of the Sierra Nevada. Elevations in the study area range from about 4,000 feet to about 5,800 feet. Development in the study area is generally limited to the town of Big Pine. In addition, local agricultural activities modify land surfaces.

Predominant rock types in most of the study area include Mesozoic plutonic rocks, Quaternary volcanic rocks, and Quaternary surficial deposits (Bateman, 1965). Quaternary surficial deposits include glacial deposits of the Sherwin ($>$ 700,000 yrs. B.P.), Tahoe (60,000 to 130,000 yrs. B.P.), and Tioga (13,000 to 20,000 yrs. B.P.) glacial stages; Pleistocene and Holocene alluvium, and Holocene talus and colluvium (Bateman, 1965; Clark, et al., 1984).

OWENS VALLEY FAULT ZONE

The Owens Valley fault zone is a major range front fault. Displacement across the fault zone is normal, down to the east. Bateman (1965) included the area in the Big Pine study area as part of a larger structure he called the Coyote warp. The Coyote warp, which is characterized by warping associated with predominantly mountain-side down normal faults, probably represents a complex left-step between well-defined frontal faults of the Sierra Nevada fault zone to the south and the Round Valley fault zone to the north. The Big Pine study area is located near the southern extent of the Coyote warp, and both east-side-down (valley-side down), and west-side down (mountain-side down) normal faults occur.

The northern extent of surface fault rupture associated with the M7.8 (Toppozada, et al., 1981) 1872 Owens Valley earthquake is thought to have occurred a few miles north of Big Pine near Klondike Lake (CDMG, 1972) (figure 2a). Whitney (1872) and Bateman (1961) reported that a component of right-lateral strike-slip displacement was observed along segments of the Owens Valley fault zone that ruptured during this event. Slemmons (CDMG, 1972) identified segments of the Owens Valley fault zone that are thought to have ruptured during the 1872 event.

Bateman (1965) mapped a broad zone of both west-side down and east-side down normal faults in the Big Pine study area (figure 2a). The principal active trace of the Owens Valley fault zone (Big Pine segment) passes just west of the town of Big Pine. The fault offsets late Quaternary basalt of Crater Mountain in the southeastern section of the study area. Late Pleistocene alluvium and Holocene alluvium are offset along this fault in the SE-1/4 Section 19, T9S, R34E (figure 2a). Principal sense of offset is normal, down to the east (valley-side down). Displacement along faults west of the Big Pine segment is principally west-side down (mountain-side down). Bateman mapped Holocene alluvium offset against Mesozoic bedrock along two faults in Sections 14 and 24, T9S, R33E (figure 2a). Bateman mapped additional down-to-the-west faults offsetting Mesozoic bedrock west of Warren Bench, but these faults are not evaluated in this FER due to the relative remoteness of the faults and the time limitations of this study. A north-trending fault offsets Holocene alluvium in Sections 20 and 29, T8S, R33E in the Shannon Canyon area (figure 2a). Bateman observed a 60°W-dipping fault plane in alluvium exposed in the north bank of Shannon Canyon.

Selected mapping by Slemmons, et al. (1970) was used in the Special Studies Zones Map (SSZ) of the NE 1/4 Big Pine quadrangle, issued in 1976 (figure 2a). Faults depicted on the 1976 SSZ map represent only a small portion of the faults mapped by Slemmons, et al. (1970) in the NE 1/4 of the Big Pine quadrangle. Slemmons identified fault traces on a small-scale map published in California Geology (CDMG, 1972) that are thought to have ruptured in the 1872 earthquake. These traces that presumably ruptured in 1872 were zoned in 1976. Additional faults mapped by Slemmons, et al. were not zoned in 1976 because it was decided that further assessment was needed in order to establish recency (E.W. Hart, p.c., March 1984). Slemmons, et al. mapped a wide zone of complex, north-trending faults (figure 2b). The majority of fault traces were mapped, using low-sun angle aerial photos, by University of Nevada, Reno students. Slemmons (p.c., September 1983) stated that no attempt was made to differentiate between late Quaternary and Holocene faults. Principal traces of the Owens Valley fault zone mapped by Slemmons, et al. (1970) roughly correspond with faults mapped by Bateman (1965) immediately west and south of Big Pine (figure 2a). However, a significant difference in location between Bateman (1965) and Slemmons, et al. occurs in Sections 19, 29, and 30, T9S, R34E (figure 2a). Also significant are the numerous faults mapped by Slemmons, et al. in Holocene floodplain deposits of the Owens River (figure 2b).

Envicom (1976) mapped a small part of the Owens Valley fault zone in western Big Pine from Big Pine Creek north to near Big Pine Canal (figure 2a). Faults mapped by Envicom closely correspond to faults mapped by Bateman (1965), although significant differences in detail exist (figure 2a).

Clark, et al. (1984) calculated late Quaternary slip rates along a principal active trace of the Owens Valley fault zone in the Fish Springs area, three miles south of the Big Pine study area (figure 1). A slip rate of about 0.4mm/yr. was estimated, based on an offset cinder cone. Offset alluvial deposits assumed to be equivalent in age to Tahoe and Tioga glacial deposits (which overlie the offset cinder cone) yield similar slip rates.

WHITE MOUNTAINS FRONTAL FAULT ZONE

A short segment of the White Mountains frontal fault zone (WMFFZ) is located in the northeast corner of the Big Pine study area (figure 2a). The WMFFZ is a north-trending zone of discontinuous normal faults bordering the western front of the White Mountains. Both valley-side-down and mountain-side-down normal faults have been mapped. This zone of recent faults presumably connects with a major west-dipping normal fault at depth, which would be consistent with large-scale uplift of the White Mountains (Bateman, 1965).

Bateman (1965) mapped Holocene alluvium offset against Pleistocene alluvium in Sections 20, 21, 28, 29, 32, and 33, T8S, R34E (figure 2a). Holcene alluvium is offset in the SE 1/4 Section 29, T8S, R34E (figure 2a).

INTERPRETATION OF AERIAL PHOTOGRAPHS AND FIELD OBSERVATIONS

Air photo interpretation by this writer of faults in the Big Pine study area was accomplished using U.S. Bureau of Land Management air photos (CA01-77, 1977, 1:24,000 scale).

Approximately three and one-half days were spent in the Big Pine area in February 1984 by this writer in order to verify selected fault segments interpreted from air photos. In addition, subtle features not observable on the air photos were mapped in the field. Results of air photo interpretation and field observations by this writer are summarized on figure 3.

Significant observations based on both air photo interpretation and field observations by this writer, and mapping by others, are summarized in Table 1. Locality numbers identified on figure 3 refer to specific data relative to fault recency, degree of definition (i.e., well defined or poorly defined), ages of deposits that are offset or that conceal faults, and additional pertinent information. Table 1, in conjunction with figure 3, contains the majority of supporting data relevant to zoning decisions.

An attempt was made to measure fault scarp profiles in order to estimate recency of faulting based on the work of Wallace (1977). Points of observation and locations where fault scarp profiles were measured are shown on figure 3 and are summarized in Table 2. It should be emphasized that these measurements represent only approximations of scarp height, scarp-slope angle, and width of scarp crest. Scarp height was measured using the method described by Lahee (1961, p. 454). Scarp-slope angle was estimated by using a Brunton compass clinometer and an improvised leveling rod, as described by Wallace (1977). The width of the scarp's crest was estimated by pacing.

A direct correlation between the ages indicated by fault scarp profiles measured by Wallace (1977) in Nevada and scarp profiles measured during investigations for this FER cannot be made due to different lithology, climate, and styles of faulting (Mayer, 1982). However, the data presented by Wallace (1977, 1978) can be used as a guide (or additional factor) when evaluating the geomorphic features and age of offset deposits (when known) for recency of faulting. Some very general guidelines for estimating scarp ages are summarized as follows: scarp-slope angles for faults in unconsolidated alluvium and colluvium no older than 10,000 to 12,000 yrs. BP can range from 10° to 35° (Wallace, 1977). The average scarp angle is about 22°, based on figure 8 of Wallace (1977), although figure 12 of Wallace (1977) indicates that scarp angles of about 19° represent minimum Holocene age. The scarp crest width for scarps no older than about 10,000 yrs. BP range from 3.2 to about 19 feet (figure 11 from Wallace, 1977). Wide variations occur, but these figures probably represent minimum (i.e. conservative) criteria suggesting Holocene ages.

OWENS VALLEY FAULT ZONE

Principal traces of the Owens Valley fault zone (OVFZ) are very well defined through much of the Big Pine study area (figure 3). Mapping by this writer generally verified faults mapped by Bateman (1965) and the limited mapping by Envicom (1976), although differences in detail exist (figures 2a, 3). It is interesting to note that the Big Pine segment mapped by Slemmons, et al. (1970) in the SE-1/4 Section 19 and NW-1/4 Section 29, T9S, R34E is located as much as 800 feet east of the fault zone mapped by Bateman (1965) and this writer (figures 2a, 2b, 3). Most faults along the Big Pine segment of the OVFZ are extremely well defined, so one would assume that a location error was made by Slemmons, et al. (1970).

The OVFZ is delineated by a well-defined, generally east-facing scarp in late Pleistocene and Holocene alluvium (figure 3). The fault zone is characterized by abundant geomorphic evidence of Holocene normal faulting such as scarps in Holocene alluvium, vertically offset drainages, and closed depressions (localities 1-6, Table 1; figure 3). Scarp profiles measured along selected fault segments support Holocene faulting and strongly indicate faulting on the order of hundreds, rather than thousands, of years old (Wallace, 1977). Geomorphic evidence indicating a right-lateral strike-slip component of displacement along the OVFZ was observed at locality 17 (figure 3) and at a point about 5,000 feet south of the study area along the east slope of Crater Mountain. Reports by Whitney (1872) and Slemmons (CDMG, 1972) indicate that surface fault rupture associated with the 1872 Owens Valley earthquake occurred in the Big Pine vicinity. Although field observations by this writer were not oriented to locating fault segments that ruptured in 1872, scarp profiles and geomorphic features along much of the OVFZ defined by localities 1-6 do suggest historic surface rupture (figure 3, Tables 1, 2).

Two parallel, north-trending traces of the Owens Valley Ranch segment of the OVFZ also are fairly well defined (figure 3). The eastern fault segment is apparently delineated by both west and east-facing scarps. However, field observations by this writer indicate that the east-facing scarp in Holocene(?) alluvium is probably erosional (locality 8, figure 3). This alluviated, poorly drained area probably delineates either a graben or a back-facing (west-facing) scarp that has subsequently been filled with alluvium. Sharp tonal lineaments and a subtle scarp along the western trace of the Owens Valley Ranch segment suggest post-alluvium offset, although the rate of deformation is probably low.

Faults west of the Owens Valley Ranch segment generally are delineated by short, back-facing scarps in Mesozoic bedrock and older alluvium that is probably pre-Wisconsin in age (figure 3, localities 10, 11). Evidence of Holocene offset is weak along these fault segments.

A number of short, north-trending faults generally characterized by back-facing scarps in late Peistocene alluvium are located between the Big Pine segment and the Owens Valley Ranch segment (figure 3). No direct evidence of Holocene faulting was observed by this writer. Scarp profiles measured by this writer suggest late Wisconsin and perhaps Holocene faulting (figure 3, Table 2).

Both Klondike Lake and Warren Lake are anomalous features in the Owens River flood plain (figure 3). A small lake just west of Klondike Lake is known locally as Little Klondike Lake and is clearly associated with faulting (locality 6, figure 3). A northeast-trending, northwest-facing scarp borders the southern side of Klondike Lake and the ground surface is displaced, down to the northwest (locality 15, figure 3). Klondike Lake is a natural closed depression, and the origin could be from either faulting or possibly from settlement due to liquefaction. Whitney (1872) reported that several lakes were formed in the Big Pine vicinity during the 1872 earthquake. It seems unlikely that Klondike Lake was formed during this event due to the obvious interaction between eolian deposition and the lake margin, although enhancement of the feature certainly could have occurred. Formation due entirely to liquefaction seems unlikely because the northwest-trending scarp is fairly linear, rather than sinuous.

The northeast-trending part of the Warren Lake segment of the OVFZ is similar to the Klondike Lake segment (figure 3). Both trend north to northeast and are delineated by northwest-facing scarps. Ground surfaces have clearly been offset (northwest side down), the northwest-facing scarps have dammed south-flowing drainages, and the scarps subsequently have been breached by the drainages (figure 3; localities 14, 15). Much of the Warren Lake segment of the OVFZ has been modified by the construction of an irrigation canal along the toe of the scarp. Scarp profiles would be relatively meaningless and were not measured.

The Shannon Canyon segment of the OVFZ is generally well defined and is characterized by geomorphic features indicating Holocene faulting (locality 12, figure 3). Short, discontinuous faults characterize the Shannon Canyon segment south of Shannon Creek (figure 3). Older alluvium (probably of pre-Wisconsin age, based on degree of dissection, reddish hue, and relative position of the alluvial fans) is faulted along most of these short segments. However, a few faults extend into Holocene alluvium and are delineated by vegetation contrasts and, locally, by subtle scarps (figure 3). Evidence of Holocene faulting is weak along most of the fault segments (locality 13, figure 3), but a low rate of slip distributed over a relatively broad zone cannot be ruled out.

WHITE MOUNTAINS FRONTAL FAULT ZONE

Relatively short, north-trending segments of the WMFFZ are located in the northeast corner of the Big Pine study area (figure 3). The faults are delineated by both west and east-facing scarps in Pleistocene alluvium. Possible evidence of Holocene faulting was observed at locality 16 (figure 3). This fault segment continues north into the Bishop quadrangle and aligns with well-defined scarps in Holocene alluvial fans (see Bryant, 1983, FER-153). Evidence of Holocene faulting is suggested by tonal lineaments in Holocene alluvium that align with well-defined scarps in Pleistocene alluvium south of Section 20, T8S, R34E (figure 3).

SEISMICITY

Seismicity within the Big Pine study area is depicted on figure 4. A scattering of epicenters in the M = 3.0 to 4.9 range occurs both east and west of the northern Owens Valley fault zone, suggesting that this segment of the fault zone is seismically active. However, the quality of epicenter locations and the paucity of the seismic network during this timeframe preclude the matching of specific seismic events with specific fault segments. A single, M = 4.0 to 4.9 event occurred along the White Mountains frontal fault zone in the Big Pine study area (figure 4).

CONCLUSIONS

OWENS VALLEY FAULT ZONE

Faults along the Big Pine segment of the Owens Valley fault zone in the Big Pine study area are well defined and are delineated by geomorphic features characteristic of Holocene normal faulting (localities 1 to 6, figure 3, Table 1). A right-lateral strike-slip component of displacement was associated with normal faulting along the Owens Valley fault zone during the 1872 earthquake (Whitney, 1872; Bateman, 1961). Geomorphic evidence of a component of right-lateral strike-slip offset was observed at locality 17 by this writer (figure 3). Additional geomorphic evidence of a strike-slip component of offset was observed about one mile south of the study area along the east side of Crater Mountain.

Generally, faults mapped by Bateman (1965) and Envicom (1976) were verified by this writer (figures 2a, 3). Faults mapped by Slemmons, et al. (1970) along the Big Pine segment locally are mislocated up to 800 feet, and additional, minor fault segments zoned for special studies in 1976 could not be verified by this writer (figures 2a, 3).

The Owens Valley Ranch segment of the OVFZ is moderately well defined and offsets late Pleistocene alluvium (figure 3). Holocene alluvium seems to be offset along the eastern fault, but field observations indicate that the east-facing scarp in Holocene alluvium is erosional (locality 8, figure 3). Evidence for Holocene faulting along the east fault is weak. A subtle east-facing scarp in Holocene alluvium, and linear vegetation contrasts delineate possible Holocene faulting along the west branch of the Owens Valley Ranch segment (figure 3). The rate of displacement along this fault segment is probably quite low.

North-trending faults west of the Owens Valley Ranch segment offset Pleistocene alluvium, but do not offset Holocene alluvium (locality 10, figure 3). Holocene faulting is suggested along the easternmost fault in this cluster, but geomorphic features in Holocene alluvium are not well defined (figure 3).

A broad zone of north-trending faults is located between the Owens Valley Ranch segment and the Big Pine segment (figure 3). These are short, distributive faults that offset late Pleistocene alluvium. No direct evidence of Holocene faulting was observed along these faults, but minor Holocene faulting cannot be ruled out.

The Klondike Lake and Warren Lake segments of the OVFZ are moderately well defined, north to northeast-trending faults that vertically offset the Owens Valley floodplain. Both faults are characterized by closed depressions, deflected and vertically offset drainages, and west to northwest-facing scarps in Holocene alluvium (localities 14, 15, figure 3). These features may have been formed in part by liquefaction during large earthquakes, but the general linearity and continuity of the scarps, and the magnitude of the features indicate faulting.

The principal north-trending fault of the Shannon Canyon segment of the OVFZ is well defined and is characterized by geomorphic features indicating Holocene faulting (locality 12, figure 3). A zone of distributive faults in Pleistocene alluvium is located south of Shannon Creek. Evidence of Holocene faulting is weak, although a few traces are delineated by vegetation contrasts and a subtle scarp in Holocene alluvium (figure 3).

WHITE MOUNTAINS FRONTAL FAULT ZONE

Short segments of the WMFFZ in the Big Pine study area are characterized by geomorphic features suggesting Holocene faulting (figure 3). These fault segments are moderately well defined and continue north of the study area where they align with well-defined faults offsetting Holocene alluvium (Bryant, 1984-FER-153).

RECOMMENDATIONS

Recommendations for zoning faults for special studies are based on the criteria of "sufficiently active" and "well-defined" (Hart, 1980).

OWENS VALLEY FAULT ZONE

Zone for special studies well-defined faults shown on figure 5. Principal references cited should be Bateman (1965), Envicom (1976), and this FER.

Do not zone faults west of the Owens Valley Ranch segment and selected traces of the Shannon Canyon segment of the OVFZ. These faults are not sufficiently active.

WHITE MOUNTAINS FRONTAL FAULT ZONE

Zone for special studies well-defined segments of the WMFFZ in the Big Pine study area as depicted on figure 5. Principal references cited should be Bateman (1965) and this FER.

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I agree with these recommendations.
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Table 1 (to FER-159). Locality descriptions listing selected data pertinent to fault recency, based on air photo interpretation and field observations by Bryant (this report). Additional data pertinent to fault recency are based on the work of others.

Locality #	Fault Name	Geomorphic feature delineating fault[1]	Youngest unit offset & source	Remarks[1]
1 (fig. 3)	Owens Valley fault zone (OVFZ) Big Pine segment	scarp; dov	Holocene (?) alluvium (Bateman, 1965; Bryant, this report)	Well-defined east-facing scarp in alluvial fan. Age of alluvium is probably Holocene. This is based on the relatively fresh granitic boulders and cobbles, lack of reddish hue in finer-grained material, and relatively well-defined constructional surface of fan. About 5-1/2 miles south of this location, an alluvial fan at Fish Springs was determined to be equivalent in age to the Tahoe glacial stage (60,000 to 120,000yrs.BP) by S.Martel (Clark, <u>et al</u>., 1983).Characteristics of this alluvium at Fish Springs: most granitic cobbles and boulders have weathered to gruss or are deeply pitted, clayey matrix, distinctive reddish hue of fines on fan surface as viewed both on ground and air photos, and relatively deep dissection of fan surface. About 100' north of locality 1, a small drainage is vertically offset about 2', down to the east.Scarp profile in relatively unconsolidated alluvium: $h=9$; $\measuredangle=26^\circ$, $c \simeq 5'$. Scarp-slope is slightly armored with cobbles and boulders to 4'-5' in diameter. About 500' south of this location, two small drainages are vertically offset, down to the east. The northern drainage ~~is offset~~ e(

1. Unless otherwise noted, all observations by Bryant (this report), based on air photo interpretation and field checking. Field observations indicated on figure 3. Refer to figure 3 for symbol explanations.

Table 1 (to FER-159) Tabulation of Observations

Locality #	Fault Name	Geomorphic feature delineating fault[1]	Youngest unit offset & source	Remarks[1]
1 (fig. 3) (contd)				is offset about 3'; the southerly drainage has a knickpoint in the stream gradient just west of the scarp. According to Slemmons (CDMG, 1972), this fault segment ruptured in 1872. The well-defined scarp in alluvium and the vertically offset drainages observed along this segment tend to support Slemmons' conclusions, although the scarp slope angles(which support Holocene faulting), may be somewhat shallow for a 112-year-old event, although the order of magnitude of age roughly coincides (Wallace, 1977).
2 (fig 3)	OVFZ Big Pine segment	scarp; dov	late Pleistocene alluvium (Bryant, this report	Construction of diversion channel 200' north of this segment this report) location has exposed alluvium on upthrown side of fault. Near top of exposure slight reddish hue suggests B soil horizons.Grussification of granitic cobbles and boulders is not as widespride as observed at Fish Springs location. Thus, age of alluvium is possibly post-Tahoe and pre-Tioga (mid-Wisconsin?).Land surfaces for the next 800' north of this location have been modified by grading for diversion channels along Big Pine Creek.

Table 1 (to FER-159) Tabulation of Observations

Locality #	Fault Name	Geomorphic feature delineating fault[1]	Youngest unit offset & source	Remarks[1]
3 (fig. 3)	OVFZ Big Pine segment	scarp	Holocene alluvium (Bryant, this report)	Offset Holocene alluvial fan. Alluvium is relatively fine-grained with a general lack of exposed cobbles and boulders. Dense vegetation at the base of the scarp and along the upthrown side have resulted in the formation of a strong A soil horizon, making age estimations from surface exposures difficult. However,the tonal quality and surface features of the upthrown block at this location are similar to location 3a along Big Pine Creek upstream from location 3.The weakly developed B soil horizon and the fresh, unpitted appearance of the granitic cobbles and boulders indicate the alluvium is Holocene.
4 (fig. 3)	OVFZ Big Pine segment	scarp; t	late Pleistocene alluvium (Bryant, this report)	Road-cut exposure across east-facing scarp. Alluvium consists of cobbles and boulders in a matrix of sand and some silt. Granitic clasts moderately weathered to gruss,but not nearly as extensively as alluvium at Fish Springs.Possible mid- to early-Wisconsin age for alluvium exposed in this roadcut. Vertical to steeply east-dipping veins of caliche (1/2" to 2" wide) observed in alluvium about 10' to 15' west of scarp slope. No clear evidence of shearing along these veins (no planar surfaces with slicken-sides or grooves). Fault plane probably is east of this location where fill prism for road obscures exposure. Caliche veins probably are small extension cracks or fissures.

Table 1 (to FER-159) Tabulation of Observations

Locality #	Fault Name	Geomorphic feature delineating fault[1]	Youngest unit offset & source	Remarks[1]
5 (fig. 3)	OVFZ Big Pine segment	scarp; cd	Holocene alluvium (Bateman, 1965; Bryant, this report)	East-facing scarp in alluvivum. Scarp profile: h = 3-1/2', ∡ = 20°, c ≃ 1'-2'. Alluvium is light greyish tan, sandy silt and is generally cohesionless. Lack of soil development and color indicate Holocene age. Alluvium is either Owens River floodplain deposits or fine-grained alluvial fan deposits from Baker Creek.
6 (fig. 3)	OVFZ Big Pine segment	scarp; cd; dd	Holocene alluvium (Bateman, 1965; Bryant this report)	East-facing scarp in Holocene eolian deposits. Deposit consists of nearly cohesionless, fine-grained, well-sorted sand. A small ridge is vertically offset, down to the east, and the eolian deposits occur on both sides of the fault. Scarp profile: h = 8', ∡ = 30°, c = 1'-2'. Area used for cattle grazing, so scarp is modified to some degree.
7 (fig. 3)	OVFZ, Owens Valley Rach segment	scarp; v.c.; linear swale	late Pleistocene alluvium? (Bryant this report)	West-facing (back-facing) scarp in alluvium. Alluvium east of fault contains numerous weathered granitic cobbles and boulders and is comparabe to alluvium of Tahoe-age at Fish Springs. Scarp profile: h = 3', ∡ = 7°, c ≃ 15'. Scarp-slope is armored with boulders and cobbles.Alluvium west of fault is relatively fine-grained and is probably Holocene. The fine-grained alluvium seems to be deposited against the west-facing scarp, rather than faulted.

Table 1 (to FER-159) Tabulation of Observations

Locality #	Fault Name	Geomorphic feature delineating fault[1]	Youngest unit offset & source	Remarks[1]
8 (fig. 3)	OVFZ, Owens Valley Ranch segment	scarp(?); v.c.; springs	late Pleistocene alluvium (Bryant, this report)	An apparent east-facing scarp in alluvium of probable Holocene age, and associated vegetation contrasts, are mapped at this location, based on air photo interpretation. Field observations indicate that the scarp may be erosional. Several springs are located along this feature, and it seems that headward erosion by the springs has produced a westward migration of east-sloping drainge channels. The head of these spring-produced drainages locally have coalesced, forming an east-facing erosional escarpment. Areas along the fault that do not have springs are not characterized by the east-facing scarp.
9 (fig. 3)	OVFZ Owens Valley Ranch segment	scarp	late Pleistocene alluvium (Bryant, this report)	West-facing (back-facing) scarp in alluvium similar to that described in locality 7. Fault at one time diverted Big Pine north, but Big Pine Creek has subsequently breached the scarp and now flows east. Apparent dip of poorly bedded alluvium just east of fault is 6^{o} west, indicating that tilting has occurred. Alluvium exposed at this location is probably Tahoe equivalent, based on weathered granitic clasts and reddish hue of matrix.

Table 1 (to FER-159) Tabulation of Observations

Locality #	Fault Name	Geomorphic feature delineating fault[1]	Youngest unit offset & source	Remarks[1]
10 (fig. 3)	OVFZ	scarp	Pleistocene alluvium (Bateman, 1965)	Well-defined, west-facing scarp does not extend into alluvium of Holocene age. Scarp clearly has been removed by lateral erosion.
11 (fig. 3)	OVFZ Baker Creek segment	scarp; t	Holocene alluvium? (Bateman, 1965)	West-facing scarp in granitic bedrock--no evidence that alluvium west of fault is offset. Scarp is eroded. Alluvium has ponded behind scarp in Baker Creek. However, scarp has been breached. South of Baker Creek fault delineated by saddle in Sherwin glacial deposits (Bateman, 1965). Evidence of Holocene offset along this fault weak.
12 (fig. 3)	OVFZ Shannon Canyon segment	scarp; t	Holocene alluvium (Bateman, 1965)	West-facing (back-facing) scarp in alluvial fan. Fan is complex and consists of alluvium of differing ages, ranging from late Pleistocene (Tahoe equivalent?) to Holocene. Age estimation based on degree of weathering of granitic boulders exposed at surface, on color, and degree of dissection of alluvium as compared with features observed at Fish Springs. Scarp profile in Holocene alluvium: h = 6', $\measuredangle = 15^{\circ}$, c $\simeq$ 15'. About 3,000 feet south of this location Bateman (1965) observed fault exposure in alluvium. Fault dips 60°W in north bank of Shannon Canyon.

Table 1 (to FER-159) Tabulation of Observations

Locality #	Fault Name	Geomorphic feature delineating fault[1]	Youngest unit offset & source	Remarks[1]
13 (fig. 3)	OVFZ Shannon Canyon segment	scarp	late Pleistocene alluvium (Bryant, this report)	West-facing scarp offsets alluvial fan. Alluvium east of fault is probably latest Pleistocene, based on the degree of weathered and pitted granitic cobbles and boulders exposed at surface. Holocene alluvium deposited against scarp on west -no evidence of offset of these deposits. Scarp profile: $h \doteq 4\text{-}1/2'$, $\measuredangle = 15^{\circ}$, $c \cong 15'$. About 1500' south of this location alluvium of probable Holocene age doesn't seem to be faulted.
14 (fig. 3)	OVFZ Warren Lake segment	scarp; dov; pa; cd	Holocene alluvium (Bateman, 1965; Bryant this report)	Northwest-facing scarp in Holocene alluvium. Ground surface is clearly offset (down to NW); however, an irrigation canal has been constructed along the base of the scarp, obscuring the natural scarp profile. Eolian deposits occur on the upthrown side of the fault-a sand dune may be truncated, but the location of the irrigation canal precludes determination of the relationship between scarp and sand dune.
15 (fig. 3)	OVFZ Klondike Lake segment	scarp; cd; v.c.	Holocene alluvium (Bateman, 1965)	Northwest-facing scarp in Holocene alluvium-no clear offset of eolian deposits observed along the scarp. Scarp is modified by wave erosion from Klondike Lake and eolian deposition. Sinuous, northwest-trending sand dune is deflected northwest around margin of lake, indicating that the lake was not originally man made. However, the depression now drains to the south, the NW-facing scarp having been dammed by man, causing deposition of lake deposits southeast of the scarp. A linear vegetation contrast delineates the probable location of the fault north northwest of the dam. Vegetation contrast under water at time of field observations in early February 1984.

Table 1 (to FER-159) Tabulation of Observations

Locality #	Fault Name	Geomorphic feature delineating fault[1]	Youngest unit offset & source	Remarks[1]
16 (fig. 3)	White Mountain frontal fault zone	scarp	Holocene (?) alluvium (Bateman, 1965; Bryant this report)	West-facing scarp in Pleistocene alluvium. Possible scarp in small Holocene alluvial fan, but not well defined. This fault aligns with well-defined scarps in alluvium just north in the southern Bishop 15' quadrangle (see FER-153, Bryant, 1983).
17 (fig. 3)	OVFZ Big Pine segment	scarp; cd; right-laterally offset ridge(?)	Holocene alluvium (Bateman, 1965; Bryant this report)	An abrupt change in the sense of displacement along this fault segment may best be explained by a right-lateral strike-slip component. The fault trace is very linear, suggesting a vertical fault plane. However, no evidence of a strike-slip component of offset was observed just north at locality 5.

Table 2 (to FER-159)

Fault Scarp Profiles

Fault Name, Location	Height	Slope Angle	Crest Width	Material Offset	Fault Type
Owens Valley Fault Zone (OVFZ)					
Big Pine segment SE-1/4 Sec 19, T9S, R34E	8'	27°	5'	Holocene alluvium	normal
Big Pine segment SE-1/4 Sec 19, T9S, R34E (same segment)	8-1/2'	25°	1'	Holocene alluvium	normal
Big Pine segment SE-1/4 Sec 19, T9S, R34E (same segment)	9'	26°	5'	Holocene alluvium	normal
Big Pine segment SE-1/4 Sec 19, T9S, R34E (same segment)	6'	26°	2'	Holocene alluvium	normal
Big Pine segment SE-1/4 Sec 19, T9S, R34E	5-1/2'	20°	10'	Holocene alluvium	back-facing scarp
Big Pine segment SE-1/4 Sec 19, T9S, R34E	6-1/2'	25°	3'	Holocene alluvium	normal
Big Pine segment NE-1/4 Sec 19, T9S, R34E (same segment)	10'	27°	5'	Holocene alluvium	normal
Big Pine segment NE-1/4 Sec 19, T9S, R34E	12'	32°	3'	Holocene alluvium	normal
Big Pine segment NW-1/4 Sec 18, T9S, R34E	25'	28°	5'	late Pleistocene to Holocene alluvium	normal
Big Pine segment NW-1/4 Sec 18, T9S, R34E	10'	24°	N/M	late Pleistocene to Holocene alluvium	normal
Big Pine segment NW-1/4 Sec 18, T9S, R34E	25'	30°	5'	late Pleistocene to Holocene alluvium	normal

Table 2 (to FER-159)

Fault Scarp Profiles (contd)

Fault Name, Location	Height	Slope Angle	Crest Width	Material Offset	Fault Type
Big Pine segment SW-1/4 Sec 6, T9S, R34E	3-1/2'	20°	1'-2'	Holocene alluvium	normal
Big Pine segment SE-1/4 Sec 35, T8S, R33E	8'	30°	1'-2'	Holocene alluvium	normal
Big Pine segment NE-1/4 Sec 35, T8S, R33E	4'	33°	5'	Holocene alluvium	normal
OVFZ SW-1/4 Sec 18, T9S, R34E	5-1/2'	15°	15'	late Pleistocene alluvium	back-facing scarp
OVFZ NW-1/4 Sec 18, T9S, R34E (same segment)	4'	14°	15'	late Pleistocene alluvium	back-facing scarp
OVFZ SE-1/4 Sec 13, T9S, R33E	8-1/2'	17°	≃ 20'	late Pleistocene alluvium	east side of graben
OVFZ SE-1/4 Sec 13, T9S, R33E	12'	15°	≃ 20'	late Pleistocene alluvium	west side of graben
OVFZ SE-1/4 Sec 13, T9S, R33E	≃ 5'	15°	N/M	late Pleistocene alluvium	back-facing scarp
Owens Valley Ranch segment SW-1/4 Sec 13, T9S, R33E	3'	7°	≃ 15'	late Pleistocene alluvium	back-facing scarp
Baker Creek segment NE-1/4 Sec 23, T9S, R33E	6'	8°	> 20'	late Pleistocene alluvium	back-facing scarp
Baker Creek segment NE-1/4 Sec 23, T9S, R33E (same segment)	10'	14°	≃ 20'	Pleistocene alluvium	back-facing scarp
Shannon Canyon segment NW-1/4 Sec 33, T8S, R33E	4-1/2'	15°	≃ 15'	late Pleistocene (?) alluvium	back-facing scarp
Shannon Canyon segment Center, Sec 20, T8S, R33E	6'	15°	15'	late Pleistocene to Holocene alluvium	back-facing scarp