CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-160

Nunez Fault, Fresno County, California

by

Earl W. Hart
March 23, 1984

INTRODUCTION

The Nunez fault lies in the Alcalde Hills 7.5-minute quadrangle, about 12km northwest of Coalinga, Fresno County (Figure 1). Surface rupture occurred along several strands of this fault in June and July 1983 in association with several earthquakes of M5.2 to M6.4. It is the purpose of this study to determine which additional strands or segments of the Nunez fault should be zoned under the Alquist-Priolo Special Studies Zones Act. The specific zoning criteria of "sufficiently active and well-defined" are discussed in Hart (1980, p. 5-6).

SUMMARY OF AVAILABLE DATA

The Nunez fault is a relatively minor oblique-slip fault that dips steeply eastward. It exhibited reverse and right-lateral slip displacements associated with several earthquakes beginning on June 10, 1983. The well-defined zones of rupture were carefully mapped by the California Division of Mines and Geology and the U.S. Geological Survey and the detailed observations were published in Hart and McJunkin (1983), part of which is reproduced in this FER (Figures 1 and 2 and Table 1).

As can be seen on Figure 2, there are two principal zones of surface rupture, which developed over a distance of 3.3km with a maximum net slip of about 60cm of reverse displacement occurring on the northern segment (locality 3, Table 1 and Figure 2). A substantial right-lateral component of slip also was recorded at localities 1 and 6. The southern segment of rupture had at least 20cm of reverse slip locally and a consistent component of right slip south of Los Gatos Road, reaching a maximum of 11cm near locality 17. Several minor, but distinct, secondary rupture zones also were mapped (Figure 2).

Structurally, the Nunez fault appears to be a relatively minor feature that may be related to other north-trending faults superimposed on the complexly folded, east-dipping sequence of Upper Cretaceous and Cenozoic strata mapped by T.W. Dibblee (1971) and E.J. Fowkes (1982). Dibblee's map is partly reproduced as Figure 3. Only the southern end of the Nunez fault was mapped by Dibblee. None of these faults are shown to offset Quaternary strata and none were previously considered to be active.

An unpublished map by Chevron, Inc. (R.C. Erickson, personal communication, 1983) shows additional bedrock faults that are partly coincident with the Nunez fault (approximately located on Figure 3). However, the precise location of these faults is uncertain. An interpretation of aerial photographs (see below) shows numerous other minor north-trending faults in the general vicinity of the Nunez fault.

INTERPRETATION OF AERIAL PHOTOS AND FIELD OBSERVATIONS

The only aerial photographs available for this brief study, which was conducted under severe time constraints, are those taken by the USGS on June 15, 1983. These detailed photographs show numerous north-trending, vertical to steeply east-dipping faults along the zone of 1983 ruptures and elsewhere in the general vicinity. For the most part, these faults are recognizable as sharply defined linear tonals that truncate the Cretaceous strata. Other than the zones of newly formed fissures and west-facing scarps, there is little evidence on the photographs to suggest that the Nunez fault was active in Holocene time. North and south extensions of the 1983 rupture zones are plotted on Fig. 4, along with the evidence for the existence and possible recency of the distal segments. The other minor faults are too numerous to show on the map, and none appears to have clear evidence of recent activity.

Field observations conducted along the 1983 rupture zone in June and July 1983, revealed the existence of pre-existing subtle scarps and sidehill benches that are permissive, if not suggestive, of Holocene faulting. Field observations also verified the existence of a steeply east-dipping fault in bedrock at Los Gatos Road where the soil thickened westward across the subtle scarp at Los Gatos Road (Locality 12, Figure 2). This suggests that previous late Quaternary (Holocene?) reverse faulting occurred at that site, in spite of the lack of clear geomorphic evidence of previous recent faulting. A steeply east-dipping fault also was exposed in Post Canyon approximately 300m south of the most southerly ruptures (M. Clark, USGS, p.c., 1983).

It is apparent that the 1983 displacements along the Nunez fault occurred along pre-existing fault strands that at least locally had minor recent displacements. However, the lack of well-developed tectonic geomorphic features along this fault suggests that previous recent faulting has been at a relatively low rate of slip. Nonetheless, future displacements may occur along the 1983 rupture zone, and the zone may extend to the north and south along the traces shown on Figure 4. Other faults in the vicinity also may be partly active, but the interpretation of aerial photos does not distinguish between faults that are inactive and those that may be slightly active. These other faults were not field-checked.

SEISMICITY AND SURFACE DEFORMATION

As indicated above, rupture along the Nunez fault was associated with several June and July 1983 earthquakes (plotted on Fig. 1), all of which show first motion data and hypocenters consistent with displacement at depth on the east-dipping Nunez fault (Eaton and others, 1983). These earthquakes were considered as aftershocks of the May 2, 1983 M6.7 earthquake, which was not associated with surface faulting (one minor exception--see Hart and McJunkin, 1983). However, 43cm of uplift did occur on the Coalinga nose structure (see Fig. 1) in association with the Coalinga earthquakes (Stein, 1983).

The distribution of earthquakes in the Coalinga region since 1972 (Eaton and others) suggests that many active faults are distributed at depth, but no surface faulting has been associated with these events and no Holocene faults are known from surface mapping. It seems likely that surface deformation in the Coalinga region, including the Nunez fault area, is probably taking place largely in the form of distributive folding and warping of the earth's surface.

CONCLUSIONS

The Nunez fault appears to be a relatively minor east-dipping fault that is associated with folding and uplift in the Coalinga area. Surface displacements that occurred in 1983 clearly identify traces that are active and well-defined. Surface evidence (linear tonals, truncated beds, and subtle scarps and benches) indicates that the Nunez fault extends a short distance to the north and south of the 1983 rupture zones, and those segments may be active. It is believed that future rupture may propagate north or south along these distal segments.

Other minor faults exist in the vicinity of the Nunez fault, but clear evidence that any of these faults have been active in Holocene time is not observable on aerial photos. Additional faults to the west (Fig. 3) were mapped by Dibblee, but they are not identified as offsetting the young terrace deposits along Los Gatos Creek.

RECOMMENDATIONS

The 1983 surface faulting clearly meets the criteria (sufficiently active and well-defined) for zoning. In addition, the north and south extensions of the rupture zones are reasonably well-defined and should be zoned as identified on Figure 4. The zone maps should cite Hart and McJunkin (1983) and this FER as references.

Earl W. Hart

Earl W. Hart
Senior Geologist
CEG 935

Reviewed and approved
March 28, 1984

Robert H. Sydnor

Robert H. Sydnor
Supervising Geologist
CEG 968

REFERENCES

Dibblee, T.W., 1971, Geologic maps of the Coalinga, Joaquin Rocks, New Idria, and Priest Valley 15-minute quadrangles: U.S. Geological Survey Open-file Report 71-87.

Eaton, J., Cockerham, R., and Lester, F., 1983, Study of the May 2, 1983, Coalinga earthquake and its aftershocks, based on the USGS seismic network in northern California in J.H. Bennett and R.W. Sherburne (editors), The 1983 Coalinga, California Earthquakes: California Division of Mines and Geology Special Publication 66, p. 261-273.

Fowkes, E.J., 1982, An educational guidebook to the geologic resources of the Coalinga district, California: West Hills College, Coalinga CA, 260 p. (Contains gelogic map of Coalinga area and text and figures on stratigraphy, structure, references, and field trips.)

Hart, E.W., 1980, Fault-rupture hazard zones in California: California Division of Mines and Geology Special Publication 42, 25 p.

Hart, E.W., and McJunkin, R.D., 1983, Surface faulting northwest of Coalinga, California, June and July 1983 in J.H. Bennett and R.W. Sherburne (editors), The 1983 Coalinga, California Earthquakes: California Division of Mines and Geology Special Publication 66, p. 201-219.

Stein, R.S., 1983, Reverse slip on a buried fault during the 2 May 1983 Coalinga earthquake--evidence from geodetic elevation changes in J.H. Bennett and R.W. Sherburne (editors), The 1983 Coalinga, California Earthquakes: California Division of Mines and Geology Special Publication 66, p. 151-160.

U.S. Geological Survey 1983, GDCL aerial photographs, 1:7,600 (approx.) scale, low-sun (morning), black and white, vertical.

Doc. #0477A

Table 1. Descriptions of observed surface faulting associated with the June 10, July 9, July 21, and July 25, 1983, earthquakes. CDMG data unless otherwise indicated. Locality numbers are identified on map, Figure 2.
(From Hart and McJunkin, 1980, Table 2)

Locality	Observations
1.	Fresh, 18 cm-high, west-facing compressional scarp with extensional cracks on upthrown block, 6/14; aligns with other scarps and moletrack features to N and S. Scarp first seen by rancher on 6/11 or 6/12 (J. Nunez, p.c., 6/13). USGS measured 3.1 cm additional uplift and 2.2 cm shortening of monument line (established 7/15) just S of road on 7/22; no additional slip measured 7/27. Data indicate reverse movement on east-dipping fault associated with earthquakes of 6/10, 7/9(?), and 7/21.
2.	Continuous, narrow zone of ruptured ground with west-facing scarps along outer edge of pre-existing, sidehill bench on east-facing slope. Estimated vertical displacement of 15 to 20 cm or more on 6/14 along east-dipping reverse fault. Offsets appeared somewhat larger on 7/22, with maximum scarp height of 30-32 cm observed at one point.
3.	Fresh, well-developed, west-facing, compressional scarp along cattle trail in bottom of gully; estimated offset to be 43 to 48 cm on 6/15. Fissures and moletracks to N and S in moist soil adjacent to gully indicate 70° to 75° east-dipping reverse fault. Observed offset was 48 cm on 7/11. USGS observed offsets of 42 cm on 6/15 and 48 cm on 7/13. However, later USGS level surveys along the centerline of cattle trail indicate 57 cm uplift on 7/15, plus 0 to 5 cm on 7/22, and 0 cm on 7/27.
4.	Very fresh, overhanging scarp 18 cm high with fault plane exposed in soil along sidehill bench on 6/15; fault plane strikes N 50° E and dips 67° SE.
5.	Large, west-facing scarp and associated moletrack features near crest of ridge, indicate east-dipping reverse fault on 6/15. USGS monument line surveyed on 7/15 indicates 36 cm total uplift. On 7/22, USGS survey showed minor additional movement of 0.15 cm uplift and 0.9 cm compression. No movement detected 7/27.
6.	Fresh compressional scarp in soil with east-side-up vertical offset estimated to be about 50 cm on 6/15. Nearby USGS monument line indicated 50±20 cm total uplift on 7/15 with additional 0.5 cm uplift and 0.6 cm compression on 7/22. No movement detected 7/27. About 100 cm to south, USGS observed 20 cm of right-lateral slip on 8/9 along a previously observed 25 cm-high scarp. This right slip component was not previously observed, but it may have been overlooked initially (M.J. Rymer, p.c.).

7. Zone of fresh left-stepping moletracks and cracks along general southwest-facing scarp; estimated roughly 5 to 10 cm of vertical uplift on individual scarps and roughly 5 cm right slip offset at fence on 6/15, but accurate measurements not possible. Fault rupture could not be traced to south in tall grass on 6/15, but discontinuous, 3 to 4 m wide zone of low moletracks, west-facing scarps, and new(?) cracks could be followed southward an additional 150 m with difficulty on 7/23. USGS monument-line surveys indicated 39±3 cm vertical uplift across the scarp on 7/15 with an additional 0.3 cm uplift and 0.9 cm compression on 7/22. No tectonic change reported for 7/27 survey.

8. East-west wire fence along steep, east-draining gully observed to be shortened (slack wire) across the projection of the fault on 6/14. Observations on 7/22 suggest further shortening, crudely measured to be 5 cm.

9. Fresh west-facing, moletrack-like scarp estimated to be about 15 cm high on 6/14 and possibly a little higher on 7/22. USGS measurements along monument line indicated the scarp to be 20 cm high on 7/15; additional uplift of 2.3 cm and shortening of 1.5 cm were measured 7/22. No additional movement detected 7/27.

10. Two fresh(?) scarplets observed 7/22 in loose soil of recently used foot path, possibly suggesting renewed uplift along degraded, west-facing scarp initially observed 6/13. Total scarp height estimated to be 15 to 17 cm on 7/22. Continuous 5-10 cm high scarp observed 6/14 this vicinity, but specific locality not measured or estimated at that time.

11. Well-defined, 1 to 2 m wide zone of moletracks, compressional scarp, and cracks; scarp faces west and estimated to be 10 to 15 cm high on 6/13. USGS monument-line surveys indicate 0.4 cm additional uplift and 0.55 cm compression between 7/15 and 7/22. A 5 to 15 m wide zone of north-trending tension cracks open as much as 5 to 6 cm, observed 6/13 in soil immediately east of the fault, suggesting that east-dipping fault plane flattens upward.

12. Paved road offset on 6/10 and west-facing scarp observed to be 15-20 cm high on 6/11 (E.J. Fowkes, p.c., 8/12). Road was repaved 6/14 and no cracks developed thereafter through 7/27. However, surveys of recently-established USGS nail-line indicated 2 mm of east-side-up movement between 7/23 and 7/27. Pre-existing fault with fresh fractures was exposed in roadcut; dip is about 60-70°E in bedrock, but dip of fault flattens upward (to west) in soil and appears to connect with moletrack/scarp feature in soil. Tension cracks, open to 2 cm, occur in conglomerate and sandstone east of fault and align with open cracks in soil to north.

13. Narrow sinuous west-facing moletrack 7 to 10 cm high, with fresh, delicate features seen in soil of recently grazed field (young terrace) on 7/23. Moletrack indicates probable slip along reverse fault associated with 7/21 earthquakes. Possible cracks and moletrack observed nearby (?) on 6/11 (Fowkes, 6/13). Open cracks in narrow zone to south reported by USGS on 7/28 to be partly left-stepping, suggesting some right slip. Pre-existing(?), low, west-facing scarp in very young terrace surface suggests previous Holocene displacement.

14. Fresh, west-facing scarplets in dirt road estimated to be 3 to 5 cm high on 7/23. No fault features or cracks observed at this locality on 7/12; indicates reverse slip along east-dipping fault associated with 7/21 earthquakes.

15. Low, sinuous moletrack and west-facing scarp about 5 to 10 cm high observed 7/23, partly very fresh and more or less continuous with newly ruptured ground to north. Some discontinuous moletracks reported in this area by E.J. Fowkes on 6/11 and M. Rymer (USGS) on 6/14. Probable rupture on 6/10 and 7/21.

16. Zone of very fresh, left-stepping cracks and west-facing scarp in cattle trail on 7/23. Estimate 7 cm uplift and at least 2 to 4 cm right slip along 70-80°E-dipping fault plane exposed in soil; fault plane is grooved, showing oblique slip (photo 7). USGS measured 7 cm vertical and 6 cm right-slip displacement on 7/28. About 100 m to south, USGS measured maximum of 11 cm right slip on 7/28, more than recognized by CDMG on 7/23. Freshness of features indicates reverse and right-lateral displacements along steeply east-dipping fault associated with 7/21 and possibly 7/25 events. No previous clear evidence of fault-rupture reported for this general locality prior to 7/23 by CDMG or USGS although "crack zone" reported in vicinity about 6/28 (P. Hughes of Chevron, Inc., p.c., 8/11).

17. Fresh, well-developed, left-stepping cracks and sharply defined moletracks in 1 to 2 m-wide zone observed 7/23. About 3 cm right-lateral slip is indicated by extensional opening of cracks. Consistent west-facing scarps indicate about 5 cm vertical offset (up on east). USGS installed monument line on 7/27; USGS observed 1.5 cm vertical and 2 cm right-lateral offset on 7/28.

18. Zone of left-stepping cracks (without scarp) observed by USGS on 7/28; indicates minor right-slip displacement. Left-stepping cracks not observed by CDMG on 7/23.

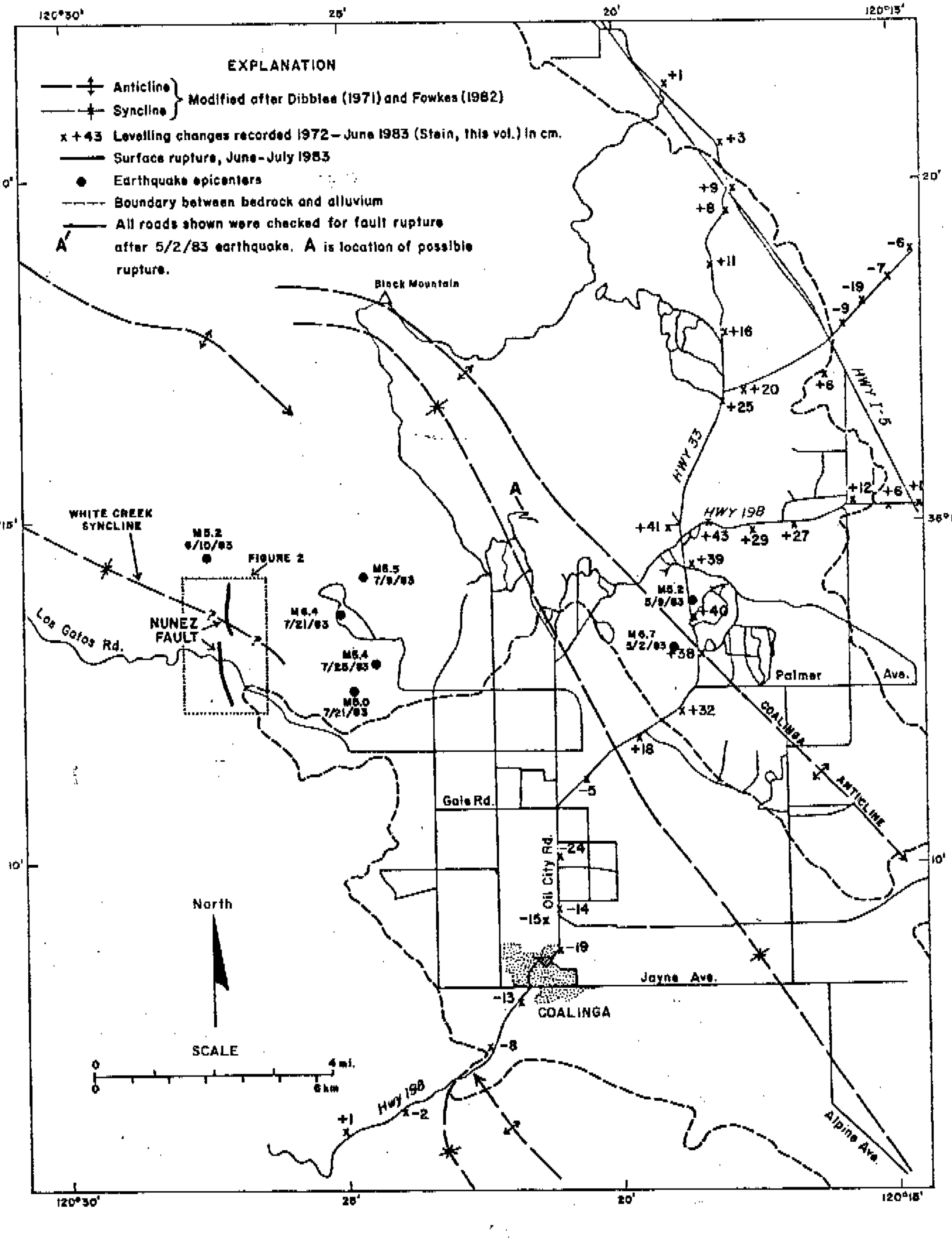
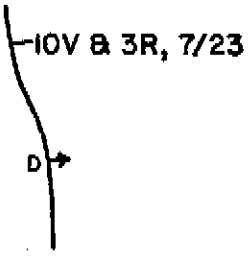


Figure 1. Map showing locations of 1983 Coalinga earthquakes, associated fault rupture, and other data. *(Map reproduced from Hart and McJunkin, 1983, Fig. 1.)*

Figure 2 (FER - 160). Trace of surface faulting along Nunez fault, associated with the Coalinga, California, earthquakes of June 10 and July 9, 21, and 25, 1983.

EXPLANATION FOR FIGURE 2



Well-defined trace of June and July 1983 fault rupture as indicated by scarps, moletracks, and cracks. Measured or estimated displacements are shown in centimeters; V is vertical offset, R is right-lateral, C is compressional. D indicates downthrown block. Date indicates month and day of observations. Arrow indicates dip of fault where observed or inferred. ( ) Parentheses indicate data from USGS.

Linear zones of extensional cracks in soil suggestive of faulting, but sense and magnitude not clear. Query indicates additional uncertainty.

o Monument survey lines established by USGS on 7/15 (north of Los Gatos Road) and 7/23 (south of Los Gatos Road)

(7) Locality described additionally in Table 1