CALIFORNIA DIVISION OF MINES & GEOLOGY

Fault Evaluation Report FER-167

Faults in the Southern Monterey Bay Area, Monterey County

by

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INTRODUCTION

Potentially active faults located in the southern Monterey Bay area of Monterey County that are evaluated in this FER include the Tularcitos, Navy, Chupines, Berwick, Cypress Point, Cachagua, Ord Terrace, and Seaside faults (figure 1). The southern Monterey Bay study area is located in parts of the Monterey, Seaside, Mt. Carmel, Carmel Valley, and Rana Creek 7-1/2 minute quadrangles (figure 1). 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 southern Monterey Bay study area is characterized by compressional tectonics related to the San Andreas fault system. Faults in the study area generally are steeply dipping reverse and reverse-oblique slip faults with associated folding in Tertiary and Quaternary sedimentary rocks (Compton, 1966; Dibblee, 1972; Clark and others, 1974).

Topography in the study area ranges from low areas of stabilized, older sand dunes to the relatively rugged relief of the Sierra de Salinas. Elevations in the study area range from sea level to over 2,000 feet. Development in the Monterey-Carmel area is quite dense, and much of the Carmel Valley area has been developed. The Tularcitos Creek area is relatively undeveloped and is mainly used for cattle grazing and other agricultural uses.

Rock types in the study area include pre-Tertiary granitic and associated metamorphic basement rocks of the Salinian block, Tertiary sedimentary rocks, including the Miocene Monterey Formation and Plio-Pleistocene Paso Robles Formation, and sparse outcrops of Quaternary alluvium (Bowen, 1969; Fiedler, 1944; Dibblee, 1972; Clark and others, 1974). Quaternary deposits, exclusive of the Paso Robles Formation and the Pleistocene Aromas Sands, include marine and fluvial terrace deposits ranging in age from Pleistocene to Holocene, late Pleistocene to modern sand dunes, and stream alluvium and colluvium of Holocene age (Clark and others, 1974; Dibblee, 1972; U.S.D.A., 1975). Landslides are very common in the study area, and have not as yet been adequately mapped.

TULARCITOS FAULT

The Tularcitos fault is a northwest-trending, steeply southwest-dipping reverse fault (Dibblee, 1972; Neel, 1963) (figures 1, 2b, 2c, 2d). Pre-Tertiary granitic basement rocks to the south are faulted over Tertiary sedimentary rocks along much of the fault trend (Dibblee, 1972; Fiedler, 1944; Dibblee and Clark, 1973; Clark and others, 1974). Wiedman (1969) indicated that the Tularcitos fault in the upper Tularcitos Valley is a northeast-dipping normal fault, although he admits that no fault exposures were observed in his study area. Neel (1963) mapped the fault in the lower Tularcitos Valley as a southwest-dipping reverse fault and observed an exposure of the fault near the intersection of Carmel Valley Road and Cachagua Grade Road (locality 1, figure 2c). Neel speculated that the Tularcitos fault is generally steeply dipping and that perhaps the fault has a significant strike-slip component, based on stratigraphic evidence. However, Neel does not speculate on the sense of strike-slip displacement nor the magnitude of offset.

Bowen (1969) mapped an essentially west-trending fault zone in the Carmel River Valley and suggested that the Tularcitos fault connects with the Cypress Point fault (figures 1, 2a, 2b). Bowen indicated that a northern segment of the Tularcitos fault offsets late Pleistocene terrace deposits (locality 11) and that the main trace is delineated by sidehill ridges and sag ponds (locality 12, figure 2b).

Dibblee (1972), Dibblee and Clark (1973), and Clark and others (1974) mapped the Tularcitos fault as concealed by Pleistocene alluvium. A set of nested terraces near the junction of the Carmel River and Tularcitos Creek (locality 2, figure 2c) are not offset by the Tularcitos fault. Clark and others (1974) did not provide evidence that the Tularcitos fault is Holocene active. Buchanan-Banks and others (1978) classified the fault as Pliocene active with no evidence of offset Pleistocene deposits (figure 1). Jennings (1975) classified the northern part of the Tularcitos fault along the south side of Carmel Valley as Quaternary active based on mapping by Bowen (1969) (figures 2a, 2b).

Curry (1984) mapped segments of the Tularcitos fault along Tularcitos Creek (figures 2c, 2d). Curry stated that displacement across the Tularcitos fault has components of both reverse and right-lateral strike-slip displacement and that evidence for Holocene offset is clear. Curry cites the presence of large sag ponds in Tularcitos Valley (localities 3, 4, figures 2c, 2d), a large landslide complex along the north side of Tularcitos Ridge (locality 5, figure 2c), the location of springs in young (Holocene) alluvium, and linear scarps and closed depressions associated with north and northeast-trending normal faults subsidiary to the Tularcitos fault as evidence of Holocene displacement (figures 2c, 2d).

Weber (1984) postulated that post-Miocene vertical displacement across the Tularcitos fault may be greater than 1,200 meters. Weber (p.c. January 1985) suggests that the Tularcitos fault may connect with the Navy fault across Carmel Valley, rather than continue west along Carmel Valley as Bowen mapped the fault (figures 1, 2a, 2b). Air photo lineaments in young (Holocene?) terrace deposits were mapped by Weber near locality 2 (figure 2c). However, these lineaments were not trenched.

Post-Miocene slip along the Tularcitos fault as indicated by Weber (1984) would yield a slip-rate of approximately 0.08mm/yr to 0.2mm/yr. The late Quaternary slip-rate for the Tularcitos fault is not known.

Kapple and others (1983) indicated that the alluvium in Carmel Valley thins noticeably east of the postulated junction of the Tularcitos and Navy faults (Sec. 19, T16S, R2E, figure 2b). Kapple stated that granitic rocks underlie the alluvium here, while to the west, where the overlying alluvium is thicker, sedimentary rocks underlie the alluvium.

NAVY FAULT

The Navy fault is a northwest-trending fault that offsets Plio-Pleistocene Paso Robles Formation, but does not offset Pleistocene older alluvium (Clark and others, 1974) (figure 2b). A northwest-trending offshore fault, part of the Monterey Bay fault zone, may offset the sea floor and possibly is continuous with the Navy fault (Greene and others, 1973; Clark and others, 1974). Buchanan-Banks and others, (1978) mapped Holocene deposits offset along a possible northern projection of the Navy fault (figure 1). However, cross sections K-K' and L-L' prepared by Greene and others (1973) do not show Holocene deposits offset along this fault. Clark and others (1974) did not indicate the style of offset along the Navy fault, but Greene and others (1977) indicated that the Navy fault is a southwest-dipping reverse fault. Both Clark and others and Greene (1977) stated that the fault is delineated locally by southwest-facing scarps (in Monterey Formation, probably located in Sec. 10, T16S, R1E, figure 2b), which is inconsistent with a southwest-dipping reverse fault.

Clark and others (1974) first mapped the Navy fault based on linear and aligned drainages, southwest-facing scarps in Monterey shale, and the juxtaposition of Monterey Formation against Plio-Pleistocene Paso Robles Formation (figure 2b). Kapple and others (1983) mapped the southern part of the Navy fault, based on Clark and others (1974). Fault traces are identical except near locality 9 (figure 2b) where Kapple and others show Pleistocene terrace deposits offset. The contact between Monterey Formation and the terrace deposits was inadvertently left off during drafting; the approximately located fault offsets Monterey Formation, not Pleistocene terrace deposits (M. Johnson, p.c., April 1985).

Rogers E. Johnson and Associates (1981) postulated that the Navy fault is a right-lateral strike-slip fault (figure 2b). Buchanan-Banks and others (1978) classified the Navy fault as Quaternary active, but they did not observe evidence of late Quaternary activity (figure 1). Bowen (1969) did not map the Navy fault.

CHUPINES FAULT

The Chupines fault is an east-west to northwest-trending fault with a generally up-to-the-north sense of displacement (Dibblee and Clark, 1973; Dibblee 1972; Clark and others, 1974) (figures 2b, 2c). However, Bowen (1969), Greene and others (1973), and Greene (1977) mapped the fault as characterized by down-to-the-north displacement. The fault offsets Plio-Pleistocene Paso Robles Formation about 3 meters, down to the south (Clark and others, 1974). Sieck (1964) postulated about 300 meters of down-to-the-north vertical displacement of granitic basement rocks, based on gravity data. Therefore, either post-late Miocene faulting along the Chupines fault is minor, or deformation has been manifested primarily as folding rather than faulting. Bowen (1969) mapped segments of the Chupines fault that do not offset late Pleistocene terrace deposits (figure 2b). However, Bowen observed possible geomorphic evidence of recent faulting along the Chupines fault at locality 13 (figure 2b) and near locality 16 (figure 2c). Bowen mapped an inferred fault that may offset late Pleistocene sand dune deposits (locality 14, figure 2b). Subsequent mapping by Clark, Dibblee, Greene, and Bowen (1974) does not show this fault segment. Clark and others considered the Chupines fault to be inactive. Buchanan-Banks and others (1978) classified the Chupines fault as Quaternary, but they did not observe evidence of late Quaternary activity (figure 1).

BERWICK FAULT

Short, northwest-trending faults were mapped by Clark and others (1974) in Berwick Canyon (figure 2b). The Berwick fault truncates Pleistocene older alluvium and is considered to be potentially active by Clark and others. Buchanan-Banks and others (1978) classified the fault as late Pleistocene (figure 1). Displacement across the fault is not known, but is apparently up on the southwest. The dip of the fault also is not known, but is probably near vertical, based on the generally linear trace of the fault (figure 2b). Bowen (1969) did not map this fault.

CYPRESS POINT FAULT

The Cypress Point fault is a northwest-trending, southwest-dipping reverse fault with up-on-the-southwest displacement (Clark and others, 1974) (figure 2a). Granitic basement rocks are faulted against Tertiary sedimentary rocks, but Pleistocene marine terrace deposits are not offset (Clark and others, 1974). The Pleistocene marine terrace is characterized by a well-developed B horizon soil profile with thick clay films (U.S.D.A., 1975). Kapple and others (1983) mapped the southern end of the Cypress Point fault across Carmel Valley, based on mapping by Clark and others (1974). They indicate that alluvium thins across the fault. However, the fault does not offset Holocene alluvium and the thinning of unconsolidated sediments can be explained by deposition across a granitic bedrock high rather than active faulting.

Holocene deposits are not offset offshore along an inferred northern projection of the Cypress Point fault (Gilbert and others, 1973). Buchanan-Banks and others (1978) indicate that late Pleistocene deposits may be offset along this seaward projection of the Cypress Point fault (figure 1).

CACHAGUA FAULT

The Cachagua fault is a northwest-trending, steeply southwest-dipping reverse fault (Dibblee, 1972; Weber, 1984) (figures 2c, 2d). Crystalline basement rocks are offset against Tertiary sedimentary rocks; late Pleistocene terrace deposits conceal traces of the Cachagua fault except in Sec. 4, T18S, R3E (figure 2c) where Dibblee (1972) mapped terrace deposits juxtaposed against basement rocks (Dibblee, 1972; Weber, 1984; Weber, p.c., January 1985) (figure 2c). The total amount of displacement across the Cachagua fault is not known, although Weber (1984) stated that vertical separation of a middle Miocene unconformity is at least 610 meters.

Weber (1984) evaluated segments of the Cachagua fault for recency of faulting and stated that geomorphic evidence of late Pleistocene to Holocene displacement was not observed along the Cachagua fault. The fault is delineated by geomorphic features more consistent with erosion along a fault (Weber, 1984). Minor bedrock faults were trenched by Weber and overlying late Quaternary terrace deposits were not offset (Sec. 24, T17S, R2E, figure 2c).

Buchanan-Banks and others (1978) classified the Cachagua fault as a Cenozoic active fault with no evidence of late Quaternary offset (figure 1).

ORD TERRACE AND SEASIDE FAULTS

The Ord Terrace and Seaside faults are northwest-trending faults mapped primarily on the basis of subsurface information. Clark and others (1974) stated that the Monterey Formation is offset by these faults (figure 2b); the Seaside fault is apparently a down-to-the-south, dip-slip fault and the Ord Terrace fault is a down-to-the-north, dip-slip fault (figure 2b). Clark and others (1974) postulated that lower Pleistocene Aromas Sand may be offset along the Seaside fault, based on regional geological relations and the location of a now inactive sulphur hot spring. Neither the Seaside nor the Ord Terrace faults offset late Pleistocene sand dune deposits. Clark and others (1974) stated that there is no evidence indicating that the Seaside or Ord Terrace faults are active.

INTERPRETATION OF AERIAL PHOTOGRAPHS AND FIELD OBSERVATIONS

Aerial photographic interpretation by this writer of faults in the southern Monterey Bay study area was accomplished using U.S.D.A. air photos (ABG, 1949, scale 1:20,000), C.D.F. air photos (CDF-ALL-MO, 1981, scale 1:24,000) and NASA false color infra-red air photos (83-127, 1983, scale 1:33,400). Air photo interpretation was performed mainly to verify fault traces mapped by others rather than to provide independent mapping.

Approximately 2-1/2 days were spent in the study area in late January 1985 by this writer in order to verify selected fault segments and to map any subtle features not observable on the aerial photographs.

TULARCITOS FAULT

Traces of the Tularcitos fault mapped by Dibblee (1972) generally are not well defined and geomorphic features indicative of Holocene reverse faulting, such as undissected scarps, associated closed depressions, and offset or disrupted drainages were not observed (figures 2b, 2c, 2d). Late Pleistocene terraces near locality 2 are not offset where Dibblee (1972) mapped the fault or elsewhere along these terraces. Geomorphic features observed by Bowen along the Tularcitos fault (localities 11 and 12) were not verified by this writer (figure 2b). Weber (1984) mapped a tonal lineament across a young (Holocene?) terrace that may be due to faulting (figure 2c). However, the tonal lineament is not visible on 1949 U.S.D.A. air photos and is not associated with additional geomorphic evidence of recent faulting.

Recently active traces of the Tularcitos fault mapped by Curry (1984) in the Tularcitos Creek area were not verified by this writer (figures 2c, 2d). The two large closed depressions cited by Curry as evidence of Holocene activity are not associated with additional geomorphic features indicating Holocene reverse or strike-slip displacement, such as vertically or laterally offset ridges, offset drainages and scarps (localities 3 and 4, figures 2c, 2d). The closed depressions (especially at locality 4) are anomalous, but may be caused by complex processes involving stream deposition, landsliding, and perhaps surface warping. The numerous small closed depressions at locality 6 (figure 2d) that Curry interpreted as indicating Holocene normal faulting are clearly formed by landsliding in the Monterey Formation. However, some minor faulting is indicated by the faceted spur, east-facing scarp, and closed depression (locality 6, figure 2d). The sense of offset along this north-trending fault is up on the the west. Recent offset (late Pleistocene to Holocene) is suggested by the geomorphic features. However, the fault does not offset Holocene alluvium to the north and south and seems to be confined to this synclinal trough. The total length of this fault is about 1050 meters.

The large landslide in crystalline bedrock mapped by Curry along the north side of Tularcitos Ridge was verified by this writer (figures 2c, 2d). However, the landslide deposits are extensively dissected, indicating a pre-Holocene age. The landslide mass has displaced Tularcitos Creek northward and, locally, has significantly disrupted the drainage system, causing Tularcitos Creek and Sycamore Gulch to aggrade their channels upstream. The northwest-trending fault Curry mapped through this large landslide mass is characterized by a broad, discontinuous trough, ponded alluvium, and modified closed depressions (figure 2c). This fault segment may be a structural feature displaced by landsliding. Alternatively, the feature may be a dissected compressional ridge formed by landsliding. Geomorphic evidence of recent faulting northwest and southeast of this segment was not observed by this writer (figures 2c, 2d).

Limited field mapping by this writer locally verified the location of segments of the Tularcitos fault mapped by Dibblee (1972), principally based on roadcut exposures (figure 2c). Faults observed in roadcuts generally dip steeply to the southwest and juxtapose crystalline basement rocks over Miocene Monterey Formation, although faulting within the Monterey Formation was also observed (figure 2c).

Late Quaternary deposits are not present along much of the fault trend, except for late Holocene colluvium and landslide deposits. Possible evidence of late Quaternary offset was observed at locality 7 where Monterey shale is faulted against previously unmapped older alluvium (figures 2c, 3). It is not certain whether this deposit is Plio-Pleistocene Paso Robles Formation or a younger alluvial deposit of late Pleistocene age. Most of the granitic cobbles in the deposit have been extensively weathered to grus, so the deposit is probably at least 100,000 ybp (Birkeland, 1974). Any soil profile developed on this alluvial deposit has been removed by erosion. The "older alluvium" is now overlain by colluvium that is probably late Holocene in age, based on the steepness of the slope and the lack of significant soil development (figure 3).

A predominantly reverse sense of displacement is indicated by the drag of beds in the "older alluvium" into the fault (figure 3). Some clasts of both granite and Monterey Formation have been tectonically rotated into the plane of the fault (figure 3). Some of these granitic clasts have been completely weathered to grus, yet retain their original, rounded shape. It would be expected that, had there been significant Holocene displacement along the Tularcitos fault, the highly weathered granitic cobbles adjacent to the fault would have been significantly deformed.

NAVY FAULT

The Navy fault mapped by Clark and others (1974) is moderately well defined and was generally verified by this writer (figure 2b). However, the fault is characterized by linear drainages, saddles, benches, and faceted spurs in Monterey Formation that are more characteristic of a fault modified by erosion (figure 2b). The faceted spurs near Sec. 10, T16S, R1E may not have been formed by faulting (figure 2b). They trend parallel to the drainage channel and are essentially anti-dip slopes underlain by Monterey Formation. Similar slopes underlain by Monterey Formation were observed in the study area that are clearly related to stream erosion rather than faulting. Well-defined scarps, closed depressions, and offset or deflected drainages indicative of Holocene reverse or strike-slip offset were not observed. In addition, geomorphic evidence of recent faulting was not observed along the fault where it was mapped by Clark and others (1974) as concealed by late Pleistocene alluvial deposits (terrace deposits) south-southwest of Monterey airport and along the southeast end of the fault where it was mapped as concealed by late Pleistocene terrace deposits (on the north side of Carmel Valley) (localities 8 and 9, figure 2b).

CHUPINES FAULT

The Chupines fault is generally not well defined and is not characterized by geomorphic features indicative of Holocene reverse faulting, such as well-defined scarps, closed depressions, or offset drainages (figure 2b).

The sidehill ridges and closed depressions observed by Bowen (1969) were not verified by this writer (locality 13, figure 2b). The closed depressions and linear trough observed by Bowen near locality 16 (figure 2e) are probably related to large-scale landsliding. Many large landslides, including block glides, occur in this area (figure 2c). The generally linear ridge at locality 14 is probably a geomorphic feature associated with late Pleistocene sand dune deposits.

BERWICK FAULT

No geomorphic evidence of Holocene dip-slip or strike-slip offset was observed along the Berwick fault (figure 2b). The fault is generally delineated by geomorphic features characteristic of a fault modified by erosion.

CYPRESS POINT FAULT

The Cypress Point fault is delineated by an east-facing scarp in crystalline basement rocks (figure 2a). The scarp appears to be modified by erosion, especially at the south end where the fault juxtaposes crystalline basement rocks against Paleocene Carmelo Formation (locality 15, figure 2a). Geomorphic evidence of Holocene offset of the Pleistocene marine terrace (Clark and others, 1974) was not observed by this writer, based on air photo interpretation. Geomorphic evidence of recent faulting was not observed in the Pleistocene terrace at locality 10 (figure 2a).

CACHAGUA FAULT

The Cachagua fault is delineated by geomorphic features characteristic of erosion along a fault (figure 2c). Geomorphic features indicating Holocene reverse faulting, such as well-defined scarps, closed depressions, and offset drainages were not observed. The offset terrace deposit mapped by Dibblee (1972) (Sec. 4, T18S, R3E, figure 2c) could not be verified.

ORD TERRACE AND SEASIDE FAULTS

Traces of the Ord Terrace and Seaside faults mapped by Clark and others (1974) (figure 2b) are surface projections of subsurface faults cutting the top of the Monterey Formation. Both of these faults are concealed by late Pleistocene and Holocene sand dune deposits, and land surfaces along segments of both faults have been extensively modified by development.

SEISMICITY

Seismicity in the study area is presented in figure 4. The seismicity suggests local activity at depth for some faults in the study area, although specific faults cannot be associated with specific earthquakes. This is due, in part, to the uncertainty of epicenter location and partly because the subsurface structure is imperfectly understood. The Cypress Point fault may be seismically active (figure 4). The fault dips to the west, so either the earthquakes are mislocated, or they are associated with the unnamed fault plotted on figure 4. This short, northwest-trending fault was not mapped by Clark and others (1974), and Bowen (1969) did not consider this fault to be a Quaternary active fault.

CONCLUSIONS

TULARCITOS FAULT

The Tularcitos fault is a complex, southwest-dipping reverse fault that is only locally well defined, based on air photo interpretation and field observations by this writer (figure 2c, 2d). However, the fault is not characterized by geomorphic features indicating Holocene faulting. Folding in Tertiary sedimentary rocks near the fault zone and observations of roadcut exposures of the fault demonstrate that the Tularcitos fault is a significant reverse fault with possible late Pleistocene offset (locality 7, figure 2c). However, late Pleistocene terraces are not offset at locality 2, and no evidence of offset Holocene deposits was observed by this writer (figure 2c). Weber (1984) postulated that approximately 1,200m of post-Miocene vertical displacement has occurred along the Tularcitos fault, suggesting a slip-rate of about 0.08 to 0.2mm/yr.

Holocene active faults mapped by Curry (1984) were not verified by this writer (figures 2c, 2d). The northernmost fault is not well defined, and two large, closed depressions cited by Curry as evidence of Holocene faulting are not associated with additional geomorphic evidence of recent reverse or strike-slip displacement (figures 2c, 2d). The small closed depressions and scarps mapped by Curry as minor Holocene normal faults clearly are related to landsliding in the Monterey Formation (figure 2d). However, the westernmost north-trending fault mapped by Curry is delineated by a faceted spur, east-facing scarp, and associated closed depression and conceivably could be a minor, recently active fault (figure 2d). The southern fault mapped by Curry is not well defined in detail, is discontinuous, and may be a structural feature displaced by large-scale landsliding (figure 2c).

NAVY FAULT

The Navy fault is a northwest-trending fault mapped by Clark and others (1974) and Greene and others (1977) as a steeply southwest-dipping reverse fault (figure 2b). The fault offsets Plio-Pleistocene Paso Robles Formation, but late Pleistocene terrace deposits are not offset (Clark and others, 1974; Greene and others, 1977) (figure 2b). Rogers E. Johnson and Associates (1981) considered the Navy fault to be a right-lateral, strike-slip fault, but did not demonstrate Holocene activity along the fault. The Navy fault is moderately well defined, but lacks geomorphic evidence of Holocene reverse or strike-slip displacement (figure 2b).

CHUPINES FAULT

The Chupines fault has been mapped as a down-to-the-south fault by Clark and others (1974) and a down-to-the-north, high-angle reverse fault by Bowen (1969), Greene and others (1973), and Greene (1977). The fault may have a cumulative vertical offset of up to 300m (Sieck, 1964), but Clark and others indicated that Plio-Pleistocene Paso Robles Formation is offset only about 3 meters. Bowen (1969) mapped the Chupines fault as concealed by late Pleistocene terrace deposits and recent geomorphic features observed by Bowen could not be verified by this writer. The Chupines fault generally is not well defined and is not delineated by geomorphic features indicating Holocene offset.

BERWICK FAULT

The Berwick fault, a northwest-trending, high-angle fault, offsets late Pleistocene alluvium as mapped by Clark and others (1974). However, the fault is not well defined and is not delineated by geomorphic features indicating Holocene offset.

CYPRESS POINT FAULT

The Cypress Point fault is a northwest-trending reverse fault characterized by an east-facing scarp in crystalline basement rock (Clark and others, 1974). Pleistocene marine terrace deposits and older alluvium of Pleistocene age are not offset along the fault (Clark and others, 1974). Geomorphic evidence of Holocene faulting was not observed along the Cypress fault.

CACHAGUA FAULT

The Cachagua fault is a northwest-trending, steeply southwest-dipping reverse fault (Dibblee, 1972; Weber, 1984). Weber (1984) did not observe evidence of late Pleistocene or Holocene offset along the Cachagua fault and Dibblee (1972) mapped the fault as concealed by late Pleistocene terrace deposits (figure 2c). Geomorphic evidence of Holocene reverse faulting was not observed along the Cachagua fault by this writer and Weber (1984) considered the fault to be delineated by geomorphic features characteristic of erosion along a fault.

ORD TERRACE AND SEASIDE FAULTS

Both the Ord Terrace and Seaside faults are concealed by late Pleistocene and Holocene sand dune deposits. The faults mapped by Clark and others (1974) are based on subsurface data (offset of top of Monterey Formation). Surface expression of these faults was not observed by this writer.

RECOMMENDATIONS

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

TULARCITOS FAULT

Do not zone. This fault is not sufficiently active nor well-defined.

NAVY FAULT

Do not zone. This fault is not sufficiently active.

CHUPINES FAULT

Do not zone. This fault is not sufficiently active nor well defined.

BERWICK FAULT

Do not zone. This fault is not sufficiently active nor well defined.

CYPRESS POINT FAULT

Do not zone. This fault is not sufficiently active nor well defined.

CACHAGUA FAULT

Do not zone. This fault is not sufficiently active nor well defined.

ORD TERRACE AND SEASIDE FAULTS

Do not zone. These faults are not sufficiently active nor well defined.

Reviewed, recommendations seem reasonable.
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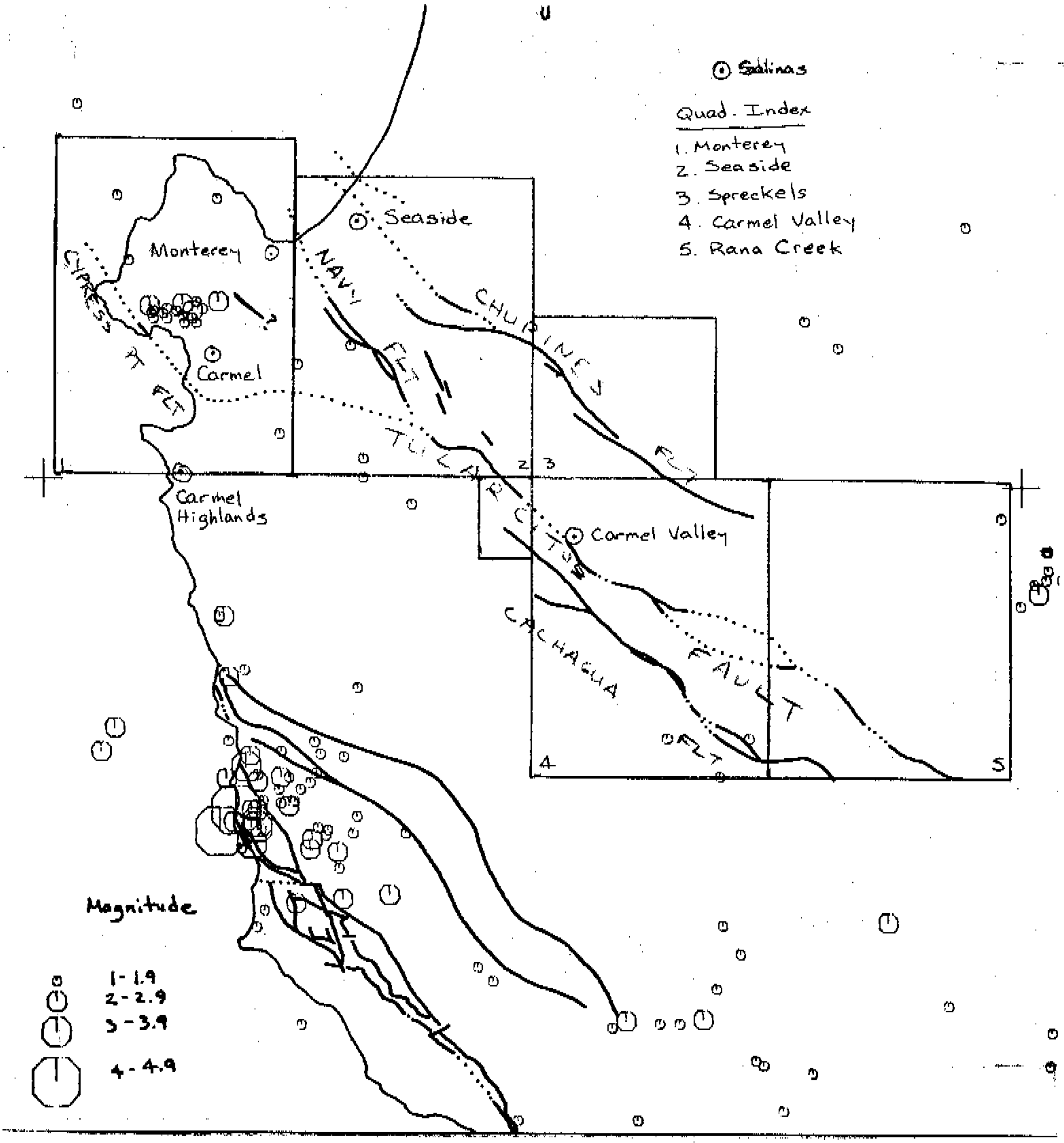

Figure 4 (to FER-167). Seismicity plot for the period 1969-1984 (C quality data)(U.S.G.S., 1985). Faults are from Buchanan-Banks and others (1978), scale 1:250,000.