CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-168

Santa Maria Valley Faults
Santa Barbara and San Luis Obispo Counties, California

by

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INTRODUCTION

Potentially-active faults in the Santa Maria Valley, which is located on the coast at the junction of southwestern San Luis Obispo County and northwestern Santa Barbara County, have been examined as part of CDMG's Fault Evaluation Program. Ninteen west- to northwest-trending faults and fault zones have been mapped within the valley or along its margins by previous workers. These faults are partly summarized by Buchannan-Banks and others (1978; see Figure 1). Several workers consider most of these faults to be members of two main fault zones, which have been termed the Orcutt Frontal fault (Crawford, 1971) and Santa Maria River-Foxen Canyon-Little Pine fault zone (Hall, 1978a). Available reports and air photos give little evidence of Holocene surface rupture along any of the faults. Based upon the available data, none of these faults meet the criteria of "sufficiently active and well defined" necessary for zoning under the Alquist-Priolo Special Studies Zones Act (see Hart, 1985, p. 5-6).

SUMMARY OF AVAILABLE DATA

The 19 faults or fault zones mentioned above and shown in Figure 1 are arbitrarily separated into four groups and discussed below:

1) The Orcutt Frontal and associated faults -- Pezzoni, "Pezzoni extension"*, Casmalia, "Corralitos Canyon", "Orcutt oil field", and "Solomon Canyon" faults.

2) The Santa Maria River - Foxen Canyon - Little Pine fault zone -- including all or part of the Santa Maria River, Santa Maria Mesa, Foxen Canyon, Garey, and Little Pine faults. The West Huasna fault zone is also discussed in this group, as it is shown to be truncated by the Santa Maria River fault.

3) Lions Head fault, "Point Sal" faults, and "Point Sal Beach" faults.

4) The Santa Maria, Bradley Canyon, and "Guadalupe oil field" faults.

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* Faults whose names are shown in quotation marks (for example, "Pezzoni extension" fault) have not previously been named. Informal names are used where necessary in this report for ease of identification.

1. ORCUTT FRONTAL FAULT AND ASSOCIATED FAULTS

Orcutt Frontal fault

The Orcutt Frontal fault, which was identified and named by Crawford (1971), is considered by some workers to be a segment of a major, west-northwest-trending fault connecting the Santa Ynez fault zone near Santa Barbara with the Hosgri fault zone offshore and northwest of Point Sal (Sylvester and Darrow, 1979; Hall, 1978b, 1981a, 1981b). Crawford interpreted the structure from oil field data, including that of Krammes and Curran (1959). His small-scale map shows the fault extending from the vicinity of Solomon Canyon westward to the ocean (see Figure 1). In their cross section, Krammes and Curran (1959) show six normal or reverse faults in the Orcutt oil field (Figure 2). Crawford's Orcutt Frontal fault appears to be the northernmost of these -- a south-dipping reverse fault with approximately 2,400 meters of displacement of the Monterey Formation (mid- to late Miocene*). Krammes and Curran interpret the fault as displacing the base of the Carreaga Formation (late Pliocene) about 230 meters, but the Paso Robles Formation is not offset. Higher in the section, a branch fault is shown to offset the mid-Pleistocene Orcutt Sand a minimum of 25 to 30 meters (north side down). This branch fault is mapped as a surface fault that also offsets young alluvium (Figure 2), but this may be a drafting error.

Other workers disagree as to the existence and location of the Orcutt Frontal fault. The best-available geologic map of the area is by Woodring and Bramlette (1950), but they did not recognize the fault shown by Crawford. They do show the several faults associated with the Orcutt Frontal fault (Pezzoni, Casmalia, etc). Buchannan-Banks and others (1978), citing Crawford, show the fault as both inferred and concealed along the north flank of the Casmalia Hills (Figure 1). Earth Science Associates (1975, Figure 2.5-4) map the (unidentified) Orcutt Frontal fault as an "approximately located or inferred" surface feature. Their trace is shown in part in Figure 3, and is located approximately 2 km southwest of the location shown by Buchannan-Banks and others in Figure 1. Cummings and others (1970, Plate 2B, Section C-C') show a concealed south-dipping reverse fault in cross-section near the fault trace of Earth Science Associates (Figure 3). The concealed fault is interpreted by Cummings and others to offset the bottom (but not the top) of the undivided Carreaga Sand-Paso Robles Formation (Pliocene to mid Pleistocene) by 225 meters. Kilbourne and Mualchin (1980) compiled available mapping but did not contribute additional data; their fault traces are not included with this report. On their small-scale maps, Hall (1978a, 1981a, 1981b) and Gray (1980) show a subsurface fault similar to that shown by Crawford, but they provide no additional data. Their traces are not included in this report.

Pezzoni Fault

The Pezzoni fault was mapped and named by Woodring and Bramlette (1950), and is located on the northeast limb of the overturned Pezzoni anticline. The fault is shown to consist of two principal segments with an inferred connection (see Figures 1 and 3). The northwest segment is a 3.6 km-long, reverse fault that is northwest-trending and vertical to steeply south-dipping.

* All age dates are from the individual authors' stratigraphic columns.

It separates Sisquoc Formation (late Miocene to middle Pliocene) on the northeast from the lower and middle members of the Monterey Formation (mid- to late Miocene) on the southwest. Dip-slip displacement of the base of the Monterey Formation is approximately 3,000 meters. A short, parallel branch fault that splays from the southeast end of this segment separates the Monterey Formation and underlying Point Sal Formation (middle Miocene). The faults are not shown to offset the Orcutt Sand (mid Pleistocene) or older landslide deposits. The curvilinear southeast segment of the Pezzoni fault is a northeast-trending, steeply-dipping, normal fault (down to the southeast). Woodring and Bramlette show this segment of the fault as separating the Sisquoc and Monterey Formations. The inferred connection between the two segments is concealed by colluvium. Woodring and Bramlette state (p. 111) that they found no evidence for a southeastward extension of the Pezzoni fault past the point where the fault bends to the southwest.

Earth Science Associates (1975, Figure 2.5-4), in its small-scale map, shows a northwestern extension of the Pezzoni fault as a "well-defined" surface feature in late Pleistocene and Holocene dune sands (Figure 3). However, on Figure 2.5E-III (amended), the extension is shown to be concealed by these same units. The extension is interpreted to join with the Orcutt Frontal fault. Sense of displacement for this extension is not indicated.

Parallel to, and about 700 meters northeast of the northwest segment of the Pezzoni fault, is a relatively short (2.1 km), steeply southwest-dipping, reverse fault mapped by Woodring and Bramlette (see Figure 1). All but a small portion of the mapped fault trace is inferred. The Carreaga Sandstone (late Pliocene) and Paso Robles Formation (late Pliocene to mid Pleistocene) are shown to be thrust northeastward over the Foxen Formation (mid- to late Pliocene) along the south flank of the overturned Santa Maria Valley syncline. [The syncline is not shown on Figures 1 and 3.] The northwest portion of the fault is partially concealed by older landslides, and concealed at its northern end by Orcutt Sand. The fault may extend northwestward beneath the Orcutt Sand to join a short splay of the Pezzoni fault, because the dip and sense of displacement of the two faults are similar and they lie on trend with each other.

Several faults in the Casmalia Hills (shown in part in Figure 7) are interpreted by Payne and others (1979) to offset Tertiary units. They show these faults to be "approximately located or inferred" surface features. However, none of the faults are included in the cited sources (Jennings, 1975; Earth Science Associates, 1975; Woodring and Bramlette, 1950), and the faults are not discussed by Payne and others.

<u>"Pezzoni extension" fault</u>

The "Pezzoni extension" fault is a short, west-trending, dip-slip fault (north side down) exposed on the coast appoximately 800 meters north of Mussel Rock (Figures 1 and 3). On their map, Woodring and Bramlette (1950) show the fault as separating Sisquoc Formation(?) on the north from the Monterey Formation on the south. The amount of offset is not indicated. They do not show the fault in cross section, nor do they discuss the fault in their report. Sylvester and Darrow (1979, p. 394) infer a connection between this fault and the Pezzoni fault, which lies 5.5 km to the southeast, based on similarities in sense of movement and the rock units separated. The inferred fault is concealed by latest Pleistocene to Holocene dune sand. Payne and others (1979) indicate that the "Pezzoni extension" fault does not displace offshore, post-Wisconsin strata (less than 17,000 - 20,000 years old).

Casmalia Fault

The Casmalia fault is a short (1 km), west-trending, steeply-south dipping, reverse fault along the north flank of the Casmalia anticline (see Figure 1). Woodring and Bramlette (1950) interpret the fault as having thrust Sisquoc Formation northward over the Carreaga Sandstone. In cross section they show the fault as having displaced the Carreaga Sandstone approximately 80 meters, and to die out at depth near the base of the underlying Sisquoc Formation. No Quaternary units are mapped along the fault trace. Small-scale, planimetric subsurface maps of the oil field (California Division of Oil and Gas, 1972) show the fault extending along the field's northeast edge for several kilometers. The fault is interpreted by Gray (1980) to connect at depth with the Pezzoni fault to the northwest and with a segment of the Orcutt Frontal fault to the southeast. Different interpretations by other workers also have been made on small-scale maps (for example, Hall, 1981a).

"Corralitos Canyon" fault

Approximately one km west of the northwest end of the Pezzoni fault (Figure 1), is a short (800 meters), west-trending fault on the south side of Corralitos Canyon (Woodring and Bramlette, 1950). The fault separates Monterey Formation on the north from older Point Sal and Lospe Formations on the south. The east and west ends of the fault are shown to be concealed by marine terrace deposits (late Pleistocene) and Orcutt Sand, respectively.

"Orcutt oil field" faults

Numerous east- and north-trending faults in the Orcutt oil field are shown by Woodring and Bramlette (1950). [Only the principal faults are plotted on Figures 1 and 4]. The faults are minor, appear to have either normal or reverse displacement, and are related to folding of the Graciosa anticline and several smaller anticlines. Dip-slip displacements of approximately 75-80 meters are indicated for three of the faults. However, Krammes and Curran (1959) indicate the presence of a large-displacement fault in the subsurface near the northwest corner of Section 24 (Figure 2). [This fault is discussed in the section "Orcutt Frontal fault", above.] Woodring and Bramlette show the youngest unit faulted to be the Paso Robles Formation, at the north end of a graben (Figure 4). However, Holocene alluvium is inferred to be faulted in three areas: 1) at the south end of the graben; 2) along a west-trending dip-slip fault (north side down) in the south half of the oil field; 3) along the west-trending main fault at the north edge of the oil field. [Woodring and Bramlette do not use a "concealed" symbol.]

"Solomon Canyon" fault

This northwest-trending, steeply-northeast-dipping, normal fault in Solomon Canyon is mapped by Woodring and Bramlette (1950) as an "imperfectly exposed" fault that is parallel to and nearly concident with U. S. Highway 101 (Figures 1 and 4). They state (p. 113) that in the preliminary edition of their map, the structure was mapped as a syncline axis between the Mt. Solomon and Las Flores anticlines. [Their cross-section C-C' is permissive of a syncline, and Worts (1951) also interpreted this structure as a syncline.] Their interpretation of more recent, unspecified subsurface data indicates the syncline is faulted, with the east side down. On their map the youngest unit offset is Holocene alluvium. The fault is shown in cross section to have approximately 900 meters of displacement of the base of the Paso Robles Formation. The overlying Orcutt Sand is not shown to be offset, although the fault extends upward to the surface. Buchannan-Banks and others (1978) show this fault as not offsetting any units younger than early Pleistocene age (Figure 1).

2. SANTA MARIA RIVER-FOXEN CANYON-LITTLE PINE FAULT ZONE AND RELATED FAULTS

Santa Maria River, Foxen Canyon, and Little Pine faults

The Santa Maria, Foxen Canyon, and Little Pine faults are interpreted by some workers to be segments of a major, northwest-trending fault zone along the northern margin of Santa Maria Valley. This major fault is hypothesized to connect the Santa Ynez fault zone near Carpinteria with the Hosgri fault zone in San Luis Obispo Bay (Hall, 1978a, 1981a,b; Sylvester and Darrow, 1979). Others workers have different interpretations (Dibblee, 1978; Gray, 1980). The best available maps of the Santa Maria River, Foxen Canyon, and Little Pine faults are by Hall (1978b, 1981c) and Dibblee (1966) for the northwest and southeast segments, respectively.

The Santa Maria River fault of Hall (1978b) is an inferred, concealed fault which extends southeastward along the river from U.S. 101 at Santa Maria to the south boundary of the Twitchell Dam quadrangle (see Figures 1 and 6). Hall (1981c) extends the inferred, concealed fault southeastward as the "Foxen Canyon (Santa Maria River)" fault, to a junction with the Little Pine fault. The Santa Maria River fault is shown in cross section to be a vertical to steeply-northeast-dipping fault (down to the southwest). The bases of the Orcutt Sand and Paso Robles Formation are shown to be displaced approximately 40 meters (down to the southwest). Holocene alluvium and late Pleistocene terrace deposits conceal the fault for most of its length (Figure 6). A small remnant of Orcutt Sand northeast of Santa Maria is inferred to be offset by the Santa Maria River fault.

The Little Pine fault is a major, northeast-dipping, reverse or thrust fault separating Jurassic and/or Cretaceous sedimentary or ultramafic rocks on the northeast from Tertiary and Quaternary sedimentary units on the southwest. Total displacement is not known, but Dibblee (1966, p. 73) estimates that it amounts to several thousand feet. According to Hall (1981c) and Dibblee (1966), the youngest unit faulted is the Paso Robles Formation, which locally is overridden by serpentinite and Franciscan sandstone along the fault southeast of Foxen Canyon (on the eastern boundary of the Foxen Canyon quadrangle in Figure 1). Both workers show the fault to be concealed locally by late Quaternary landslide debris and Holocene alluvium. [With the exception of these local deposits, post-Paso Robles Formation units along the Santa Maria River, Foxen Canyon, and Little Pine faults are restricted to the vicinity of the Santa Maria Valley. Because of the lack of mid- or late Pleistocene sediments southeast of Zaca Creek (in the southeast quarter of the Foxen Canyon quadrangle), and the lack of time during the study, the Little Pine fault was not evaluated beyond that point.]

Garey fault

The Garey fault, which was interpreted and named by Hall (1978b, 1981c), extends 35 km southeastward from its junction with the Santa Maria River fault (see Figures 1 and 6). Hall interpreted the structure from oil well and water well data, although Worts (1951, p. 43) inferred the existance of a fault in this location based upon water level contours. The fault is shown in cross section by Hall to be vertical to steeply-dipping, with various senses of vertical offset. He states that strike-slip is indicated by differences in stratigraphy across the fault, and probably occurred prior to deposition of post-Miocene units (Hall, 1981c). The youngest unit displaced by the Garey fault is the Paso Robles Formation. The oldest units not faulted are river terrace deposits (late Pleistocene) and Holocene alluvium.

Santa Maria Mesa fault

The Santa Maria Mesa fault (Hall, 1978b, 1981c) is a largely inferred and concealed fault that extends 26 km southeastward from its junction with the Santa Maria River fault (see Figures 1 and 6). The Santa Maria Mesa fault offsets the Monterey and Sisquoc Formations. In cross-section, the fault is mapped as vertical to southwest-dipping. The sense of displacement along the fault is not indicated. The youngest units faulted are the Carreaga Sand (Pliocene) and, possibly, a late Pleistocene terrace deposit. Late Pleistocene terrace deposits and Holocene alluvium conceal the northwestern segment of the fault. The southeastern segment has no Quaternary units (other than landslide deposits) along its length, and is interpreted by Hall to die out in a region of parallel folds between the Camuesa and Hildreth faults (not shown in Figures 1 and 6).

West Huasna fault zone (southeast segment)

The West Huasna fault zone extends northwestward from its junction with the Santa Maria River fault, to join with the Oceanic fault near San Luis Obispo (Jennings, 1975). [Due to time constraints, only the 11 km-long segment at the southeast end is evaluated in this report.] At its southeast end, the West Huasna fault zone is 1 to 1.5 km wide, with two parallel main strands and several short, subparallel, branch faults (Hall, 1978b; Worts, 1951; see Figures 1 and 6). Although the junction is concealed by river alluvium, Hall shows the fault zone as truncated on its southeast end by the Santa Maria River fault and the Santa Maria Mesa fault . In cross section, he shows the fault zone as vertical to steeply west-dipping. Sense of displacement along the zone is not given by Hall, but Dibblee (1978) indicates that the fault is a right-lateral, strike-slip fault. The youngest unit offset is the Orcutt Sand, with approximately 50 meters of dip-slip separation of the unit's base. The oldest unfaulted units are several late Pleistocene terrace deposits, which are located at various elevations.

3. LIONS HEAD FAULT, "POINT SAL" FAULTS, AND "POINT SAL BEACH" FAULTS

Lions Head fault

The Lions Head fault, named by Woodring and Bramlette (1950), is shown by them to be a northwest-trending, vertical to steeply-southwest-dipping, normal fault with a length of 8 km (see Figures 1 and 7). Recent offshore geophysical surveys indicate that the fault has a northwest extension, which is shown in Figure 1 (McCulloch and others, 1977, 1980; Payne and others, 1979; Buchannan-Banks and others, 1978). A concealed southeastern extension (not shown in Figures 1 and 7) is inferred by Sylvester and Darrow (1979) and by Gray (1980). Additional fault mapping by Arnold and Anderson (1907), Dibblee (1954), and Hopson and others (1975) is similar to that shown by Woodring and Bramlette; the additional traces are not included in Figure 7.

Woodring and Bramlette interpret the Lions Head fault as separating "undifferentiated igneous rocks of the Franciscan formation" [Jurassic ophiolite complex of Hopson and others] on the northeast from Monterey and Sisquoc Formations on the southwest for most of the length of the surface trace. Near the fault's southeast end, Monterey Formation lies on the northeast and Sisquoc Formation lies on the southwest. In cross section, more than 1,200 meters of post-Jurassic sediments are shown faulted against the "igneous rocks." Woodring and Bramlette state (p. 111) that where exposed on the coast, the fault zone has a width of approximately 50 feet [15 meters], and Hopson and others indicate that a second, narrower shear zone is exposed on the coast approximately 35 meters south of the main fault zone. Although Woodring and Bramlette interprete the fault as having normal displacement, Dibblee (1978, p. 50) states that right-lateral, strike-slip offset along the fault is indicated by the presence of east-trending, tightly-compressed, drag folds in the adjacent Monterey and Sisquoc Formations.

A late Pleistocene marine terrace unit (approximate elevation 55 feet) is shown by Woodring and Bramlette locally to conceal the fault. However, Arnold and Anderson show that the terrace unit is offset near the fault's southeast end. Sylvester and Darrow also indicates that the terrace unit is faulted, but they did not specify a location. No units of Holocene or latest Pleistocene age are mapped along the trace of the Lions Head fault, but based upon a geophysical study of the offshore region, Payne and others believe the western (offshore) extension of the Lions Head fault does not displace overlying stata of post-Wisconsin age (less than 17,000 to 20,000 years old).

<u>"Point Sal Beach" faults</u>

Sixteen faults within the Jurassic ophiolite are shown by Hopson and others (1975) at Point Sal Beach (Figure 5). [Most of the faults are too short to be shown on Figure 1.] The east-trending fault between the beach and Brown Road separates the ophiolite on the north from Lospe and Point Sal Formations (early to mid Miocene) on the south. The locations of the remaining faults are inferred from abrupt changes in mineralogy. Sense of displacement is not given for any of the faults. Woodring and Bramlette do not show any of the faults, and Dibblee (1954) shows only the east-trending fault. His fault location is similar to that shown by Hopson and others. The east-trending fault is shown by Hopson and others to be concealed at its eastern end by Orcutt Sand, and at the beach by Quaternary alluvium. However, Dibblee shows the alluvium faulted against the ophiolite. Hopson and others also show some of the other traces locally to be concealed by Orcutt Sand or late Pleistocene marine terrace deposits (see Figure 5).

"Point Sal" faults

Hopson and others (1975) show 9 faults in the Jurassic ophiolite at Point Sal (Figure 5). [Most of the faults are too short to be shown on Figure 1.] The locations of eight of the faults are inferred from abrupt changes in mineralogy, and no sense of displacement is given for any of these faults. Only one fault is confirmed by Woodring and Bramlette (1950); it is a southeast-trending, southwest-dipping reverse fault separating the ophiolite from the Knoxville Formation (Jurassic). Dibblee (1954) does not show any of the faults. Inland from the beach, all of the faults are concealed by latest Pleistocene and Holocene dune sands.

Two additional faults along the beach are shown by Woodring and Bramlette. A northeast-trending, northeast-dipping, normal fault is located about 1 km north of Point Sal (Figures 1 and 5). It separates the Point Sal Formation on the northwest from the Lospe Formation on the southeast. Also shown in Figures 1 and 5 is an east-trending fault in the Monterey Formation that is located approximately 200 meters south of Mussel Rock. However, no sense of displacement is given. Both of the faults are concealed inland from the beach by latest Pleistocene and Holocene dune sands.

4. SANTA MARIA, BRADLEY CANYON, AND "GUADALUPE OIL FIELD" FAULTS

Although numerous subsurface faults may exist beneath the late Pleistocene and Holocene sediments in Santa Maria Valley, only three faults are shown on available maps: the Santa Maria, Bradley Canyon, and "Guadalupe oil field" faults.

Santa Maria fault

The Santa Maria fault is a concealed and partially inferred reverse fault beneath the City of Santa Maria (Figure 1). Canfield (1939), interpreted the structure from oil field data. He shows the fault to be northwest-trending and steeply northeast-dipping, with a length of 5.6 km. A short, branch fault splay off of the main fault at its southeast end. Worts (1951) extended the main fault at each end, for a total subsurface length of 12 km. The surficial geologic map of Woodring and Bramlette (1950) does not show this concealed fault. In cross-section, Canfield shows the Santa Maria fault to have about 200 meters of displacement of the Foxen Formation (mid-Pliocene) and the overlying "blue gravel" unit ("Paso Robles"). Worts interprets the fault as displacing the Carreaga Sand and Paso Robles Formation approximately 50 meters, with the fault concealed by Orcutt Sand and Holocene dune sand.

Bradley Canyon fault

The Bradley Canyon fault was interpreted and named by Worts (1951), based on data in oil well logs (Figures 1 and 6). He shows the fault to be a concealed, north-trending, dip-slip, fault (east side down), but does not show it in cross section. Total length of the fault is 8.5 km, including an inferred surface extension across the Santa Maria River to connect with a short fault that is located in a ravine on the north side of the river. Hall (1978b) also mapped the Bradley Canyon fault using well logs, but places the fault slightly to the west of Wort's fault location. He interprets the Bradley Canyon fault as being truncated on its north end by the Santa Maria

River fault (Figure 6). In cross section, Hall infers that the Sisquoc Formation is offset 100 meters (down to the east) along the possibly vertical fault plane. Although Worts states (p. 43) that the fault displaces Carreaga Sandstone and Paso Robles Formation, Hall shows the fault to be concealed by these units. The short fault north of the river (Figure 6) is shown by Worts to separate undivided Tertiary units on the east from Franciscan/Knoxville(?) rocks on the west, and to displace Orcutt Sand (mid-Pleistocene) and late Pleistocene terrace deposits. Worts interprets the fault as truncating the Bradley Canyon fault, but Hall does not concur. Instead, Hall shows the short fault as separating Paso Robles Formation on the southwest from Franciscan mélange on the northeast, and as concealed at each end by unfaulted Orcutt Sand.

"Guadalupe oil field" faults

Two subsurface faults are shown by Lawrence (1964) in his cross section of the Guadalupe oilfield (Figure 1). He interprets them to be northwest-trending, southwest-dipping, normal faults. Only the two km-long southwest fault is shown on Lawrence's subsurface contour map (top of the early Pliocene Sisquoc Formation), as the northeast fault does not displace the unit. The southwest fault lies adjacent to the Orcutt Frontal fault of Crawford (1971), but is interpreted by Lawrence to be a normal fault. Approximately 15 meters of dip-slip separation of the basal section of the overlying Foxen Formation has occurred along the southeast fault. [Post-Sisquoc oblique-slip along the southwest fault may be indicated by the fold structures south of the fault that are not apparent to the north.] The faults are not verified by Woodring and Bramlette (1950), or Gray (1980).

AIR PHOTO INTERPRETATION AND FIELD OBSERVATIONS

Two sets of black and white air photos were available to the author: 1) U.S. Department of Agriculture, 1954, series BTM, scale 1:20,000; and 2) Woodward-Clyde Consultants, 1979, low sun angle, scale 1:24,000(?). Field inspection of selected fault traces was done by the author during the period April 1-4, 1985.

1. ORCUTT FRONTAL AND ASSOCIATED FAULT

Orcutt Frontal fault

The trace of the Orcutt Frontal fault shown by Earth Science Associates (1975) in Figure 3 of this report appears to be located along the northwest-trending break-in-slope between the northeast-dipping Orcutt Sand and the modern alluvium and dune sand. On the air photos, the contact or break-in-slope between these units is discontinuous, being partly concealed by numerous latest Pleistocene and Holocene alluvial fans. The alluvial fans show no evidence of recent dip-slip faulting--there are no scarps or breaks-in-slope on the fans, or increased drainage incision on the upthrown block. The three fault traces mapped by Earth Science Associates as surface features in Holocene sand dunes northwest of the Casmalia Hills (Figure 3) could not be confirmed. No evidence of Crawford's fault trace was noted on the air photos, nor was any evidence seen of the branch fault shown by Krammes and Curran (1959) in the Orcutt Sand on the northside of the Orcutt oil field.

Pezzoni fault

The northwest segment of the Pezzoni fault trace (Figure 3) is poorly defined on the air photos. It is partially concealed by massive landslides, but can be traced as an alignment of widely separated saddles or notches. No evidence of recent surface rupture (scarps, tonals, deflected drainages, etc.) was seen on the photos.

The southeast segment is well defined on the air photos as a northeast-facing eroded scarp in bedrock. A possible fault-line scarp in bedrock, with a 25°SE slope, was observed in the field at the southeast end of the fault. The scarp crest is rounded at the top, and colluviun mantles the base of the scarp. Further to the southwest, on line with the fault trace, is another southeast-facing hill with a similar scarp-like appearance, which is permissive of a possible extension of the southwest end of the fault. The wide, flat-bottomed ravine that lies between the fault trace and hill contains no active channel and no incision on the upthrown block. These conditions indicate that if recent fault rupture occurred at the southeast end of the Pezzoni fault, uplift occurred prior to stabilization of the ravine channel.

The inferred fault shown by Payne and others (1978) between the Pezzoni fault and the Lions Head fault at Shuman Canyon was not verified on the air photos (Figure 7). Permissive evidence for a fault along the suggested trend is: 1) part of the inferred fault parallels the northwest-trending, unnamed canyon west of Casmalia Canyon; and 2) strata within the unnamed canyon appear to be truncated, possibly by normal or reverse faulting (Figure 7).

Casmalia fault

The central segment of the Casmalia fault can be traced on the air photos as a broad saddle and break-in-slope above a linear drainage, adjacent and parallel to a resistant sandstone bed (Figure 1). Inferred extensions of the fault to the east and west could not be verified. The western extension is inferred to cross a north-trending creek, but there is no air photo evidence of increased erosion on the southern (supposedly upthrown) block. There is no evidence of recent fault movement along the inferred eastern extension.

"Pezzoni extension" fault

The location of the "Pezzoni extension" fault could not be verified on the air photos or in the field by the author (Figure 3). The southern fault block was partly exposed at the beach. The fault and northern block were completely concealed by beach and dune sand. No permissive evidence of recent fault movement was seen by the author, either on the air photos or in the field.

"Orcutt oil field" faults

In general, the fault traces shown in the Orcutt oil field (Figure 4) are poorly defined on the air photos. No permissive evidence of recent fault movement in the Holocene alluvium (scarps, tonals, or increased erosion on the upthrown block) was seen for any of the faults.

"Solomon Canyon" fault

Other than the broad, linear valley of Solomon Canyon, the location of the "Solomon Canyon" fault (Figure 4) could not be verified. No evidence of surface fault rupture in Holocene alluvium and Paso Robles Formation was noted by the author, either on the air photos or in the field.

"Corralitos Canyon" fault

The "Corralitos Canyon" fault (Figure 1), is moderately well-defined on the air photos and in the field as a fault-line scarp. The south-facing scarp is marked by resistant beds of Monterey Formation on the downthrown (northern) block, with the older and less resistant Point Sal Formation on the southern (upthrown block). The feature is erosional, and no evidence of recent fault rupture was identified, either on the air photos or in the field.

2. SANTA MARIA RIVER - LITTLE PINE FAULT ZONE

Santa Maria River fault

No air photo evidence was seen of faulting in the Holocene alluvium within the Santa Maria River channel. A small deposit of Orcutt Sand, which is located on the north bank of the Santa Maria River northwest of the mouth of the Cuyama River, is inferred to be offset by the Santa Maria River fault (see Figure 6). Some faint tonals on the terrace riser in the Orcutt Sand are visible on the USDA photos. These tonals are parallel to, but several tens of meters northeast of the fault's inferred position. No field evidence of faulting was seen in road cuts or on the terrace surface; however, the terrace riser was not field-checked.

Foxen Canyon fault

No air photo evidence was seen of faulting (scarps, tonals, deflected drainages, etc.) in the extensive Holocene alluvium and late Pleistocene terrace deposits along the inferred trend of the Foxen Canyon fault (the fault is not shown in Figure 6).

Little Pine fault (northwest end)

The northwest end of the Little Pine fault zone was examined on air photos, but not field-checked due to lack of time. The fault can be traced as a highly-eroded, southwest-facing scarp. No air photo evidence was seen of faulting in the Holocene alluvium or late Quaternary landslide deposits along the fault zone (the fault zone is not shown in Figure 6).

Garey fault

The Garey fault (Figure 1) is moderately well-defined on the air photos as an alignment of saddles and broad linear troughs in the Paso Robles Formation south of Sisquoc. The fault is poorly defined or concealed north of Sisquoc (Figure 6). No air photo evidence was seen of surface faulting (scarps, deflected drainages, tonals, etc.) in the late Pleistocene terrace deposits or Holocene alluvium northwest of Foxen Canyon.

Santa Maria Mesa fault

No air photo evidence was seen of faulting (scarps, tonals, deflected drainages, etc.) in the extensive Holocene alluvium and late Pleistocene terrace deposits along the inferred trend of the Santa Maria Mesa fault (Figure 6).

West Huasna fault zone (southeast segment)

Surface traces of the West Huasna fault zone are poorly defined on the air photos by alignments of widely-separated linear drainages and broad saddles. The faults are difficult to trace in the field. Extensive landslides have obliterated most of the eastern trace along the Cuyama River (see Figure 6). Field and air photo evidence against recent (Holocene) activity along the fault zone includes the following items: (1) a small, unfaulted alluvial fan overlies Holocene terrace deposits that conceal the eastern fault trace along the Cuyama River; and (2) both main traces of the fault are locally concealed by several apparently unfaulted, late Pleistocene terrace deposits (at Elevations 305 meters, 366 meters, and 427 meters; 1,000 feet, 1,200 feet, and 1,400 feet, respectively).

3. LIONS HEAD FAULT, "POINT SAL" FAULTS, AND "POINT SAL BEACH" FAULTS

Lions Head fault

The late Pleistocene terrace deposits that overlie the western segment of the Lions Head fault (see Figure 7) have been partially offset by movement along the fault, as reported by Sylvester and Darrow (1979). At the beach, the fault is well exposed in bedrock where wave active has stripped away the colluvium. Colluvium and vegetation conceal the overlying terrace deposits, but a recent small landslide has exposed the faulted base of the unit. Although poorly exposed in the west-facing landslide scar, the base of the terrace unit is vertically offset approximately .5 meters (down to the south). No evidence of fault rupture of the upper surface of the marine terrace was seen on the air photos or in the field. Age of the terrace unit is tentatively estimated by this writer as approximately 80,000 years, based on data in Dames and Moore (1980) for a terrace at a similar elevation near Point Conception. However, correlation of two discontinuous terraces located approximately 50 km apart must be considered tenuous at best.

To the southeast, the Lions Head fault can be traced as a discontinuous alignment of linear troughs and low, southwest-facing scarps. A scarp, tonals, and break-in-slope were seen in the older marine terrace deposits, which are probably younger than the Orcutt Sand. At the west end of the longest fault segment (1.9 km southeast of the beach exposure; see Figure 7) is a 10 cm-high scarp in colluvium derived from the ophiolite and Monterey Formation. The southwest-facing scarp has a slope of approximately 5°-10°. Near the junction of the southern branch fault (0.7 km southeast of above location; 2.6 km southeast of beach) the break-in-slope in colluvium on the splay fault has a 19° SW dip. Southeast of this junction, the fault is poorly exposed. The inferred extension of the Lions Head fault south of Shuman Canyon (Payne and others, 1978) could not be verified on the air photos.

"Point Sal" faults and "Point Sal State Beach" faults

Some of the inferred "Point Sal" faults and "Point Sal Beach" faults can be traced on the air photos as erosion-enhanced features in bedrock, such as scarps, short linear drainages, ravines, and ridge saddles (Figure 5). However, latest Pleistocene or Holocene dune sands conceal most of the inferred fault traces at Point Sal. The location of the main, east-trending fault at Point Sal Beach (Dibblee, 1954; Hopson and others, 1975) was verified on the air photos as a broad linear drainage and saddle. I saw no air photo evidence of recent displacement along any of the faults. Field inspection shows that the west half of the main, east-trending fault is concealed by a large, active landslide in the Point Sal and Lospe Formations. The landslide pre-dates the 1954 USDA photos, but continued activity of the landslide has destroyed dirt roads that appear in good condition on the photos.

4. SANTA MARIA, BRADLEY CANYON, AND "GUADALUPE OIL FIELD" FAULTS

Santa Maria and "Guadalupe oil field" faults

There is no air photo evidence of surface faults or differential uplift in Holocene and latest Pleistocene alluvium along the projected traces of the subsurface Santa Maria and "Guadalupe oil field" faults (Figure 1).

Bradley Canyon Fault

No air photo evidence was seen of surface fault rupture or differential uplift in Holocene and latest Pleistocene alluvium along the projected trace of the Bradley Canyon fault (Figure 6). Although Worts (1951) inferred that Bradley Canyon may be a surface expression of faulting, there is no evidence of a significant change in terrace surface elevations across the canyon. Both Worts and Hall (1978b) show a fault in a ravine north of the Santa Maria River (Figure 6). The existance and trend of the fault could not be verified, either on the air photos or in the field, due to poor exposures.

CONCLUSIONS

1. The Orcutt Frontal fault is a significant, south-dipping reverse fault, with approximately 2,400 m of displacement of the Miocene Monterey Formation, that is a largely known from subsurface data (Crawford, 1971; Krammes and Curran, 1959). Except at the Orcutt oilfield, where a branch of the fault is shown to truncate the mid-Pleistocene Orcutt Sand (Krammes and Curran), there is no known evidence that identifies this fault as a surface feature. Its mapped position to the west-northwest (Envicom, 1975; Buchannan-Banks and others, 1978) presumably is based upon the uplifted Casmalia and Solomon Hills to the south, and on largely unpublished subsurface data. However, the surface trace was not mapped by Woodring and Bramlette (1950), and neither its position nor recency could be verified during this study. Although the fault may have been active in late Quaternary time, there is no evidence of scarps or other deformation in the Holocene and late Quaternary fans and terraces that flank the hills, or in the Holocene dune deposits that cover most of the adjacent portion of the Santa Maria Valley.

2. The Pezzoni, "Pezzoni extension", Casmalia, "Solomon Canyon", and "Orcutt oil field" faults are a group of discontinuous surface faults in the Casmalia and Solomon Hills (Woodring and Bramlette, 1950; Earth Science Associates, 1975; Payne and others, 1978) that may be continuous at depth (Sylvester and Darrow, 1979; Gray, 1980). With the exception of the "Solomon Canyon" fault, which is interpreted by Woodring and Bramlette to be a northeast-dipping normal fault, the faults are west-northwest-trending, southwest-dipping reverse faults. The maximum displacement varies for each fault, being 3,000 meters for the Pezzoni fault, 2,400 meters for the main "Orcutt oil field" fault, 900 meters for the "Solomon Canyon" fault, 80 meters for the Casmalia fault, and an unknown amount for the "Pezzoni extension" fault. Most of the surface traces are poorly defined to moderately well defined on the air photos, being largely concealed by late Quaternary landslides or terrace and dune sand deposits. Inferred Holocene faulting in the Orcutt oil field and in Solomon Canyon (Woodring and Bramlette, 1950) could not be verified, either on air photos or in the field.

3. The "Corralitos Canyon" fault shown by Woodring and Bramlette (1950) is moderately well-defined along its short length by erosion of the footwall block. The amount of displacement is not known, but probably is relatively minor. Late Pleistocene terrace deposits and mid Pleistocene Orcutt Sand are shown to be unfaulted.

4. The southeast end of the West Huasna fault zone includes a major fault that offsets units as young as mid-Pleistocene (Hall, 1978b; Dibblee, 1978). The amount and sense of displacement have not been established, although Dibblee states that the sense of displacement is right-lateral strike-slip. The various fault traces are poorly defined on available air photos, and are difficult to trace in the field. Individual fault strands locally are overlain by apparently undisturbed Holocene alluvium and late Pleistocene terrace deposits, or are obscured by massive landslides. There is no known air photo or field evidence of latest Pleistocene or Holocene fault rupture.

5. The Santa Maria River fault and Foxen Canyon fault are inferred subsurface extensions of the Little Pine fault (Hall, 1978b; 1981c). The northwest-trending faults are shown by Hall to be vertical to steeply northeast-dipping. Sense and amount of displacement along the Santa Maria River fault and Foxen Cayon fault are not known, but Hall shows the Paso Robles Formation and Orcutt Sand to have 40 meters of dip-slip displacement. The faults have no surface expression where concealed by late Pleistocene terrace deposits and Holocene alluvium.

6. The Little Pine fault is a major, northwest-trending, northeast-dipping reverse fault which lies southeast of the Santa Maria River and Foxen Canyon faults. It separates Mesozoic units on the northeast from Cenozoic units on the southwest (Dibblee, 1966; Hall, 1981c). Total displacement along the fault is not known, but is believed by Dibblee (1966) to amount to several thousand feet. The youngest unit shown to be faulted is the Paso Robles Formation (Pleistocene), and the fault locally is concealed by late Quaternary landslides and Holocene alluvium. No air photo evidence of faulting in late Quarternary deposits was seen along the northwest end of the fault zone. Field verification of the Little Pine fault was not done during this study.

7. The Garey and Santa Maria Mesa faults are largely inferred, vertical to steeply-dipping faults that branch from the Santa Maria River fault (Hall, 1978b, 1981c; Worts, 1951). Sense of displacement and age of the Garey fault is believed by Hall (1981c) to be strike-slip, based upon stratigraphic discontinuities of pre-Pliocene units. No sense of displacement is given for the Santa Maria Mesa fault. All of the Garey fault and the northwest segment of the Santa Maria Mesa fault are concealed by late Pleistocene terrace deposits and Holocene alluvium. The youngest units faulted are the Carreaga Sand and Paso Robles Formation. The Santa Maria Mesa fault locally may offset a late Pleistocene terrace deposit, but this could not be verified.

8. The Lions Head fault is an important normal fault that separates Tertiary sedimentary and Jurassic ophiolitic rocks. The fault is moderately well-defined along its western half, and poorly defined along its eastern half where concealed by late Pleistocene terrace deposits. Evidence of recency of faulting is located at the fault's west end, where the base of the youngest late Pleistocene terrace deposit is vertically offset .5 meters (south side down). However, no evidence of faulting in the upper surface of the terrace unit was seen on the air photos or in the field. A geophysical survey by Payne and others (1979) indicates that the offshore western extension of the Lions Head fault does not displace post-Wisconsin strata (less than 17,000 - 20,000 years old). The inferred southeastern extension of the fault shown by Sylvester and Darrow (1979) and Gray (1980) could not be confirmed by this writer.

9. The "Point Sal" and "Point Sal Beach" faults are inferred by Hopson and others (1975) to displace Jurassic ophiolite rocks. The "Point Sal" faults are largely concealed beneath late Pleistocene to Holocene dune sand. These faults are exposed in bedrock along the beach, but no evidence of surface faulting in the dune sand deposits was visible on the air photos. Some of the "Point Sal Beach" faults locally are covered by Orcutt Sand, late Pleistocene terrace deposits, and/or active landslide deposits. There is no air photo or field evidence of recent displacement along these faults.

10. The Santa Maria and "Guadalupe oil field" faults, which were interpreted from oil field data, could not be identified as surface features on available air photos. Movements along these inferred, subsurface faults predate the mid-Pleistocene (Canfield, 1939; Worts, 1951; Lawrence, 1964).

11. The Bradley Canyon fault is an inferred, concealed fault mapped by Worts (1951) and Hall (1978b) on the basis of unpublished subsurface data. The fault cannot be followed as a surface feature on air photos between Bradley Canyon and the Santa Maria River. Worts (1951) inferred a structural relation between the southern segment of the fault and Bradley Canyon, but there is no evidence of differential uplift across the canyon. Offsets of the Orcutt Sand and late Pleistocene terrace deposits, shown by Worts on the north bank of the river, could not be confirmed by either this writer or Hall (1978b).

RECOMMENDATIONS

Based upon the conclusions reached in the previous section, none of the faults examined in this FER meet the requirements of "sufficiently active and well-defined" necessary for zoning, and they should not be zoned.

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Report reviewed, recommendations are reasonable.
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12/18/85

REFERENCES

Arnold, R., and Anderson, R., 1907, Geology and oil resources of the Santa Maria oil district, Santa Barbara County, California: U. S. Geological Survey Bulletin 322, 161p, 1 plate, scale 1:125,000.

Buchannan-Banks, J. M., Pampeyan, E. H., Wagner, H. C., and McCulloch, D. S., 1978, Preliminary map showing recency of faulting in coastal south-central California: U. S. Geological Survey Miscellaneous Field Studies Map MF-910, 3 sheets.

California Division of Oil and Gas, 1974, California oil and gas fields, Volume II: south, central coastal, and offshore California: California Division of Oil and Gas Publication No. TR 12, unpaginated.

Canfield, C. R., 1939, Subsurface stratigraphy of Santa Maria Valley oil field and adjacent parts of Santa Maria Valley, California: American Association of Petroleum Geologists Bulletin v. 23, no. 1, p. 45-81.

Crawford, F. D., 1971, Petroleum potential of Santa Maria province, California, _in_ Cram, I. H., _editor_, Future petroleum provinces of the United States -- their geology and potential: American Association of Petroleum Geologists Memoir 15, volume 1, p. 316-328.

Cummings, J. R., Yates, P. J., Loo, F. M., Taweel, M. E. Jr., and Loo, C. B., 1970, Seawater intrusion: Pismo-Guadalupe area: California Department of Water Resources Bulletin 63-3, 76 p., 4 plates.

Dames & Moore, 1980, Final geoseismic investigation, proposed LNG Terminal, Little Cojo Bay, California: unpublished consulting report for western LNG Terminal Associates, Vol. 1., Summary and Conclusions.

Dibblee, T. W. Jr., 1950, Geology of southwestern Santa Barbara County, California: California Division of Mines Bulletin 150, 95 p., 2 plates, scale 1:62,500.

Dibblee, T. W. Jr., 1954, Geologic maps of parts of the Point Sal and Santa Maria 15' quadrangles, California: unpublished maps in C.D.M.G. Regional Mapping Program files, scale 1:62,500.

Dibblee, T. W. Jr., 1966, Geology of the central Santa Ynez Mountains, Santa Barbara County, California: California Division of Mines and Geology Bulletin 186, 99 p., 4 plates, scale 1:62,500.

Dibblee, T. W., Jr., 1978, Analysis of geologic-seismic hazards to Point Conception LNG Terminal Site: unpublished report for County of Santa Barbara in C.D.M.G. Regional Mapping Program files, 72 p.

Earth Science Associates, 1975, Section 2.5, Geology and Seismology, _in_ Final Safety Analysis Report, Units 1 and 2, Diablo Canyon Site, San Luis Obispo County, California [USAEC Dockets 50-275 and 50-323].

Gray, L. D., 1980, Geology of Mesozoic basement rocks in the Santa Maria basin, Santa Barbara and San Luis Obispo Counties, California: Unpublished MS Thesis, San Diego State University, 4 plates.

Guptill, P. D., Heath, E. G., and Brogan, G. E., 1981, Surface fault traces and historical earthquake effects near Los Alamos Valley, Santa Barbara County, Califonia: U. S. Geological Survey Open File Report 81-271, 56 p. and appendices, 3 plates.

Hall, C. A., 1973, Geology of the Arroyo Grande quadrangle, California: California Division of Mines and Geology Map Sheet 24, 8 p., 1 plate, scale 1:48,000.

Hall, C. A., Jr., 1978a, Origin and development of the Lompoc-Santa Maria pull-apart basin and its relation to the San Simeon-Hosgri strike- slip fault, western California, in Silver, E. A., and Normark, W. R., editors, San Gregorio-Hosgri fault zone, California: California Division of Mines and Geology Special Report 137, p. 25-31.

Hall, C. A., Jr., 1978b, Geologic map of Twitchell Dam and parts of Santa Maria and Tepusquet Canyon quadrangles, Santa Barbara County, California: U. S. Geological Survey Miscellaneous Field Studies Map MF-933, 2 sheets, scale 1:24,00.

Hall, C. A., Jr., 1981a, San Luis Obispo Transform fault and middle Miocene rotation of the western Transverse Ranges, California: Journal of Geophysical Research, v. 86, no. B2, p. 1015-1031.

Hall, C. A. Jr., 1981b, Evolution of the western Transverse Ranges microplate: Late Cenozoic faulting and basinal development, in Ernst, W. G., editor, the geotectonic development of California, Rubey Volume I, p. 559-582.

Hall, C. A. Jr., 1981c, Map of geology along the Little Pine fault, parts of Sisquoc, Foxen Canyon, Zaca Lake, Bald Mountain, Los Olivos, and Figueroa Mountain quadrangle, Santa Barbara County, California: U. S. Geological Survey Miscellaneous Field Studies Map MF-1285, 2 sheets, scale 1:24,000.

Hall, C. A. Jr., and Corbato, C. E., 1967, Stratigraphy and structures of Mesozoic and Cenozoic rocks, Nipomo quadrangle, southern Coast Ranges, California: Geological Society of America Bulletin, v. 78, no. 5, p. 559-582, 2 plates, scale 1:48,000.

Hart, E. W., 1985, Fault-rupture hazard zones of California: California Division of Mines and Geology Special Publication 42, 24 p.

Hopson, C. A., Frano, C. J., Pessagno, E. A., Jr., and Mattinson, J. M., 1975, Preliminary report and geologic guide to the Jurassic ophiolite near Point Sal, southern California coast: Geological Society of America, Cordilleran Section, 71st annual meeting, guidebook for Field Trip no. 5, 36 p.

Jennings, C. W., 1975, Fault map of California with locations of volcanoes, thermal springs, and thermal wells: California Division of Mines and Geology Geologic Data Map No. 1, scale 1:750,000.

Kilbourne, R. T., and Mualchin, L., 1980, Geology for planning: Guadalupe and Point Sal 7-1/2' quadrangles, Santa Barbara and San Luis Obispo Counties, California: California Division of Mines and Geology Open File Report 80-5SF, 49p., 4 plates, scale 1:24,000.

Krammes, K. F., and Curran, J. F., 1959, Correlation section 12 across Santa Maria basin from Cretaceous outcrop in Santa Ynez Mountains northerly to Franciscan outcrop north of Santa Maria River, California: American Association of Petroleum Geologists, Pacific Section, scales 1:12,000 and 1:48,000.

Lawrence, E. D., 1964, Guadalupe oil field: California Division of Oil and Gas, Summary of operations, California oil fields, v. 50, no. 2, p. 71-77, 6 plates.

Payne, C. M., Swanson, O. E., and Schell, B. A., 1979, Investigation of the Hosgri fault, offshore southern California, Point Sal to Point Conception: U. S. Geological Survey Open File Report 79-1199, 18 p., 3 plates.

Sylvester, A. G., and Darrow, A. C., 1979, Structure and neotectonics of the Western Santa Ynez fault system in southern California: Tectonophysics, v. 52, p. 389-405.

U.S. Department of Agriculture, 1954, black and white photographs, series BTM, scale 1:20,000, photos 1K 23-30, 33-34, 45-53; 2K 20-29, 44-48, 101-104, 117-129; 3K 3-15, 86-95; 10K 15-27, 37-39, 76-85; 11K 20-27; 12K 22-26, 63-68.

Woodring, W. P., and Bramlette, M. N., 1950, Geology and paleontology of the Santa Maria District, California: U. S. Geological Survey Professional Paper 222, 185 p., 2 plates, scale 1:24,000.

Woodward-Clyde Consultants, 1979, black and white photographs, low sun angle, scale 1:24,000(?), photos 1-27 to 1-34.

Worts, G. F., Jr. 1951, Geology and ground water resources of the Santa Maria Valley area, California: U. S. Geological Survey Water Supply Paper 1000, 169 p., 6 plates.

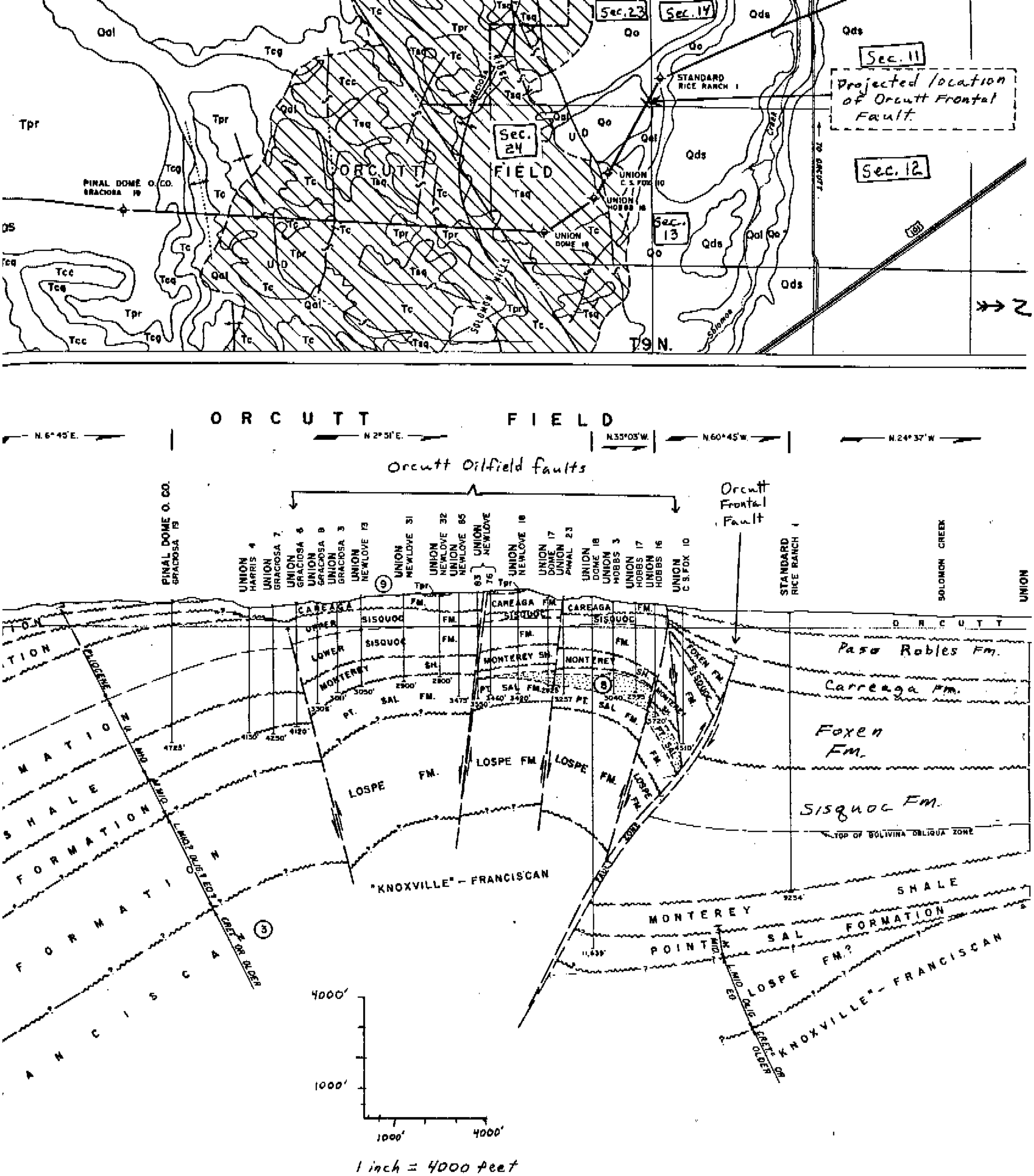

Figure 2 to FER-168: Geologic map and cross section through the Orcutt oil field (from Krammes and Curran, 1959).

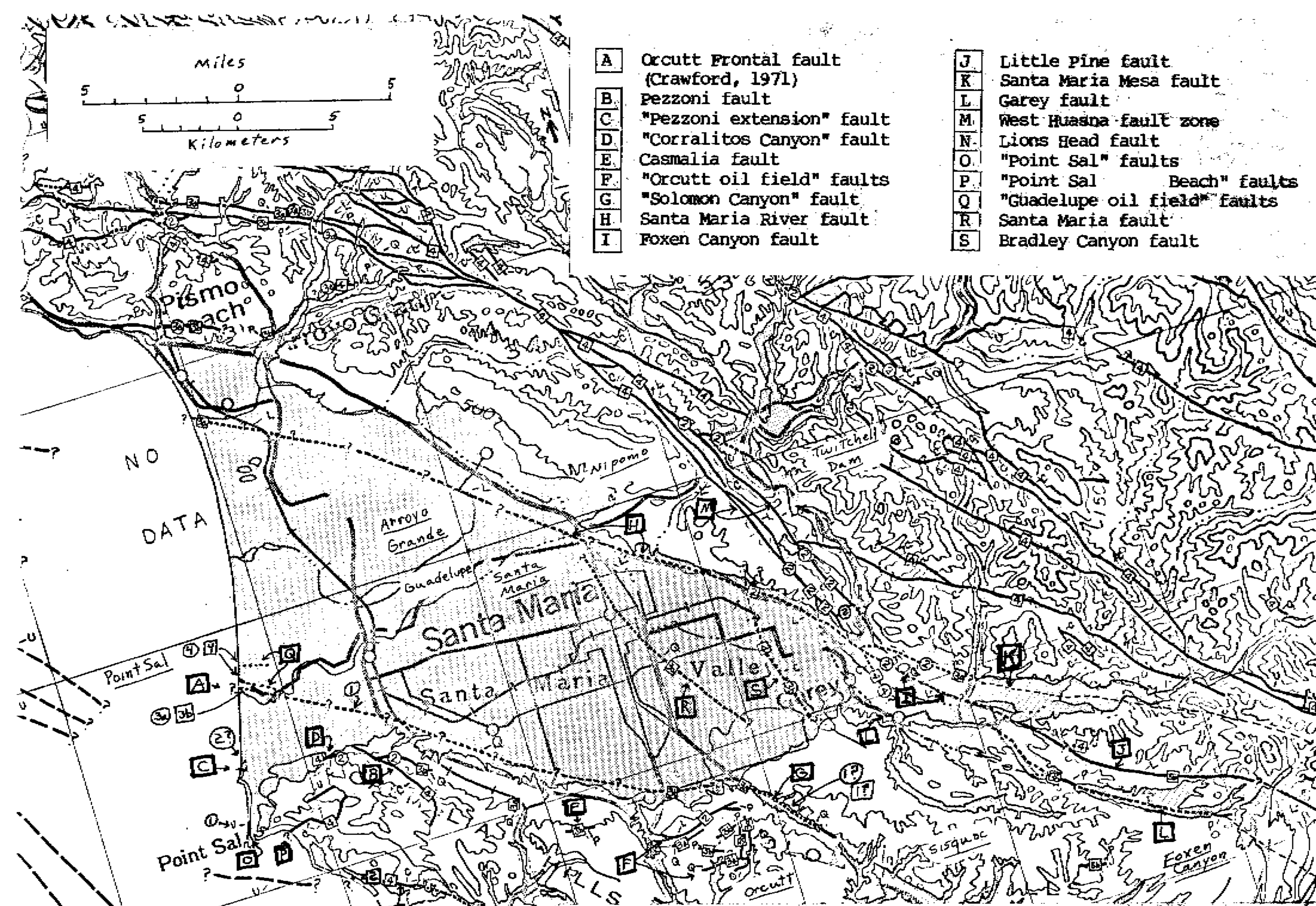

Figure 1 to FER-168: Faults, recency of faulting, and quadrangles in the Santa Maria Valley study area. Base map modified from Buchannan-Banks and others (1978). See rear of map for explanation of fault classification.

○ Oldest known unfaulted stratigraphic unit deposited across or intruded along the fault. Latest fault movement predates age of unit

□ Youngest known stratigraphic unit displaced by fault. Latest fault movement postdates age of unit

◁ Geomorphic feature formed by fault movement. Latest fault movement inferred from type of feature

GEOLOGIC CONTROL	YEARS BEFORE PRESENT[1]
	0
[1] ◁1 (1)	Holocene
	10,000
[2] ◁2 (2)	Late Pleistocene
	700,000
[3] (3) — [3a] (3a)	Early Pleistocene
	2 million
[3] (3) — [3b] (3b)	Late Pliocene
	4 million
[4] (4)	Early Pliocene and late Miocene
	12 million
(5)	Middle Miocene and older

Figure 1 to FER-168