SUBSIDENCE AND GROUND FISSURES IN THE SAN JACINTO BASIN AREA, SOUTHERN CALIFORNIA

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The San Jacinto basin is an extraordinarily deep and narrow pull-apart basin located at a right step in the San Jacinto fault zone, an important fault zone of the San Andreas fault system in southern California. The basin ranges in width from 3 to 4 km. The thickness of sedimentary fill within the basin is on the order of 3 km (Fett, 1968; Shawn Biehler, oral commun., 1988). The basin is bounded on the east by the Claremont fault and on the west by the Casa Loma fault (fig. 1). Both the Casa Loma and the Claremont faults are major strands of the San Jacinto fault zone. Within the area of the San Jacinto basin, the east-dipping Casa Loma fault has components of right-slip and normal-slip, and the similar dipping Claremont fault has components of right-slip and reverse-slip. The scarp of the Casa Loma fault is a relatively subtle and low scarp whereas the scarp of the Claremont fault is bold, rising to over 600 m above the basin floor (Morton and Sadler, 1989). The high Claremont scarp, due to the reverse-slip component, is produced by regional compression and uplift to the east and northeast of the San Jacinto basin. At the turn of the century most of the basin was an artesian basin (Waring, 1919).

Basin fill is supplied primarily by the San Jacinto River, which drains a large part of the San Jacinto Mountains area to the east of the San Jacinto basin. The San Jacinto River enters the east end of the basin and flows northwest along the length of most of the basin. At the north end of the basin additional fill is derived from a thick section of Pliocene continental sedimentary rocks on the east side of the Claremont fault. At the north end of the basin is a closed depression that contains ephemeral Mystic Lake. The closed depression at the north end of the basin is not the result of more rapid subsidence than elsewhere in the basin, but rather the lack of sufficient sedimentary material needed to balance subsidence. Tectonic subsidence and subsidence related to aquifer-system compaction has been well documented for the basin (Fett and others, 1967; Lofgren, 1976; Lofgren and Rubin, 1975; Morton, 1972; 1977). Tectonic subsidence for the past 40,000 years is in the range of 3 to over 5 mm/yr and has an average of about 4.5 mm/yr (fig. 2). The subsidence rates are based upon ^{14}C dates on wood samples collected from drill holes within the basin (see Hanson abstract for related discussions). The most visible expression of land-surface deformation is earth fissures, which are common in the northern part of the basin and several kilometers to the west.

Much of the aquifer system in the basin had a hydraulic head of about 3 m above land surface at the time of European settlement within the basin. By the end of the 1940’s very few flowing wells existed within the basin. In the early 1970’s ground-water withdrawal had lowered the hydraulic heads to about 24–30 m below land surface. Land subsidence has been attributed to aquifer-system compaction related to lowering of hydraulic heads (Lofgren, 1976). Releveling in the basin by the Metropolitan Water District between 1939 and 1959 indicates an average maximum annual rate of total land subsidence of about 3.5 cm (Proctor, 1962). An aqueduct pipe placed across the Casa Loma fault in 1958 was vertically deformed about 60 cm by 1973, for an annual rate of about 4 cm/yr (Morton, written commun., 1976). A highway resurvey in the early 1970's indicated a maximum rate of subsidence along the highway in the western part of the basin of about three cm/yr (Riverside County Road Department, oral commun., 1975). Considering the long-term tectonic rate of subsidence, land subsidence due to aquifer compaction caused by ground-water withdrawal is on the order to 2.5–3 cm/yr.

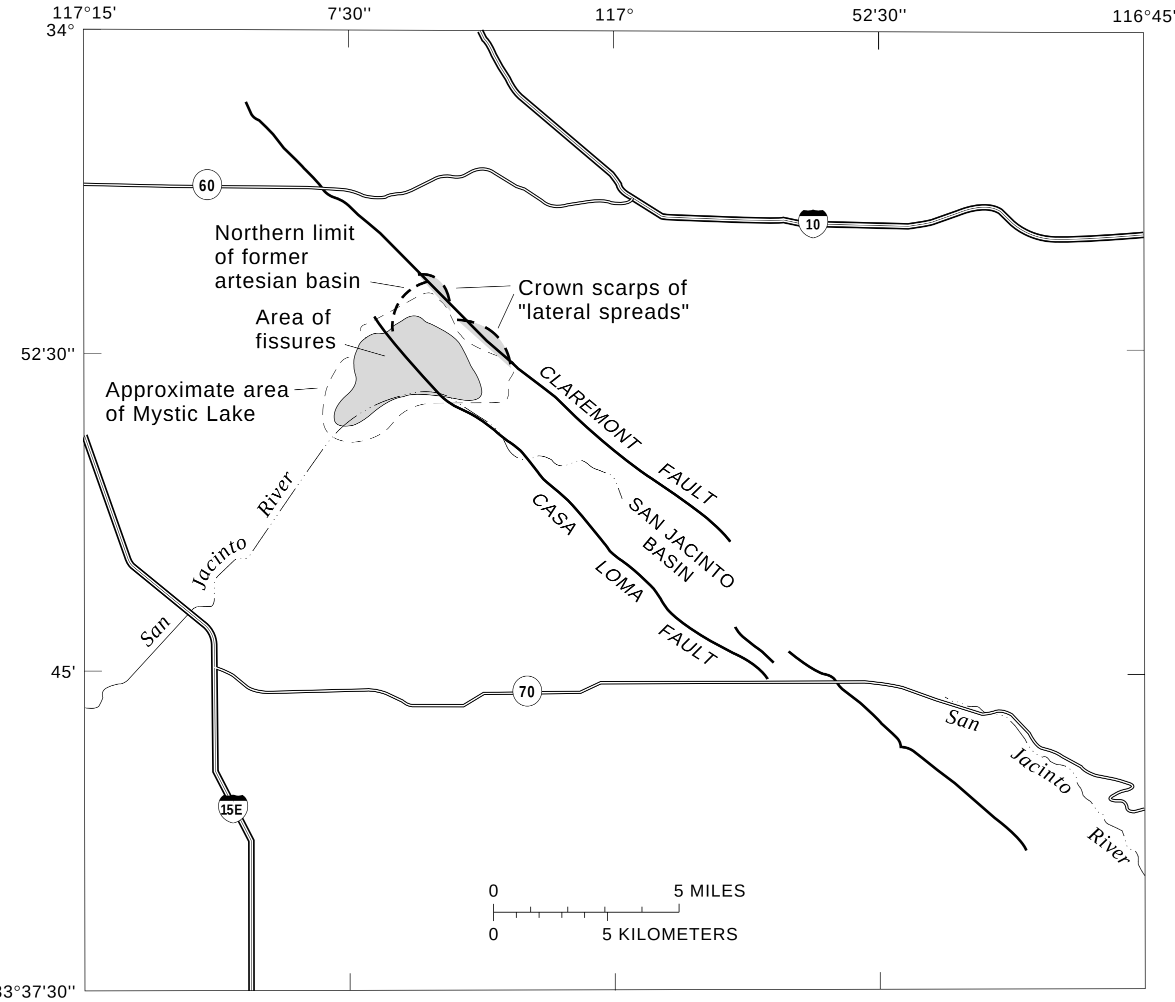

Figure 1. Generalized map of the San Jacinto basin area, California.

Earth fissuring, presumably consequent to the lowering of aquifer-system hydraulic heads, apparently first became evident in the early 1950's. (See Schumann, Ward and others, and Haneberg and Friesen abstracts for discussions of other earth fissures; also see Haneberg and Helm abstracts for possible mechanisms of earth fissure formation.) Most of the fissures occur on nearly horizontal ground. In the early 1950's most of the fissuring was limited to a relatively small area about 1 km long in the basin and another small area, 1.5 km long west of the basin (Morton, 1977). A few scattered fissures were reported from near the Claremont fault in the southeastern part of the basin (Fett and others, 1967). These early fissures were relatively short, most being 100–200 m long. By 1973 fissuring had greatly expanded both within the basin and to the west over an area of about 18 km^2. In addition, a few isolated fissures were located as far as 4 km west of the main area of fissures. The fissuring to the west of the basin occurred over the northern part of a several hundred-meter-deep, west-oriented, sediment-filled canyon. As the fissures grew in number they also grew in length. A number of fissures had a length over 1 km by 1973 (Morton, 1977). Some of the older fissures have been filled with sediment so little if any surface expression remains, while others have been periodically reactivated and lengthened with reactivation. By the late 1970's a few long fissures, about 1 km in length, developed west of the basin at a distance of about 10–12 km south of the main area of fissures. Some of these isolated fissures were reactivated in 1992.

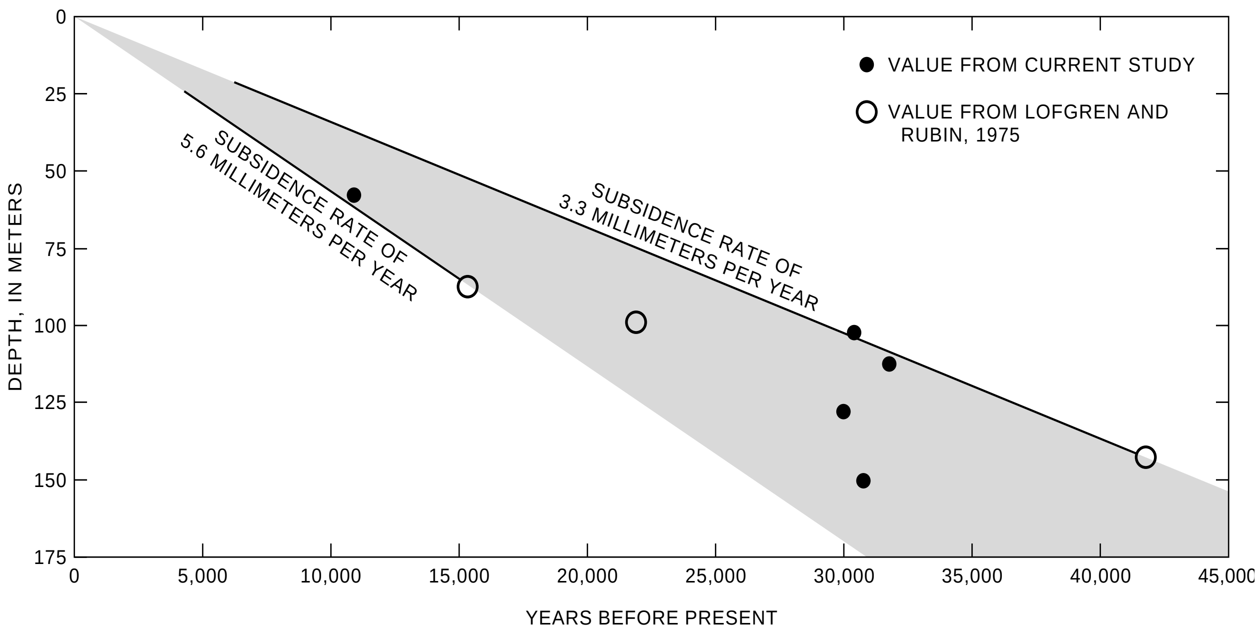

Figure 2. Depth and ages of C14 dated material from the San Jacinto basin, California, and inferred rates of subsidence.

In the late 1980's a different form of fissuring started along the east side of the northern part of the basin. Here on gentle slopes extending east from the Claremont fault are large areas that are underlain by material slowly moving downslope into the basin (Morton and Sadler, 1989). These features are somewhat like slow-moving “lateral-spread” landslides. The width of the larger features is more than 1 km. A discontinuous scarp is produced at the head of the moving mass, and some lateral zones of deformation form in the upper lateral part of the moving mass. Vertical displacement of the scarp area of one of these masses was as much as 1 m over a 2-year period in the late 1980's. Extensional fissures developed in the headward parts of the mass moving away from the scarp area. The morphology of these fissures resemble those fissures within the basin.