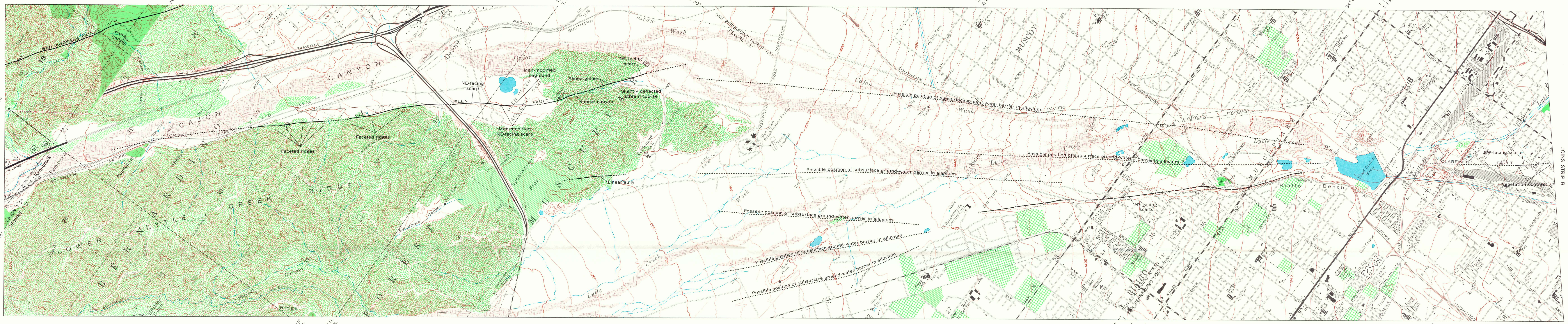
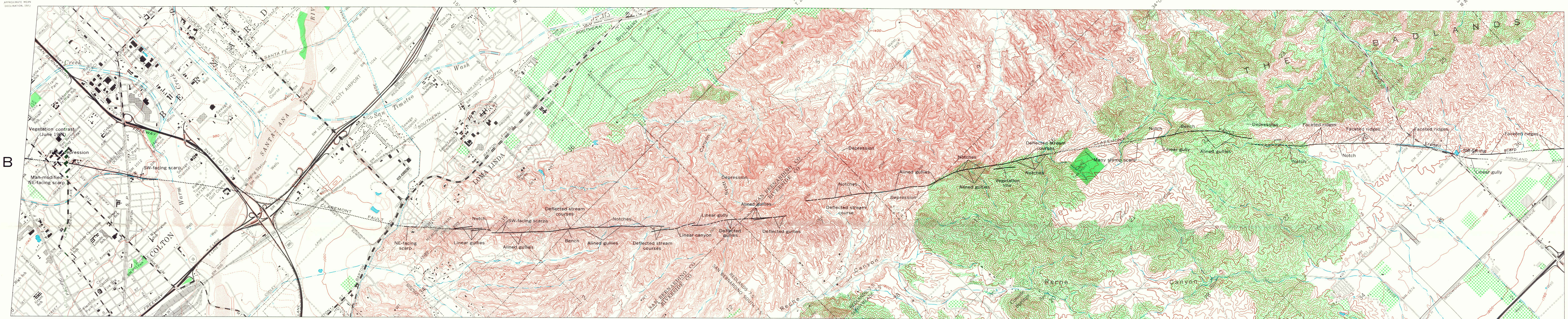




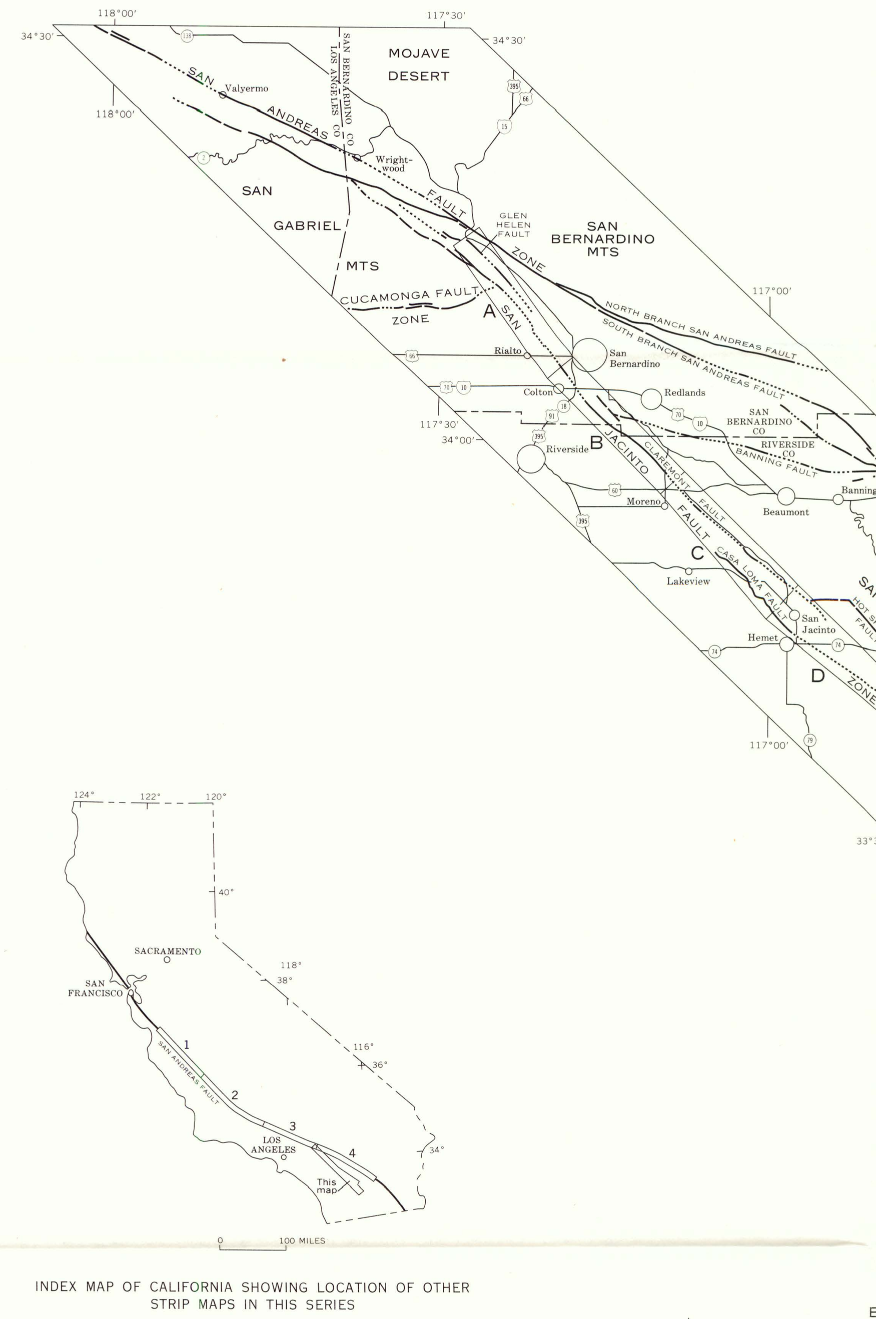
Base from U.S. Geological Survey, 7.5' and 15' quadrangles as indicated

SCALE 1:24 000

CONTOUR INTERVALS 20, 40, AND 80 FEET
DASHED LINES REPRESENT 5 AND 10 FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

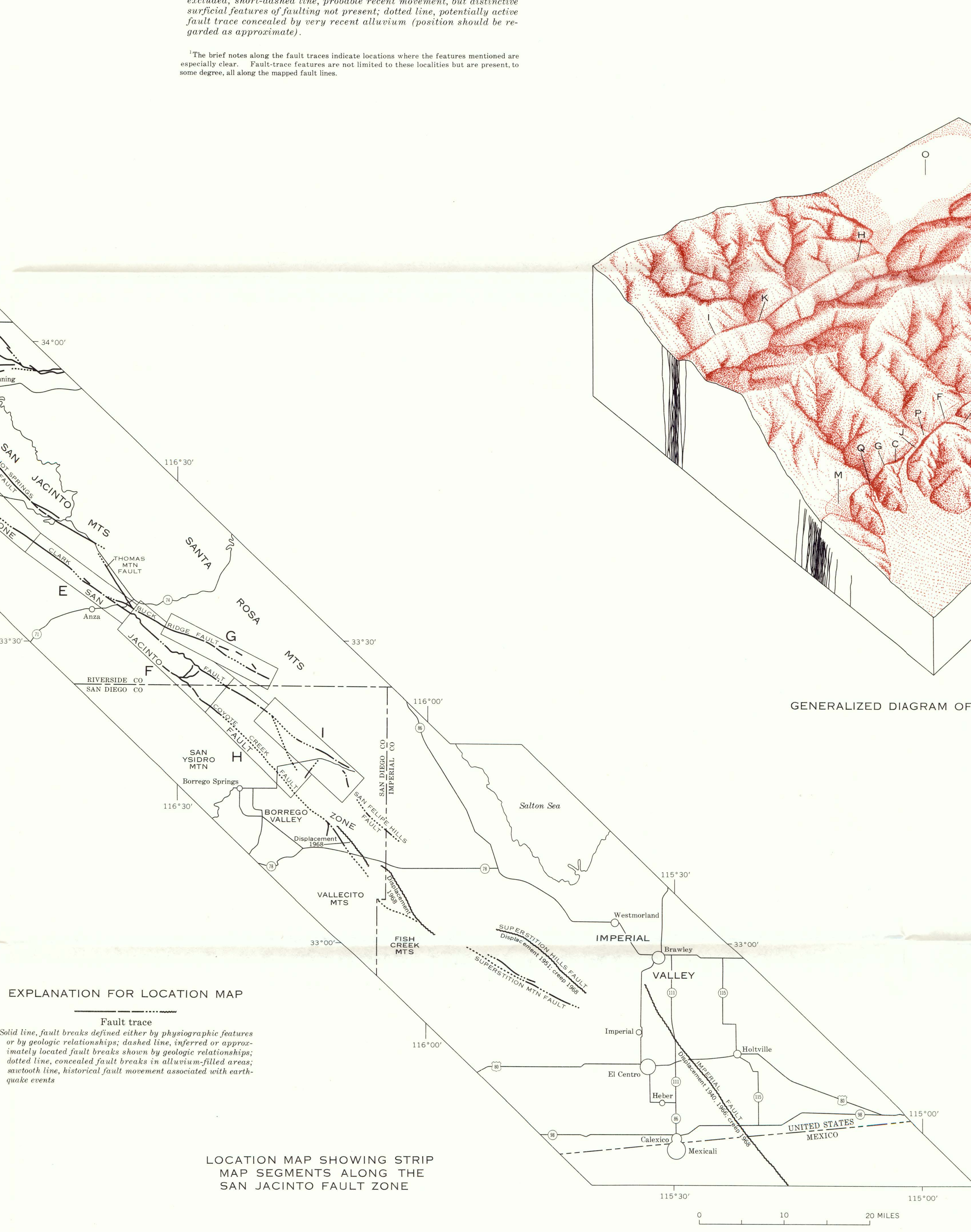
EXPLANATION

Fault trace



INDEX MAP OF CALIFORNIA SHOWING LOCATION OF OTHER STRIP MAPS IN THIS SERIES

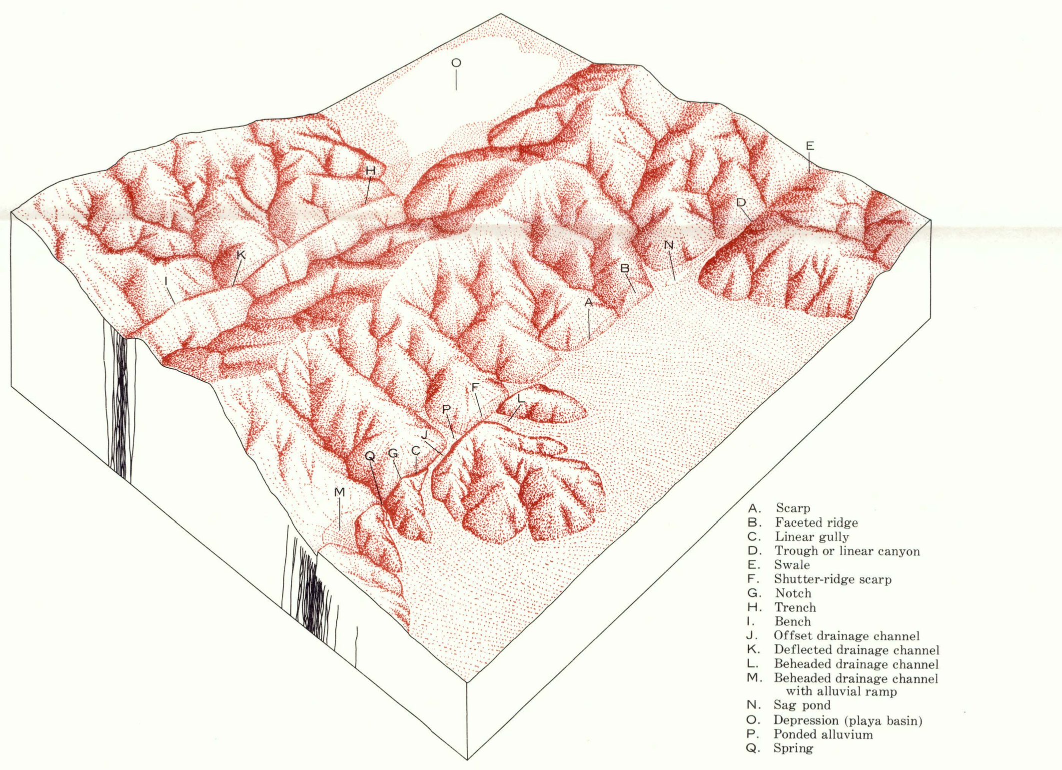
1. Brown, R. D., Jr., 1970, Map showing recently active breaks along the San Andreas and related faults between the northern Gabilan Range and Cholame Valley, California: U.S. Geol. Survey Misc. Geol. Inv. Map I-575
2. Vedder, J. G., and Wallace, R. E., 1970, Map showing recently active breaks along the San Andreas and related faults between Cholame Valley and Tejon Pass, California: U.S. Geol. Survey Misc. Geol. Inv. Map I-574
3. Ross, D. C., 1969, Map showing recently active breaks along the San Andreas fault between Tejon Pass and Cajon Pass, California: U.S. Geol. Survey Misc. Geol. Inv. Map I-553
4. Hope, R. A., 1969, Map showing recently active breaks along the San Andreas and related faults between Cajon Pass and Salton Sea, California: U.S. Geol. Survey open file report



EXPLANATION FOR LOCATION MAP

Fault trace

LOCATION MAP SHOWING STRIP MAP SEGMENTS ALONG THE SAN JACINTO FAULT ZONE



GENERALIZED DIAGRAM OF FAULT FEATURES

PURPOSE OF THIS STRIP MAP

This strip map of the San Jacinto fault zone is one of a set designed to show the lines of inferred most recent movement within the San Andreas fault system. The character and location of these lines are important to scientists and engineers who study faulting and earthquakes and should be helpful to those concerned with land use and development on or near the faults. The mapped lines mark suspected displacements of the ground surface by rupture or creep within the San Jacinto fault zone. Map users should keep in mind that these lines are primarily guides for locating fault traces on the ground and are not necessarily located with the precision needed for engineering or land-use projects.

THE SAN ANDREAS FAULT SYSTEM AND THE SAN JACINTO FAULT ZONE

The San Andreas fault system comprises a group of major subparallel flaws or breaks in the earth's crust that extends at least from the Gulf of California in northern Mexico northwestward through western California, a distance of more than 600 miles (*see* Crowell, 1962). Throughout its history, the direction of movement on faults in the San Andreas system has been dominantly horizontal in the right-lateral sense. The San Jacinto fault zone constitutes one of the principal members of the San Andreas system in the southernmost part of the state. This fault zone includes subparallel branching and en echelon faults that lie within a nearly linear belt, as much as 7 miles in width, extending from the San Gabriel Mountains southeastward into Imperial Valley (see index map). Although many previous workers applied the term "San Jacinto fault" to different major fractures within the zone, the lack of continuity of any single strand through the entire length of the zone argues against its applicability as a name. Thus the San Jacinto fault of several earlier studies—that fracture having the greatest length, continuity, and cumulative displacement, as well as the most convincing evidence of recent right-lateral movement—is herein termed the Clark fault (first used by Dibblee, 1954). Similarly, the break along the northeastern side of San Jacinto Valley, also previously called the San Jacinto fault, is here designated the Claremont fault, following Fraser (1931). Other recently active breaks within the zone include the Glen Helen fault, Buck Ridge fault, and Coyote Creek fault (see index map for locations). Additional faults known to lie within or converge with the San Jacinto fault zone, including the Hot Springs fault, the Thomas Mountain fault, and the western extremity of the Banning fault, show no obvious evidence of recent activity. The pattern of southeastward divergence of fractures within and southeast of the area of this strip map suggests further that the Imperial fault, San Felipe Hills fault, Superstition Hills fault, and the Superstition Mountain fault, all in western and central Imperial Valley, are part of the San Jacinto fault zone (*see* Dibblee, 1954).

Movement along any of the fault strands within the San Jacinto zone commonly has been distributed along several nearly parallel breaks that differ in amount of total displacement and possibly differ in age. The entire complex zone of movement has been active over a span of millions of years and through the course of its history probably has accumulated a net right-lateral offset of about 15 miles (Sharp, 1967).

LOCATION OF THE FAULT BREAKS

The faults shown on this map were located both by field investigation and by study of vertical aerial photographs. The segment of the fault zone southeast of Hemet was examined on the ground during the period 1961-63 with the use of 1:20,000 scale aerial photographs taken in 1953. The San Bernardino area was checked in the field in 1969. The remaining portion of the zone northwest of Hemet was mapped solely by interpretation of aerial photographs of 1:12,000 scale flown in June 1967, and 1:20,000-scale photos taken in 1953. Fault traces identified either in the field or on the photographs were transferred to the topographic maps by visual inspection. Fault features large enough to be represented by the contours on the topographic map are generally accurate in location to within 50 feet, but in areas of low relief where map contours are far apart and do not delineate small-scale fault features, locations may vary from their true positions by as much as 150 feet. Geologists and engineers who make specific use of these maps should confirm the location of lines by surveying from control points on the ground and should determine whether the mapped features are truly fault controlled.

FIELD RECOGNITION OF MOST RECENT FAULTING

Recently active fault breaks can generally be recognized by topographic features or by contrasts in vegetation that reflect varying ground water depths or soil differences across the fault. The most common features are scarps, trenches or troughs, notches, parallel ridges, offset drainage channels, sag ponds, ponded alluvium, undrained depressions, and shutter ridges (see block diagram). These features have been developed by repeated movements and by erosion and deposition along the fault. Horizontal and vertical displacements result from successive shifts amounting to a few inches or a few feet during earthquakes, from intervals of slow fault creep between earthquakes, or from a combination of both. Regardless of their specific origin, the displacements produce scarps and other topographic features that delineate the fault lines shown on the map. The annotations along the fault traces indicate selected examples of these features that are not limited to the designated places; similar features are present to some degree all along the mapped fault lines. As opposing fault blocks slide laterally, some blocks are relatively depressed to form sags or sag ponds, or elongate grabens may form between parallel breaks. Other slivers are raised, tilted, or slid diagonally to produce elongate ridges and shutter ridges. Notches and trenches or troughs along the faults may reflect increased erosion of the crushed and broken rocks in the fault zone, or they may be primary fault features.

Surface features due to faulting are short lived; their recognition is limited by the durability of small, easily destroyed geomorphic features whose preservation is largely dependent on climate. In arid regions these fault features are usually best preserved and, in some cases, may be older than similar features in more humid regions. They may be obliterated by erosion, obscured by vegetation or alluvium or other sediment, or modified or destroyed by the activities of man. Where slip has been entirely lateral, differential relief may not have been produced and the recently active break may not be identifiable. Only when fault movement is relatively recent are fault features as well preserved as those along portions of the San Jacinto fault zone.

LAND USE SIGNIFICANCE OF LOCATING RECENT FAULT BREAKS

Sudden movements along faults of the San Andreas system have repeatedly produced disastrous earthquakes in California. In 1857 right-handed horizontal displacement across the San Andreas fault in southern California may have been as much as 30 feet, and in 1906 similar dislocations on the same fault in northern California amounted to as much as 20 feet. In 1940 severe structural damage resulted from horizontal movement of as much as 14 feet along the Imperial fault (Ulrich, 1941; Richter, 1958), a member of the San Jacinto fault zone southeast of the area shown in this strip map. Destructive or potentially destructive earthquakes centering within the area of this strip map have occurred near San Jacinto and Hemet in 1899 (no magnitude data) and 1918 (magnitude 6.8), near the central part of Reche Canyon in 1923 (magnitude 6.25), in Terwilliger Valley in 1937 (magnitude 6.0), and about 6 miles southeast of Clark Lake in 1954 (magnitude 6.2) (Daneš, 1907; Allen and others, 1965); ground breakage may have occurred during each of these events. Slight right-lateral ground displacement on the Superstition Hills fault, a break within the San Jacinto fault zone in western Imperial Valley, accompanied a magnitude 5.6 earthquake in 1951 (Allen and others, 1965). Another strand within the zone, the Coyote Creek fault, moved a maximum of 15 inches about 8 miles southeast of the area of this map at the time of a magnitude 6.5 earthquake in 1968 (Allen and others, 1968). Based on the total record of seismicity to date, the San Jacinto fault zone appears to be the most seismically active member of the San Andreas system in southern California (Allen and others, 1965; Brune and Allen, 1967).

At various points along the San Andreas fault in central California, the positions of recent scarps coincide with lines of documented historic breakage accompanying earthquakes and with lines of displacement resulting from slow creep (Brown and others, 1967; Brown and Wallace, 1968). Geomorphic studies by Wallace (1968) in the Carrizo Plain area along the San Andreas fault zone show that displacements have recurred many times along the same trace during the last 10,000 to 20,000 years. Similarly, lines of surface offset located after the 1968 earthquake on the Coyote Creek fault about 10 miles southeast of the area of this strip map coincide almost exactly with the positions of earlier breaks where they were indicated by scarps (Allen and others, 1968). In the area immediately north of Anza (strip E—this map), the positions of beheaded stream courses and offsets in the distribution of distinctive gravels of probable Pleistocene age indicate that repetitive movements have taken place along a single strand of the San Jacinto fault for a period possibly in excess of 200,000 years (Sharp, 1967).

In summary, these observations suggest that the line of most recent ground rupture is likely to break again during future major earthquakes. Thus, the most recently active breaks should be recognized as geologically hazardous by builders, planners, engineers, landowners, school boards, civil-defense officials, or by anyone concerned with existing man-made structures, land utilization, or planned construction on or near these features. At present, no one can predict when movement on these faults will recur or which ones will move next, but it is virtually certain that some will move again. It should not be inferred, however, that movement will be confined entirely to these mapped features or that movement will occur on all of them. *Surface fracturing may develop anywhere within the fault zone or on branching or otherwise related faults beyond the fault zone.*

SPECIAL FEATURES OF THE SAN JACINTO FAULT ZONE BETWEEN THE SAN BERNARDINO AREA AND BORREGO VALLEY

The most conspicuous large-scale features of the San Jacinto fault zone are its overall linearity, its southeastward-divergent branches, and the en echelon arrangement of some of its component faults. Throughout its length, the pattern of recent fracturing is generally one of subparallel, nearly linear fault strands whose trends are usually somewhat more westerly than the overall trend of the zone. Where neighboring en echelon faults overlap, such as at San Jacinto Valley (strips C and D) and between Dry Wash and Coyote Canyon (strips F and H), the sense of overlapping configuration is that of sidestepping to the right. Because of the slightly divergent character of the branching and en echelon breaks, the zone increases both in complexity and in width toward the southeast. The maximum width of the fault zone within the area of this strip map is about 7 miles near the boundary between Riverside and San Diego counties.

The San Jacinto fault zone converges with the San Andreas zone in the eastern San Gabriel Mountains just northwest of the area of this strip map. Although older breaks assignable to the San Jacinto zone are defined by geological relationships nearly continuously from lower Lytle Creek to a point near Valyermo, some 40 miles northwest of San Bernardino, physiographic evidence of recent fault movement in this sector has not been observed. It is probable that the line of most recent movement within the northern end of the San Jacinto fault zone lies along the Glen Helen fault and perhaps joins the San Andreas zone in the vicinity of Blue Cut, just north of this strip map (*see* Ross, 1969).

East and southeast of Anza at Table Mountain and at White Wash (strip F), short sectors of the San Jacinto fault show no evidence of recent strike-slip faulting, despite their being bracketed by segments of the fault where features of recent horizontal offsets are unusually well defined. At these two places the fault is exposed as a shallow-dipping thrust fault, suggesting the possibility that recent movement there has been of this type. However, interpretable physiographic effects either were not produced by such movement, or they have been completely removed by subsequent erosion.

Topographic depressions along the San Jacinto fault zone are attributable both to tectonic movements and to landslide features. Hog Lake north of Anza (strip E) is a good example of a sag pond created by downward movement of the ground surface adjacent to the most recent breaks of the San Jacinto fault. The Clark Lake basin (strip I) can also be considered as a large sag structure bounded on the northeast by the Clark fault and on the west by the breaks along the eastern margin of Coyote Mountain. Closure of another type of basin apparently has been caused by large-scale tilting of the land surface between different fault strands. Many examples of such basins that were closed by headward down-tilting of former drainage channels exist on the elongate ridge between the Clark fault and the Coyote Creek fault from the San Diego County line southeastward to Coyote Mountain (strip H). A large number of depressions have developed along the upper edges of landslide masses, usually near steep slopes. Most of these basins are of small size. Examples of such depressions can be found on the ridge a mile northwest of Jackass Flat (strip F) and at several places in the badlands between Horse Creek Ridge and San Jacinto Valley (strip D). Many of the depressions at the latter locality probably formed or were modified during the strong earthquake of 1899, which was centered near the San Jacinto Valley (*see* Daneš, 1907).

The Casa Loma fault, on which vertical offset of the floor of San Jacinto Valley has taken place, probably is continuous southeastward at depth with the San Jacinto fault. However, the sinuous character of the Casa Loma fault scarp indicates that the latest movement has been dip-slip in nature (Proctor, 1962), whereas right-lateral offsets probably have dominated along the San Jacinto fault in Holocene time. This contrast, when considered with the fact that the principal break of the fault zone in San Jacinto Valley is apparently the Claremont fault, about 3 miles northwest of the Casa Loma fault, suggests that recent lateral offsets have been absorbed in the intervening segment of the valley floor on branch faults that show no obvious surficial expression (Sharp, 1967).

At several places where potentially active fault strands are completely concealed by very young alluvial deposits, data other than physiographic evidence have been used in determining their positions. In the region around Lytle Creek Wash (strip A), groundwater data of Dutcher and Garrett (1963) have demonstrated the existence of faults that act as barriers to subsurface flow within young alluvium. However, constraints on the locations of many of these barriers are very loose, and the positions shown could differ as much as several hundred feet from the real positions. Near the southern end of Coyote Mountain (strip H), gravity data of Biehler and others (1964) and W. J. Arabasz (unpublished) provide some control on the probable locations of the Coyote Creek fault and the unnamed fault bounding Coyote Mountain on the east. Along the eastern margin of Clark Valley (strip I) a concealed fault is shown parallel to the southwest face of the Santa Rosa Mountains. This fault is intended to show a probable geological relationship between the granitic rocks of the southern Santa Rosa Mountains and younger deformed sediments exposed in eastern Clark Valley; its representation as a single linear break may be a gross oversimplification, and in its northern half it could be mislocated by possibly as much as a mile.

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Biehler, S., Kovach, R. L., and Allen, C. R., 1964, Geophysical framework of northern end of Gulf of California structural province, p. 126-143 *in* van Andel, T. H., and Shor, G. G., Jr., eds., Marine geology of the Gulf of California: Am. Assoc. Petroleum Geologists Memoir 3, 408 p.
Interpretation of geologic structure in the Imperial Valley region based on regional gravity data, seismic refraction profiles, seismicity, and previous geological mapping is presented.

Brown, R. D., Jr., Vedder, J. G., Wallace, R. E., Roth, E. F., Yerkes, R. F., Castle, R. O., Waananen, A. O., Page, R. W., and Eaton, J. P., 1967, The Parkfield-Cholame, California, earthquakes of June-August, 1966—Surface geologic effects, water resources aspects, and preliminary seismic data: U.S. Geol. Survey Prof. Paper 579, 66 p.
Surface faulting, movement rates, engineering geology, and seismic activity along an active 23-mile segment of the San Andreas fault are described. Fault movements are related to a 5.5 magnitude earthquake and to its aftershocks of lower magnitude.

Brown, R. D., Jr., and Wallace, R. E., 1968, Current and historic fault movement along the San Andreas fault between Paicines and Camp Dix, California, p. 22-41 *in* Dickinson, W. R., and Grantz, A., eds., Proceedings of conference on geologic problems of San Andreas fault system: Stanford Univ. Pub. Geol. Sci., v. XI, 374 p.
Between Paicines and Cholame, rates of movement of the fault zone are determined by offset fences, and recent activity is shown by fresh breaks in pavement. South of Cholame the most recent break along the fault shows no evidence of movement for at least 40 years, although this segment moved during the great Fort Tejon earthquake of 1857.

Brune, J. N., and Allen, C. R., 1967, A micro-earthquake survey of the San Andreas fault system in southern California: Seismol. Soc. America Bull., v. 57, no. 2, p. 277-296.
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Previously described displacement along the fault is reviewed, and suggested cumulative displacements of about 175 miles are proposed for parts of the fault in southern California.

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Proctor, R. J., 1962, Geologic features of a section across the Casa Loma fault, exposed in an aqueduct trench near San Jacinto, California: Geol. Soc. America Bull., v. 73, p. 1293-1296.
Evidence for dip-slip movement on the Casa Loma fault in San Jacinto Valley is presented.

Richter, C. F., 1958, Elementary seismology: San Francisco, W. H. Freeman, 768 p.
This is a general treatise on the science of seismology and includes discussion of many large California earthquakes. In pages 487-495, the geologic effects, casualties, and damage associated with the Imperial Valley earthquake of 1940 are described.

Ross, D. C., 1969, Recently active breaks along the San Andreas fault between Tejon Pass and Cajon Pass, southern California: U.S. Geol. Survey Misc. Geol. Inv. Map I-553, scale 1:24,000.
Strip map of a part of the San Andreas fault.

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This paper presents an extensive account of damage in the epicentral region of the earthquake and a brief description of the line of ground displacement.

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Presents evidence for recurring movements along the same fault breaks and evidence that movement is right-lateral and spasmodic in the Carrizo Plain area.

MAP SHOWING RECENTLY ACTIVE BREAKS ALONG THE SAN JACINTO FAULT ZONE BETWEEN THE SAN BERNARDINO AREA AND BORREGO VALLEY, CALIFORNIA

By
Robert V. Sharp
1972

Other recently active breaks that have not produced distinctive surficial features may be present

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1972

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