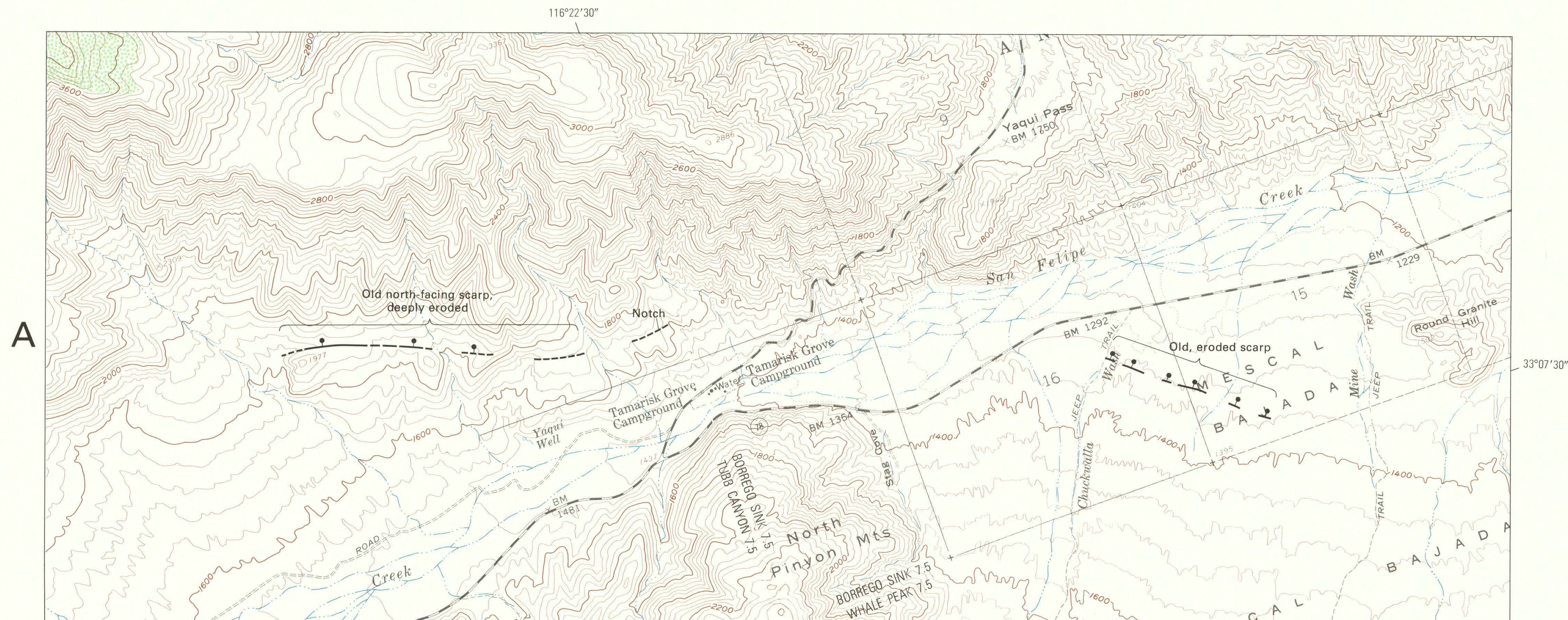
MAP SHOWING RECENTLY ACTIVE BREAKS ALONG THE ELSINORE AND ASSOCIATED FAULTS, CALIFORNIA, BETWEEN LAKE HENSHAW AND MEXICO

By
Malcolm M. Clark
1982

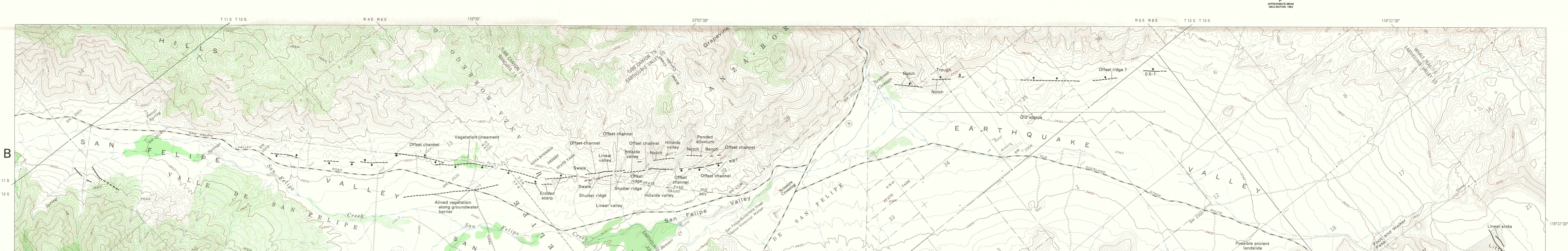
Other recently active breaks that have not produced distinctive surficial features may be present

A



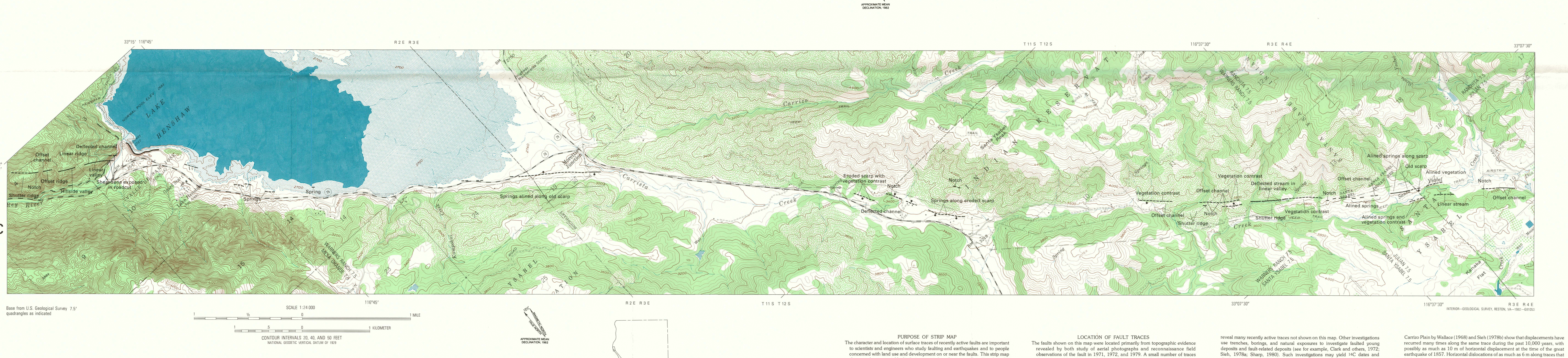
APPROXIMATE MEAN DECLINATION, 1982

B



APPROXIMATE MEAN DECLINATION, 1982

C



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

SCALE 1:24 000

CONTOUR INTERVALS 20, 40, AND 50 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

APPROXIMATE MEAN DECLINATION, 1982

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1982—G81053

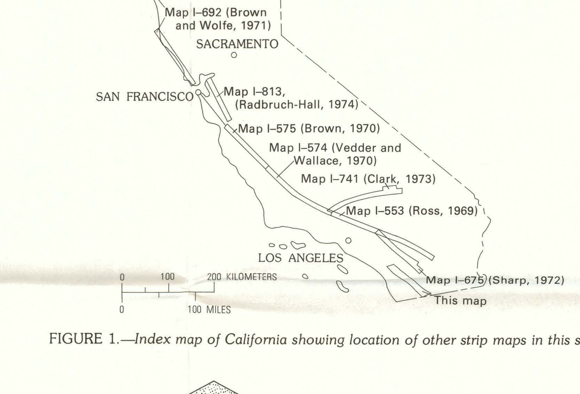


FIGURE 1.—*Index map of California showing location of other strip maps in this series.*

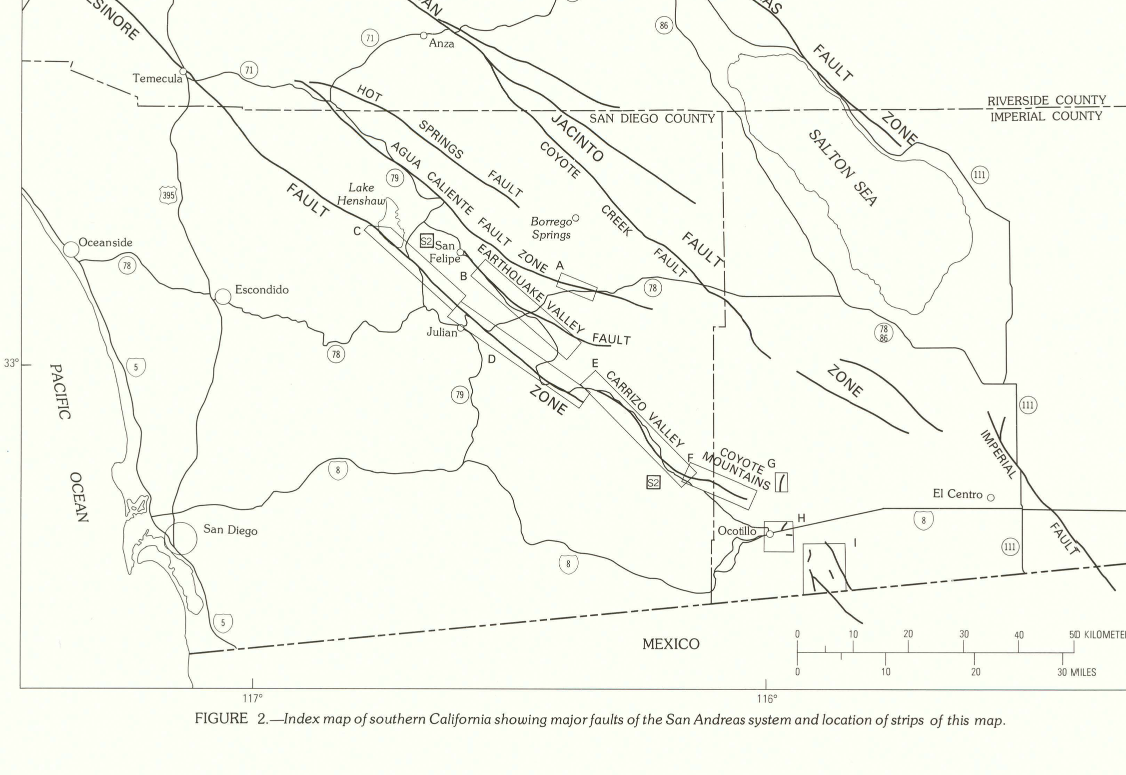
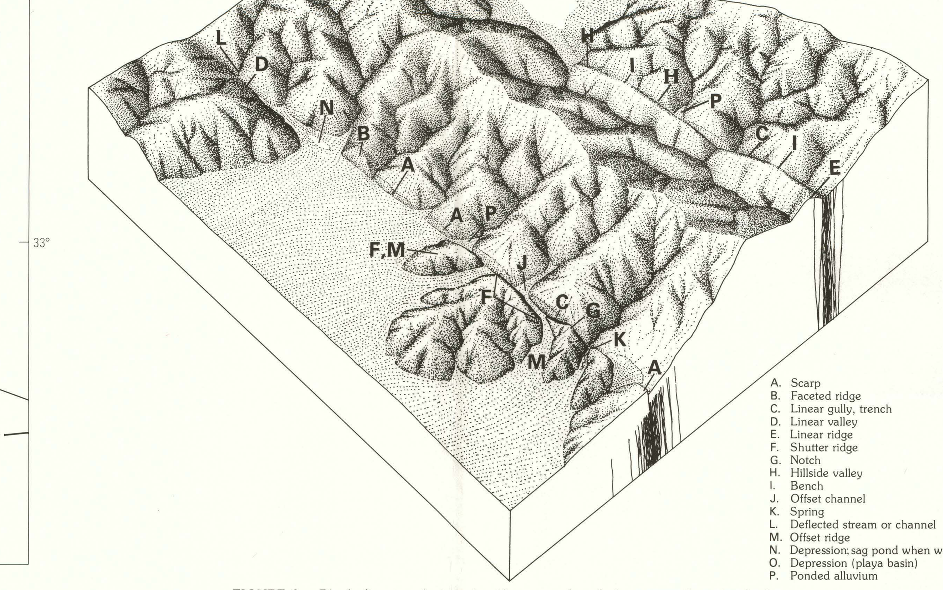


FIGURE 2.—*Index map of southern California showing major faults of the San Andreas system and location of strips of this map.*



A. Scarp
B. Faceted ridge
C. Linear gully, trench
D. Linear valley
E. Linear ridge
F. Shutter ridge
G. Notch
H. Hillside valley
I. Bench
J. Offset channel
K. Spring
L. Deflected stream or channel
M. Offset ridge
N. Depression; sag pond when wet
O. Depression (playa basin)
P. Ponded alluvium

FIGURE 3.—*Block diagram showing landforms produced along recently active faults.*

PURPOSE OF STRIP MAP

The character and location of surface traces of recently active faults are important to scientists and engineers who study faulting and earthquakes and to people concerned with land use and development on or near the faults. This strip map shows surface traces of faults that appear to have been recently active along the Elsinore and nearby fault zones between Lake Henshaw and Mexico (fig. 2). The mapped traces mark known or suspected recent faulting of the ground surface by either sudden rupture or creep within and near the Elsinore fault zone. The lines on the map that represent fault traces are primarily guides for locating these traces on the ground; they are not located with the precision needed for certain engineering projects or land uses. As used with this map, "recent" means late Quaternary time, roughly the past 100,000 years.

THE ELSINORE FAULT AND FAULT ZONE AND THE SAN ANDREAS FAULT SYSTEM

The Elsinore fault is generally considered to be part of the San Andreas system of major subparallel fractures or breaks in the earth's crust. This system extends at least from the Gulf of California in Mexico northwestward through southern and western California for more than 1,000 km. Throughout its history, the sense of movement on the major faults of the San Andreas system has been dominantly horizontal and right lateral; total offset is measured in tens to hundreds of kilometers (see Crowell, 1962). The Elsinore fault zone is the westernmost of the prominent members of the San Andreas fault system on land in southern California. Eastward, this group includes the Earthquake Valley and Hot Springs faults and the Agua Caliente and San Jacinto fault zones in the Peninsular Ranges and the San Andreas fault zone along the northeast side of the Salton Trough (fig. 2).

The Elsinore fault resembles the other major faults of the San Andreas system in its northwest trend and the presence of some right-lateral slip in its geologic record. It differs from them by the absence of large amounts of right slip in its record and the local presence of either major or dominant components of vertical slip. Northwest of Lake Elsinore (fig. 2), Weber (1977) finds as much as 9–11 km of total right-lateral offset of basement rocks; southeast of Lake Elsinore, Kennedy (1977) measures as much as 5 km of right-lateral displacement in Pleistocene time (roughly the past 2 m.y.). In the region of the fault zone shown in the central part of this map, however, Weber (1977) and Todd and Hoggatt (1979) argue for maximum possible horizontal displacement of basement rocks across the Elsinore fault zone of only 2 km. Todd and Hoggatt (1979) further postulate Pleistocene displacement in and near this part of the Elsinore fault zone to be dominantly vertical. Overall, the fault displays in only a few places the uninterrupted linear or en echelon patterns characteristic of many parts of the San Jacinto and San Andreas faults. Yet the right-laterally-offset landforms and rocks that do occur along parts of the Elsinore fault zone, including those shown on this map, support its inclusion in the San Andreas system of northwest-trending strike-slip faults in southern California.

The San Jacinto and San Andreas fault zones appear to be the most active faults of this part of the San Andreas system, either by their record of strong historic earthquakes, historic displacement, or excellent preservation of fault-generated topography along much of their extent (Sharp, 1972; Sharp and others, 1981; Clark, 1972a; and Clark, unpublished data, 1980). The Elsinore and other subparallel faults west of the San Jacinto fault zone have had few large historic earthquakes, have no record of historic displacement, and in only a few places display clear geologic evidence of recent displacement. Nevertheless, the apparent kinship of this group of faults, together with the presence along the Elsinore and Earthquake Valley faults of scattered features characteristic of active faults, suggests that these faults have recently displaced the surface, at least locally. Indeed, along the southwest side of the Coyote Mountains (Strip F), the Elsinore fault zone displays very well preserved features of fault topography (described below) comparable in appearance to topography on historically active parts of the San Jacinto and San Andreas fault zones. Geologic mapping by Kennedy (1977) and Weber (1975) northwest of Lake Henshaw and by Todd (1977, 1978) and Hoggatt (1979) near Carrizo Valley (Strip E) demonstrates either Holocene (past 10,000 yr) or late Quaternary displacement along these parts of the Elsinore fault zone. A study by Langenkamp and Combs (1974) of microseismicity of a part of the Elsinore fault zone shown on this map shows concentration of very small earthquakes in and near the fault zone that indicates continuing small displacements at depth in the zone and implies a potential for larger displacements and associated larger earthquakes.

Displacement within the Elsinore fault zone has been distributed along many subparallel and branching faults that differ in age, amount, and type of relative displacement. This complex zone of movement ranges in width from a few tens of meters to several kilometers or more. In accordance with terminology used for the San Andreas (Wallace and Vedder, 1969), San Jacinto (Sharp, 1972), and Garlock fault zones (Clark, 1973), this zone or band of parallel and apparently interrelated faults is here called the *Elsinore fault zone* and the surface traces of most recent movement, the *Elsinore fault.*

LOCATION OF FAULT TRACES

The faults shown on this map were located primarily from topographic evidence revealed by both study of aerial photographs and reconnaissance field observations of the fault in 1971, 1972, and 1979. A small number of traces shown are visible only on aerial photographs or were not checked in the field, but many traces or parts of traces shown along Carrizo Valley (fig. 2) and along the southwest boundary of Coyote Mountains were identified only in the field and are too small to be evident on the aerial photographs used.[1] All traces were recorded on aerial photographs and transferred to base maps with a projector. Most fault traces are plotted within 20 to 30 m of their correct position in areas where fault-zone topography is large enough to influence the shape of contour lines of the base map. At some places, fault traces may be as much as 60 m from their correct position. Geologists, engineers, and others who make specific use of this strip map should independently verify position of the mapped faults and confirm their fault origin.

FIELD RECOGNITION OF RECENT FAULTING

Recently active faults can be recognized in the field by their distinctive topography, by their displacement of young deposits and soils, or by their influence on local deposition. The most common topographic features of active faults are scarps, benches, troughs, notches, linear ridges and valleys, depressions, shutter ridges, and offset channels and ridges (see fig. 3). Displaced young deposits may show either structural and stratigraphic discontinuities or contrasting colors, textures, and vegetation. Deposits created by active faults include ponded alluvium and sediments that accumulate in sag ponds (depressions). All of these features of recently active faults have developed from repeated displacement accompanied by erosion and deposition along the fault. Horizontal and vertical displacement along a fault result from either successive slip that ranges from a few millimeters to several meters during earthquakes or intervals of slow fault creep between earthquakes, or a combination of both. Regardless of their specific origin, displacements of the ground surface produce the features marked by the fault traces on the map. Annotations along the fault traces point out many examples of these features. Some are cited because they are exceptionally clear or well preserved, but such features are generally present to some degree all along the mapped faults.

Fault features may be evidence of recent fault activity in several ways. Either they are easily destroyed, by their very existence indicating recent creation by faulting, or they affect young deposits, in this way demonstrating displacement younger than the deposits themselves. Deposits created by faulting, of course, must be younger than the responsible displacement.

Topographic features generally are the most obvious evidence of recent faulting. Vertical displacement may produce scarps, benches, changes in slope, and graben (downdropped blocks). Lateral displacement along faults offsets channels and ridges and creates shutter ridges, scarps, benches, troughs, hillside valleys, and changes in slope. Displacement may also relatively depress fault blocks to form scarps, depressions, and sag ponds. Slivers between parallel traces may rise, tilt, or slide diagonally to produce graben, linear ridges, and shutter ridges. Concentration of erosion by such fault topography may produce or enlarge trenches, troughs, and notches. The younger the deposits in which fault topography appears, the more compelling is the evidence for very recent displacement.

Active faults that offset young deposits or soils may produce visible effects without topographic form. Horizontal displacement can juxtapose contrasting deposits and soils to produce either contrasts in color or texture or distinctive vegetational effects. Other active faults may be visible only in natural or man-made exposures in gullies, roadcuts, or excavations. Faults can dam moving ground water in young deposits to form vegetation boundaries and springs. Faults can collect or concentrate either ground water or surface runoff to produce alined vegetation.

Deposits that mark active faults occur wherever fault topography traps sediment, as in depressions and sag ponds. Fault deposits are particularly evident where faults cross slopes in bedrock or coarse material. Benches, hillside valleys, and uphill-facing scarps intercept fine material such as sand and silt eroded from upslope and create ponded alluvium and sandy or silty benches that contrast with surrounding coarser materials.

A thorough evaluation of recent faulting requires investigation of all of these features of active faults; the reconnaissance investigation for this map concentrated on fault topography. Investigations that use detailed geologic mapping make extensive use of stratigraphic and structural relations to discover faults in young deposits. For example, 1:24,000-scale geologic maps in the Mason-Carrizo Valley area (Strips D-E; Todd, 1977, 1978; Hoggatt, 1979) reveal many recently active traces not shown on this map. Other investigations use trenches, borings, and natural exposures to investigate faulted young deposits and fault-related deposits (see for example, Clark and others, 1972; Sieh, 1978a; Sharp, 1980). Such investigations may yield ^{14}C dates and displacement rates; so far none has been carried out on this part of the Elsinore fault. As detailed geologic mapping and special fault studies continue in the Elsinore fault zone, many faults will be added to this map and some will be eliminated. These investigations will gradually increase our knowledge of rates, amount, and style of past movement.

Not all features noted on this map require recent displacement. Topographic forms such as scarps and ridges created by faulting in very resistant rock may persist for a long time after cessation of faulting. Notches, trenches, or troughs may result solely from relatively rapid erosion of the crushed and broken rocks of an inactive fault zone. Such features may show the location of a fault but do not necessarily indicate recent activity. To unequivocally demonstrate recent faulting, topographic forms must either occur in young deposits, and hence be younger than these deposits, or be developed in relatively soft material in which erosion will quickly erase all but very young fault topography. Similarly, vegetation contrasts and springs commonly develop along faults in old deposits whether or not the faults have been recently active. Recent displacement is indicated only where such features clearly are related to displacement of young deposits.

Most features created by recent faulting are ephemeral; they may be obliterated by erosion, buried by alluvium or other sediment, obscured by vegetation or soil creep, or modified or destroyed by human activity. Fault features persist only in places where the rate of fault displacement that creates them exceeds or equals the rate of the process that either removes or conceals them, or they survive in places where faulting is so recent that these processes have not had time to change the features. The degree of preservation of these features of active faults may be a rough measure of the rate of displacement of that particular fault or fault segment, except as noted below.

The hazard posed by active faults is clearly related to displacement rate. The higher that rate, the higher the probability of significant displacement and earthquakes at any given time. A proper evaluation of future earthquake hazard requires detailed examination of past fault behavior at a given site, as discussed here. For a preliminary evaluation, it is prudent to assume that areas containing well-preserved or numerous features of recent activity may have a high potential for displacements and earthquakes.

Topographic features along the Elsinore fault may have a large range of ages. Eroded 5- to 20-m-high scarps in unconsolidated sediment along parts of the Elsinore fault zone apparently were produced by multiple displacements and may be tens to hundreds of thousands of years old. The high escarpment along the Elsinore fault zone at the Coyote Mountains (strip F) may have grown during a far longer period. In contrast, numerous 1- to 2-m-high scarps along parts of the fault at the base of the Coyote Mountains cross all but the very youngest parts of washes or alluvial fans, evidence of faulting since the most recent episode of major flooding or deposition in those places, possibly during the past several hundred years. Unfortunately, our very meager knowledge of erosion and deposition rates and of the exact ages of young deposits along the Elsinore fault prevents our making accurate estimates of the age of the youngest fault features. Nevertheless, the fact that surface fault features are preserved at all and the similarity of many of these features to those on the historically active Coyote Creek fault, 30 km to the northeast in the San Jacinto fault zone (fig. 2) in a similar climate, indicate that parts of the Elsinore fault have moved in Holocene time. The fault must then be considered capable of movement at any time.

SIGNIFICANCE OF LOCATING RECENT FAULT TRACES

Some scarps and offset channels plainly show that parts of the Elsinore fault have broken repeatedly along the same strands. In some places, abrupt increase in scarp height of several meters in passing from younger to older alluvium demonstrates earlier episodes of displacement of the older deposits along the same fault trace. Benches or small younger scarps near the base of eroded scarps 10 to 30 m high suggest that the large scarps were created by many separate small offsets. In similar fashion, variation of the amount of horizontal offset of stream channels along a single linear break a few kilometers long from a few meters on small young channels to tens of meters on large older ones reveals repeated episodes of horizontal displacement along the same line.

Other faults of the San Andreas system and nearby fault zones display similar evidence of repeated movement along the same narrow strands, some of it associated with historic earthquakes. In 1940, severe structural damage resulted from earthquake shaking that accompanied horizontal movements of more than 4 m along previously active strands of the nearby Imperial fault, part of the San Andreas fault system; the earthquake of October 15, 1979, was associated with renewed displacement of as much as 0.8 m along part of the fault trace that ruptured in 1940 (Sharp and others, 1980). Ground breakage during the 1968 Borrego Mountain earthquake along the Coyote Creek fault closely followed old fault traces (Clark, 1972a). Geomorphic studies of the San Andreas fault in the Carrizo Plain by Wallace (1968) and Sieh (1978b) show that displacements have recurred many times along the same trace during the past 10,000 years, with possibly as much as 10 m of horizontal displacement at the time of the great earthquake of 1857. Horizontal dislocations of as much as 6 m along traces that had undergone movement in prehistoric time accompanied the disastrous earthquake of 1906 in central California. And the left-lateral Garlock fault, which forms the northern boundary of the Mojave Desert, shows clear and spectacular evidence of repeated Pleistocene and Holocene displacement along the same traces (Clark, 1973).

In summary, all these observations indicate that the line of most recent ground breakage is likely to break again during major earthquakes. Recently active traces should be recognized as geologically hazardous by builders, planners, engineers, landowners, school boards, civil defense officials, or anyone concerned with existing man-made structures, land utilization, or planned construction on or near these most recent fault breaks. No one can yet accurately predict when movement on recently active faults will recur or which faults will move next, but it is virtually certain that some will move again. A point that must be emphasized is that movement need not be confined to mapped features nor need it occur on all of them. Surface fracturing may develop anywhere within the fault zone or on branching or other faults beyond the fault zone. Gaps or discontinuities along the main fault traces shown on this map do not necessarily represent stable or unfaulted segments; they may be places where no obvious surficial evidence for faulting survives.

SIGNIFICANT CHARACTERISTICS OF RECENTLY ACTIVE TRACES OF THE ELSINORE FAULT IN SAN DIEGO AND IMPERIAL COUNTIES

The most recently active trace of the Elsinore fault has a discontinuous and highly varied expression. Only locally does it display the throughgoing linear continuity of topographic and other features characteristic of major active strike-slip faults such as the San Andreas, large parts of the San Jacinto, and the Garlock faults. Over much of its length, the Elsinore fault is dominated by erosional features such as trenches and notches that appear to owe their origin to differential erosion in the pulverized rock of the fault zone rather than to recent displacement of the land surface. Southeast of Vallecito Valley (Strip D), no topographic evidence of faulting exists along the regional projection of the Elsinore fault; but 5 km east of this projected trend in Carrizo Valley (Strip E) is an irregular zone of numerous recent scarps that have characteristics of *normal faults* (dip-slip faults that react to extension of the earth's crust). These scarps are the local expression of the Elsinore fault. Only along the southwest base of Coyote Mountains (Strip F) does the Elsinore fault display clear evidence of very recent surface displacement comparable to that of other major active strike-slip faults. Scarps together with offset channels in alluvium clearly indicate recent horizontal surface offset elsewhere in the area of this map only in Rodriguez Canyon (Strip D) and San Felipe Valley (Strip B). At none of these places are the fault features as well preserved or as continuous as along the trace at the base of Coyote Mountains.

Many explanations for variable expression of the most recently active trace along the Elsinore fault are possible. Among them are: rate of displacement, sense of faulting, distribution of rainfall, and variation in type and character of rock and terrain.

Rate of Displacement. One of the most plausible explanations is that displacement rates vary broadly with location, and fault features are best preserved where rates of Holocene displacement are greatest. Or displacement rates may vary with the passage of time at the same location along the Elsinore fault zone, as seen by Sharp (1980) along the San Jacinto fault zone. Or overall, the Elsinore fault may have a uniform but very low rate of displacement, expressed by large infrequent earthquakes that recur at a given site only at intervals of thousands or tens of thousands of years. According to this concept, areas with fresh fault features are merely those most recently offset. Future displacement would tend to occur elsewhere along the zone. Evaluation of this last explanation requires further study of earthquake recurrence intervals along the fault.

Sense of Faulting. Dominant dip-slip faulting might explain some of the discontinuous, poorly preserved nature of recent traces of the Elsinore fault. If vertical components of displacement are indeed locally dominant, the curved, discontinuous, and less linear patterns of dip-slip faults would be expected. And if *reverse faults* occur in the Elsinore fault zone (dip-slip faults that react to compression of the earth's crust), such faults would be expected to leave relatively poor evidence of recent activity. Vertical components of faulting certainly are the explanation for the irregular, but very clearly expressed, traces in Carrizo Valley (Strip E). Whether vertical motion is the cause elsewhere in the Elsinore fault zone remains to be investigated.

Distribution of Rainfall. Areas where preservation of fault features is poorest tend to be areas of greater rainfall, hence of increased erosion and deposition. Annual rainfall along the fault increases from about 75 mm (3 in.) near Mexico to more than 1,000 mm (40 in.) northwest of Lake Henshaw (Rantz, 1969). Although rainfall has some influence on preservation of fault features, other factors are apparently more important, because large changes in degree of preservation occur along segments of the Elsinore fault that have essentially uniform rainfall. Brown and Wolfe (1972) found no difference in preservation of youngest fault features between regions of high and low rainfall along the San Andreas fault from north of San Francisco to the Transverse Ranges.

Variation in the Type and Character of Rock and Terrain. Local geologic setting affects erosion and deposition rates and influences surface expression along a fault. These factors have not yet been studied along the Elsinore fault.

Until these possible causes can be evaluated by careful study, comparisons with segments of known active faults elsewhere in comparable climate and terrain may give the best estimate of relative activity. The most recently active trace as it appears in the field or on maps of historically active parts of the San Andreas and San Jacinto faults in southern California (Allen and others, 1972, p. 2; Clark, 1972, pl. 1; Sharp, 1972; Clark, unpublished data), 1980 that have annual rainfall of 500 mm (20 in.) or less display continuity and preservation of form comparable to the best-preserved parts of the Elsinore fault in similar terrain and rainfall. These comparisons suggest that parts of the Elsinore fault in Rodriguez Canyon, in Carrizo Valley, and along Coyote Mountains may have moved within the past several hundred years. In contrast, large segments of the Elsinore fault in this region of low rainfall that either lack faulted topography or show poorly preserved features may not have moved significantly for a much longer period of time.

Along historically active parts of the San Andreas fault in the Transverse Ranges, terrain and rainfall are comparable to the configuration and precipitation of the area along the Elsinore fault northwest of Banner Canyon (Strip D); parts of the San Andreas northwest of San Francisco that slipped in 1906 receive much more rain than falls in this section of the Elsinore fault. Yet these parts of the San Andreas fault display continuity and preservation of faulted topography that is apparently equal to that of much drier parts of the fault (Ross, 1969, Vedder and Wallace, 1970, Brown and Wolfe, 1972). Those observations strongly reinforce the conclusion that preservation of faulted topography is broadly and significantly related to rate or recency of displacement. Thus much of the Elsinore fault appears to have lower displacement rates than either historically active parts of the San Andreas and San Jacinto fault zones or large parts of the Garlock and San Jacinto faults that have excellent preservation of faulted topography but have not been active in historic time.

NORTHWEST OF LAKE HENSHAW

Searches on aerial photos and investigation at several places on the ground from Lake Henshaw to near Temecula (fig. 2) revealed no unequivocal evidence of surface faulting. Prominent, but broad, fault features of erosional origin mark the trend of the fault as mapped by others from lithologic and structural evidence. No clear-cut evidence of displacement of the present ground surface was found along this segment of the fault except for a series of offset channels immediately northwest of Lake Henshaw (Strip C). Although the high rainfall (as much as 1,000 mm/yr) and steep rugged terrain are unfavorable for preservation of faulted topography, none has survived even in flat or protected areas along the fault. Apparently the rate of displacement along this segment of the fault has been slower than that along most of the fault to the southeast.

LAKE HENSHAW TO THE HEAD OF RODRIGUEZ CANYON (STRIPS C AND D)

This part of the Elsinore fault zone is more clearly defined than the segment to the northwest; nevertheless, erosional features are dominant. A relatively narrow zone of springs, notches, benches, and valleys shows the trace of the fault along much of this segment, but all of these features can be explained as well by differential erosion along the fault as by recent faulting. The only suggestions of faulted topography are a series of offset channels and ridges in Santa Isabel drainage 15 km southeast of Lake Henshaw (Strip C) and at the head of Banner Canyon (Strip D). Even at these places, there are few scarps in alluvium and little evidence to unequivocally indicate recent displacement. Along the northeast side of Banner Canyon, a series of alined benches and local vegetation contrasts clearly mark the trace; from Banner Canyon southeast to the head of Rodriquez Canyon, the position of the trace has almost no clear topographic definition and suggests little recent displacement.

HEAD OF RODRIGUEZ CANYON TO VALLECITO VALLEY (STRIP D)

The lower part of Rodriguez Canyon displays clear evidence of recent displacement. For a distance of almost 1 km opposite the mouth of Oriflamme Canyon, the trace is marked by a southwest-facing scarp as much as 3 m high that offsets slope deposits and along which gullies show right-lateral offset. To the southeast, in Mason Valley, less obvious and discontinuous traces offset some channels and alluvial surfaces. Southeastward from Mason Valley, the Elsinore fault progressively loses the broad throughgoing structural or topographic expression that characterizes it from Lake Henshaw to Mason Valley. Between Mason and Vallecito Valleys, no continuity of topographic expression of the fault is discernible. In Vallecito Valley, a scarp as much as 2 m high, prominently marked by vegetation, apparently offsets alluvium vertically; no lateral displacement is apparent. No topographic, lithologic, or structural expression of the fault extends southeast from this scarp into the granitic terrane that lies across the regional trend of the Elsinore fault.

CARRIZO VALLEY (STRIP E)

In the vicinity of Carrizo Valley, the nature of the recent trace of the Elsinore fault is radically different from that northwest of Vallecito Valley. The position of the fault as determined from both this study and the geologic mapping of Todd (1977) is almost 5 km east of the regional trend of the fault established between Vallecito Valley and Lake Henshaw. Displacement here is dominantly vertical. The active fault traces that form the southwest boundary of this part of Carrizo Valley lack the straight throughgoing continuity of nearly vertical strike-slip faults. Rather, they display the shorter, irregular courses and multiple discontinuous traces characteristic of many normal faults. Fault planes exposed on the faces of scarps dip 50°–70° toward the downthrown block. Almost all of the traces mapped in Carrizo Valley are marked by scarps in alluvium. Some are very old, rounded and deeply incised by erosion; others are fresh and little affected by erosion. In some places, these scarps displace the very young deposits that flank broad active stream channels.

Although most of the Holocene displacement along this part of the Elsinore fault zone clearly has taken place along the normal faults described here, the 1973 M_L 4.8 earthquake and its aftershocks concentrate along the projection of the main Elsinore fault zone about 5 km south of Agua Caliente Springs (Allison and others, 1978), their location suggesting current activity west of the normal faults. Focal-mechanism solutions are compatible with dominant right slip along a steeply dipping northwest-trending fault. Nevertheless, no evidence has been found of significant late Quaternary surface displacement in the epicentral area of these earthquakes.

COYOTE MOUNTAINS (STRIPS F AND G)

Along the southwest base of Coyote Mountains (Strip F), the recent trace of the Elsinore fault displays the continuity, preservation, and character typical of historically active strike-slip faults. The trace is marked by hillside benches, valleys, and offset channels and ridges created by displacement of the present surface. Low fresh scarps in channel deposits aline with higher scarps in the older deposits flanking the channels. Traces appear to be fresher and more recently active here than in any other part of the Elsinore fault shown on this map. The broadly linear nature of the fault zone, the horizontal offsets, and the variable sense of vertical displacement indicate significant horizontal slip, but exposures and local changes in trend show that the fault dips at a high angle into the mountains. This dip, together with the uplifted nature of the Coyote Mountains, indicates long-term consistency of a component of thrusting of terrain on the northeast side of the fault over valley deposits to the southwest.

Along the east base of the Coyote Mountains is a 3-km-long north-trending fault with well-preserved low scarps of probable Holocene age (Strip G). At its south end, rounded scarps of this trace in alluvium are 3 to 4 m high; along strike in younger channel deposits, the scarps are about 1 m high, demonstrating continuing displacement along the same trace. At this place, vertical displacement, mountain side up, appears to dominate. Northward from here, the trace passes through alluvial deposits with notable continuity. At its north end, the straightness of the fault across terrain of moderate relief suggests a very steep dip, but no direct evidence of horizontal displacement was found during a brief inspection.

COYOTE MOUNTAINS TO MEXICAN BORDER (STRIPS H AND I)

Southeastward from Coyote Mountains to the Mexican Border, the Elsinore fault zone displays a broad, poorly defined band of relatively short discontinuous faults marked by low eroded scarps that cross flat alluvial plains and folded Tertiary sedimentary rocks. These scarps lack clear evidence of lateral offset, and some display the curved nature of many normal faults. They appear to be considerably older than the scarps along Coyote Mountains and in Carrizo Valley.

EARTHQUAKE VALLEY FAULT (STRIP B)

Prominent scarps offset surfaces of alluvium and older rocks along the Earthquake Valley fault. Along the northeastern edge of San Felipe Valley, this fault also offsets channels in a right-lateral sense. None of the recent fault traces in San Felipe Valley are as well preserved as the traces along Coyote Mountains, evidence of a relatively lower rate of displacement. But the number and consistency of offset channels along much of the trace indicate continuing significant displacement over a long period. In Earthquake Valley, where offset channels are absent, the trace, though not continuous, follows along the base of a prominent old northeast-facing scarp.

The playa of Little Blair Valley, at the southeast end of Earthquake Valley, contains linear depressions that are similar to long narrow depressions that developed along the surface rupture of the Borrego Mountain earthquake of 1968 (Clark, 1972b). This similarity suggests a tectonic origin for the depressions in Little Blair Valley, although a nontectonic cause is also possible. The existence of the closed basins of Little Blair and Blair Valleys is itself evidence that active tectonism is deepening these basins faster than sediment can fill them or erosion can cut down their walls.

AGUA CALIENTE FAULT ZONE (STRIP A)

Two eroded scarps in alluvium in the Agua Caliente fault zone near Tamarisk Grove are shown because they were prominent on the aerial photographs used for this study. No comparable faulted topography was noted elsewhere along nearby parts of this fault zone.

EXPLANATION

Fault traces

Solid line, obvious topographic, surficial, or photogeologic evidence of recent movement shown by such features as alined scarps, benches, ridges, offset channels, vegetational anomalies, and faulted young deposits[1]*; long-dashed where position of trace uncertain because of erosion of fault features; short-dashed line, less obvious evidence of recent movement, but very likely a fault trace; queried where tectonic origin uncertain. Ball on relatively downthrown side of scarps along breaks on which movement may have been horizontal; hachures on relatively downthrown side of scarps along breaks on which most movement has been vertical*

[1]Notes along the fault traces indicate clear examples of various fault features. The features noted are not limited to these locations, but are present to some degree all along the mapped fault lines, generally as scarps. The number of notes at different places on the map is roughly proportional to the abundance and degree of preservation of the features described.
The notes also give estimates of the heights of scarps and amount of offset of channels (in meters) that appear to preserve tectonic displacement; that is, neither the height of the scarps nor the position of the channels has been greatly changed by erosion since they were displaced. All horizontal offsets noted on this map are right lateral.

Field investigations in 1971, 1972, 1973, and 1979 by M. M. Clark, assisted by R. M. Gulliver, 1971; J. B. Pinkerton, 1973; and P. R. Vaughan, 1979.

[1] This investigation used photographs of two different scales: 1:20,000-scale U.S. Department of Agriculture 1953 ABN and AXN series along all of the faults shown and 1:12,000-scale USGS 1967 WRD series from Ocotillo (Strip H) to Lake Henshaw (Strip C) along the Elsinore fault zone and along the Earthquake Valley fault (Strip B).

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