DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

MISCELLANEOUS FIELD STUDIES
MAP MF 505

MAP SHOWING RECENT TECTONIC MOVEMENT ON THE CONCORD FAULT, CONTRA COSTA AND SOLANO COUNTIES, CALIFORNIA

By
Robert V. Sharp
1973

STRIP A

Index map showing traces of active faults in the San Francisco Bay region. Area of the strip map of the Concord fault is stippled.

Ongoing tectonic movement along several faults of the San Andreas system in the region around San Francisco Bay has been well established by many geologic and geophysical studies. This paper presents new documentation of recent activity on the Concord fault, a strand that lies near the northward projection of the Calaveras fault zone in the eastern part of the bay area (see index map). The Concord fault extends at least from the north shore of Suisun Bay in Solano County to the southeasternmost part of Ygnacio Valley. The fault passes through the downtown area of Concord, for which it has been named (see Calif. Dept. Water Res., 1964), and it trends about N. 30° W., approximately parallel to the San Andreas fault.

The most pronounced topographic expression of the Concord fault is the linear boundary between Ygnacio Valley and the Diablo Range (see strip map). The general correspondence of the fault trace with the straight mountain front resembles the relation found along the Hayward fault about 25 km to the west (Radbruch, Bonilla and others, 1966). North of Concord, where the fault traverses chiefly a flat alluvial surface, the trace is marked by more subtle topographic features including sags and scarps. The topographic evidence of recent activity on the Concord fault is concentrated mainly in the area between downtown Concord and Suisun Bay, but young fault topography also extends a few kilometers southeast of Concord along the west side of Lime Ridge. Beyond the segments where evidence of young movement is clear, the probable position of the fault trace has been inferred by analogy to the relation of topography and faulting where recent offset is evident.

Very recent movement on the Concord fault has caused small right-lateral offsets of a few centimeters at most on curbs, sidewalks, bridges, railroad tracks, and other man-made structures. Because much of the region traversed by the fault has been converted from agricultural to suburban use too recently to have yet recorded offset, most of the evidence of recent movement is found in a relatively old part of Concord near the present downtown area where curbs and sidewalks date back to 1949. Signs of recent displacement are also found near Avon, between 5 and 8 km northwest of downtown Concord. The small lateral offsets that have been observed at all of the different locations presumably reflect principally the youth of the affected man-made features.

The geographic distribution as well as the apparent age and clarity of recent movement documented along the Concord fault suggest three contrasting sectors, termed here from north to south the Avon, Concord, and Ygnacio Valley segments. Evidence gathered to date indicates that ground displacement by slow creep apparently has occurred along at least part of the Avon segment. The Concord segment, in contrast, may have moved intermittently at different rates in the recent past and may have moved relatively rapidly after an earthquake of intermediate magnitude in 1955. No evidence indicating that the Ygnacio Valley segment has moved at the surface in recent time has yet been found.

Avon segment

The Avon segment extends from the north shore of Suisun Bay southeastward to Buchanan Field (see strip A of map). Within this segment, evidence of recent displacement has been found along two subparallel traces. The probable main fault strand extends generally along the tidal channel of Pacheco and Walnut creeks, and a secondary line of offset has been found within the refinery complex of Avon.

South of Suisun Bay, evidence for right-lateral movement on the main fault strand in the Avon segment has been found only on the Santa Fe railroad bridge over Pacheco Creek (at Maltby, panel A of strip map) and on the Waterfront Road bridge over the same channel west of Avon. Measurement of the displacement on the railroad bridge (abutment dated 1965) is difficult because of the marked curvature of the structure produced by the offset; however, the amount of lateral movement probably exceeds 5 cm. The bridge over the Pacheco Creek channel along Waterfront Road is also slightly offset, but the zone of tectonic bending probably includes the west abutment. Linear features are lacking at the abutment, so that the combined offset within the bridge and abutment is unknown.

The fault at Avon displaces three railroad sidings and at least four concrete structures in the refinery between 3 and 7 cm right laterally. Although a concrete culvert beneath the sidings at the position of the offset is dated 1913 and the sidings have existed since 1916 (M. Morris, Southern Pacific Co., oral commun., 1973) the displacement of the tracks may have occurred within a small fraction of the time since then.

North of Suisun Bay, evidence of lateral ground movement has been found only at one locality on the northern set of two Southern Pacific railroad tracks. Although this offset lies virtually on line with the projected trace of the Concord fault from south of Suisun Bay, it conceivably could have resulted from movement on an unknown fault of different orientation. Because the track closer to the bay is not offset, the extrapolation of the Concord fault north of Suisun Bay along the indicated trace should be regarded as tentative. The trace as shown is consistent, however, with the pattern of faulting indicated by geological relations in the hills farther northwest (see, for example, Calif. Dept. Water Resources, 1931, plate D-IX).

Between the warped railroad bridge at Maltby and Buchanan Field, only one man-made feature, State Highway 4, crosses the Concord fault as a continuous linear element. The highway is not edged with curbs, so that detection of lateral offset would be difficult without comparison to early surveys of the highway alinement. However, the alinement of the linear scarplike slope bordering the Walnut Creek channel on the east between Maltby and Highway 4 suggests that the fault trace probably passes close to or beneath the Highway 4 bridge over Walnut Creek. Although the bridge shows no obvious signs of tectonic bending, it may have rotated slightly as a unit to accommodate right-lateral movement in the underlying ground. Because suitable reference lines beyond the ends of the bridge do not exist, however, rotation of the structure cannot be demonstrated.

The relatively old runways and taxiways along the east side of Buchanan Field show no indication of fault movement along the southwest bank of Walnut Creek. This lack of deformation increases the probability that the trace passes beneath the Highway 4 bridge.

Comparison of earthquake epicenters since the mid-1930's with the alinement of the Avon segment suggests that movement is probably occurring by the mechanism of slow creep. Recent earthquakes recorded in the immediate area have been small (see, for example, Lee and others, 1972, fig. 4), and none of the observed offsets has an obvious association with any specific seismic event.

Concord segment

The most abundant evidence of ongoing fault displacement is found in the Concord segment, used here to designate the interval between Buchanan Field and the westward-flowing section of Pine Creek at the base of Lime Ridge (see strip B of map). This part of the fault had been recognized previously as a groundwater barrier between Clayton and Ygnacio valleys (Bader, 1969, p. 8). The fault trace is marked intermittently by a zone of linear sags and mostly southwest-facing scarps.

Right-lateral displacement on several relatively old sidewalks and curbs delineates the trace of the Concord fault in the downtown Concord area. Although seasonal shrinkage and swellage of the adobe soil has produced a multitude of minor lateral offsets as well as compressional and extensional effects in pavements throughout the Concord area, the position, amount of offset, and the right-lateral sense of displaced features along the trace of the Concord segment show remarkable consistency not found elsewhere in the town. This consistency and the fact that adjacent but mechanically independent curbs and sidewalks, such as those found on Ashbury Drive (point E on the strip map), show nearly identical bends as they cross the fault trace constitute the most convincing evidence that the movements are tectonic in origin rather than resulting from soil creep or related phenomena.

Right-lateral offsets of as much as 15 cm have been measured on the series of five southwest-trending streets between Salvio Street and Ashbury Drive (points A to E on the strip map). Table 1 lists the offsets, together with the names and other data about these and other streets in the same area. Discrepancies in the amounts of apparent movement measured on opposite sides of the same streets could reflect limitations in the method of measurement, as well as slight variations in response of features at different positions along the zone of ground deformation. Because of street curvature or insufficient length of the offset lines within the zone of tectonic warpage, all of the measurements should be regarded as approximations of the actual recent offset.

Table 1. Table showing right-lateral offsets and ages of streets in Concord.

Point	Name of street	Feature measured	Date of construction[1/]	Approximate right-lateral offset[2/] (cm)
A	Salvio St.	Sidewalk (N side)	1956	7
B	Willow Pass Rd.	Curb (S side)	1949	15
C	Concord Blvd.	Curb (N side)	1953	12
		Curb (S side)	1953	8
D	Clayton Rd.	Curb (S side)	Unknown	14
E	Ashbury Dr.	Curb (N side)	1950	6
		Sidewalk (S side)	1950	11
F	Laguna St.		1963	No obvious offset
G	Oakmead Dr.		1960	No obvious offset
H	Monument Blvd.		1969	No obvious offset

1/ Data provided by C. D. Tedeschi and M. M. Goto, City of Concord, 1973

2/ Offsets measured with alidade.

The construction dates of these streets are graphed against amount of offset in figure 1. Unfortunately, the data do not allow a clear distinction to be made between the possibilities of intermittent slow creep and relatively rapid movement after an earthquake. *The simplest interpretation of the data (dashed line in fig. 1) would suggest nearly* continuous creep with some variation in rate of movement from the late 1940's to the early 1960's but with little activity since. It must be pointed out however, that the pavements on Laguna Street, Oakmead Drive, and Monument Boulevard could actually be offset slightly by broad flexure that is not readily visible because the streets are curved. Although to say that the Concord segment is not moving at the present time would be premature, the data suggest that there was little movement at least through most of the 1960's.

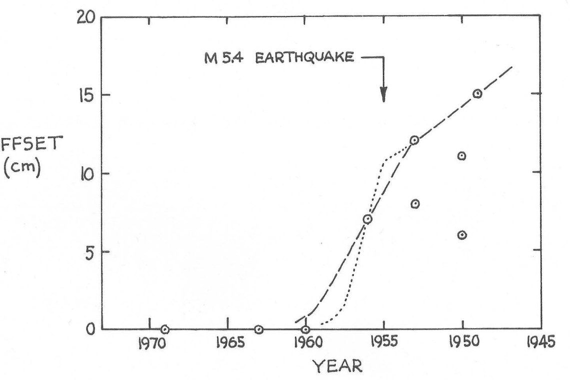


Figure 1. Graph showing amounts of offset of curbs and sidewalks of different ages in Concord. Dashed line represents continuous creep model. Dotted line represents model of accelerated creep after the 1955 earthquake.

The measurements of offset also allow the interpretation that the creep rate increased in the mid-1950's (dotted line in figure 1), perhaps initiated by the relatively strong (magnitude-5.4) earthquake in October 1955 (Murphy and Cloud, 1957, p. 25-27). The instrumental epicenter of the earthquake nearly coincides with the trace of the Concord fault at the point where the streets are offset. The postearthquake age of the offset on Salvio Street suggests that, instead of sudden displacement at the time of the earthquake, there was possibly a period of accelerated creep that may have terminated by 1960.

The series of streets northwest from Salvio Street to the new freeway (State Highway 24) do not have continuous curbs or sidewalks, and many of the short sections of curbing appear to be very recent. As a result, the fault traces could not be accurately located in that interval.

Ygnacio Valley segment

The Ygnacio Valley segment of the Concord fault extends south of the westward-flowing section of Pine Creek (strip B of map). No direct evidence yet indicates either the exact position of the trace or the existence of recent surficial movement in this segment. However, the linear northeastern edge of the valley probably follows closely the trace of the fault in a manner similar to the mountain front along much of the Hayward fault (see Radbruch, Bonilla, and others, 1966).

If the Ygnacio Valley segment has moved during the time of activity on the Concord segment, then offset should have affected the alinement of the relatively old Contra Costa and Ygnacio canals. Southwest of Citrus Avenue (point J on the strip map) the concrete lining of the Contra Costa Canal is straight, suggesting that the fault trace, if recently active, must lie northeast of Citrus Avenue, where judgement of the linearity of the canal is less certain. The Ygnacio Canal also crosses the inferred trace of the fault (point K on the strip map), but the newly widened and repaved Ygnacio Valley Road passes over and conceals the canal at the probable fault intersection.

The most compelling evidence for current activity on the Ygnacio Valley segment is the marked concentration of small earthquakes now being recorded near the suspected trace of the fault (Lee and others, 1972, fig. 4). Although well-located epicenters of very small earthquakes have been possible only since 1971 in this area, the linear distribution of seismic events along the trace is already becoming evident. On the basis of the seismic record to date (1971-72), the Ygnacio Valley segment appears to be as active at depth, and perhaps more so, than the Avon and Concord segments to the north.

REFERENCES

Bader, J. S., 1969, Groundwater data as of 1967, San Francisco Bay subregion, California: U.S. Geol. Survey open-file report, 12 p.

Calif. Dept. Water Resources, 1931, Economic aspects of a salt water barrier below confluence of Sacramento and San Joaquin rivers: Calif. Dept. Water Resources Bull. 28, 450 p.

Calif. Dept. Water Resources, 1964, Faults and earthquake epicenters in California: Calif. Dept. Water Resources Bull. 116-2, 96 p.

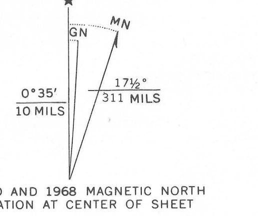
Lee, W. H. K., Meagher, K. L., Bennett, R. E., and Matamoros, E E., 1972, Catalog of earthquakes along the San Andreas fault system in central California for the year 1971: U.S. Geol. Survey open-file report, 67 p.

Murphy, L. M., and Cloud, W. K., 1957, United States earthquakes, 1955: U.S. Coast and Geodetic Survey, 83 p.

Radbruch, D. H., Bonilla, M. G., and others, 1966, Tectonic creep in the Hayward fault zone, California: U.S. Geol. Survey Circ. 525, 13 p.

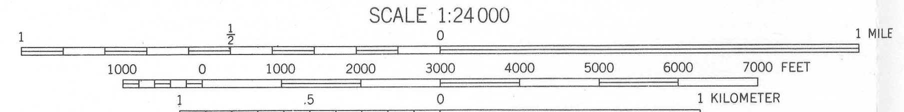
EXPLANATION

A ——— B	ACTIVE FAULT TRACE SHOWN BY OFFSET MAN-MADE STRUCTURES OR BY YOUNG TOPOGRAPHIC FEATURES. LETTERS INDICATE LOCALITIES DISCUSSED IN TEXT.
— — — —	FAULT TRACE SUGGESTED BY RELATIVELY OLD TOPOGRAPHIC FEATURES. NO DIRECT EVIDENCE OF ACTIVE MOVEMENT, BUT ACTIVITY NOT UNLIKELY. EXACT POSITION OF TRACE UNCERTAIN.
—?—?···?···	INFERRED FAULT TRACE ILLUSTRATING PROBABLE CONTINUITY. NO DIRECT EVIDENCE OF ACTIVE MOVEMENT. EXACT POSITION OF TRACE UNCERTAIN. DOTTED WHERE CONCEALED BY WATER.
RL	RIGHT LATERAL



UTM GRID AND 1968 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000



CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
DEPTH CURVES IN FEET—DATUM IS MEAN LOWER LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 4 FEET

For sale by U. S. Geological Survey, price $.50