UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

FIELD TRIP GUIDE TO THE HAYWARD FAULT

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OPEN-FILE REPORT 89-500

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INTRODUCTION

This guide briefly introduces interested planners, earth scientists, and others to the Hayward fault, to what is already known about it and to scientific research in progress. The Hayward fault, an active branch of the San Andreas fault system, lies near the eastern edge of the densely populated San Francisco Bay plain, cutting through the cities of San Pablo, Richmond, El Cerrito, Berkeley, Oakland, San Leandro, Hayward, Union City, and Fremont. In 1868 a large damaging earthquake (about magnitude 6.8) occurred from rapid slip on the Hayward fault between Oakland and Mission San Jose (*Lawson*, 1908). Figure 1 shows the extent of the 1868 surface rupture. An earthquake of similar magnitude occurred in this region in 1836 and is often presumed to have ruptured the northern part of the Hayward fault, but no direct evidence of this rupture has been found.

The Hayward fault is characterized by right-lateral, strike-slip displacement (*i.e.*, looking across the fault, the other side moves horizontally to the right.) The slip on the fault occurs in two modes: 1) rapidly in earthquakes such as in 1868, and 2) slowly and aseismically, without associated earthquakes. Aseismic slip is often called creep. Creep has occurred on the Hayward fault more or less steadily at least since the 1920s and probably since the large 1868 earthquake. Dashed lines in figures 1 and 2 show the 70-km-long creeping trace of the Hayward fault and segments of other faults exhibiting creep. This field guide highlights eight locations on the south-central part of the creeping trace between Oakland and central Fremont (Figure 3). Creep on the Hayward fault seems to transfer from the Calaveras fault near the Mission Fault. South of the Mission fault, the Calaveras fault creeps 10 to 15 mm/yr (1 in. = 25.4 mm); to the north it creeps 0 to 5 mm/yr. (More precisely, creep rate near Calaveras Reservoir is about 5 mm/yr and near Halls Valley, locality C in Figure 2, is about 10 mm/yr. No data are available between these points.) Near the Mission fault, the Hayward fault creeps about 9 mm/yr, but to the north the creep rate appears nearly constant at 5 to 6 mm/yr. No one has reported creep on the Mission fault. Interestingly, similar to the higher creep rate, much of the high rate of seismic activity associated with the Calaveras fault (south of the Mission fault) departs from the Calaveras and appears to associate with the Mission and Hayward faults to the north (Figure 2.)

The largest concentration of magnitude 3 and larger earthquakes (shown as squares in Figure 2) on the Hayward fault is near Lake Chabot, which is also the northern end of the 1868 fault rupture. The straight line by the fault in figure 1 illustrates how the 70-km-long creeping Hayward fault is generally oriented N35°W except for a 700-m bend away from this trend near Lake Chabot. This bend near Lake Chabot thus appears to be the most important segment boundary along the creeping trace and may be a starting point for large earthquakes.

This field guide discusses evidence bearing on the relationship of varying historic rates of creep over the length of the fault to 1) structural complexity of the fault zone, and 2) the available geologic evidence on much-longer-term surface slip rates. Correctly understanding these relationships is important in evaluating the potential for future large earthquakes similar to those in 1836 and 1868. The trip includes eight stops, is about 20 miles long, and can be made in about four hours by car. All stops are shown on a topographic base map (Figure 3), but bringing street maps of Oakland, Hayward, and Fremont is advisable. Most walking is on flat streets and sidewalks; only one stop (#4) requires a short but precariously steep walk, with lug-soled shoes advised. All stops are presently accessible, but some have private property adjacent that must not be entered without permission.

FIELD GUIDE STOPS

1. Oakland Creep Gap?

[Encina Way; exit Interstate 580 (I580) at 98th Ave./Golf Links Rd./Knowland Zoo.]

Before 1988, it seemed that there might be a much lower slip rate along a 20-km-long segment of the Hayward fault in Oakland (Figure 4 A.) This hypothetical gap in the normal creep rate coincides with the part of the fault adjacent to the bend near Lake Chabot and is along a segment not ruptured since at least 1836. If real, such a gap could indicate a higher earthquake hazard in Oakland than elsewhere along the fault. However, surveys made in 1988 of cultural features (curbs, buildings, sidewalks, and fences) offset by the fault in Oakland suggested that creep rates in Oakland appear to be in the usual 5-6 mm/yr range (Figure 4 B), although some sites show lower rates probably because of local complexity of faulting [*Lienkaemper and Borchardt*, 1988].

At stop #1 [Encina Way], we see one example of how historic creep rate is inferred from offset cultural features. Figure 4 C shows the alinement of the south curb. The offset does not look very large in the field, because the zone of fault deformation is over 20 m wide. Later (stops 3, 6, and 8) we will see cultural features that are more obviously offset, where the deformation is more narrowly confined. Development of *en echelon* cracks in the pavement is only slight here; much better development can be seen at stops 3 and 8.

2. Fairmont Hospital Creep Damage.

[Fairmont Hospital compound; Exit I580 at 150th Ave./Fairmont Drive.]

Figure 5 shows the position of the creeping trace of the Hayward fault with respect to various buildings. Some of the buildings north of the auditorium have already been removed. The auditorium, built in 1915, has a steel framework and walls of unreinforced clay tile. It has been recommend for demolition. The west end of the building shows signs of severe racking from fault creep. "F Building", a 1930 structure (wood frame on concrete slab) shows sizable gaping cracks in stucco where it is being pulled apart by creep. "E building", a reinforced concrete structure built in 1950, shows no obvious creep damage yet at the east corner where the fault passes underneath. Subtle evidence of creep is visible in adjacent curbs, walks and driveways. See *Messinger* [1982] for a detailed discussion of building damage from creep at this site. See also *Taylor* [1982] for detailed discussion of fault location and creep evidence in this area.

3. Downtown Hayward.

[D and C Streets; Exit I580 at Foothill Blvd./Highway 238.]

Figure 6 illustrates the fault offset on two out of several old curbs in central Hayward that show obvious and sizeable fault offset from several decades of creep [*Nason*, 1971]. Note that the D Street curb clearly shows two distinct fault offsets. As one goes northward dominant slip transfers from the east trace to the west trace. North of C Street the east trace is no longer evident. In the public parking lot on the west trace between D Street and the old City Hall look for cracks in the asphalt pavement. Notice the left-stepping progression of overlapping shears, often described as an *en echelon* pattern. This left-stepping pattern is a typical feature of right-slip faulting.

4. Offset Stream Channel.

[From Mission Blvd. (Highway 238) exit left on Corrine, take 2nd right at Chicoine Ave., take 2nd left on MacDonald Way.]

From the end of MacDonald Way, climb the steep path uphill, pass through the gate, walk to the right. The nearby natural (dry) stream channel, like the curbs in Hayward, is offset right-laterally, but by several meters, the effect of many centuries of creep and earthquakes. The fault passes just below the prominent outcrop of resistant Cretaceous conglomerate. Stand west of the fault and south of the channel. The channel is straight on the east side of the fault. The farther west one stands, the larger the offset appears. This appearance could be a result of: 1) multiple cycles of larger slip events, or 2) the effect of broadly distributed slip, or 3) differential or fortuitous erosional effects.

5. Geologic Slip Rate at Masonic Home, Union City.

[From Mission Blvd. turn left on O'Connell Lane. Stop near bridge on left side. Do not enter fenced area without permission.]

Looking northward across the perennial stream that flows in the ditch along the north edge of O'Connell Lane, one can see the land surface rise gently to the north (see Figures 3 C and 7). This rise is the crest of an alluvial fan formed a few thousand years ago by this same stream, but it has been displaced right-laterally (northward) by about 40 to 50 m along the Hayward fault. The fault zone here is 5-10 m wide and is located where O'Connell Lane begins to climb steeply up the hill front. In 1989 the U.S. Geological Survey and the California Division of Mines and Geology (USGS and CDMG) excavated a 4- to 6-m-deep, 130-m-long trench parallel to the fault to expose gravel-filled channels and layers of flood-deposited silt in this ancient offset fan. Figure 7 illustrates what we learned this year; the project is still in progress. We have evidence that the fan has been offset by the fault enough to have formed a distinct new apex at the fault at least six times, symbolized in the figure by letters C, E, G, I, K, and M. We have submitted 24 radiocarbon samples to labs to establish the ages of these fan deposits, but have no results yet. We know roughly that apexes E and C are of Holocene age (*i.e.*, younger than about 10,000 yr) and apex G is early Holocene or latest

Pleistocene. The oldest apexes (I, K, and M) are Pleistocene-aged (from the last ice age) because their deposits contain teeth of horses and camels that lived during the latest ice age. The locations shown for these apexes are approximate. They are based on the trends of gravel channels (wavy lines in Figure 7) exposed in a 1-m-wide trench over about 20 m to the fault trace. Future trenching will locate these apexes more accurately and allow the computation of a slip rate for each apex. A more accurate topographic map of the canyon east of the fault will be made soon, because downcutting and erosion of the channel mouth east of the fault must be better understood. For example, the oldest apexes (M and K) correlate to a broader stream terrace (*i.e.*, not the modern narrow channel) that is still visible in remnants above the fault scarp on O'Connell Lane (in the old orchard). The transition to a narrow canyon took place while apex I was active. A major change in overbank sediment composition also occurred at this time, from yellow brown sandy silt to dark gray brown clayey silt. This change probably represents an important climatological change, possibly the end of the last Pleistocene glaciation. By far the greatest sedimentation took place during the active time of apex E. Deposits of apex E correspond almost exactly with the modern topographic expression of the fan. Speculatively, this great pulse of sedimentation may have occurred in a dry period of early Holocene recognized elsewhere in the northern hemisphere. The predominant geologic unit in this watershed, a Pliocene continental unit (similar in composition to the Orinda Fm.), is highly susceptible to erosion, and would be much more so if sparsely vegetated as during a dry period. Since the abandonment of apex E, an order-of-magnitude less sedimentation has occurred.

Ultimately, we hope to learn from this study whether the slip rate during geologic time is similar to the historic creep rate of 5-6 mm/yr along most of the fault or to the higher rates we have measured in southern Fremont of 8-10 mm/yr since the 1920s (Figure 4 B). Regional strain data from long (Geodolite) trilateration lines allow that up to 11-12 mm/yr of right slip could be associated with the Hayward fault if one partitions strain among the major strike-slip faults. We know from studies at Parkfield [*Segall and Harris*, 1987; *Lienkaemper and Prescott*, 1989 in press] that short-term, historic surface-slip (creep) rates can be much smaller than either 1) rates at depth inferred from geodesy, or 2) long-term rates of slip derived from geologic studies (such as this one at Masonic Home) that include the slip from large earthquakes in addition to steady interseismic creep. Knowing long-term slip rates along the Hayward fault could ultimately help us better infer the likelihood of a future large earthquake during a given time interval from the present onward [*Working Group on California Earthquake Probabilities*, 1988].

6. Shinn Railroad Station, Fremont.

[Exit Highway 238 (Mission Blvd.) at Highway 84 (Mowry Ave.); turn right on Shinn St.; cross Southern Pacific (SP) tracks, pass U.S. Gypsum (USG) warehouse on right; head east along north fence of USG to its east end.]

The north fence of USG (south of the road) and the guardrail (north of the road) both clearly show large distinct offsets in a zone less than 7-m wide (Figure 8). Interestingly, the vertical deformation zone may be wider. Here "vertical creep" is defined as the vertical displacement at the fault from projecting the linear regression best-fit lines inward. No regional sense of vertical component is proven by this short line; however slip in the 1868 earthquake just north of here and geologic observations south of here (in Shinn Park) do show that the northeast side is distinctly downdropped in this area, unlike most places along the Hayward fault. Offsets of the 1909 SP and 1908 Union Pacific (formerly Western Pacific) railroad tracks were measured by *Bonilla* [1966], but major straightening of the tracks and the proximity of a designed curve just west of the station makes offsets inexact and probably suggest only minimum estimates (~4 mm/yr) of long-term creep rate.

7. Tule Pond, a Tectonic Sag.

[Return to Highway 84 (Peralta Blvd.), head east, turn right (south) on Mowry, left on Civic Center Drive, left on Walnut until just southeast of Fremont BART station.]

To the north of Walnut Avenue the pond still contains water, but is partly paved over by the BART parking lot. To the south, the marshy area is confined by two steep escarpments; both are active traces of the Hayward fault. Looking at Figure 3 C, one sees that the fault makes an *en echelon* step-over to the right. On right-slip faults, such right-ward steps produce extensional deformation between the two traces, the origin of this classic sag pond. In contrast, left steps produce compressional deformation within the step-over area. A subtle and complicated example of a left step-over can be seen at our next stop at Fremont City Park (Figure 9). The low ground near Lake Elizabeth (similar in position to the natural Stivers Lagoon that it now covers) is better described as an area of blocked drainage caused by uplift in a left step-over (*i.e.*, a particular variety of a tectonic *shutteridge*). Notice that the pavement and curbs along Walnut Avenue do not show obvious creep effects yet.

8. Fremont City Park, Historic and Holocene Slip Rates.

[Head south on Walnut Ave., turn left on Paseo Padre Parkway, take first left after Stevenson Blvd. (Sailway Dr.), start by ex-library building.]

Few active faults have been mapped in as much detail as the Hayward fault in Fremont City Park. The location of fault has been compiled by Alben Greger of the Fremont City staff from several trenching studies by consultants and from surface creep evidence. Figure 9 is simplified after part of this map, which is available from the City of Fremont. Despite the fact that the main trace is so narrow (1-5 m) and remarkably straight, much remains uncertain about how to interpret fault deformation here. Begin looking for evidence of creep in the north end of the parking lot of the old library (figures 9 and 10). Look at the offset curb at the north end of the landscaped center divider. Just to the right of the asphalt path to the lake see another offset curb. The path has subtle *en echelon* cracks. Just north of this path was another joint USGS-CDMG trenching study to learn long-term slip rate (Figure 10).

The joint USGS-CDMG trenching study in 1986-1987 showed that slip rate on the main trace (and secondary traces within 10 m) has averaged 5.5 ± 0.5 mm/yr during the last 8030 (radiocarbon) years, based on a 44.5-m offset of a buried gravel-filled channel [*Borchardt et al.*, 1988]. This rate is similar to creep rates in recent decades as measured on an offset curb in the park and at Shinn Station (Stop #6). However, we cannot be certain that all right-lateral deformation is occurring here as discrete slip near the main trace. In a larger view from the Tule Pond to south of the City Park, the Hayward fault makes a 200-m bend, formed by a right step-over on the north and a left step-over to the south. From stratigraphic evidence in the USGS-CDMG trenches and earlier consultants' trenches, we can deduce that since 8,000 yr ago Holocene sediments that were deposited dipping gently westward have been tilted in a 200-m-wide zone to now dip eastward. Earlier researchers interpreted the eastern edge of this eastward-dipping zone as an eastern fault trace, but logs of trenches cut across this eastern boundary rule out a surface-fault trace. A more likely explanation is that at some shallow depth (~200 m), the principal trace lies about 200 m to the east of the surface trace, thus causing considerable deformation at the surface eastward of the main trace. Paleomagnetic signatures are too weak in the sediments at this site to either distinctly confirm or deny right-lateral rotational deformation, so the total right-slip we observed in the last 8,000 yr is only a minimum value. The upper limit to slip rate here during this 8,000-yr period must remain unknown for now. For this reason we are studying the Holocene slip record at another site (Masonic Home, Stop #5), hoping that we can measure the rate for the *entire* Hayward fault zone there.

Other interesting features in the Park include a *scissor point* just north of the USGS-CDMG trench site (see Figure10.) A scissor point is a location on a strike-slip fault where the vertical component of slip changes sense. For example, at the hill on which the Fremont Civic Center is built, the east side has been distinctly uplifted along the fault (about 6 m uplift, before construction lowered the hilltop), occurring largely, if not entirely, during the Holocene. At the trench site (trenching revealed 5-6 m downwarp in 8,000 yr) vertical change was east side down. This scissor point is clearly visible on the ground and is obvious in the topographic contours in Figure 10.

Walking south from the old library the fault forms a low broad pressure ridge. Find the distinct curb offsets on Sailway Drive. Continue walking south to the Senior Center parking lot. The curb on the south side has a distinct offset formed by creep since 1968. To the south, the fault passes through the center of the old Community Center. The building is used only for storage now. The City monitors building deformation from creep using survey markers in the concrete-slab floor. Look for subtle creep effects in the walkways on the west side of the building and evidence of racking of the wood frame.

DISCUSSION

Much has been learned in the last two decades, both about the precise location of the active fault trace and about the creeping behavior of the Hayward fault, since creep was first documented in the early 1960s (*e.g.*, *Cluff and Steinbrugge*, 1966, *Radbruch*, 1967). However we still cannot say with much certainty when the next large earthquake is likely to occur on this fault. In fact, *if* the 1868 and 1836 earthquakes were *not* in the historical record, scientific arguments could be made, using known rates of fault creep this century and regional strain from recent decades, that large earthquakes seem unlikely if not impossible. Clearly we need to learn *much* more about the Hayward fault before we can make useful predictions about its future behavior. Current work at the USGS and other cooperating institutions focuses on: 1) learning long-term geologic slip rates, 2) searching for geologic evidence of prehistoric earthquakes, 3) compiling more detailed maps of the active deformation zone to understand variation of slip rates along strike, and 4) installing denser geodetic monitoring to obtain a clearer understanding of relationship of creeping versus locked patches. A "locked" patch, not necessarily extending to the Earth's surface, is apparently required to generate an earthquake. Ultimately the goal is to discover the location and extent of locked patches on the fault and deduce how much strain may have accumulated on them. Surface creep data seem to indicate that no buried locked patches extend upward to the surface, *i.e.*, no extensive (>10-km-long) creep gaps appear to exist. Present geodetic data permit that such patches may or may not exist at depth. Improved data may help solve this problem partially, but geodetic models are inherently weak in resolving slip versus depth.

We must continue working to accurately measure geologic rates of slip, because these ultimately improve critical assumptions that go into geodetic and seismological models of fault behavior. Despite the higher costs and greater difficulties of doing scientific work in an increasingly urbanized environment, we can continue to improve our understanding of how the Hayward fault behaves.

Acknowledgements. I cannot possibly thank or fully reference all of those who have contributed significantly to the improved understanding of the Hayward fault. For assistance with my own work I thank the city governments of all the cities cut by the fault, most especially those of Fremont and Oakland; and also Masonic Homes of California and Glad-a-Way Gardens for their enthusiastic support of our work to learn long-term Hayward fault slip rates.

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FIGURE CAPTIONS

Figure 1. Map of the creeping trace of the Hayward fault. Segments of faults where creep is known shown by dashed pattern. Extent of surface rupturing in 1868 is shown; the 1836 rupture extent is entirely speculative. SF, San Francisco; *CR*, Calaveras Reservoir. See text for further explanations.

Figure 2. Seismicity of the San Francisco Bay region, 1969-1988, from U.S.G.S. catalog. Squares indicate M 3 and larger earthquakes. Since 1979 three earthquakes of M 5.8 and larger have occurred, indicated by large black dots(A, 1980, Livermore; B, 1979, Coyote Lake; C, 1984, Morgan Hill [M 6.2]). Since 1984 3 earthquakes M 5 and larger have occurred, smaller black dots (on stars). Creeping fault segments, dashed.

Figure 3. Map of Holocene active traces of Hayward fault (bold dashed line) and field guide stops (centers of cross hairs symbols). Holocene active traces with no documented creep shown by double dashed pattern. Scale and orientation (N35°W) shown in panel C. Map is preliminary and may not include all active secondary traces or represent full width of deformation zone. Questions regarding legal requirements for owners of real estate within the official boundaries of the Alquist-Priolo Special Studies Zone should be directed to the County Geologist or Engineer [Hart, 1985].

Figure 4. Slip rate along Hayward fault: A) modified from *Prescott and Lisowski* [1983]. B) triangles and solid squares, trilateration data [*Prescott and Lisowski*, 1983]; open circles, cultural features [*Lienkaemper and Borchardt*, 1988], solid circles, alinement arrays [*Harsh and Burford*, 1982], small squares, other data: after B. Lennert (written commun., 1985), *Brown et al.* [1981], *Blanchard and Laverty* [1966], and *Nason* [1971]. C) Field guide stop #1, Encina Way south curb. Solid squares represent surveyed position of the curb line relative to a least-squares best fit of points surveyed northeast of the fault. The three western-most points are assumed to be outside of the fault zone. Slip rate, 5.6 mm/yr, is based only on curb data (*i.e.*, more erratic fence data not used).

Figure 5. Map of Hayward fault at Fairmont Hospital, Alameda County, simplified from *Messinger* [1982]. Stop #2.

Figure 6. Curb offsets in downtown Hayward after *Nason* [1971]. Stop #3.

Figure 7. USGS-CDMG trench site at Masonic Home, Union City. Offset prehistoric stream channels. See text for explanation (Stop #5).

Figure 8. Offset fence and guardrail near Shinn railroad station, Fremont. Stop #6. Dotted lines represent linearly regressed best fits, similar to Figure 4 C.

Figure 9. Map of Hayward fault in Fremont City Park. Stop #8. The many trenches and seismic lines symbolized here are referenced on a larger map of this area by Alben Greger, available from Fremont City Civic Center. Inset area is shown enlarged in Figure 10.

Figure 10. Map showing the location of USGS-CDMG 1986-1987 trenches across the Hayward fault (A, B, C) and parallel to it (1-6) located in Fremont City Park (see inset location in Figure 9.) Patterned area represents distribution of 8,000-yr-old gravel and sandy gravel deposits offset by the fault. Contour interval is 1-ft, map grid interval is 20-m.

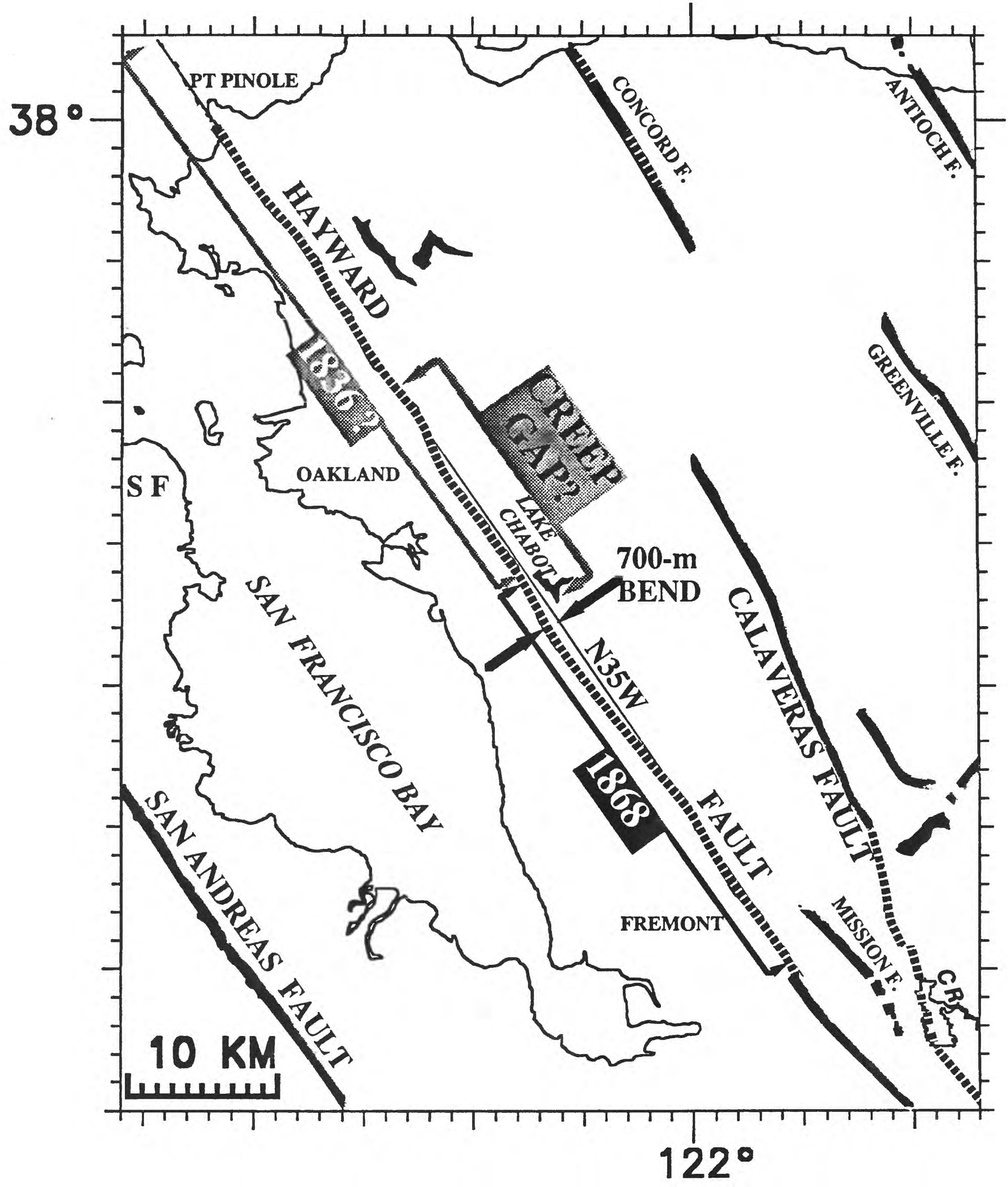

38°
122°
PT PINOLE
CONCORD F.
ANTIOCH F.
HAYWARD
1836?
CREEP GAP?
GREENVILLE F.
S F
OAKLAND
LAKE CHABOT
700-m BEND
CALAVERAS FAULT
SAN FRANCISCO BAY
N35W
1868
FAULT
SAN ANDREAS FAULT
FREMONT
MISSION F.
CR
10 KM

Figure 1

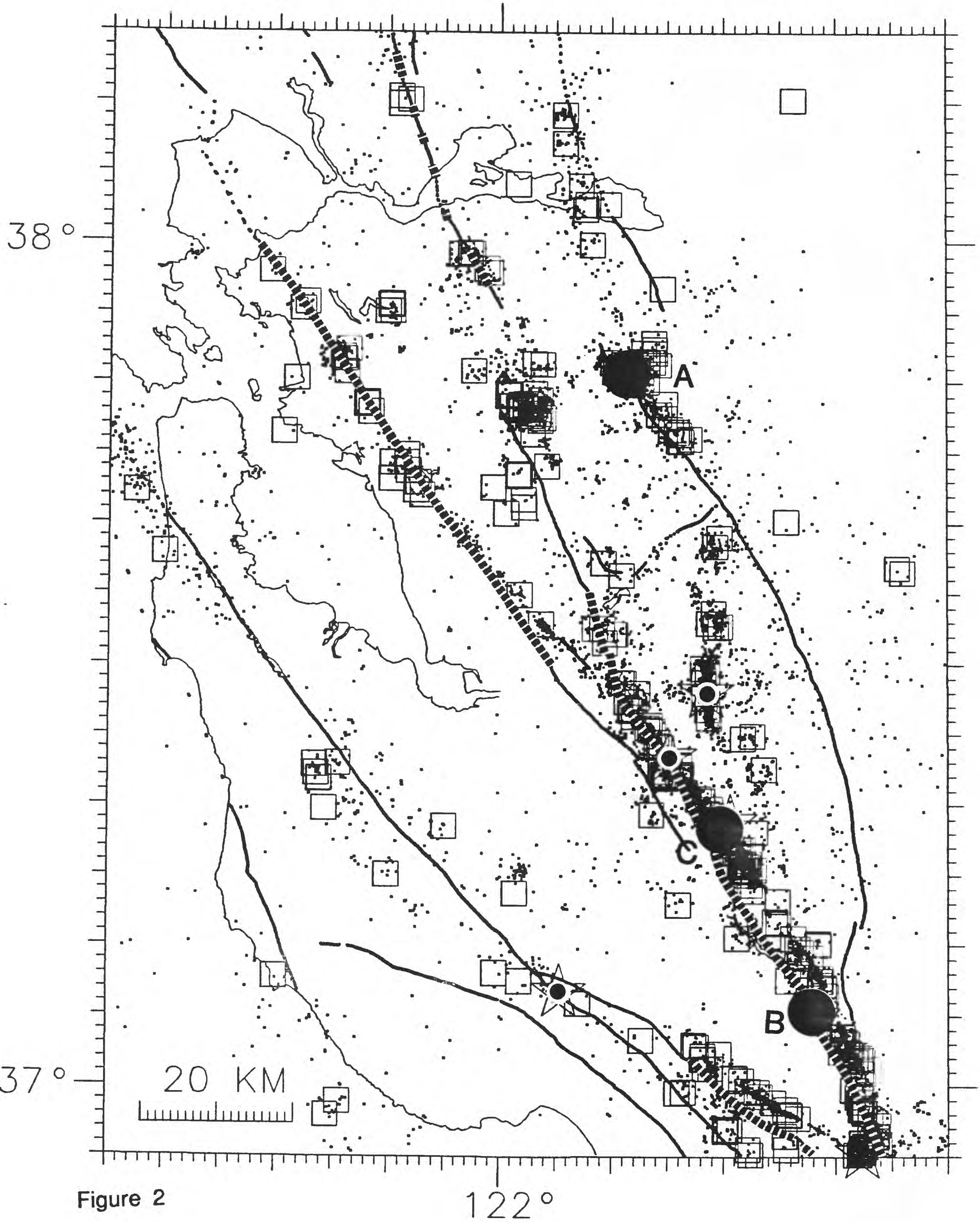


Figure 2

Figure 3 A. (northwest) Location of Hayward fault.

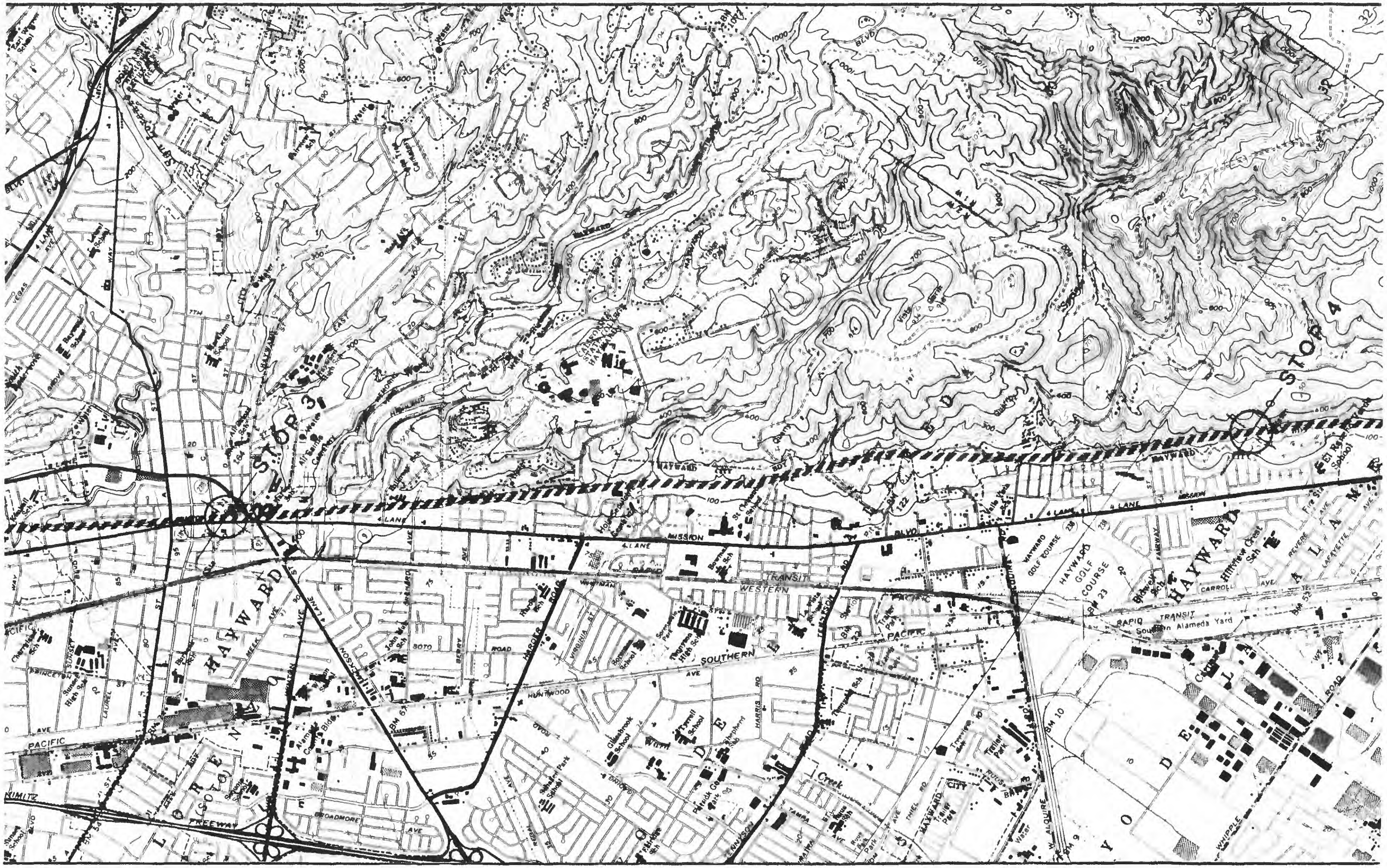


Figure 3 B. (central) Location of Hayward fault.

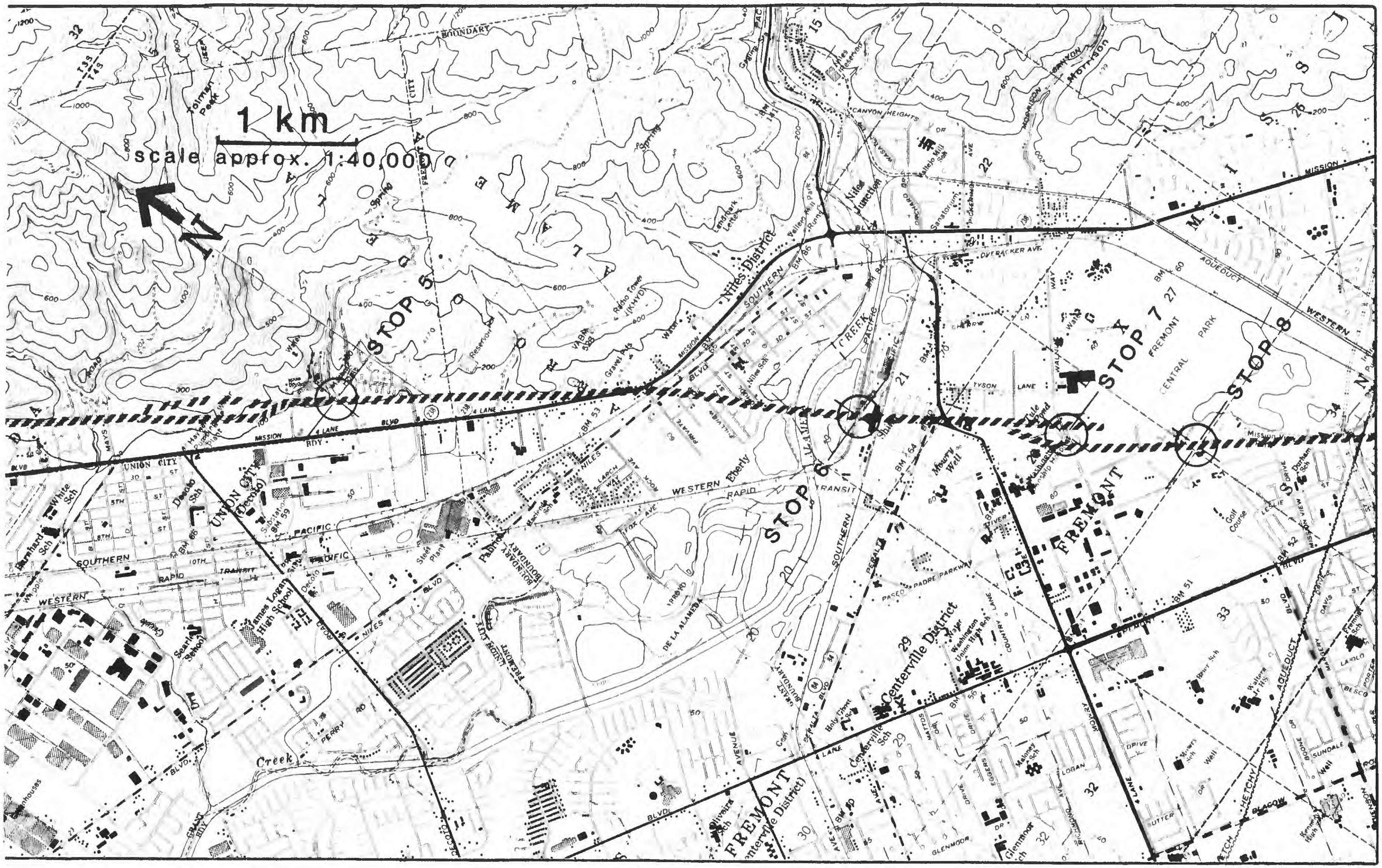


Figure 3 C. (southeast) Location of Hayward fault.

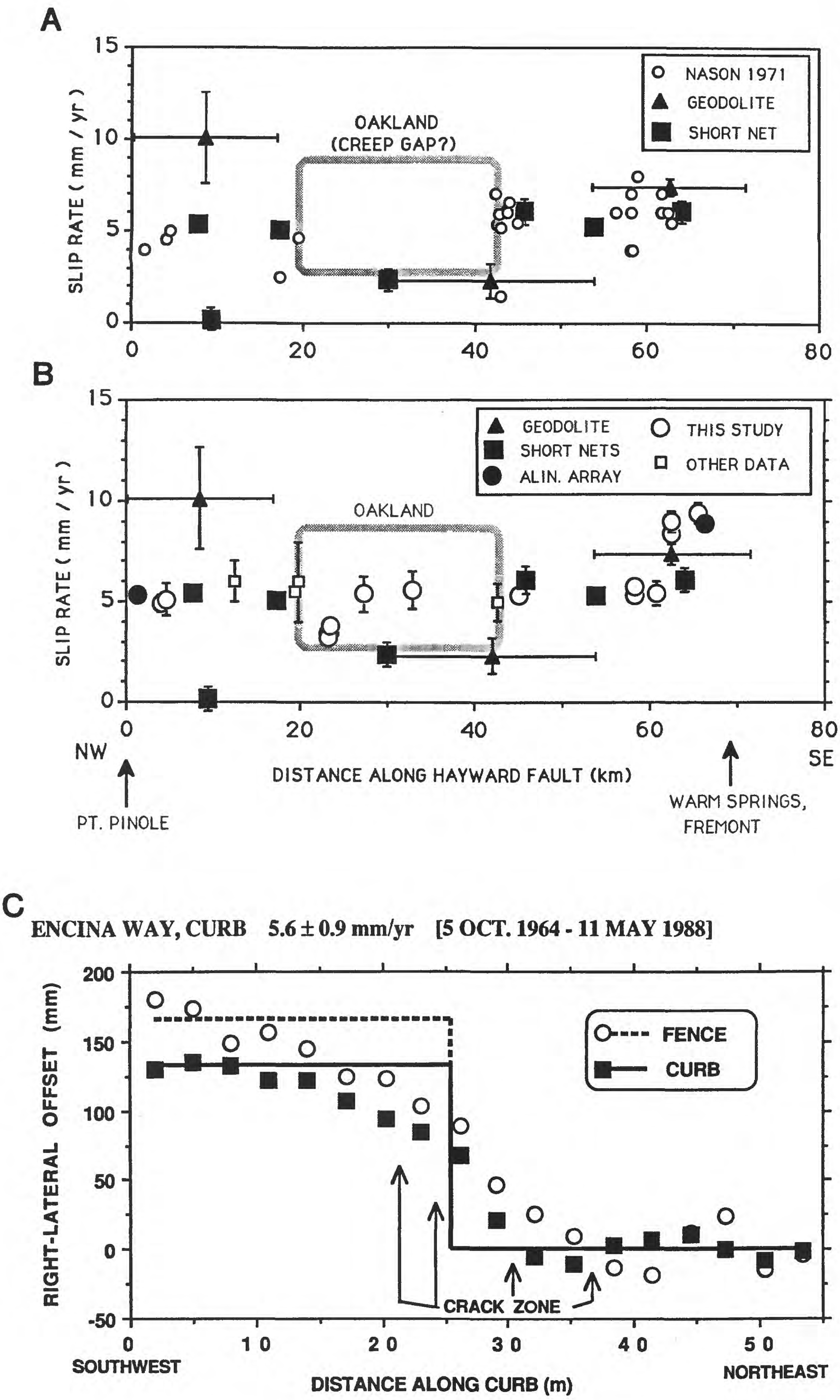
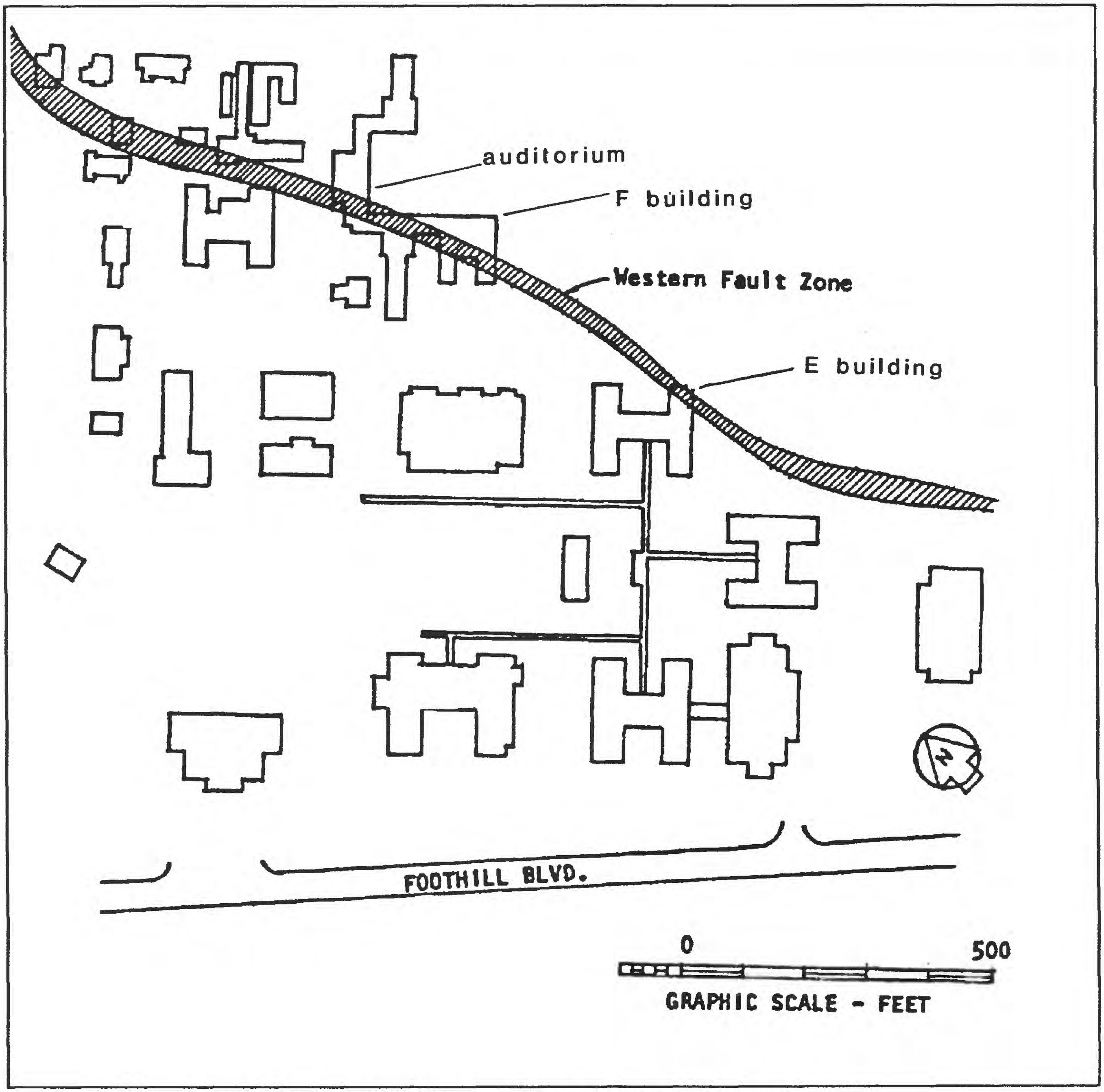

A
15
10
5
0
0
20
40
60
80
SLIP RATE (mm / yr)
NASON 1971
GEODOLITE
SHORT NET
OAKLAND
(CREEP GAP?)
B
15
10
5
0
0
20
40
60
80
SLIP RATE (mm / yr)
GEODOLITE
SHORT NETS
ALIN. ARRAY
THIS STUDY
OTHER DATA
OAKLAND
NW
SE
DISTANCE ALONG HAYWARD FAULT (km)
PT. PINOLE
WARM SPRINGS, FREMONT
C
ENCINA WAY, CURB 5.6 ± 0.9 mm/yr [5 OCT. 1964 - 11 MAY 1988]
200
150
100
50
0
-50
RIGHT-LATERAL OFFSET (mm)
FENCE
CURB
CRACK ZONE
0
10
20
30
40
50
SOUTHWEST
DISTANCE ALONG CURB (m)
NORTHEAST

Figure 4



LOCATION HAYWARD FAULT, FAIRMONT HOSPITAL

Figure 5

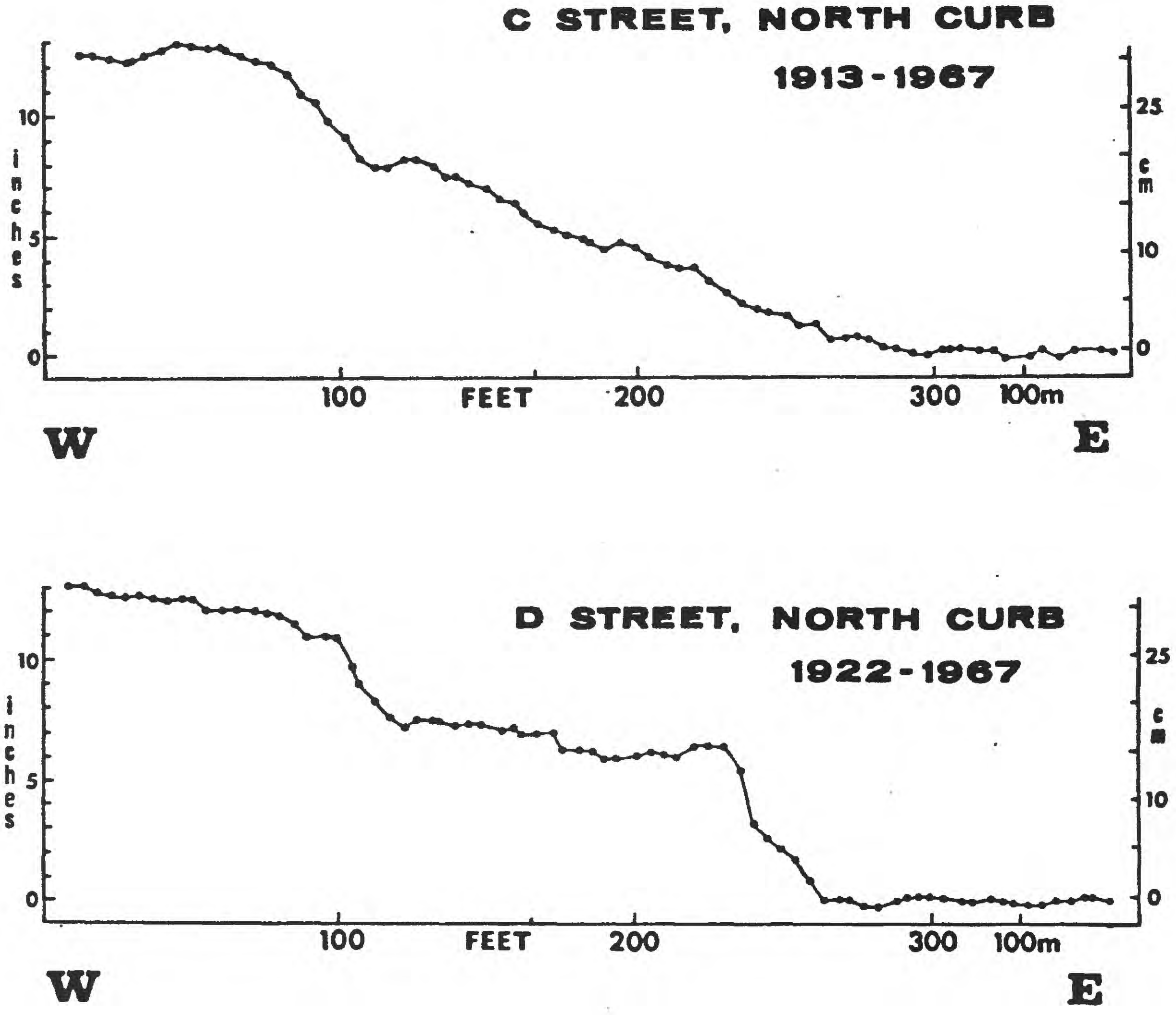


Figure 6 DOWNTOWN HAYWARD CURB OFFSETS

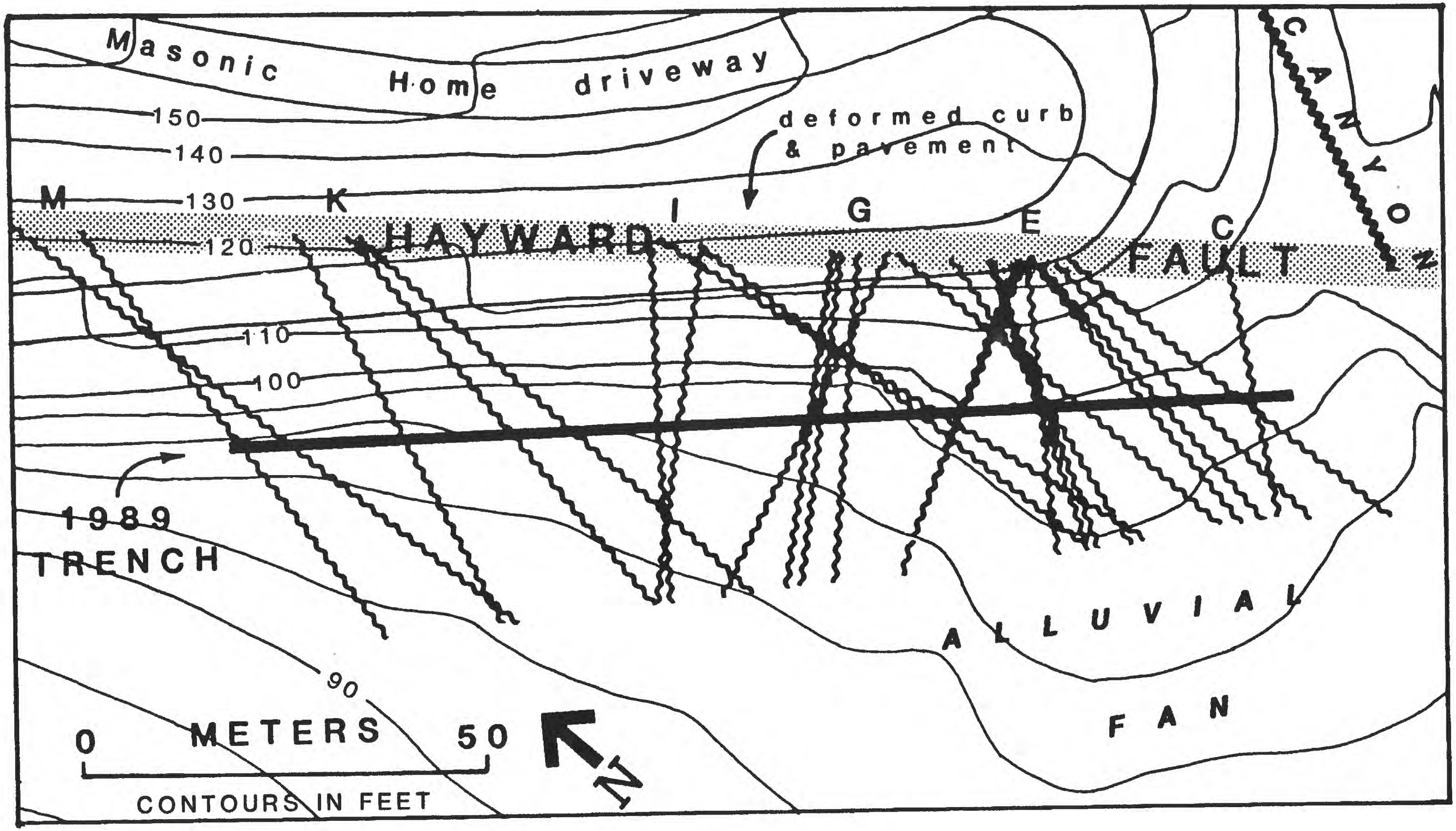

Masonic Home driveway
deformed curb & pavement
150
140
130
120
110
100
90
M
K
I
G
E
C
HAYWARD FAULT
CANYON
1989 TRENCH
ALLUVIAL FAN
0 METERS 50
CONTOURS IN FEET
N

Figure 7

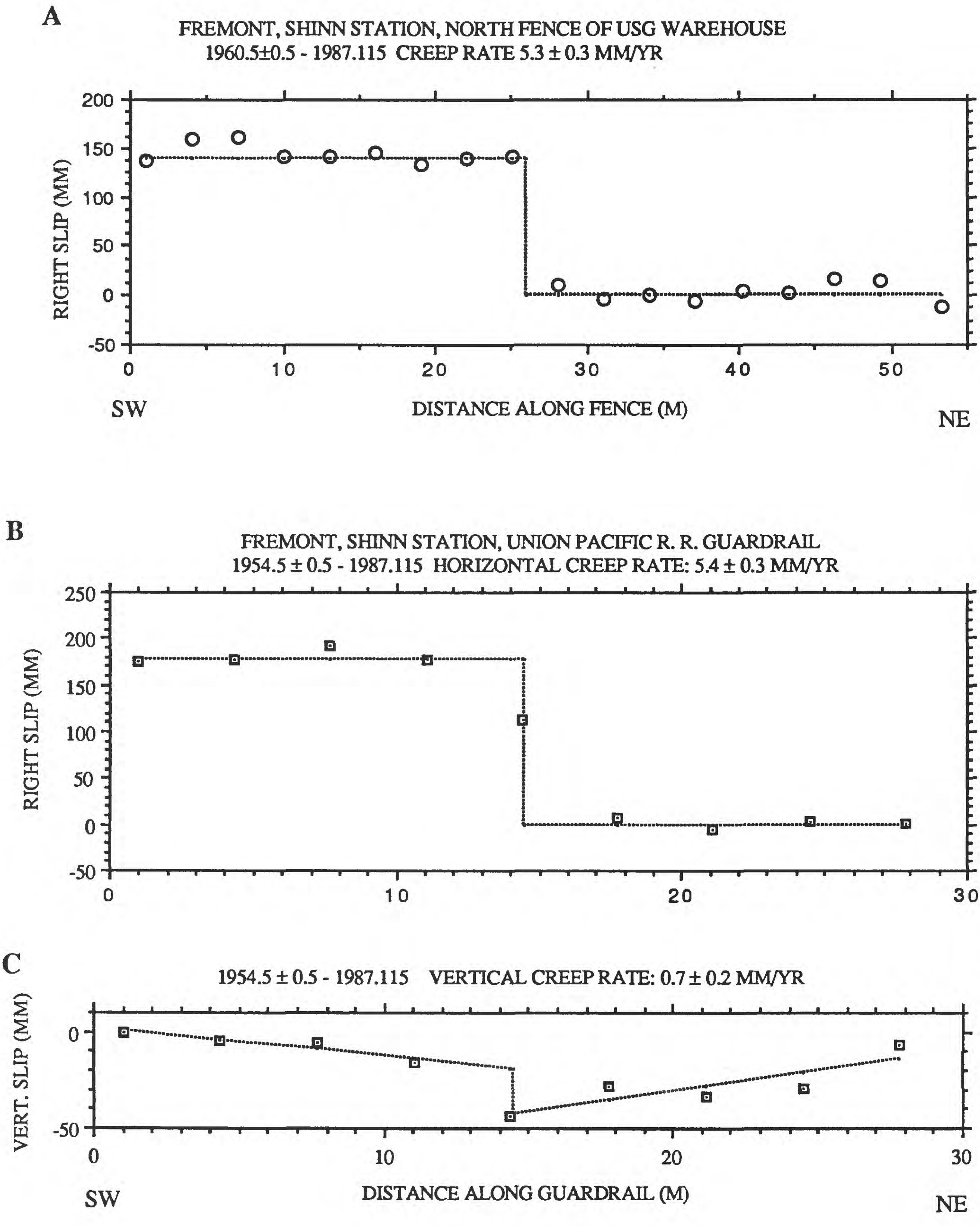

A
FREMONT, SHINN STATION, NORTH FENCE OF USG WAREHOUSE
1960.5±0.5 - 1987.115 CREEP RATE 5.3 ± 0.3 MM/YR
RIGHT SLIP (MM)
200
150
100
50
0
-50
0
10
20
30
40
50
SW
DISTANCE ALONG FENCE (M)
NE
B
FREMONT, SHINN STATION, UNION PACIFIC R. R. GUARDRAIL
1954.5 ± 0.5 - 1987.115 HORIZONTAL CREEP RATE: 5.4 ± 0.3 MM/YR
RIGHT SLIP (MM)
250
200
150
100
50
0
-50
0
10
20
30
C
1954.5 ± 0.5 - 1987.115 VERTICAL CREEP RATE: 0.7 ± 0.2 MM/YR
VERT. SLIP (MM)
0
-50
0
10
20
30
SW
DISTANCE ALONG GUARDRAIL (M)
NE

FIGURE 8

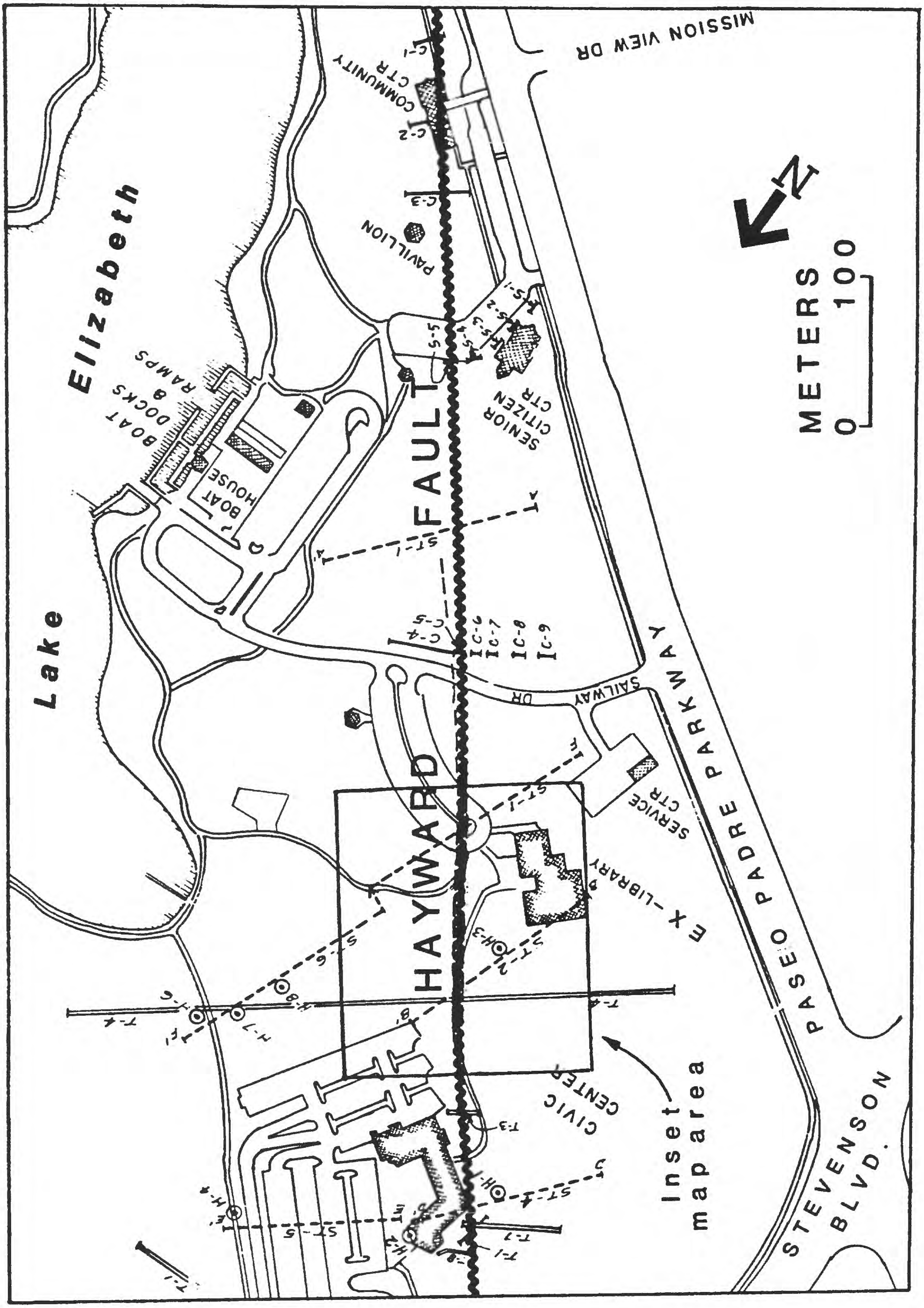


Figure 9 **FREMONT CITY PARK, LOCATION OF HAYWARD FAULT**

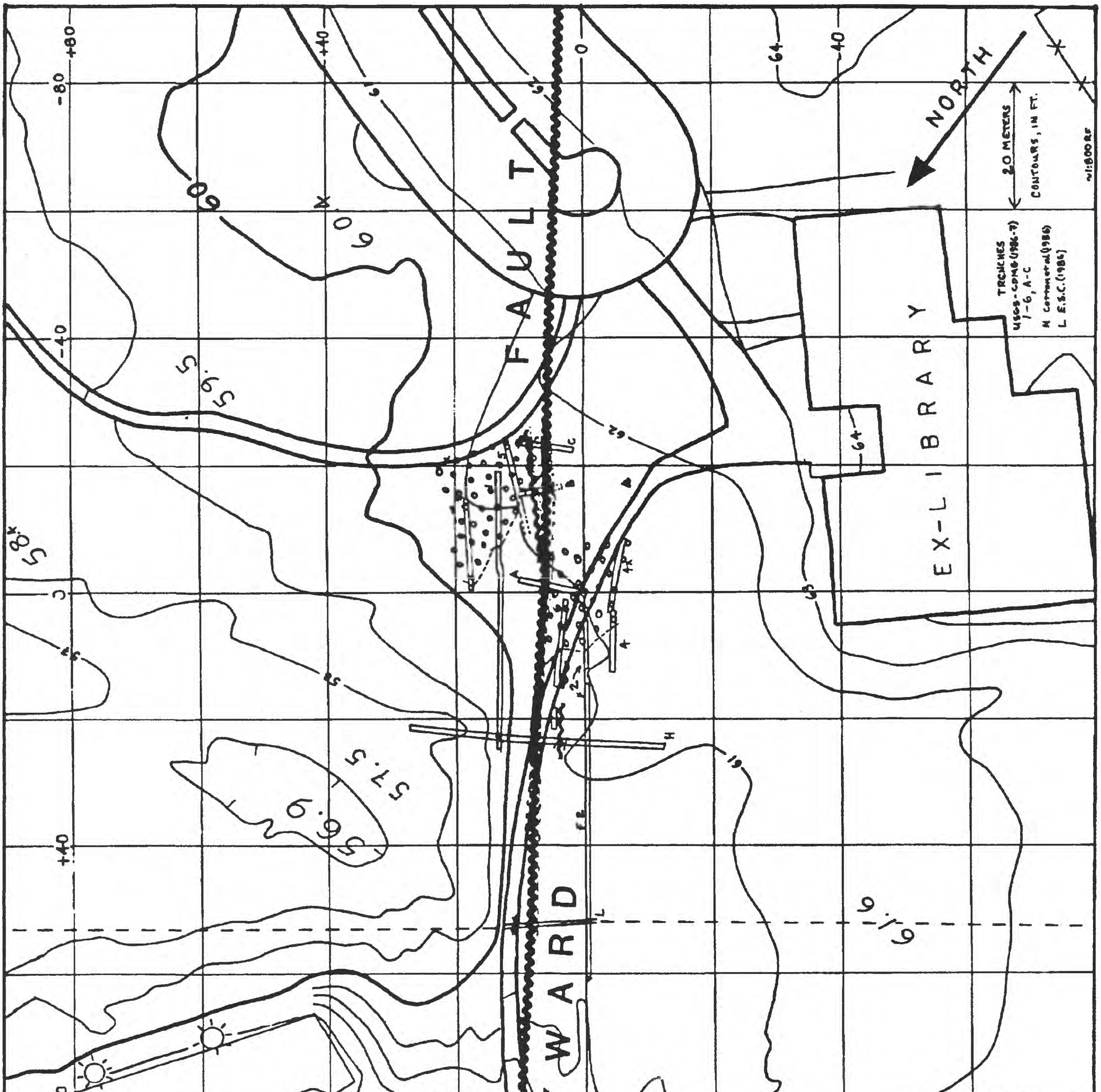


Figure 10 **FREMONT CITY PARK, USGS-CDMG TRENCH SITE, 1986-1987**