Title

INVESTIGATIONS FOR GROUND STABILITY IN THE VICINITY OP THE CALAVERAS FAULT, LIVERMORE AND AMADOR VALLEYS, ALAMEDA COUNTY, CALIFORNIA

Permalink

https://escholarship.org/uc/item/2z30q2ft

Authors

Gibson, William M.
Wolleriberg, Harold A.

Publication Date

1966-11-08

UCRL-17265

University of California

Ernest O. Lawrence Radiation Laboratory

INVESTIGATIONS FOR GROUND STABILITY IN THE VICINITY OF THE CALAVERAS FAULT, LIVERMORE AND AMADOR VALLEYS, ALAMEDA COUNTY, CALIFORNIA

Berkeley, California

Submitted to Bull. of Geol. Soc. Am.

UCRL-17265
Preprint

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

INVESTIGATIONS FOR GROUND STABILITY IN THE VICINITY OF THE CALAVERAS FAULT, LIVERMORE AND AMADOR VALLEYS, ALAMEDA COUNTY, CALIFORNIA

William M. Gibson and Harold A. Wollenberg

November 8, 1966

INVESTIGATIONS FOR GROUND STABILITY IN THE VICINITY OF THE CALAVERAS FAULT, LIVERMORE AND AMADOR VALLEYS, ALAMEDA COUNTY, CALIFORNIA

W. M. Gibson
U. S. Coast and Geodetic Survey, Retired

H. A. Wollenberg
Lawrence Radiation Laboratory
University of California
Berkeley, California

November 8, 1966

ABSTRACT

Geologic and geodetic studies were made in the area of Camp Parks, a site proposed for a 4600-ft-diameter, circular, 200-BeV proton accelerator in the western portion of the Livermore Valley. The area is underlain by Pliocene sediments of the Orinda formation and by Quaternary alluvium, and is transected by the Calaveras, Pleasanton, and Parks faults. The reflection of the Pleasanton faults in the alluvial surface suggests that the area is presently undergoing active tectonism.

A geodetic network, established in 1964 in cooperation with the U. S. Coast and Geodetic Survey, combined precise leveling across the western Livermore Valley and precise horizontal measurements across the Pleasanton and Calaveras faults. A previously installed large-area triangulation network encompassing the Livermore Valley was reobserved; there were no significant changes of position since 1947-1948. Reobservation of the 1964 network one year later showed the development of a subsidence basin in the southern San Ramon Valley with vertical differences on the order of 0.05 ft, consistent clockwise horizontal movement

across the Pleasanton faults, and an apparent thrusting movement across the Calaveras fault. Though the directions of horizontal movement are meaningful, the values of distance are questionable, since only one year elapsed between measurements. It is considered that subsidence in response to withdrawal of ground water is superimposed on tectonic movements.

INTRODUCTION

In 1963, the Lawrence Radiation Laboratory, under the auspices of the Atomic Energy Commission, organized an Accelerator Study Group for preliminary planning relative to a proposed 200-BeV proton accelerator.

One of the activities of the Study Group was to evaluate any requirements of the accelerator that might have an important bearing on site selection. Camp Parks, in the western Livermore-Amador Valley (see location and geologic map, Fig. 1) was recognized as a desirable site from the standpoints of cost and proximity to the Radiation Laboratory, transportation, water, power, and leading educational institutions. The engineering feasibility of Camp Parks as a site needed to be determined.

Preliminary investigations included studies of the area's geology, soils, earthquake history, tectonics, and subsidence, with a view to projections of future stability. The geologic, tectonic, and subsidence investigations are reported here.

The proposed particle accelerator would be circular (average radius of 2300 ft), would be located underground, and would have as its essential elements a vacuum pipe in which the orbit of the protons would be controlled by 528 magnets, each weighing approximately 30 tons. The setting and maintaining of the alignment of the magnets would be one of the most critical parameters. Random misalignments of a single magnet of 0.03 to 0.06 in. could be tolerated; misalignments of this order would be much less critical if several of the magnets were constrained to move together. Thus the probability of horizontal or vertical tectonic movements as well as ground subsidence needed evaluation.

For an evaluation of the stability of the Camp Parks site, existing data on ground-water levels, geodetic elevations and positions, and earthquake investigations were examined, and plans and specifications drawn up for obtaining additional data through a geologic and geodetic survey program. Descriptions of the field observations and subsequent evaluations follow.

SITE GEOLOGY AND FAULTING

The site occupies gently southward-sloping alluvial terrain at the base of foothills bordering the north side of the Livermore-Amador Valley. (The regional geology of the area is described by Hall (1958). Detailed geologic mapping of the site area was done by Wollenberg.) The map (Fig. 1) shows the location and geologic setting of the Camp Parks area. Sandstone, siltstone, and claystone in the Orinda formation of Pliocene age crop out in the hills in the northern part of Camp Parks, and are overlain by alluvium to depths of 100 ft in the southern part. Beds of the Orinda formation have been folded into anticlinal and synclinal structures, strike roughly N 60° W, and dip 30 to 40° on the average.

The alluvial sediments which overlie the Orinda formation are horizontally bedded or lenticular and are fairly heterogenous. Some clay is present in almost all horizons; loose sands are not predominant except in isolated small bodies. With the exception of the 4- to 5-foot-thick surface layer of "adobe" and its underlying 2-foot-thick layer of brownish silt, there are no marked clay, silt, or sand horizons covering extensive areas; rather the vertical distribution of alluvial types suggests randomly thickening or thinning beds. Gravelley zones are common to both clayey and sandy matrices and are not confined to one particular horizon or area. The alluvium is quite compressible near the surface but at depths of 60 to 100 ft, where it is in contact with the Orinda formation, the alluvium is firm and nearly indistinguishable from the Orinda.

Several faults transect the area (see Fig. 1). The most prominent is the Calaveras which strikes roughly NNW and borders the west side of the Livermore-Amador Valley. The Pleasanton fault and its East Branch roughly parallel the Calaveras fault and border the site on the west; the Parks fault roughly parallels U. S. Highway 50 approximately 1 mile south of the site. A sharp change of relief and a line of springs at the base of the hills in the northern portion of Camp Parks indicate the northwestward-striking Hill Front fault.

Information from monument boreholes in the Camp Parks area indicates the effects of the Pleasanton fault on the alluvium. Contours of the ground-water surface (Fig. 2) immediately west of the West Branch of the Pleasanton fault show a depressed surface, indicating that the fault acts as a low-permeability barrier, inhibiting flow from east to west. (Water-surface contours were plotted from borehole data collected in the early Summer of 1963 and Spring of 1964, and from well records furnished by the Calif. Dept. of Water Resources.) Contours of sand-to-clay ratio (Fig. 3) correspond roughly to the water surface; an area of high clay content immediately west of the West Branch apparently corresponds to the depressed water surface shown in Fig. 2.

The effects of the Pleasanton faults on Quaternary and Recent alluvium, and the expression of the faults on the topographic surface (as evidenced by contrast in tone on aerial photographs taken in 1940 prior to construction of the military base) indicate that tectonic activity may be presently occurring in the area. For this reason, precise measurements across the faults were emphasized in the geodetic program.

GEODETIC INVESTIGATIONS, 1964-65

To determine the site's tectonic stability, the U. S. Coast and Geodetic Survey observed the following precise horizontal and vertical control networks for LRL:

(1) remeasurement of a large-area triangulation network covering the Livermore Valley area;

(2) precise horizontal and vertical measurements of quadrilateral figures spanning the Pleasanton faults in Camp Parks, and a four-monument, in-line figure spanning the Calaveras fault (accuracy for triangulation: triangles close to within 1 second);

(3) installation of a network of bench marks and its precise leveling from Pleasanton through Camp Parks (accuracy for leveling: loops close to within 3 mm X square root of their distance in kilometers).

Figure 1 shows the location and layout of the networks.

The bench marks comprising the Camp Parks network are of three general kinds. The most substantial type (Fig. 4) was designed and established for horizontal and vertical measurements by the Accelerator Study Group early in 1964. Large 40-foot bore holes (18 inches in diameter) were filled with concrete to near the ground surface. This depth was considered adequate to isolate the monuments from motion caused by surface phenomena. The monuments, 16 inches in finished diameter, were established at corners of selected "fault strain quadrilaterals" spanning the Pleasanton and Pleasanton East Branch faults. A line of similar monuments was established on the centerline of Dublin Boulevard, with two on each side of the Calaveras fault. Typical sections of the deep monuments are shown on Fig. 4. The quadrilaterals and the line, planned to afford a means for detecting and monitoring small horizontal and vertical ground movements, are believed to be responsive to ground movement at the 40-ft depth. A second type of monument consisted of a concrete protective mass surrounding the top of, but free from contact with, a copper-weld rod driven to refusal at depths varying from 25 to 104 feet. Copper nails were set in the concrete for use as surface bench marks. The rods are believed to be responsive to vertical movement at the depth to which driven, but lack the necessary rigidity to suffice for horizontal measurements. The third type of monument is a traditional 4-foot-long concrete post, the top of which is flush with the surface of the ground. It may reflect both horizontal and vertical surface movements.

REGIONAL HORIZONTAL MOVEMENT

The network of first-order triangulation established by the U. S. Coast and Geodetic Survey in 1947 and 1948 was reoccupied in 1964. The triangulation stations occupied were as follows:

LIVERMORE EAST BASE 1947

LIVERMORE WEST BASE 1947

VERN 1947

DOOLAN 1947, replaced by DOOLAN 2, 1957

ALAMO 1947

FALLON 1946

The Livermore Base Line was remeasured by means of a Model 2-A geodimeter, and the overall length found consistent with taped lengths measured in 1948 (i.e., 1 part in 145 000).

The remeasurement of the Livermore Valley net in 1964 showed that no appreciable horizontal movement had occurred since 1948. The net is encompassed by the larger quadrilateral, MOCHO-MT. DIABLO-MT. TAMALPAIS-SIERRA MORENA, described by Whitten (1959). A later report by Parkin (1965) indicates that considerable clockwise distortion with respect to a fixed line, MT. DIABLO-MOCHO, occurred in that quadrilateral between 1951 and 1957; from 1957 to 1963 very little distortion occurred. The quiescence of the Livermore Valley area from 1948 to 1964 is not compatible with indicated movement in the larger quadrilateral. This means that from 1948 to 1964 the Livermore Valley did not undergo appreciable differential horizontal strain.

FAULT MOVEMENT

Remeasurement after one year of the quadrilaterals spanning the Pleasanton faults, and the line of monuments spanning the Calaveras fault indicates very small but consistent horizontal displacement. The discrepancies between the 1964 and 1965 measurements are plotted as vectors along with vertical control data on Fig. 5. Lengths of the vectors are not conclusive evidence of the magnitudes of the horizontal movements because of the shortness of the time base (one year). However, the apparent clockwise directional trend on the quadrilaterals is significant, indicating a right-lateral component across the Pleasanton faults. The vectors indicate an apparent shortening of the line spanning the Calaveras fault with a slight right-lateral component.

Combining vertical and horizontal components across the Calaveras fault suggests a thrusting resultant with the west side moving over the east. This is compatible with the observed westward dip of the fault plane at the Calaveras Dam (Hall, 1958) (about 15 miles south of Camp Parks), and stratigraphic indications of a down-thrown east side.

VERTICAL MOVEMENT SURVEYS

The specifications for the precise leveling and the subsequent methods used were planned to achieve meaningful ground-movement data in the shortest practicable time.

Repetition of the first-order leveling over the network of bench marks indicated definite ground subsidence in the Amador and San Ramon Valleys. The Pleasanton fault in the Camp Parks area forms the eastern border of the San Ramon Valley subsidence area, the Calaveras fault the western border. The Pleasanton East Branch fault and Parks fault do not seem to influence the subsidence. Active pumping is presently underway about 1 mile east of the Calaveras monument line in the subsidence basin. This groundwater supplies the rapidly growing residential developments in the area.

Precise first-order leveling was run over the networks of bench marks and triangulation stations in May 1964 and again in June 1965. Comparable methods and instruments and use of the same field party on both occasions guarded against detraction in accuracy through differing techniques.

Figures 6 and 7 show the elevation discrepancies in the 13-month period at depth and at the surface. Discrepancies in Fig. 6 result from comparisons in which the elevation of Bench Mark B-8 near Sunol was held constant on both years. Figure 7 results from comparisons of the surveys of surface bench marks, also measured with respect to Bench Mark B-8 near Sunol. Differential vertical movement between the surface and underlying firm material is evident.

If, despite all known precautions, small accumulative or compensatory errors exist in the surveys, they are more likely to become significant with increasing distance from the origin. Selection of Bench Mark P-1 in Camp Parks as a base instead of Bench Mark B-8 near Sunol (see Fig. 1) facilitates interpretation and tends to obviate the magnitude of error accumulation. Figures 8 and 9 show the elevation discrepancies derived by equating at P-1 rather than at B-8. Figure 8 shows zero discrepancies over part of the primary area of interest, eliminates almost all of the indications of uplift (which are questionable), and provides a reasonable scattering of subsidence indications east of the Pleasanton fault and north of U. S. 50 that are generally too small (1 to 3 mm) to be conclusive.

Comparison of Figs. 7 and 9 shows that equating the surveys at P-1 does not make the surface bench mark discrepancies entirely reasonable. The magnitude of the uplift indications is decreased and the subsidence indications are increased; this condition is more acceptable than the reverse.

We had considered that the Parks fault (Fig. 1), striking nearly east-west about one mile south of Camp Parks, would serve as a "buffer," similar to the Pleasanton faults, isolating the Camp Parks area from expected water-withdrawal subsidence in the Amador Valley. This expectation was based on the Thronsen and Hansen (1963) study of the Livermore Valley groundwater regime, in which the Parks fault was shown as a low-permeability barrier, inhibiting the southward flow of groundwater from the northern recharge area into aquifers in the valley alluvium. Examination of the vertical-control contour map (Fig. 6) indicates that the Parks fault does not appreciably affect the subsidence contours as does the West Branch of the Pleasanton fault. This may be due perhaps, to the present introduction of South Bay Aqueduct water into valley aquifers northeast of Pleasanton, retarding subsidence in the groundwater sub-basin bounded by the Pleasanton and Livermore faults.

CONCLUSIONS

It is doubtful if successive geodetic surveys for earth movement have ever shown as much consistency. The horizontal survey discrepancy vectors are consistently clockwise with reference to the points held fixed, but are too small in magnitude to be entirely acceptable as proof of horizontal ground movement without further measurable movement at the Pleasanton fault line. The Pleasanton fault is evidently a barrier or partial barrier to groundwater and accounts for differential subsidence with respect to the fault.

Although minor in magnitude, vertical differential ground movement is shown at the Calaveras fault. The differential movement on the east portion of the Calaveras fault monument line is undoubtedly ground subsidence. The higher elevations of the two stations west of the fault on this line may represent a small survey-error accumulation and datum discrepancy and should not be interpreted as uplift, yet. If horizontal movement is confirmed here by later repetitions, a good case will have been made for thrusting movement. Geological evidence of thrust faulting has been reported elsewhere along the Calaveras fault.

We must not rule out the possibility of tectonic downward movement of the valley block along the border faults, and this may indeed be the background upon which the water withdrawal subsidence is superimposed.

The Lawrence Radiation Laboratory is unable to continue support of remeasurements over these networks. An important contribution awaits the organization with authority in earth sciences and incentive to continue the investigations for a few more years.

This work was done under the auspices of the U. S. Atomic Energy Commission.

The cooperation of the U. S. Coast and Geodetic Survey who performed the geodetic work is gratefully acknowledged.

REFERENCES CITED

C. A. Hall, Geology and Paleontology of the Pleasanton Area, Alameda and Contra Costa Counties, California, Univ. of Calif. publications in Geological Sciences, Vol. 34, No. 1, pp. 1-90, 1958.

E. J. Parkin, Vicinity of Hayward, California, Study of Earth Movement Determined by Triangulation 1951-1957-1963; U. S. Coast and Geodetic Survey unpublished report dated April 1965.

R. E. Thronsen and W. R. Hansen, Ground Water Geology of Alameda County Area, Appendix C (p. 151) in Alameda County Investigation, Calif. Dept. of Water Resources Bulletin 13, March 1963.

C. A. Whitten, Notes on Remeasurement of Triangulation in the Vicinity of San Francisco, California Div. of Mines Special Report 57, p. 57, 1959.

FIGURE CAPTIONS

Figure 1. Geologic map also showing the geodetic network in the vicinity of the Livermore and Amador Valleys, Alameda Co., Calif. Geologic base after Thronsen and Hansen (1963).

Geologic symbols

Qal	Quaternary alluvium	K	Cretaceous formations
TQl	Livermore gravels	—— $\frac{U}{D}$ – –	upthrown downthrown fault
Tpo	Orinda formation	– – – –	location approximate
Tm	Miocene formations	· · · ·	location inferred

Geodetic symbols

⊛	Deep concrete monuments	o	Large area triangulation stations

– – – Leveling traverses

Figure 2. Contours on ground-water surface in Camp Parks alluvium. Shaded area is Orinda formation. Datum is sea level.

Figure 3. Contours of sand/clay ratio in upper 40 feet of Camp Parks alluvium. Shaded area is Orinda formation.

Figure 4. Cross sections of deep concrete monuments.

Figure 5. Diagram showing horizontal and vertical movement from May 1964 to June 1965 in Camp Parks area. Vectors indicate horizontal movement; numerals indicate vertical movement. Vertical discrepancies in thousandths of a foot. Data taken from deep concrete monuments. (a) Fault strain quadrilaterals. Vertical discrepancies

equated at bench mark P-1. (b) Dublin Boulevard line. Vertical discrepancies equated at bench mark B-8 near Sunol.

Figure 6. Contours showing vertical movement at depth from May 1964 to June 1965 in the Camp Parks area. Vertical discrepancies equated at B-8 near Sunol. Values in thousandths of a foot.

Figure 7. Contours showing vertical movement of the surface in May 1964 and June 1965 in the Camp Parks area. Measurements made on surface bench marks equated with respect to B-8 near Sunol. Values in thousandths of a foot.

Figure 8. Values of vertical movement at depth in the Camp Parks area. Measurements made from deep-seated bench marks equated with respect to P-1. Values in thousandths of a foot.

Figure 9. Values of vertical movement at the surface in the Camp Parks area. Measurements made on surface bench marks equated at P-1. Values in thousandths of a foot.

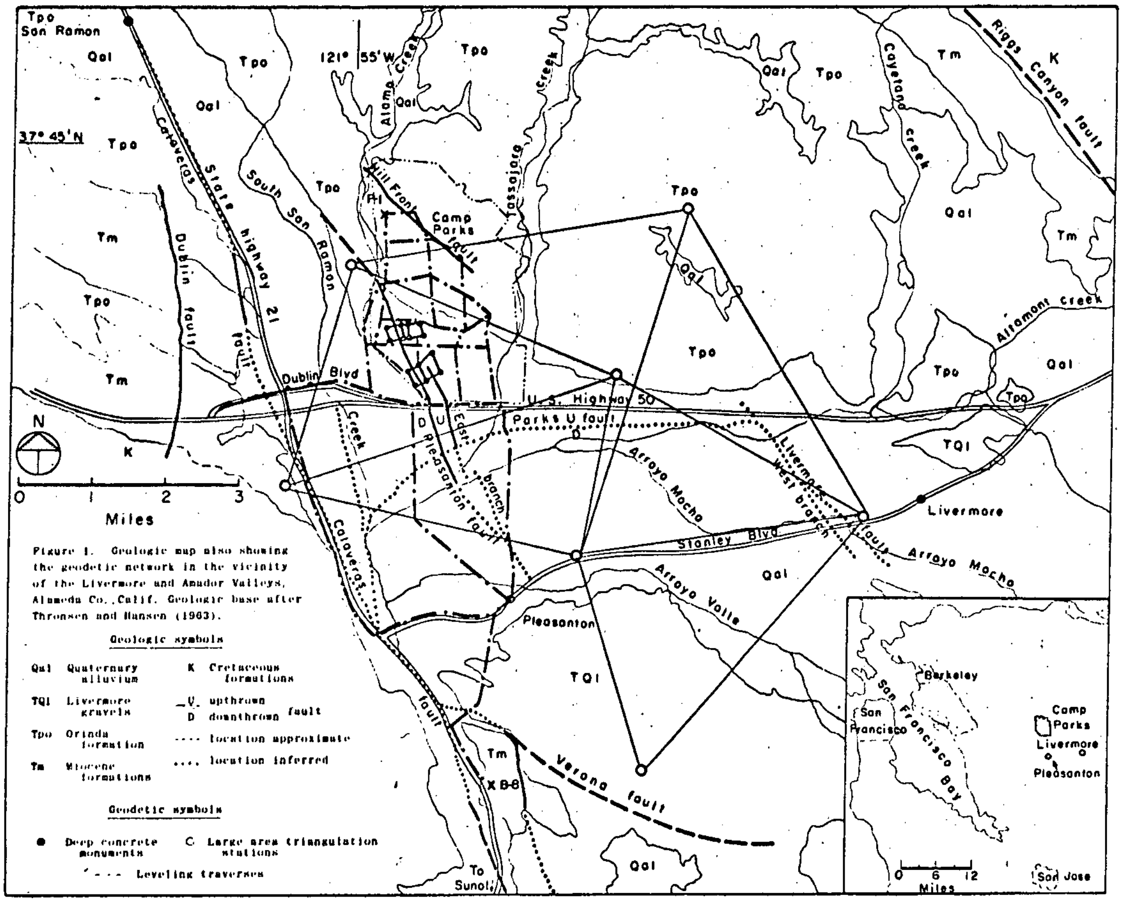


Figure 1. Geologic map also showing the geodetic network in the vicinity of the Livermore and Amador Valleys, Alameda Co., Calif. Geologic base after Thronsen and Hansen (1963).

Fig. 1

XBL671-201

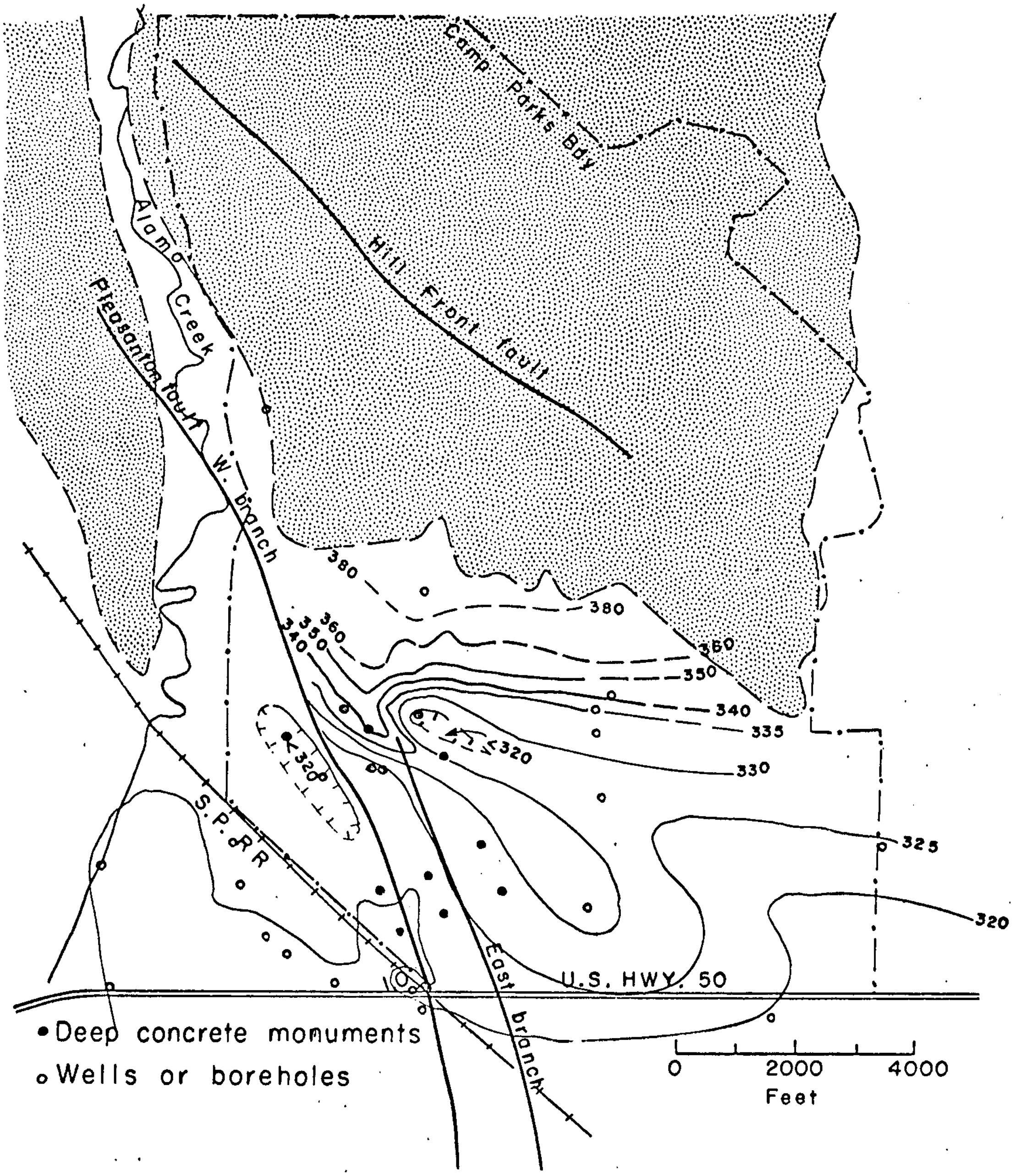
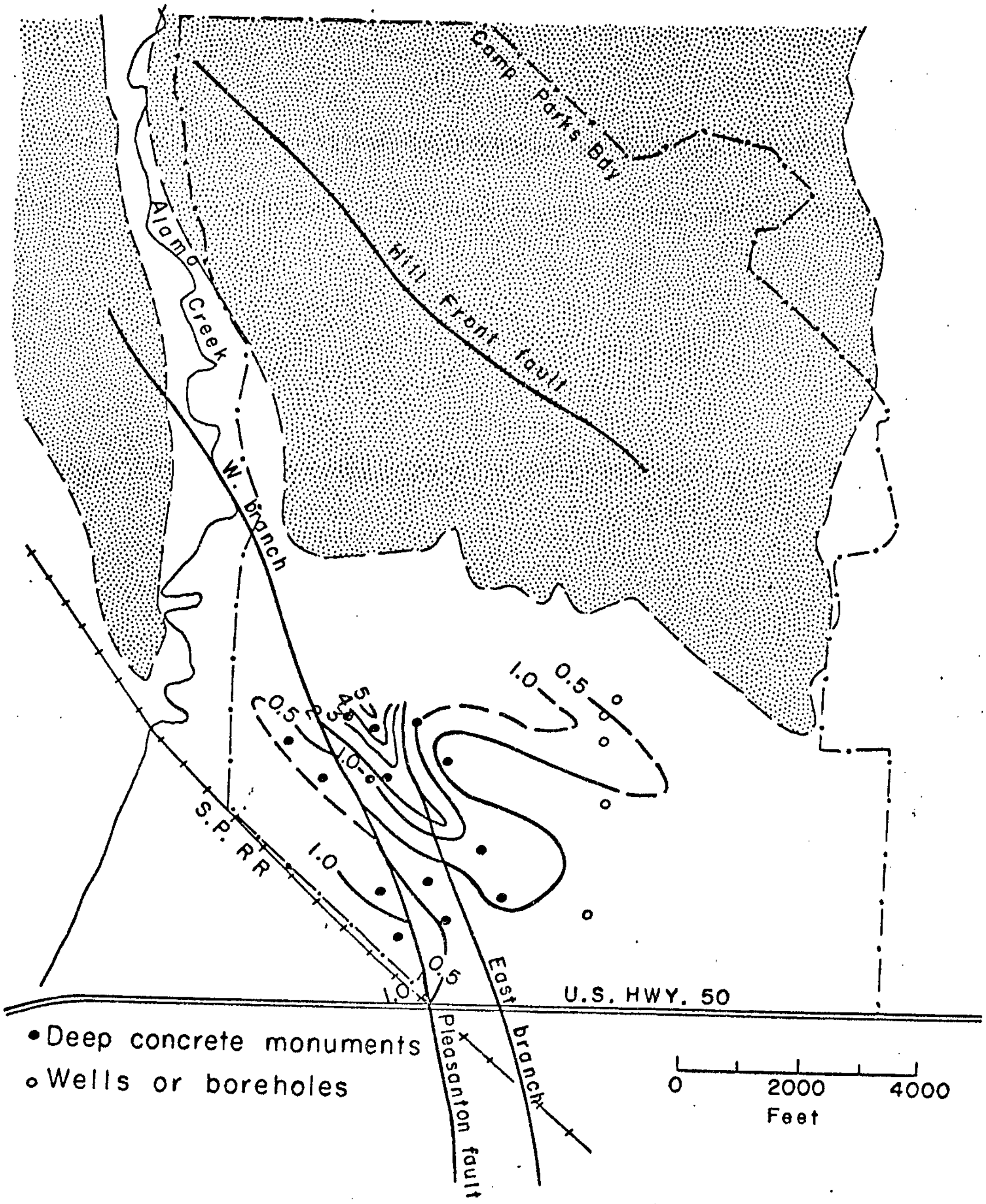


Fig. 2

XBL671-198



XBL671-194

Fig. 3

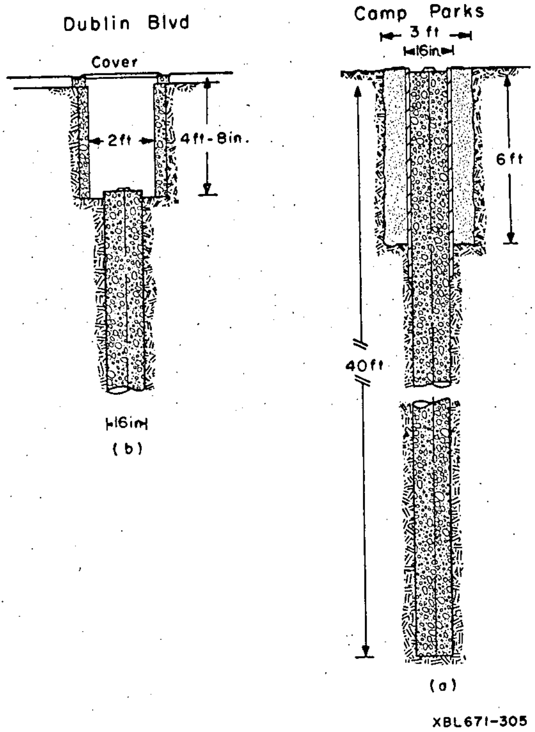

Dublin Blvd
Cover
2 ft
4 ft - 8 in.
16 in
(b)
Camp Parks
3 ft
16 in
6 ft
40 ft
(a)
XBL671-305

Fig. 4

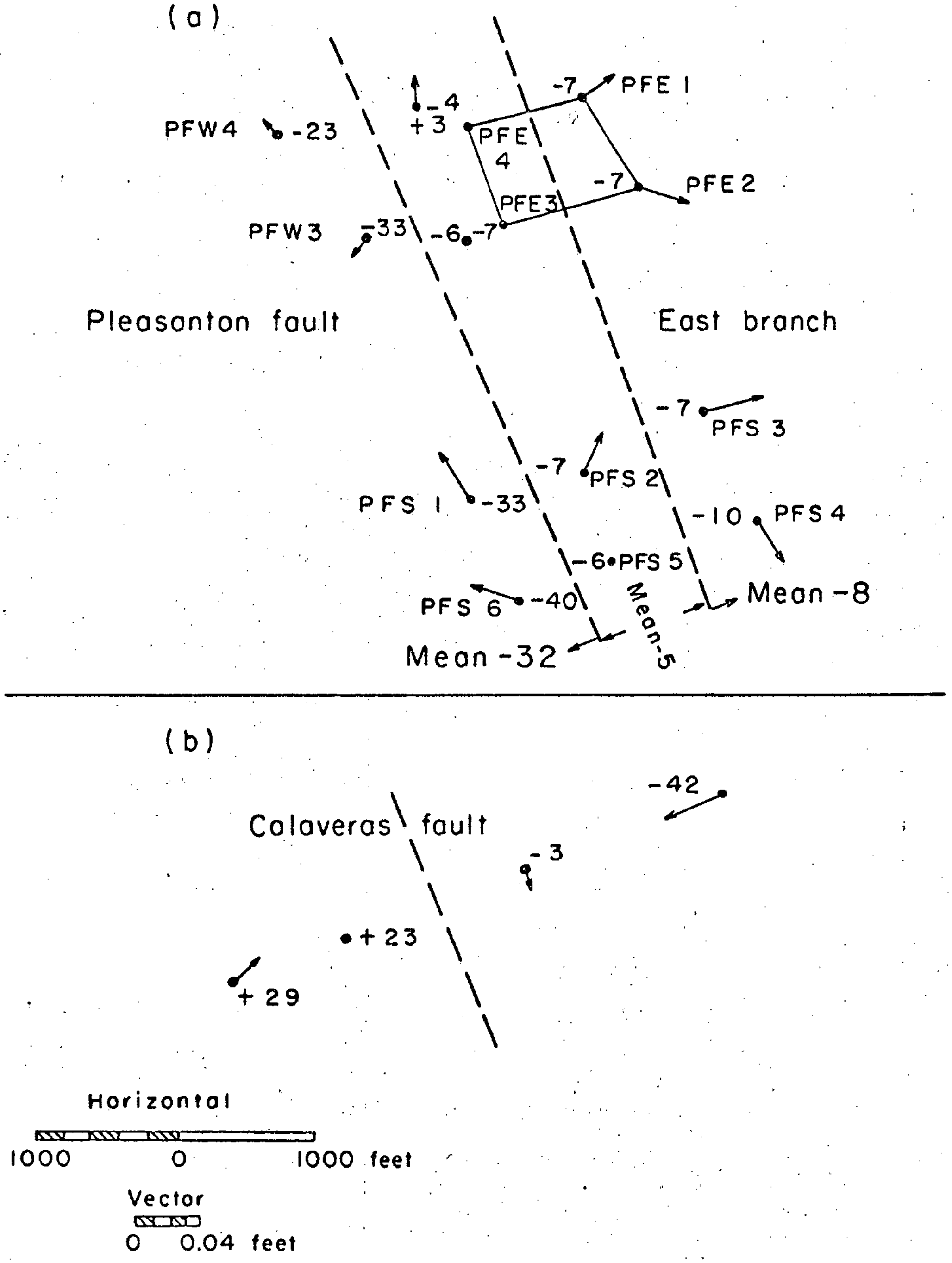


Fig. 5

XBL671-197

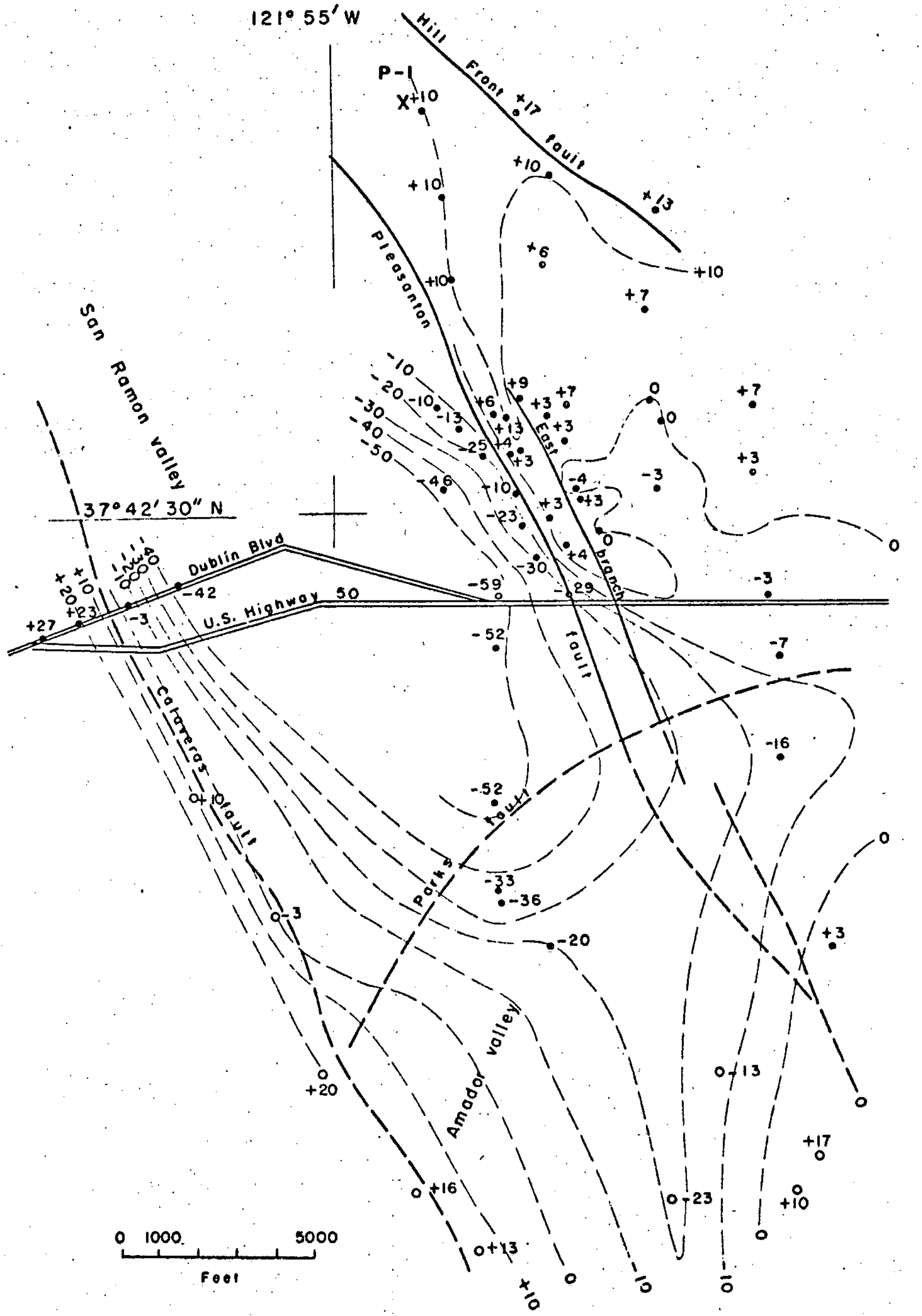
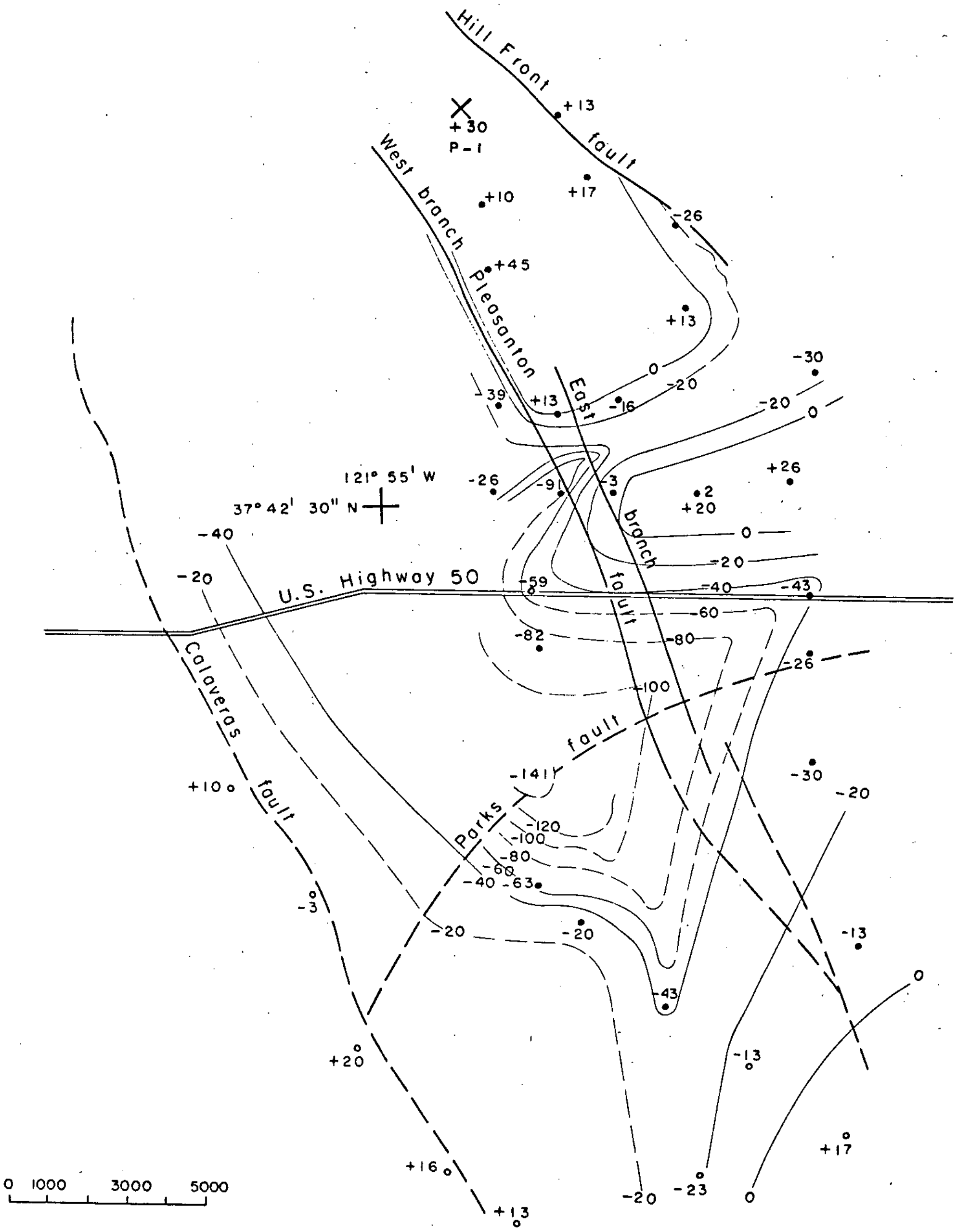


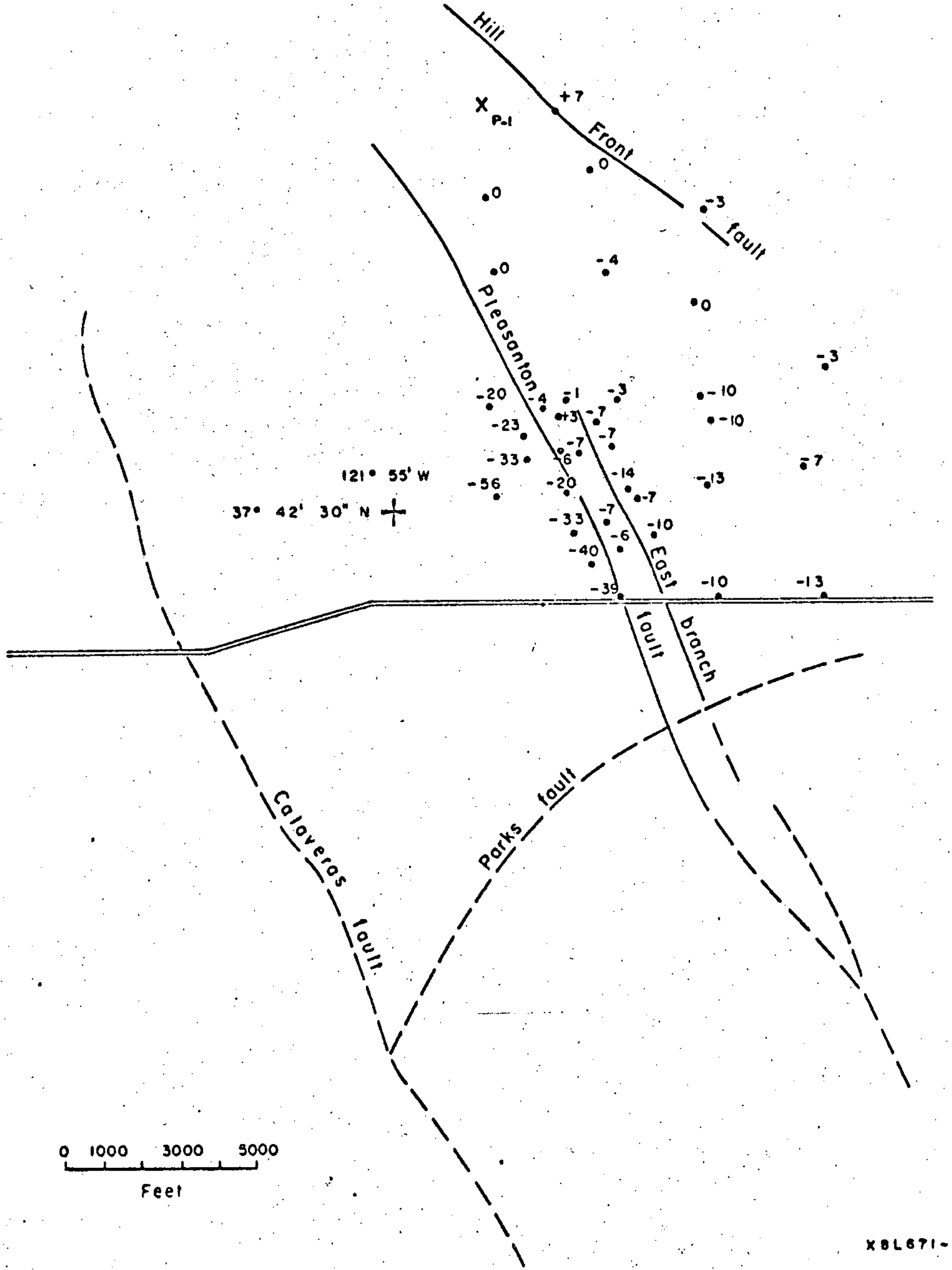
Fig. 6

XBL 671-199



XBL671-196

Fig. 7



XBL671-200

Fig. 8

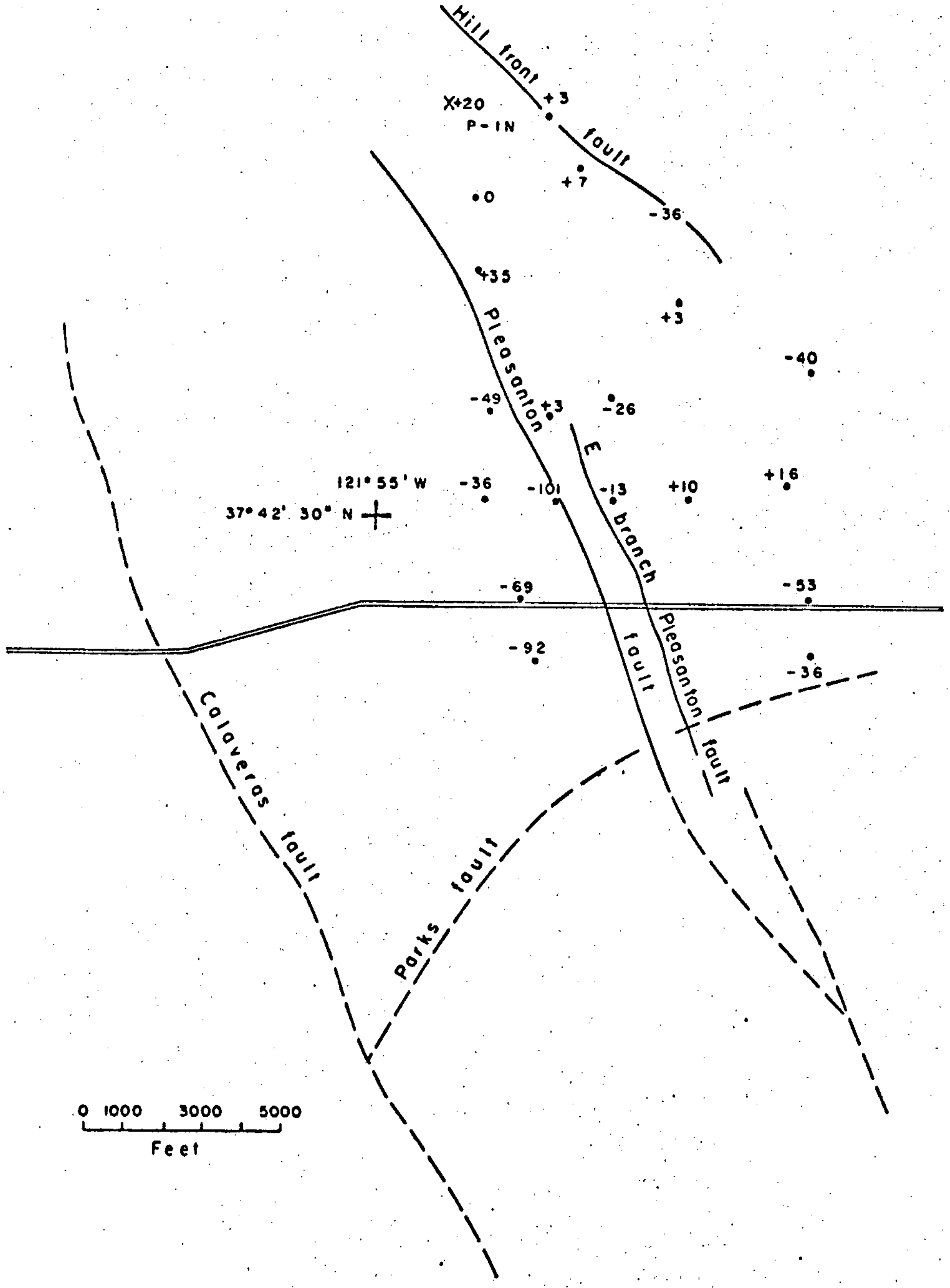


Fig. 9

XBL671-195