DRY TILT AND NEARFIELD GEODETIC INVESTIGATIONS OF CRUSTAL MOVEMENTS, SOUTHERN CALIFORNIA

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REPORT SUMMARY

Dry Tilt and Nearfield Geodetic Investigations
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Investigations

By means of telescopic spirit leveling (dry tilt) of small aperture triangular arrays, precision leveling of short lines across faults, and precision surveying of alignment arrays and trilateration networks, we have been monitoring the following physical phenomena within the southern California uplift and in other areas of potentially active crustal movement:

1. The regional pattern and timing of tilt, if any, and
2. The nature of strain accumulation and release, if any, across well-defined active and potentially active faults.

During 1979-80 we resurveyed 49 dry tilt arrays from 2 to 10 times each. Most of the arrays are located along the San Andreas fault zone from Frazier Park to Cajon Pass. Others are located along the frontal fault system of the San Gabriel Mountains. Twenty-four of the arrays have been in place nearly 4 years, and others have been added more recently.

We have established 19 short level lines across active faults in such diverse places as San Fernando, Death Valley, Palmdale, San Juan Bautista and Santa Barbara. Some of these lines were established 10 years ago and have accumulated as many as 14 resurveys. Two lines, one across the San Andreas fault near Valyermo, and one across the Llano fault 30 km east of Palmdale, were established in the present contract period.

Two leveled alignment arrays established four years ago across the San Andreas fault were resurveyed twice each in the past year.

Thirteen trilateration arrays have been established across several faults in southern California in the last three years. Only those across the Santa Cruz Island fault zone were surveyed in the past year.

Results

We have observed no local or regional tilt activity which we would regard as anomalous, and indeed there has been no earthquake activity in the study area which would be expected to have produced such activity. Thus, the anomalous tilts we observed in the Juniper Hills-Lake Hughes area in Winter and Spring of 1978 ceased in the late 1978 and 1979, just as the earthquake swarm activity there has also ceased along that segment of the San Andreas fault zone.

With one exception, resurveys of the short level lines have documented only non-tectonic effects related to thermoclasticity and subsidence related to withdrawal of groundwater for agricultural irrigation. Where the irrigation is fairly continuous and involved large withdrawal volumes that exceed recharge rates (San Juan Bautista, Duravan Ranch), the subsidence is episodic in detail but continuous in annual rate and direction. Where the withdrawal is of small volume and less than presumed recharge rates (Pallett Creek) the subsidence is small, 1 mm over a line length of 200 m, and recovers completely when the well is not pumped.

The exception is the Mesa Valley Farm leveled alignment array located across the most recently active trace of the San Andreas fault between Gorman and Frazier Park. Precise leveling shows that 3 mm differential vertical separation has taken place between July 1978 and August 1980. This is a stretch of the fault which is not known to have moved since at least 1911 if not 1857. The separation corresponds temporally with the stress changes observed by others across the San Andreas fault in southern California and may be the surficial strain manifestation of the stress changes.

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INTRODUCTION

The Problem

The inevitability of major damaging earthquakes in California and the possibility that the southern California uplift (Castle and others, 1976; 1977) may represent a precursor of such an earthquake spawned an intensive and comprehensive investigation of geophysical phenomena related to earthquakes with the ultimate objective of being able to predict earthquakes. However, even as those studies have progressed, the very existence of the southern California uplift has been a subject of controversy and considerable debate (e.g. Jackson and Lee, 1979).

In the meantime, this study of tilt and nearfield strain is one of the many studies being conducted by numerous agencies and institutions to determine whether or not southern California is undergoing the preparatory stages for a major earthquake.

Thus, by means of telescopic spirit leveling (dry tilt), precision leveling of short lines across faults, and precision surveying of alignment arrays and trilateration networks, we are attempting to document the following physical phenomena near potentially active faults in southern California.

1) The regional pattern and timing of tilt, if any, and
2) The nature of strain accumulation and release, if any, across well-defined fault traces.

The Methods

Dry Tilt - The techniques and equipment used in dry tilt are described by Kinoshita and others (1974) and Sylvester (1978b). In general, the dry tilt method of measuring crustal tilt utilizes a precision optical level in the center of an array of three precision leveling rods set on each of three or more permanent benchmarks geometrically arranged at the apices of a triangle having side lengths of from 30 to 40 m. Tilt vectors are calculated from elevation changes of the benchmarks.

Details on site selection, monument installation and survey procedures and errors are given in previous technical reports (Sylvester, 1977a; 1978a) and by Sylvester (1978b). The accuracy of the dry tilt method is from 3 to 4 μrad in Hawaii (Kinoshita and others, 1974) and from 3 to 5 μrad in southern California (Sylvester, 1978b).

Four years of accumulated surveys have yielded a variety of data ranging from a nearly unambiguous precursory tilt prior to a major earthquake (M 5.7), to equally clear tilt signals which we believe are related to an earthquake swarm on the San Andreas fault (Sylvester, Mowles and Frischer, 1979), to data that can best be catagorized as random noise. We have established redundant arrays at about half of the sites and have been getting good correspondence with the primary arrays in the last year. These observations are discussed below and are illustrated by data plotted variously in terms of N and E components (Appendix I).

Short Level Lines - Short level lines (200 to 1600 m), comprised almost entirely of permanent benchmarks no more than 40 m apart throughout the line, are surveyed according to First Order, First Class procedures using either a shaded Wild N3 precision tilting level or a Wild NAK2 Automatic level and Wild GPL-3 invar precision leveling rods. The acceptable closure error in these surveys may not exceed 1 mm x distance$^{1/2}$ in kilometers in our procedure and specifications.

Leveled Alignment Arrays - Leveled alignment arrays consist of from 12 to 20 permanent benchmarks set in a line from 65 to 100 m long. The line is centered on, and is oriented approximately perpendicular to, a well-defined fault trace. A theodolite is erected at one end of the line, and brightly marked precision calipers are used to measure the horizontal deflection of each monument with respect to a reference line given by the theodolite. This technique has been used to document creep on the San Andreas fault in central California (Nason and Tocher, 1970; Nason, 1971; Rogers and Nason, 1971; Harsh, 1977; Burford and Harsh, 1980). Terrain permitting, we also level the benchmarks or our alignment arrays so that slip is uniquely determined.

Trilateration Arrays - Repeated surveys of small aperture quadrilaterals are done routinely by many investigators to document horizontal movement on faults. Quadrilaterals are nearly square or rectangular arrays of generally four to six permanent benchmarks with side lengths of from 50 to 2000 m. The geometry of the array is measured by repeated trilateration using an electronic distance meter (EDM).

DRY TILT

Array Locations

We have established 49 dry tilt arrays in and around the southern California uplift as defined originally by Castle and others (1976). Location data and survey histories of each individual dry tilt array are given in Table I. Most of the arrays straddle the San Andreas fault zone (Fig. 1); some are located along the frontal faults of the San Gabriel Mountains to test Thatcher's (1976) hypothesis that the southern California uplift may presage an earthquake along that fault system; other arrays, such as those in Santa Barbara and the Mojave Desert, are purposely located at the periphery of the uplift to test surveying procedures, background noise, and to document the aerial extent of tilting, if any, related to the central part of the uplifted area.

Dry Tilt Results

General Statement - All of the results over four years can be summarized by the statement that no consistent patterns or anomalies emerge throughout the network as a whole that indicate regional or local tilt which can be sensibly attributed to the kind of regional tectonics that are believed to produce the southern California uplift. This conclusion is reached from qualitative analysis of synoptic tilt vector maps compiled for the network on monthly, seasonal and annual bases (not presented in this report). On the other hand, a noteworthy exception to this generalization took place on 11 of 24 dry tilt arrays extant in 1978. In the winter and spring of that year each of the 11 arrays shows a significant tilt excursion ranging from 25 to 315 μrad.

We postulated that the tilts near the San Andreas fault may be related to the earthquake swarm activity along the San Andreas fault which occurred in 1976-1977 (Sylvester, 1979; Sylvester, Mowles and Frischer, 1979). According to McNally and Kanamori (1977) and McNally and others (1978) a swarm of small earthquakes occurred on or near the Palmdale segment of the San Andreas fault between November 1976 and March 1977, and in fact, continued throughout most of 1978 into 1979 (K. McNally, personal communication, 1979). The earthquake epicenters are clustered in two geographic areas, Juniper Hills and Lake Hughes, with little or no earthquake activity between the two clusters. The timing of the tilt anomalies progressed from NW to SE along the San Andreas fault.

Clearly the earthquake swarms were manifestations of strain release along two patches of the fault. We postulated that the tilt anomalies were a manifestation of strain release along the San Andreas between the two clusters of swarms. The release of strain was slow, perhaps a slow earthquake in the terminology of Sacks (1978), occurring over a period of as much as 20 weeks, judging by the commencement of tilt on our arrays. Sacks (1978) reported that propagation velocities for vertical strain events are about 2 km/month. Our data are permissive to infer that the release (or accumulation) of strain proceeded from NW to SE in the gap along the San Andreas fault between the two earthquake clusters. Lisowski and Savage (1979) report no horizontal strain event of magnitude greater than a few parts per million was observed in the Juniper Hills area in the time interval 1971-1977. Our tilt data however, suggest that a significant release of strain did occur in 1978, and may be related to the strain events Savage (1979) and Niell (1979) have observed in 1979 and 1980. But in the present contract period, 1979-80, we have not observed any unusual excursions on any of the dry tilt arrays, and indeed there has been no seismic activity anywhere near our arrays that should be expected to have produced tilts at any of our sites.

SHORT LEVEL LINES

Short level lines yield reliable information about relative vertical crustal movements across faults and if the arrays of benchmarks are non-linear, they can be used to determine tilt direction.

The locations of our short level lines are shown in Figure 2, and location and survey data are given in Table II. The lines in Santa Barbara and Death Valley were not surveyed during this contract period.

Pallett Creek

The Pallett Creek line was established to determine if vertical strain is occurring across the Punchbowl fault, which is a northwest-striking high angle reverse (and oblique slip?) fault that dips about 70° SW (Fig. 3). Dissected Quaternary fanglomerate overlies the fault and the associated crush zone, and they are not noticeably offset (Noble, 1954). Nevertheless, McNally and Kanamori (1977) found that some of the focal mechanisms in the Juniper Hills earthquake swarm are consistent with a SW-dipping thrust fault (McNally and others, 1978). This interpretation is not compatible with observed geologic displacements on the San Andreas fault in the area or with the surface dip of the Punchbowl fault which is the only major dip slip fault in the area.

The Pallett Creek level line comprises 70 permanent benchmarks in an irregular, generally N-S line 1600 m long (Fig. 4). So many permanent benchmarks yield a great degree of redundancy.

Relative to a leveling in August 1978, the line tilted relatively southward on the south of the Punchbowl fault about 1 microradian through March 1979. Between March and August 1979, it tilted relatively northward about 2 microradians and has remained there to July 1980. The simplest and most reasonable interpretation is that the flexing of the line is a thermoelastic effect. There are no other level lines or tiltmeters against which to check this interpretation, and the line is not optimally oriented to be sensitive to EW tilt.

An interesting manifestation of subsidence related to groundwater withdrawal shows up where the line crosses the Punchbowl fault (Fig. 4). The fault acts as a barrier and reservoir for groundwater that migrates from south to north. A water well is located in the fault zone and is pumped for irrigation, generally in late summer. Eight benchmarks across the fault zone subsided nearly one millimeter each in September 1978, then recovered fully by March 1979 relative to all other benchmarks in the line. In August 1979, the subsidence zone is even broader (200 m), but just as deep (1 mm) as in the previous year, and it recovered as shown by bulge in the July 1980 elevation across the fault zone.

San Juan Bautista

A level line one kilometer long was established in 1975 across the San Andreas fault where it has created a 15 m high scarp along the NE edge of the town of San Juan Bautista (Fig. 5). The purpose of the line is to determine whether or not vertical creep is occurring simultaneously with the well-documented horizontal creep (Nason and others, 1974).

Southwest of the fault the level line overlies crushed granite and a thin veneer of alluvium, whereas NE of the fault the benchmarks are driven deep into clay soil of San Juan Bautista Valley where groundwater is heavily pumped for irrigation.

The level line has been resurveyed 14 times (Fig. 6) with the only noteworthy results being the demonstrable instability of some of the benchmarks at the SW end of the line, and subsidence of the four benchmarks NE of the fault relative to a benchmark 200 m SW of the fault (Sylvester, Brown and Riggs, 1979). The four benchmarks subsided evenly in time and progressively with distance from the fault a maximum of 67 mm in 5 years. Sylvester, Brown and Riggs (1979) have argued that the progressive spatial and temporal subsidence over a broad zone is a manifestation of subsidence of San Juan Bautista Valley due to groundwater withdrawal.

Duravan Ranch

A precision level line consisting of 14 permanent benchmarks was established across a new fault at Duravan Ranch near Cantil in the Mojave Desert (Clark, 1974) in September, 1974(Fig. 7) to determine the nature and rate of vertical displacement.

The line was lengthened to 850 m by the addition of seven additional benchmarks in 1977. Studies to date indicate that the cause of the faulting is differential subsidence by groundwater withdrawal for agricultural purposes 8 km west of the ranch (Clark and others, 1978).

We have releveled the line 11 times and have found that the offset occurs right at the fault scarp (Fig. 8) rather than being spread over a zone, and it occurs almost regularly at an average rate of 35 mm per year (Sylvester, 1977a, 1977b).

Both fault blocks tilt basinward (NWW) at a rate of about 100 microradians per year as determined from two dry tilt arrays and from the elevation changes of any three nonlinear benchmarks in the level line on each side of the fault.

Timber Canyon

An L-shaped array of 10 permanent benchmarks in a line 322 m long was established on the surface of a broad alluvial fan in the Santa Clara River Valley (Fig. 2). The purpose of the array was to document crustal tilt related to the San Cayetano fault. Unfortunately several of the points were run over or plowed up by a bulldozer before a resurvey could be done, and we decided not to reestablish the line.

Grapevine

The SW corner of San Joaquin Valley in the vicinity of Wheeler Ridge is one of the most tectonically active parts of California. The Pleito thrust is one of the main faults between the San Joaquin Valley and the Transverse Ranges to the SW.

In 1979 we established a level line across a fault scarp marking the most recently active trace of the Pleito thrust (Fig. 9). The line contains 25 permanent benchmarks in a nearly linear distance of 800 m, including three preexisting benchmarks of the national Geodetic Survey's primary vertical control line from Tidal 8 (Long Beach Harbor) to Bakersfield. Two resurveys have been done since our initial survey of the line in August 1979 (Fig. 10). They show elevation changes of less than one millimeter which may represent the benchmarks equilibrating after installation, because the two repeated surveys are virtually identical with each other.

New Leveling Arrays

We established two non-linear leveling arrays during the contract period: Big Rock Springs (Fig. 11) and Llano (Fig. 12).

The array at Big Rock Springs comprises 24 permanent benchmarks in a Z-shaped line 394 m long. The line straddles the most recently active trace of the San Andreas fault which is marked by a scarp raised in the great earthquake of 1857. The initial leveling of the array was done in the late fall, 1980.

The Llano array is an irregularly Z-shaped array comprised of 26 permanent benchmarks in a line 619 m long across the Llano fault scarp in southeastern Antelope Valley. The fault forms a prominent, 10 m high, north-facing scarp in Late Pleistocene and Holocene alluvium (Guptill and others, 1979).

Reverse movement along the fault at depth has caused folding of the surficial sedimentary rocks. Except for development of a small scarp across an eroded part of the main scarp, reverse faulting has not propagated to the surface.

Leveled Alignment Arrays

We established leveled alignment arrays in 1976 at the only two sites within the Palmdale uplift where recent surficial cracks have been found along faults (Fig. 2 and Table III).

The array on Mesa Valley Farm (Fig. 13) straddles the most recently active trace of the San Andreas fault in Tejon Pass, about halfway between Frazier Park and Gorman. The fresh cracks in Tejon Pass are found on Peace Valley Road and highway I-5. The cracks on Peace Valley Road are vaguely en echelon, but are old enough to have had vegetation growing in them when we found them in 1976. Leveling, which is more than an order of magnitude more sensitive than aligning, revealed no displacement at the fault trace in 1976 and 1977, nor have several nail triangles across the cracks themselves.

But in the period June 1978-August 1980, 3mm differential vertical separation took place across the 1857 earthquake trace of the San Andreas fault without accompaniment of horizontal separation (Fig. 14). The 3mm elevation change is well within the precision limits of detection, and we regard it as real. The timing of the movement is constrained by only 3 levelings, but corresponds, in general, to timing of changes in regional horizontal components of stress (Savage, 1979). One can conclude permissively that the elevation changes we observe across this part of the fault are surficial manifestation of those regional stress changes. But much more compelling data would be desirable, so we upgraded the leveling line to an S-shaped array comprised of 20 permanent benchmarks in a line 410 m long (Fig. 13). The increased number of benchmarks in a non-linear arrangement will give us better control of the direction and amount of vertical separation over a broader part of the fault zone, and we intend to survey the array more frequently than once a year.

In December, 1976, Dave Beeby (CDMG) showed us fresh en echelon cracks in the road pavement in a major roadcut across the north branch of the Nadeau fault at 47th St. E in Palmdale (Fig. 15), and he told us the cracks were first noticed in 1972. We established a leveled alignment array across the fault about 100 m northwest of the roadcut, as well as nail triangles across the cracks. We have observed no elevation or length changes whatsoever in four years of monitoring. The general consensus about the origin of the cracks is that they formed as a result of hydration and dehydration of the relatively recently daylighted gouge in the roadcut. It is of interest to note here that the cracked section of road was patched in winter, 1977, obliterating the cracks, and that in spring, 1978, the cracks had reappeared through the patching, but with no observed changes in our geodetic figures.

TRILATERATION SURVEYS

We have established small aperture trilateration arrays across several faults in southern California to determine horizontal strain. Repeated surveys of small aperture arrays are done routinely elsewhere in California to document horizontal movement on the San Andreas and related faults (Harsh, 1977; Lisowski and Prescott, 1977). Several agencies, including the U.S. Geological Survey, the National Geodetic Survey and the California

Department of Water Resources regularly monitor trilateration arrays across the San Andreas fault in the Palmdale area. Most are large aperture arrays having line lengths greater than 10 km (Prescott and Savage, 1976) and they are resurveyed relatively infrequently (Lisowski and Savage, 1979).

We have established most of our arrays across active and potentially active faults that are not monitored by other agencies, such as the Santa Ynez, Santa Cruz Island and Death Valley faults. We reoccupy arrays previously established by other agencies on the San Andreas fault.

All surveys are done with a Hewlett-Packard Model 3808 electronic distance meter (EDM). The sensitivity of the instrument over line lengths of from 100 to 1000 m is 0.0024 m.

During the past year we resurveyed only the array across the Santa Cruz Island fault (Fig. 16). One of the monuments had been bulldozed since our last survey in 1978. We took the opportunity to establish and survey a larger, stronger, doubly-braced quadrilateral across the Santa Cruz Island fault at the same location as our other one.

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TABLES

TABLE I. LOCATION DATA FOR DRY TILT SITES, SOUTHERN CALIFORNIA

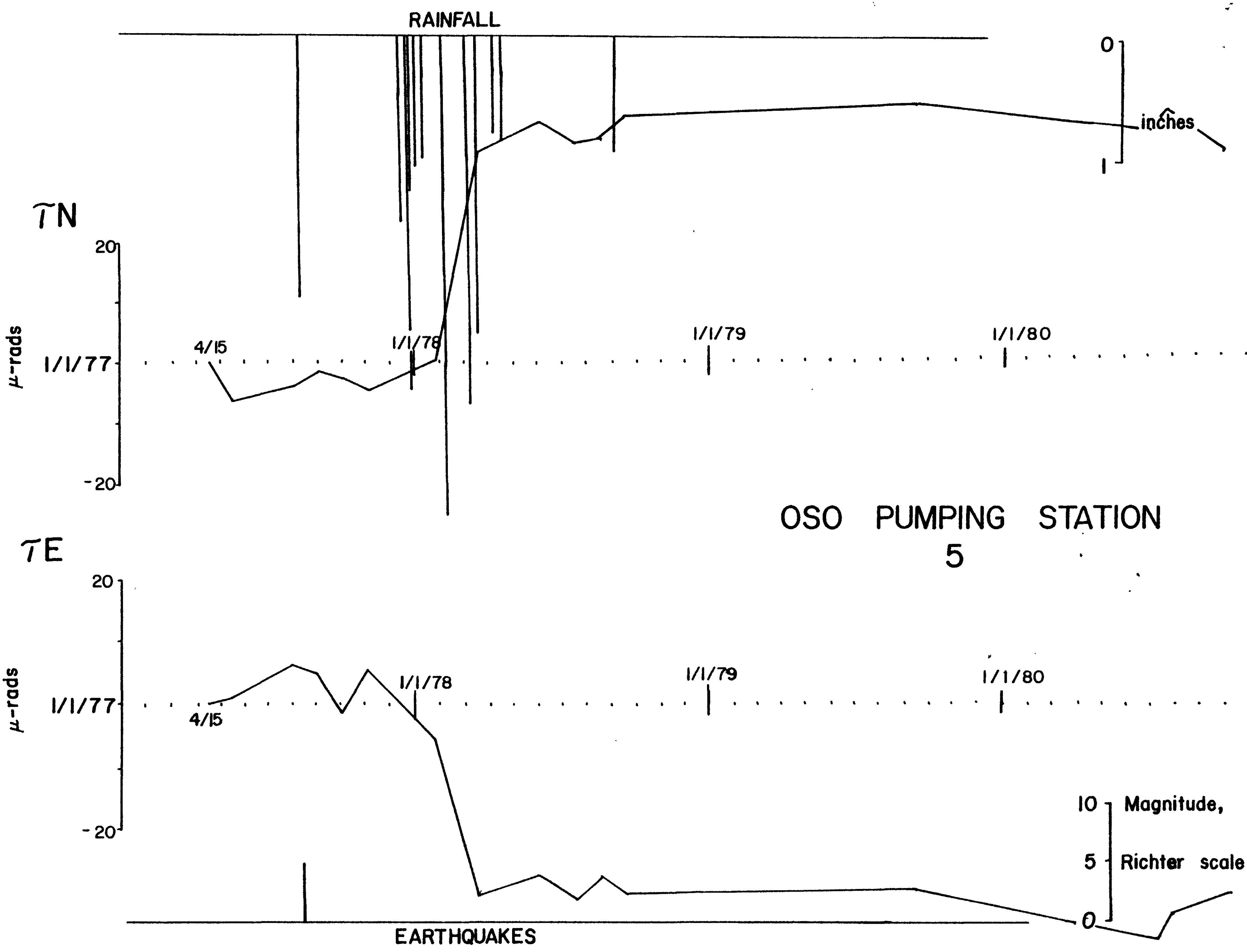
NAME	MAP#	LATITUDE	LONGITUDE	QUADRANGLE	ESTABLISH DATE	INITIAL SURVEY	MOST RECENT SURVEY	TOTAL SURVEYS
UCSB	1	34°24'54"	119°50'10"	Goleta	12/76	4/77	9/80	30
Jeffrey Pine Flat	2	34°48'26"	119°06'08"	Cuddy Valley	10/76	4/77	9/80	17
Cuddy Flat	3	34°50'25"	118°59'51"	Frazier Mtn.	11/76	4/77	9/80	19
Hungry Valley	4	34°44'15"	118°52'05"	Black Mtn.	10/76	2/77	9/80	21
Oso Pumping Station	5	34°48'44"	118°42'50"	La Liebre Ranch	12/76	4/77	9/80	15
Sawmill	6	34°41'52"	118°34'08"	Burnt Peak	11/76	3/77	9/80	20
Rye Canyon Road	7	34°25'30"	118°35'08"	Newhall	11/76	1/77	8/80	25
Drinkwater Flat	8	34°34'06"	118°27'49"	Green Valley	4/77	5/77	9/80	18
Indian Springs	9	34°42'12"	118°42'12"	Lake Hughes	11/76	4/77	9/80	20
Elizabeth Lake	10	34°40'03"	118°22'54"	Lake Hughes	11/76	4/77	9/80	27
Live Oak	11	34°22'45"	118°24'06"	Mint Canyon	12/76	1/77	8/80	29
Wentworth	12	34°15'29"	118°22'22"	Sunland	12/76	3/77	8/80	28
Escondido	13	34°30'00"	118°15'20"	Agua Dulce	8/77	8/77	9/80	18
Rose Bowl	14	34°09'25"	118°10'05"	Pasadena	12/76	3/77	9/80	29
Ave 25 E.	15	34°33'21"	118°05'04"	Palmdale	11/76	1/77	9/80	28
Pearblossom Cutoff	16	34°31'21"	118°05'45"	Palmdale	11/76	1/77	9/80	27
Soledad Pass	17	34°29'59"	118°07'08"	Pacifico Mtn.	11/76	1/77	9/80	28
90th St. E.	19	34°39'58"	117°58'05"	Littlerock	3/77	4/77	9/80	26
Longview	20	34°27'23"	117°54'02"	Juniper Hills	7/77	7/77	9/80	24
Azusa	21	34°09'41"	117°54'04"	Azusa	7/77	8/77	9/80	19
Aerojet	22	34°07'38"	117°55'38"	Azusa	7/77	8/77	9/80	20
Saddleback Butte	23	34°48'00"	117°41'30"	Hi Vista	12/76	3/77	9/80	27
Largo Vista	24	34°27'13"	117°45'55"	Valyermo	11/76	1/77	9/80	27
Blue Ridge	25	34°22'27"	117°41'20"	Mt. San Antonio	7/77	7/77	9/80	14
Upper Cajon Creek	26	34°22'36"	117°34'06"	Phelan	11/76	1/77	9/80	21
Cucamonga South	27	34°09'44"	117°31'05"	Cucamonga Peak	6/77	8/77	9/80	17
Cucamonga North	32	34°10'28"	117°32'11"	Cucamonga Peak	6/77	7/78	9/80	11

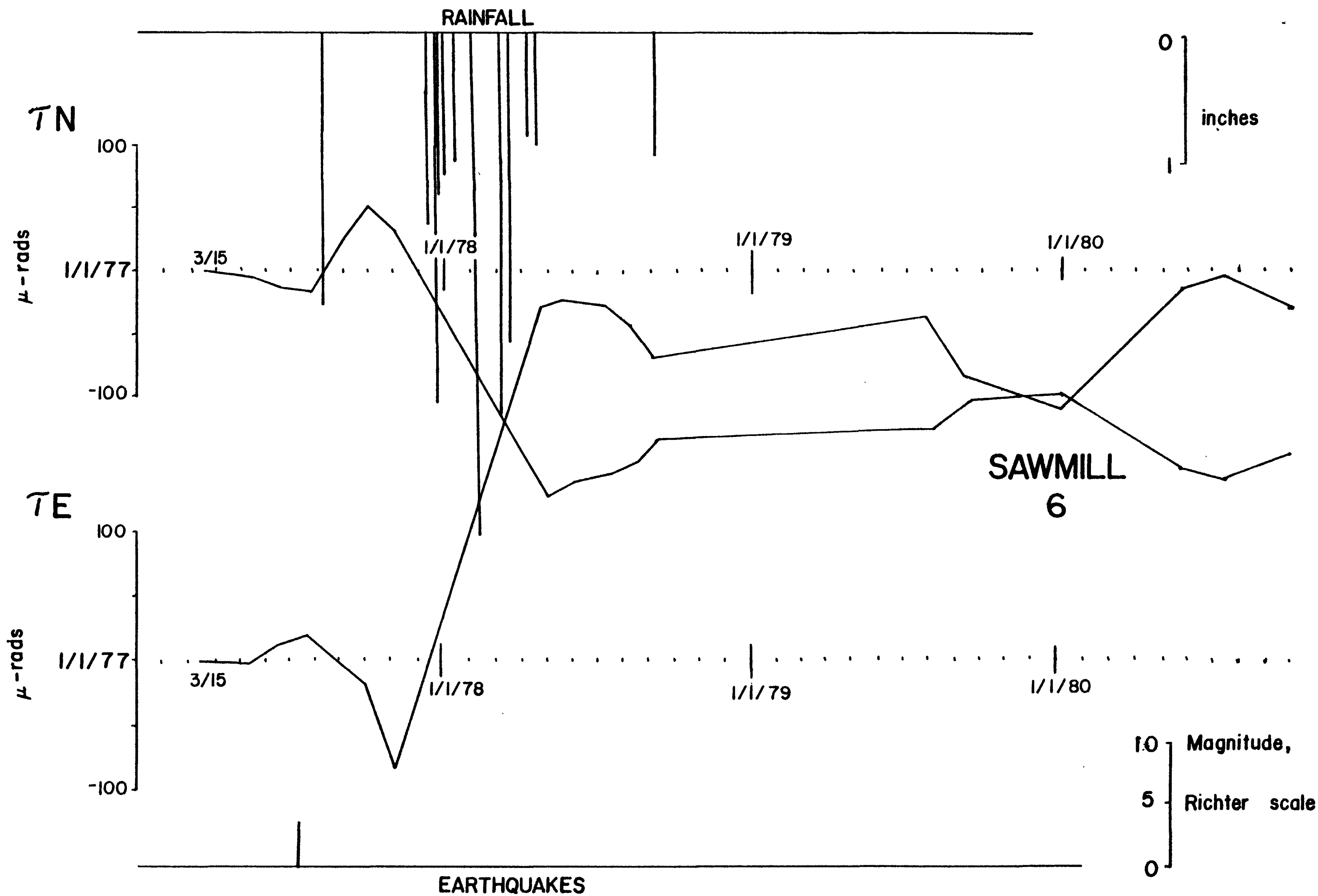
TABLE I (continued)

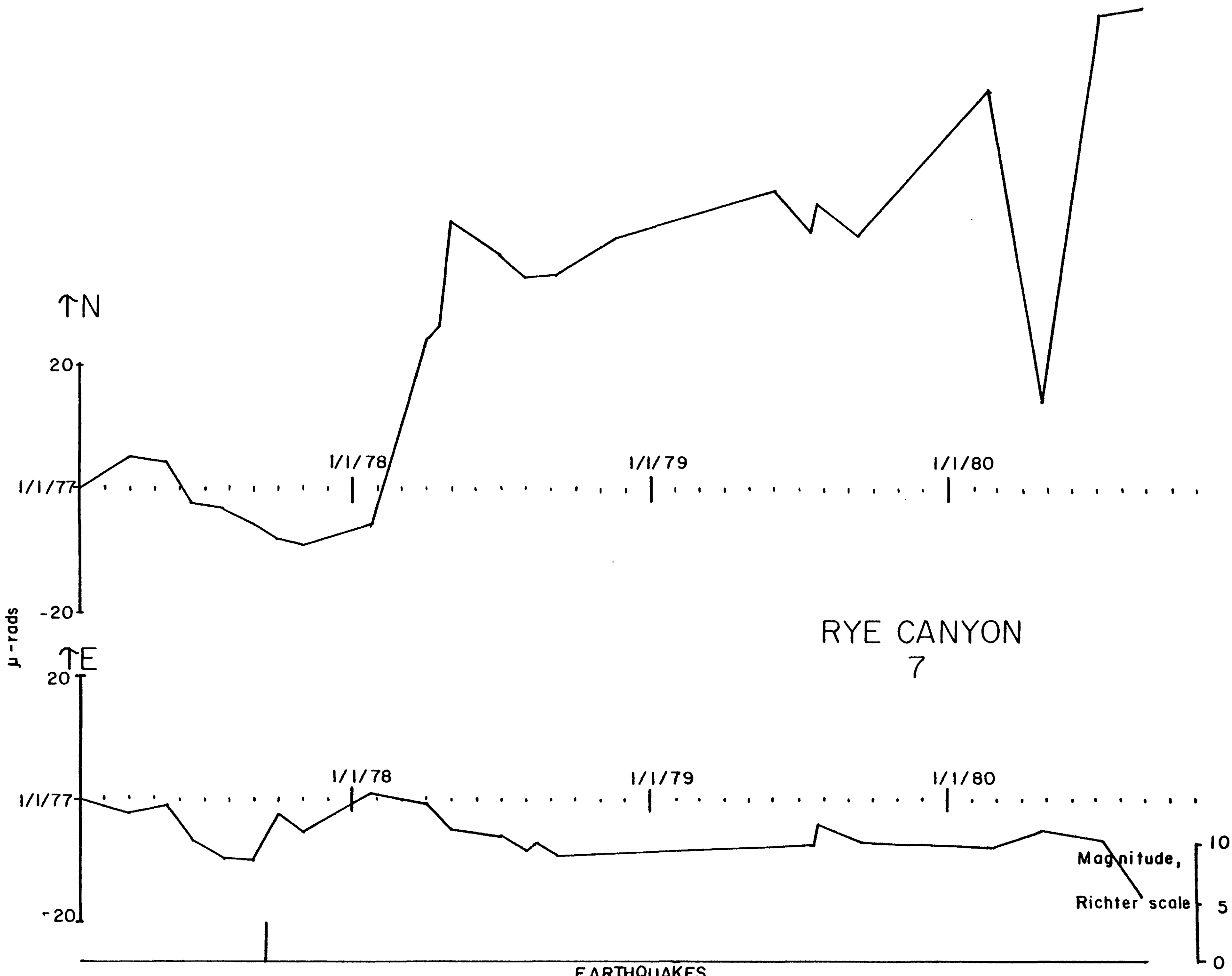
NAME	MAP#	LATITUDE	LONGITUDE	QUADRANGLE	ESTABLISH DATE	INITIAL SURVEY	MOST RECENT SURVEY	TOTAL SURVEYS
Cima Mesa	34	34°27'50"	117°57'30"	Juniper Hills	1/78	1/78	9/80	25
Murphy Lane	36	34°26'02"	117°54'00"	Juniper Hills	1/78	3/78	9/80	23
Punchbowl Park	37	34°25'07"	117°51'50"	Valyermo	1/78	3/78	9/80	24
VABM Ward	38	34°27'50"	117°57'30"	Juniper Hills	1/78	4/78	9/80	24
Buck Canyon	39	34°20'26"	118°19'48"	Sunland	2/78	4/78	9/80	20
Wilson Canyon	40	34°27'11"	118°20'38"	San Fernando	2/78	3/78	8/80	21
Barrel Springs	41	34°32'16"	118°04'58"	Palmdale	5/78	6/78	8/80	16
Llano	42	34°29'50"	117°50'00"	Valyermo	5/78	6/78	9/80	21
Lone Tree	43	34°18'19"	117°30'29"	Telegraph Peak	5/78	6/78	9/80	10
Lovejoy	44	34°35'11"	117°48'24"	Lovejoy Buttes	5/78	6/78	9/80	14
Sheep Creek	45	34°21'36"	117°36'13"	Telegraph Peak	5/78	6/78	9/80	10
Old Lady	49	35°17'13"	117°53'24"	Cantil	4/78	8/78	8/80	4
Honeycup	50	35°17'06"	117°53'17"	Cantil	4/78	8/78	8/80	4
Landing Strip	33	34°27'13"	117°55'15"	Juniper Hills	1/78	1/78	11/78	13
Kentucky Springs	52	34°26'24"	118°06'07"	Pacifico Mtn.	12/78	1/79	9/80	8
Cowhead Potrero	53	34°52'30"	119°17'25"	Apache Canyon	12/78	4/79	9/80	10
Mill Potrero	54	34°51'00"	119°11'07"	Sawmill Mtn.	12/78	4/79	9/80	9
Penny Pines	55	34°50'04"	119°05'14"	Cuddy Valley	12/78	4/79	9/80	9
Quail	56	34°45'29"	118°47'36"	Lebec	12/78	4/79	9/80	6
Baughman Spring	57&18	34°22'00"	118°06'19"	Chilao Flat	12/76	3/77	9/80	18
Pinon Flat East	58	33°35'00"	116°26'00"	Palm Desert 15'	9/79	9/79	8/80	5
Pinon Flat West	59	33°35'00"	116°26'00"	Palm Desert 15'	9/79	9/79	8/80	3

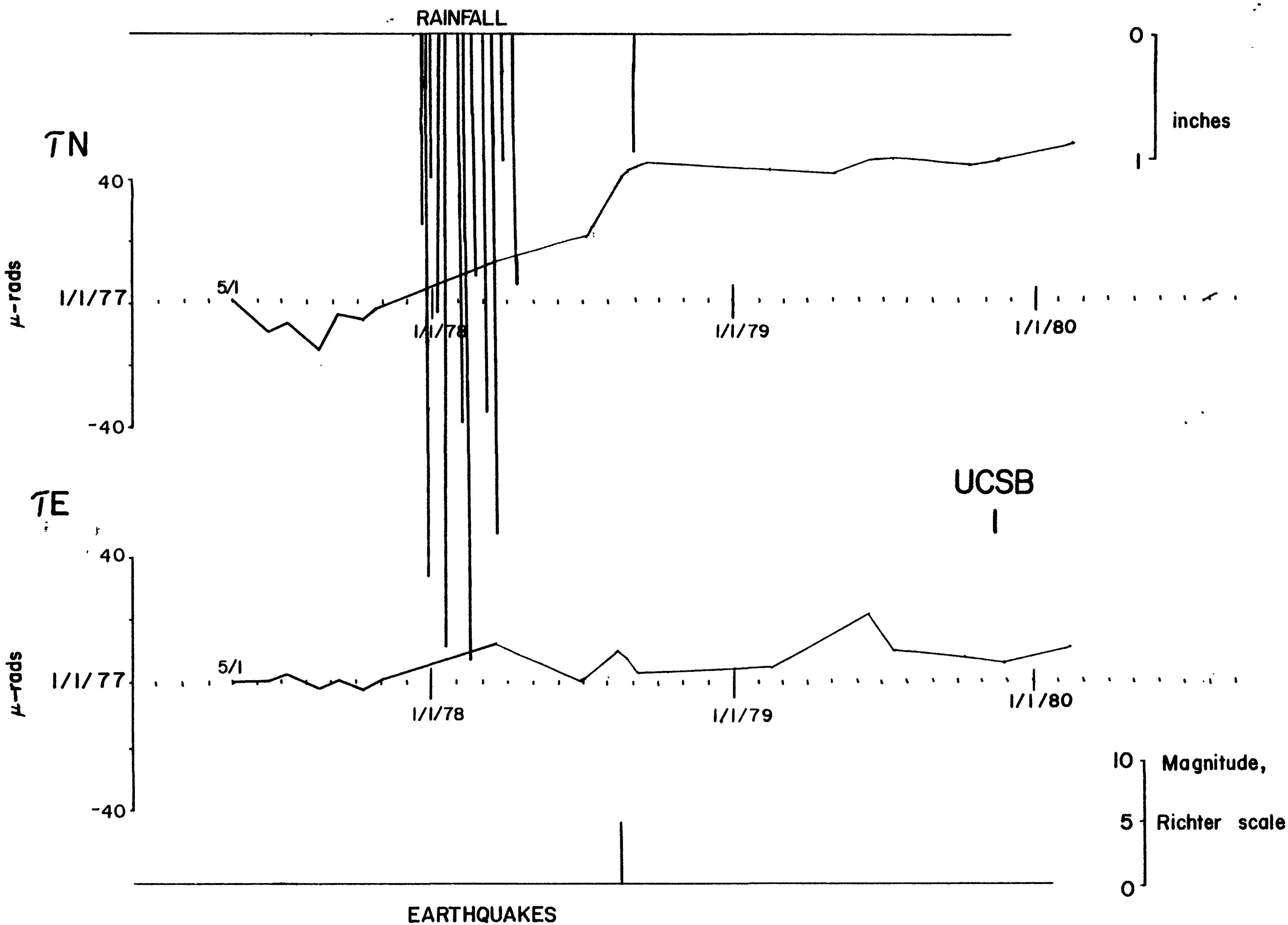
TABLE II. UCSB SHORT LEVEL LINES

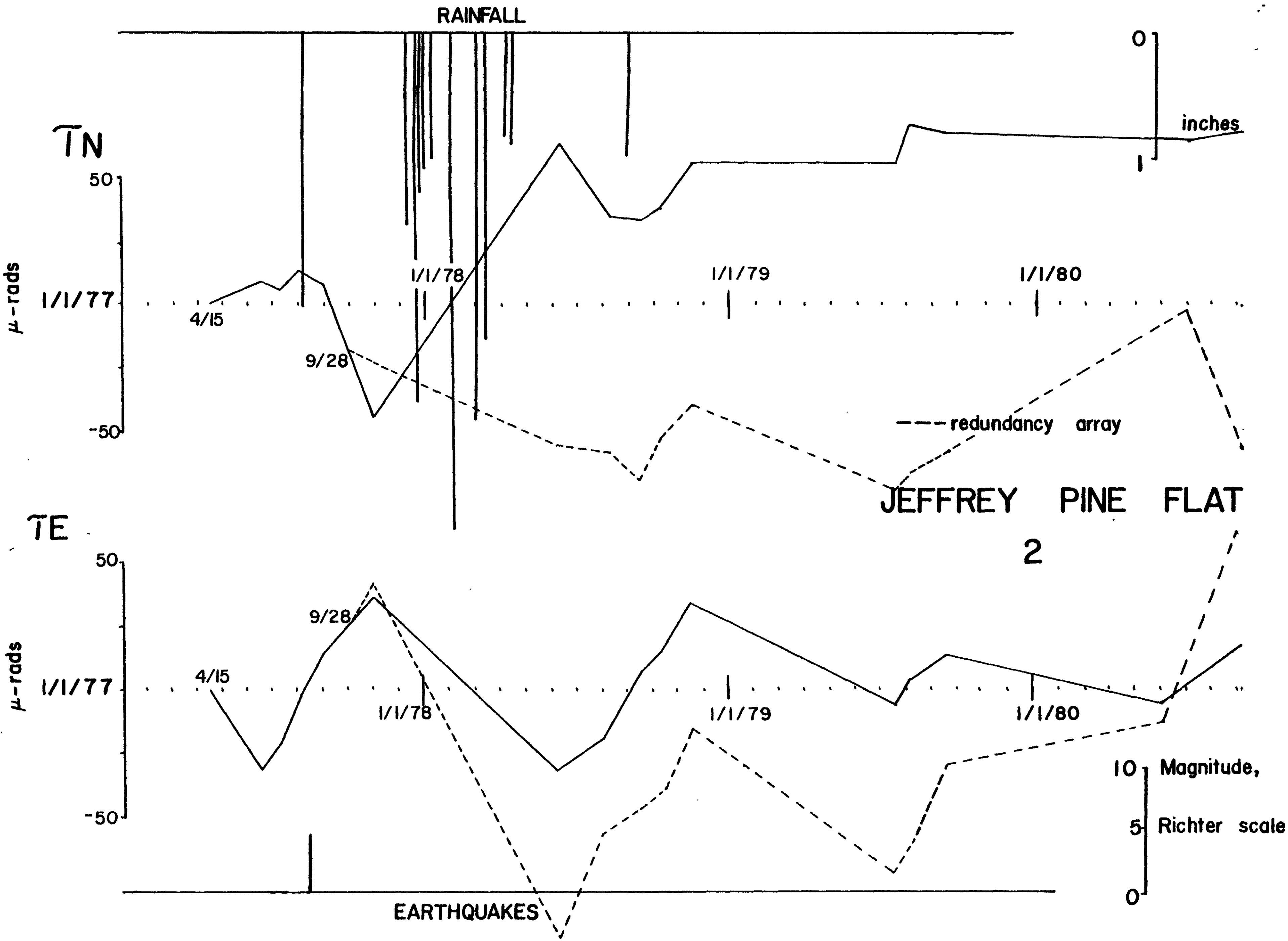
LOCATION	LATITUDE	LONGITUDE	QUADRANGLE	INITIAL SURVEY	MOST RECENT SURVEY	TOTAL # SURVEYS	LINE NUMBER
SANTA BARBARA							
Cook	34°25'10"	119°43'00"	Santa Barbara	5/71	6/80	8	
Cabrillo	34°22'20"	119°41'25"	Santa Barbara	9/70	7/79	14	
Lorinda	34°25'20"	119°43'25"	Santa Barbara	8/70	7/77	5	
Castillo Connect	34°25'00"	119°43'25"	Santa Barbara	10/73	9/78	3	
Portesuello	34°25'20"	119°43'35"	Santa Barbara	8/70	8/78	6	
Bath	34°24'10"	119°41'40"	Santa Barbara	4/71	8/78	6	
Chapala	34°24'50"	119°41'30"	Santa Barbara	4/71	8/78	6	
Natoma	34°24'50"	119°41'25"	Santa Barbara	8/70	8/78	6	
Castillo	34°24'50"	119°41'35"	Santa Barbara	2/72	7/77	4	
Yanonali	34°25'00"	119°41'10"	Santa Barbara	7/70	8/77	4	
State	34°24'55"	119°41'55"	Santa Barbara	10/70	8/78	5	
Yanonali-Castillo				1/71	8/78	3	
DURAVAN	35°17'05"	117°53'25"	Cantil	9/74	8/80	11	
SAN JUAN BAUTISTA	36°50'48"	121°32'00"	San Juan Bautista	9/75	8/80	14	
SAN FERNANDO	34°18'03"	118°25'35"	San Fernando	2/71	12/76	9	
JUNCAL	34°29'00"	119°30'15"	Carpinteria	2/70	8/80	4	
DEATH VALLEY							
Triangle Spring	36°42'40"	117°07'20"	Stovepipe Wells	10/71	4/78	3	130
Sewage Treatment	36°30'20"	116°52'25"	Chloride Cliff	3/73	9/74	4	100
Artist's Drive	36°25'50"	116°51'00"	Furnace Creek	3/72	4/78	4	50
Hanaupah	36°14'05"	116°53'00"	Bennett's Well	10/71	4/78	5	70
PALLETT CREEK	34°25'10"	117°54'00"	Juniper Hills	6/78	7/80	7	
PINON FLAT	33°35'00"	116°26'00"	Palm Desert	9/79	10/80	6	
GRAPEVINE	34°55'30"	118°55'30"	Grapevine	7/79	7/80	2	
UNA LAKE	34°33'00"	118°06'15"	Palmdale	3/79	8/79	2	
BIG ROCK SPRINGS	34°26'04"	117°50'00"	Valyermo	10/80		1	
LLANO	34°31'06"	117°47'53"	Lovejoy Buttes				


RAINFALL
0
inches
1
τN
20
μ-rads
1/1/77
-20
4/15
1/1/78
1/1/79
1/1/80
OSO PUMPING STATION
5
τE
20
μ-rads
1/1/77
-20
4/15
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

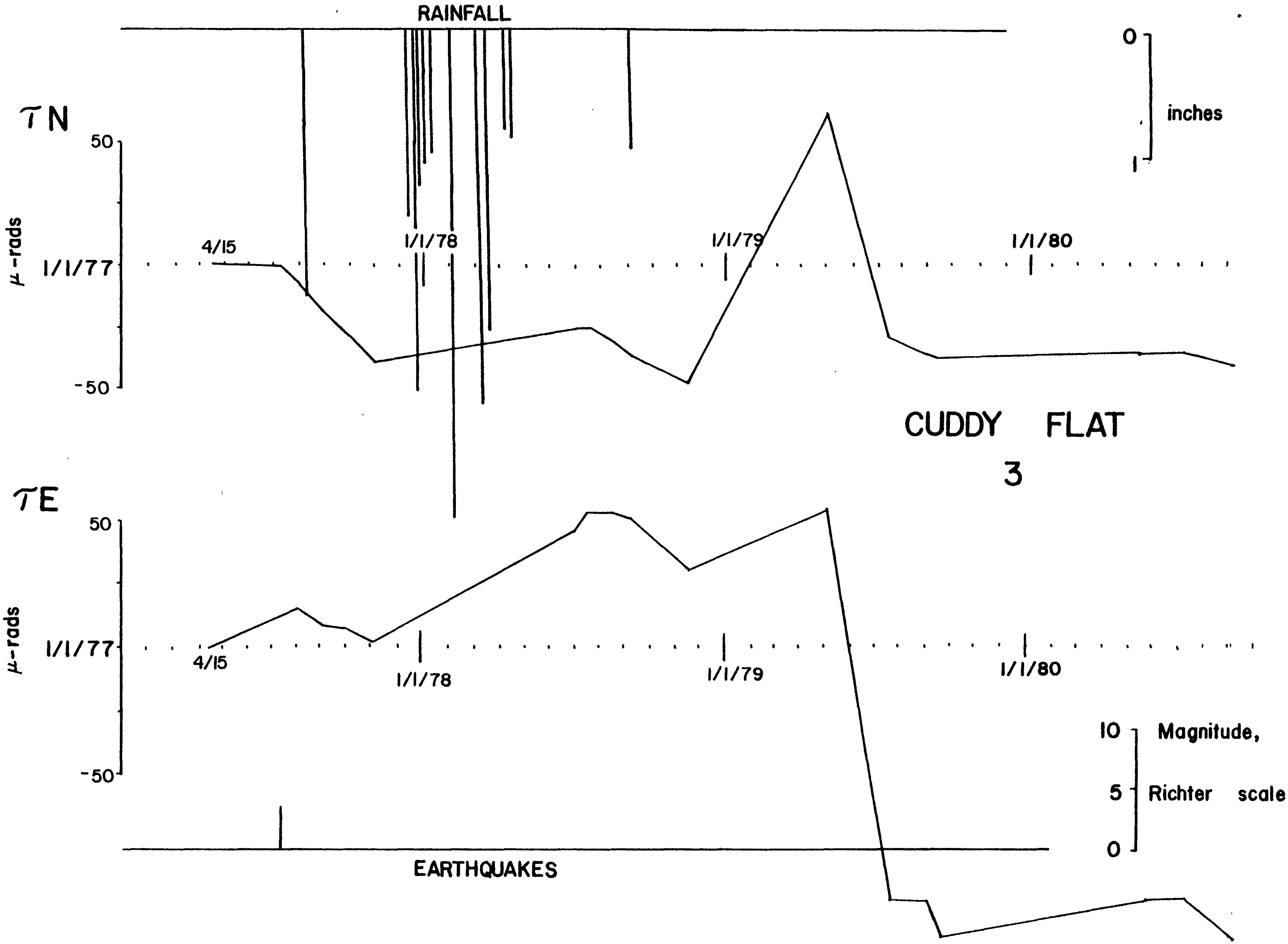

RAINFALL
0
inches
1
τN
100
μ-rads
1/1/77
-100
3/15
1/1/78
1/1/79
1/1/80
SAWMILL
6
τE
100
μ-rads
1/1/77
-100
3/15
1/1/78
1/1/79
1/1/80
1.0
Magnitude,
5
Richter scale
0
EARTHQUAKES


↑N
20
1/1/77
-20
1/1/78
1/1/79
1/1/80
μ-rads
↑E
20
1/1/77
-20
1/1/78
1/1/79
1/1/80
RYE CANYON
7
Magnitude,
Richter scale
10
5
0
EARTHQUAKES

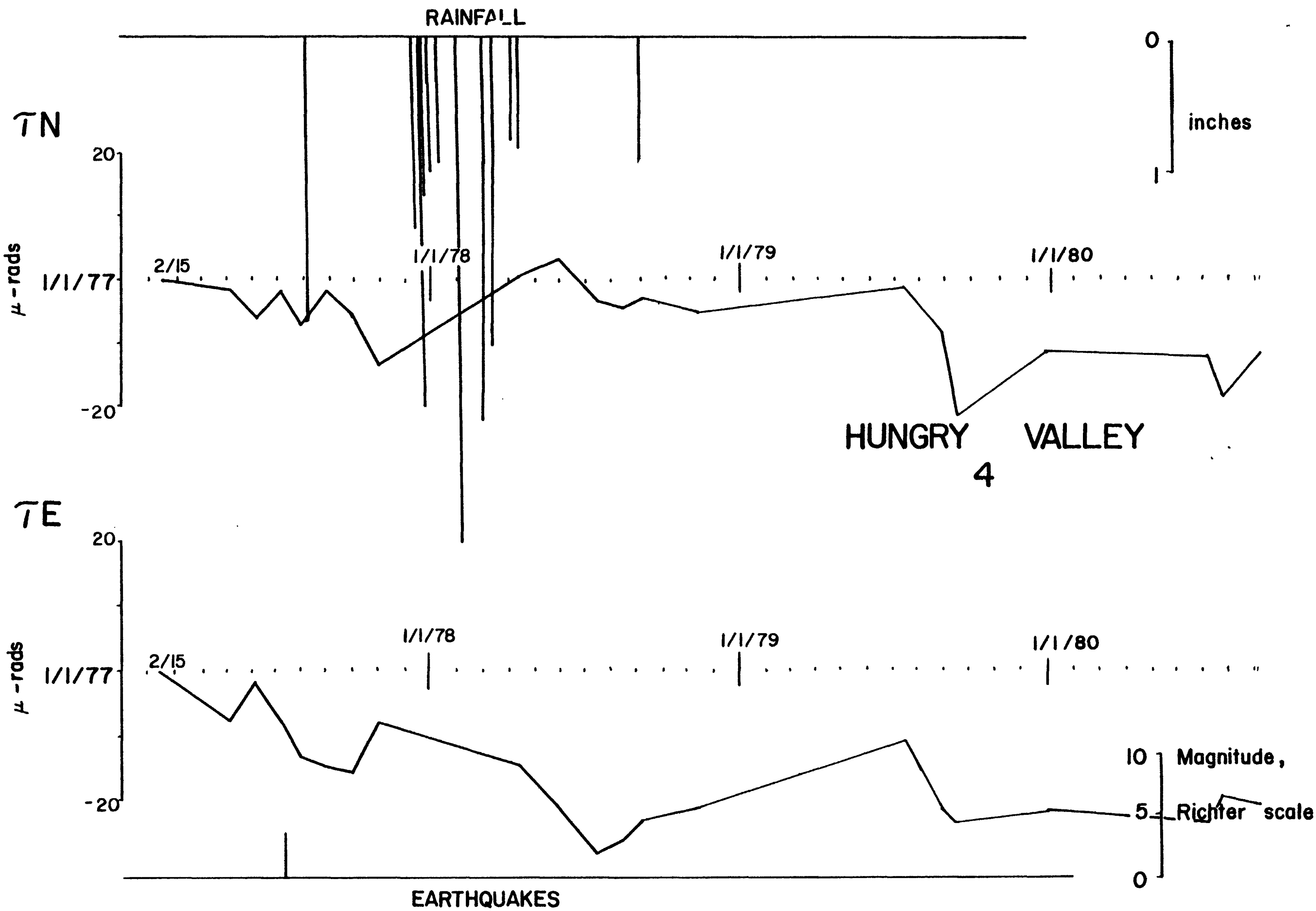

RAINFALL
0
1
inches
τN
40
-40
μ-rads
1/1/77
5/1
1/1/78
1/1/79
1/1/80
UCSB
1
τE
40
-40
μ-rads
1/1/77
5/1
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

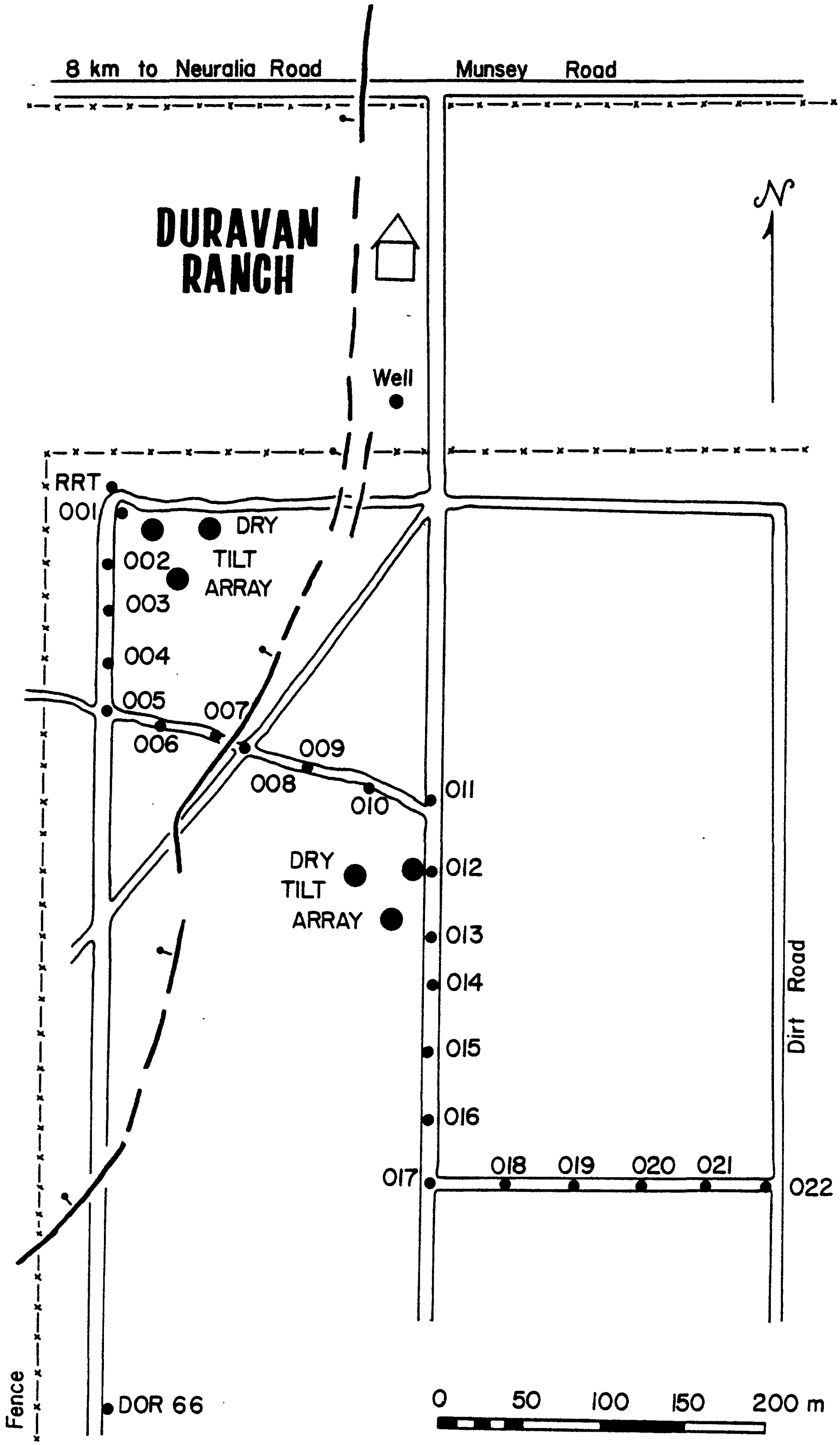


RAINFALL
0
inches
1
TN
50
μ-rads
1/1/77
-50
4/15
9/28
1/1/78
1/1/79
1/1/80
redundancy array
JEFFREY PINE FLAT
2
TE
50
μ-rads
1/1/77
-50
4/15
9/28
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES



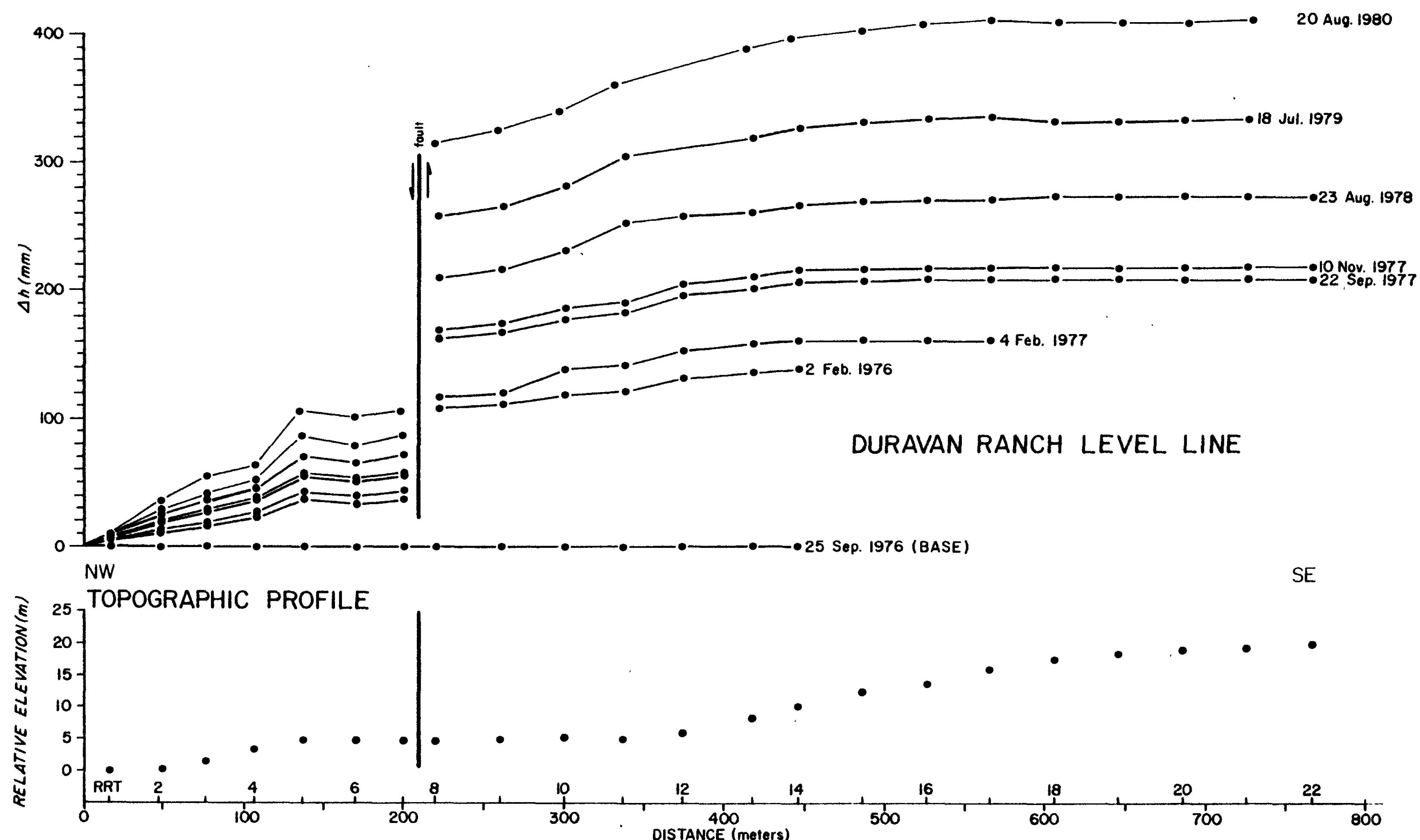
RAINFALL
0
inches
1
τN
50
μ-rads
1/1/77
-50
4/15
1/1/78
1/1/79
1/1/80
CUDDY FLAT
3
τE
50
μ-rads
1/1/77
-50
4/15
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES


RAINFALL
inches
0
1
τN
μ-rads
20
1/1/77
-20
2/15
1/1/78
1/1/79
1/1/80
HUNGRY VALLEY
4
τE
μ-rads
20
1/1/77
-20
2/15
1/1/78
1/1/79
1/1/80
Magnitude, Richter scale
10
5
0
EARTHQUAKES



DURAVAN RANCH LINE

Fig. 7



DURAVAN RANCH LEVEL LINE
20 Aug. 1980
18 Jul. 1979
23 Aug. 1978
10 Nov. 1977
22 Sep. 1977
4 Feb. 1977
2 Feb. 1976
25 Sep. 1976 (BASE)
fault
Δh (mm)
NW
SE
TOPOGRAPHIC PROFILE
RELATIVE ELEVATION (m)
RRT
DISTANCE (meters)

Fig. 8

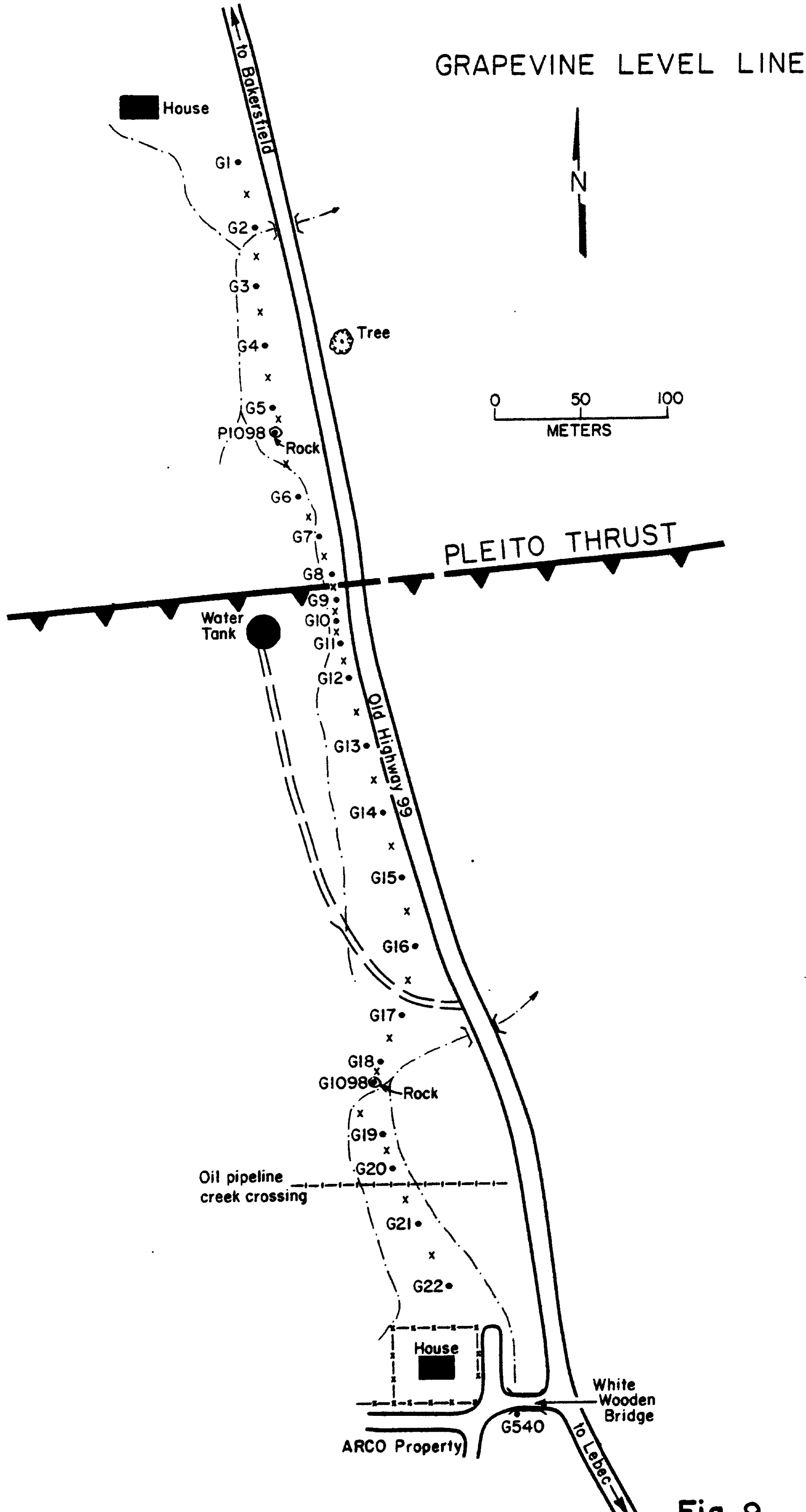

GRAPEVINE LEVEL LINE
N
0 50 100
METERS
House
to Bakersfield
G1
G2
G3
G4
G5
P1098
Rock
Tree
G6
G7
PLEITO THRUST
G8
G9
G10
G11
Water Tank
G12
Old Highway 99
G13
G14
G15
G16
G17
G18
G1098
Rock
G19
G20
Oil pipeline creek crossing
G21
G22
House
White Wooden Bridge
G540
ARCO Property
to Lebec

Fig. 9

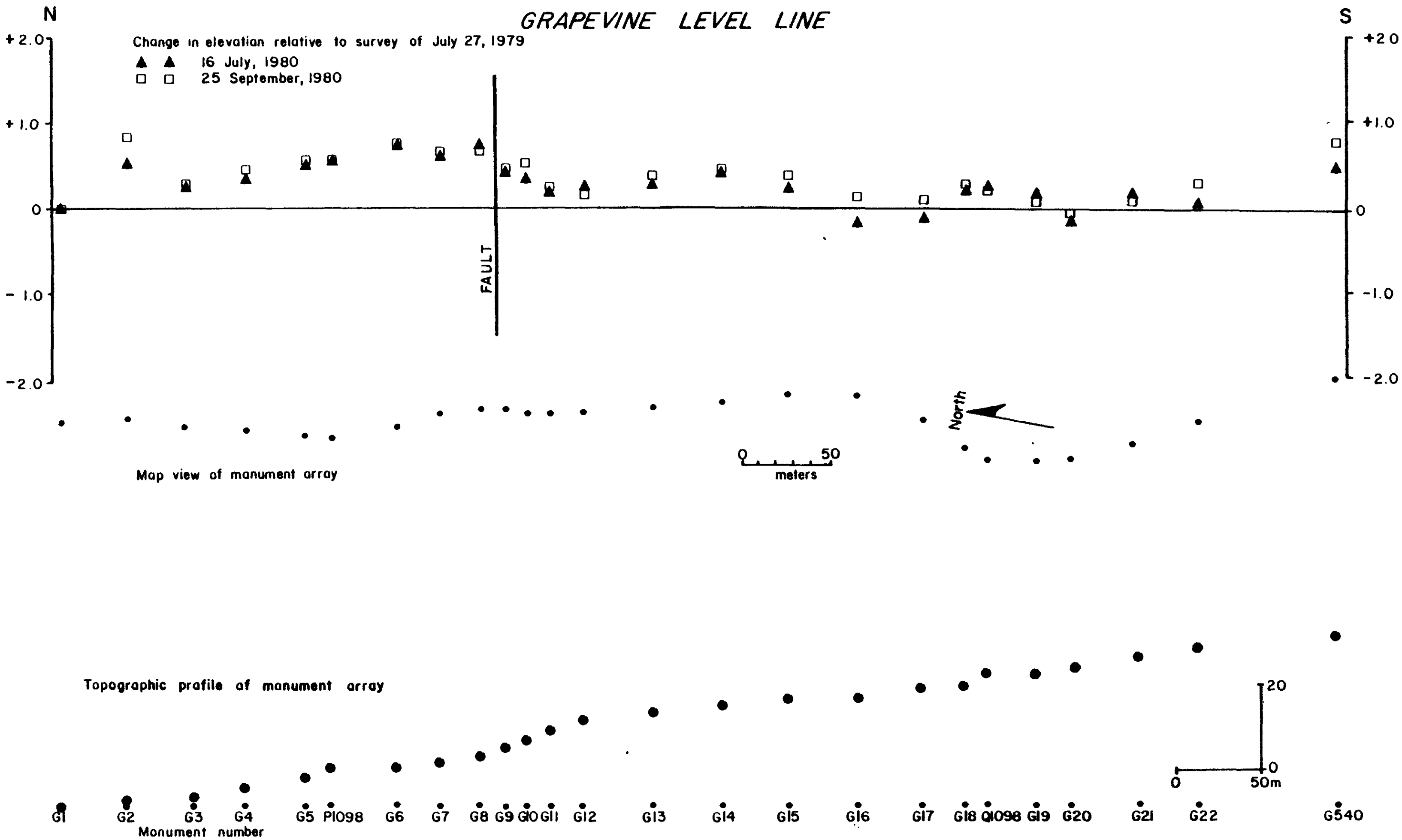

GRAPEVINE LEVEL LINE
N
S
Change in elevation relative to survey of July 27, 1979
16 July, 1980
25 September, 1980
+2.0
+1.0
0
-1.0
-2.0
FAULT
North
0 50
meters
Map view of monument array
Topographic profile of monument array
20
0
0 50m
G1 G2 G3 G4 G5 P1098 G6 G7 G8 G9 G10 G11 G12 G13 G14 G15 G16 G17 G18 Q1098 G19 G20 G21 G22 G540
Monument number

Fig. 10

BIG ROCK SPRINGS LEVELING ARRAY

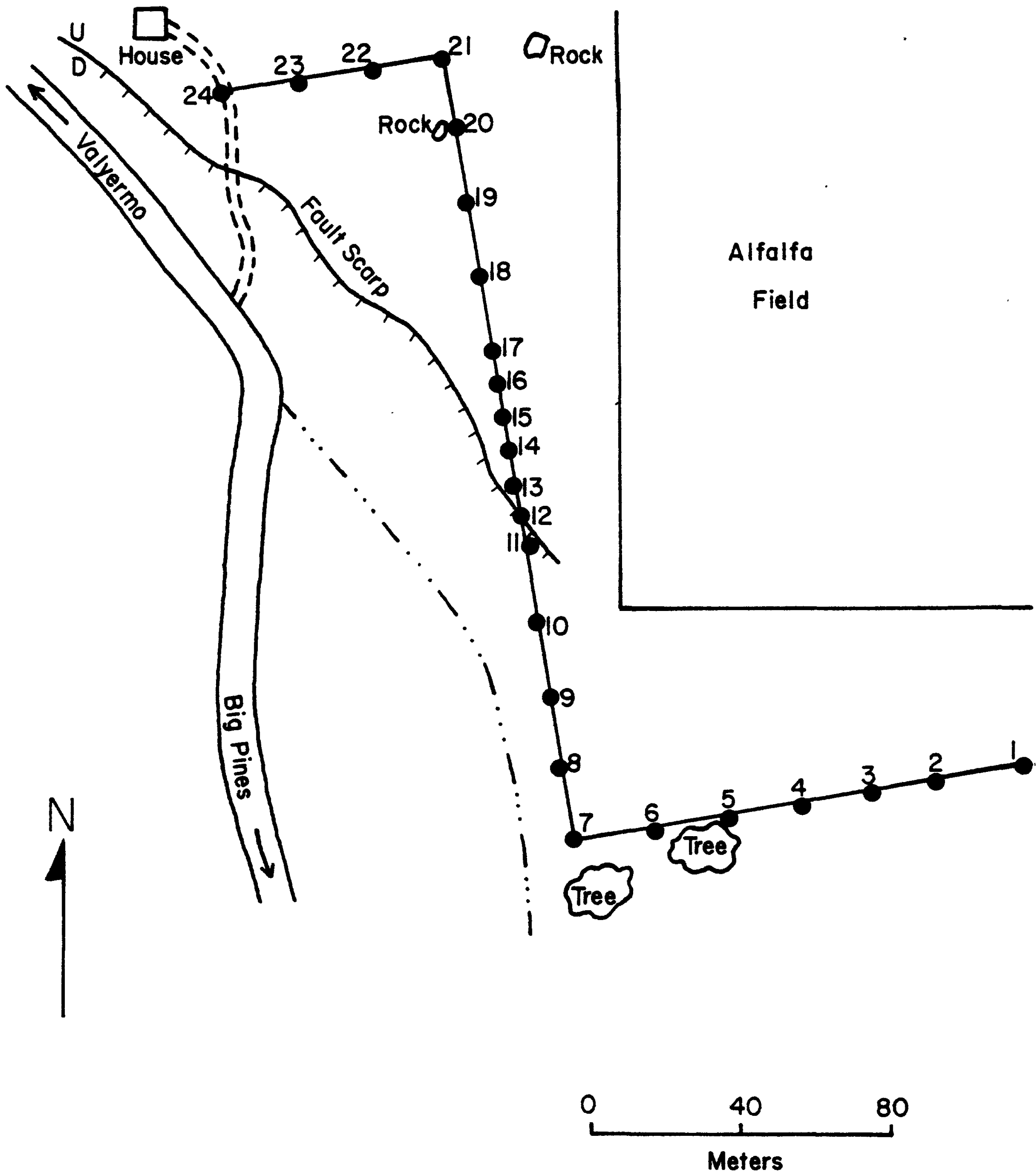


Fig. 11

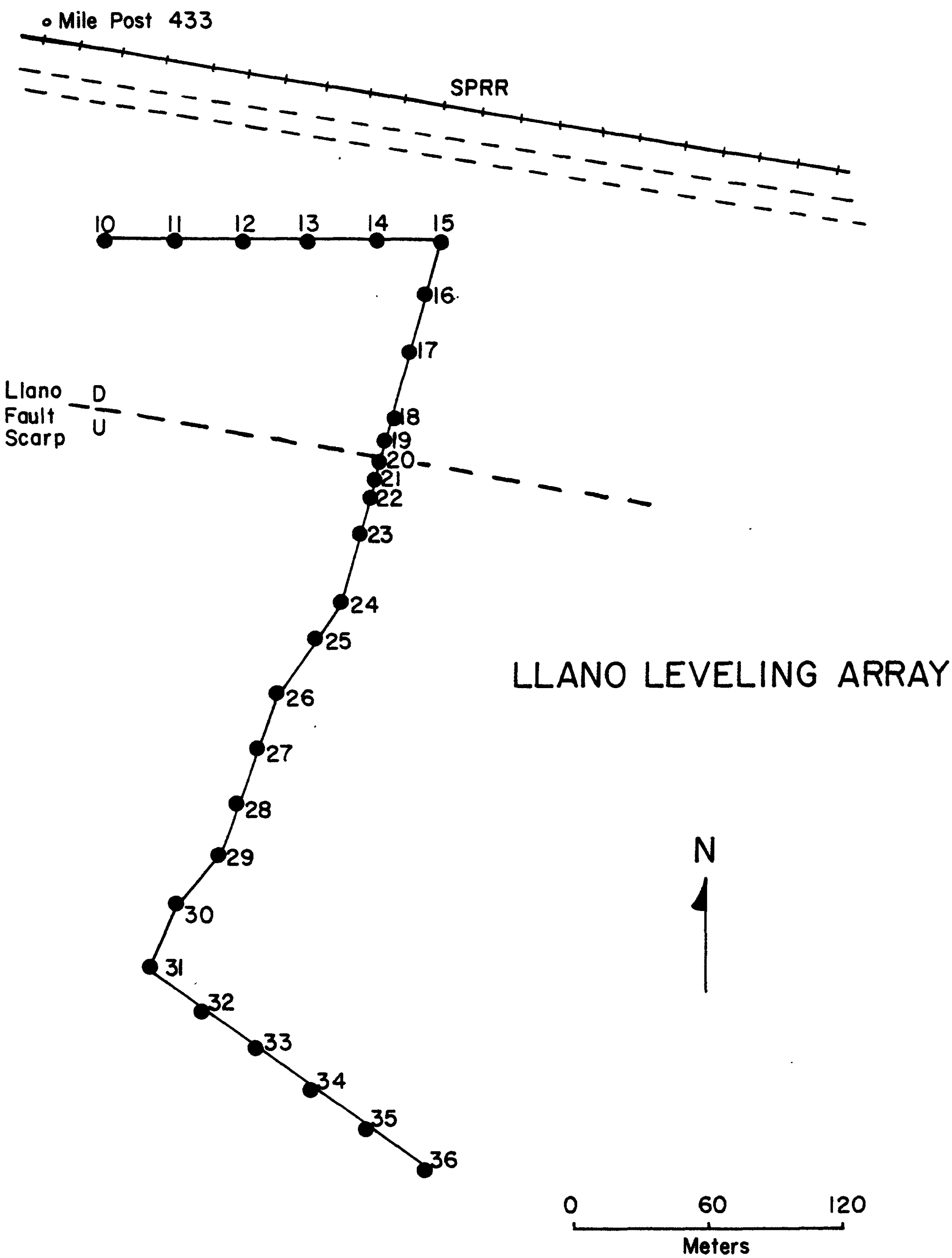

Mile Post 433
SPRR
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
Llano Fault Scarp
D
U
LLANO LEVELING ARRAY
N
0
60
120
Meters

Fig. 12

MESA VALLEY ALIGNMENT/LEVELING ARRAY

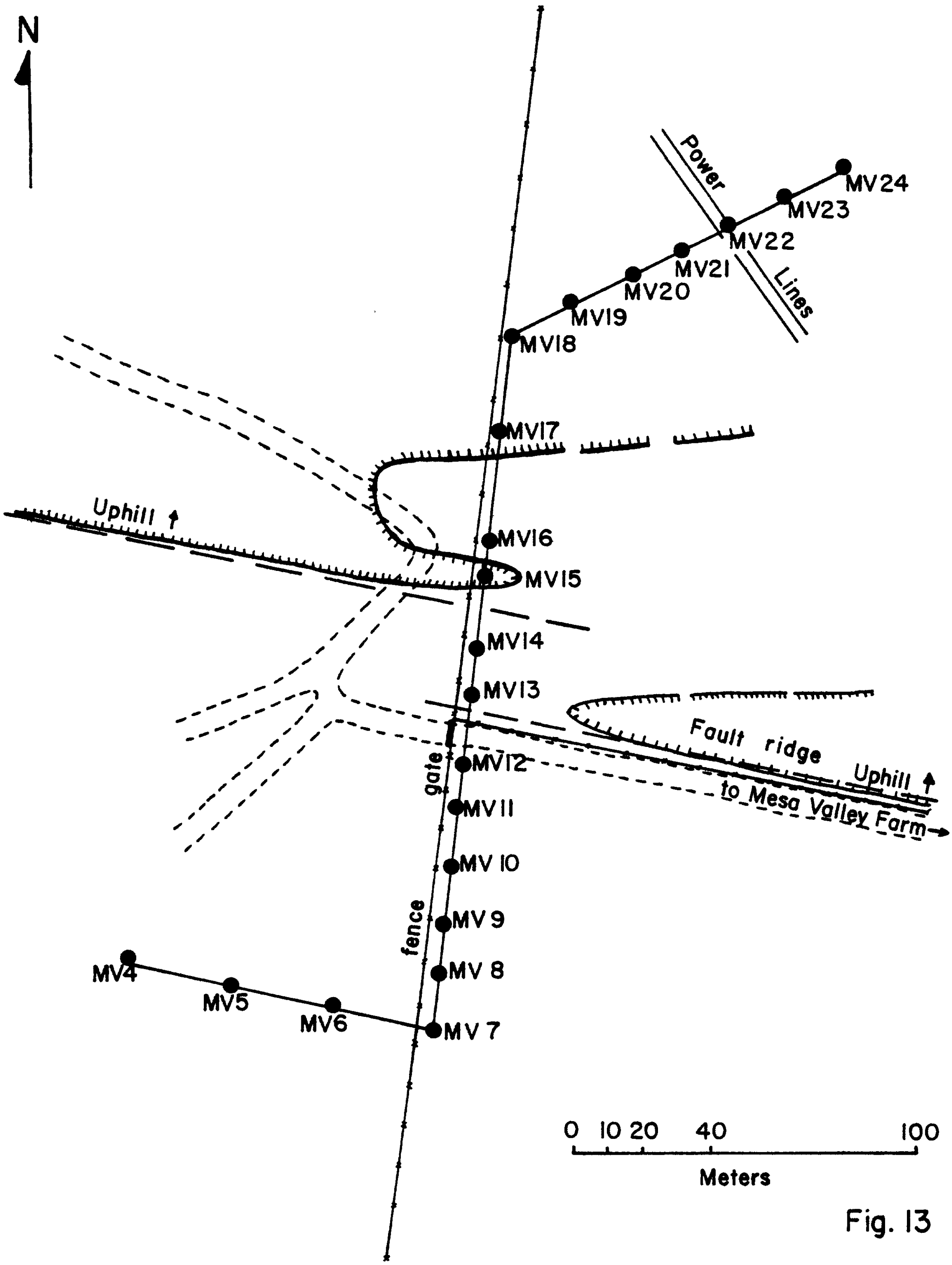


Fig. 13

MESA VALLEY FARM LEVEL LINE

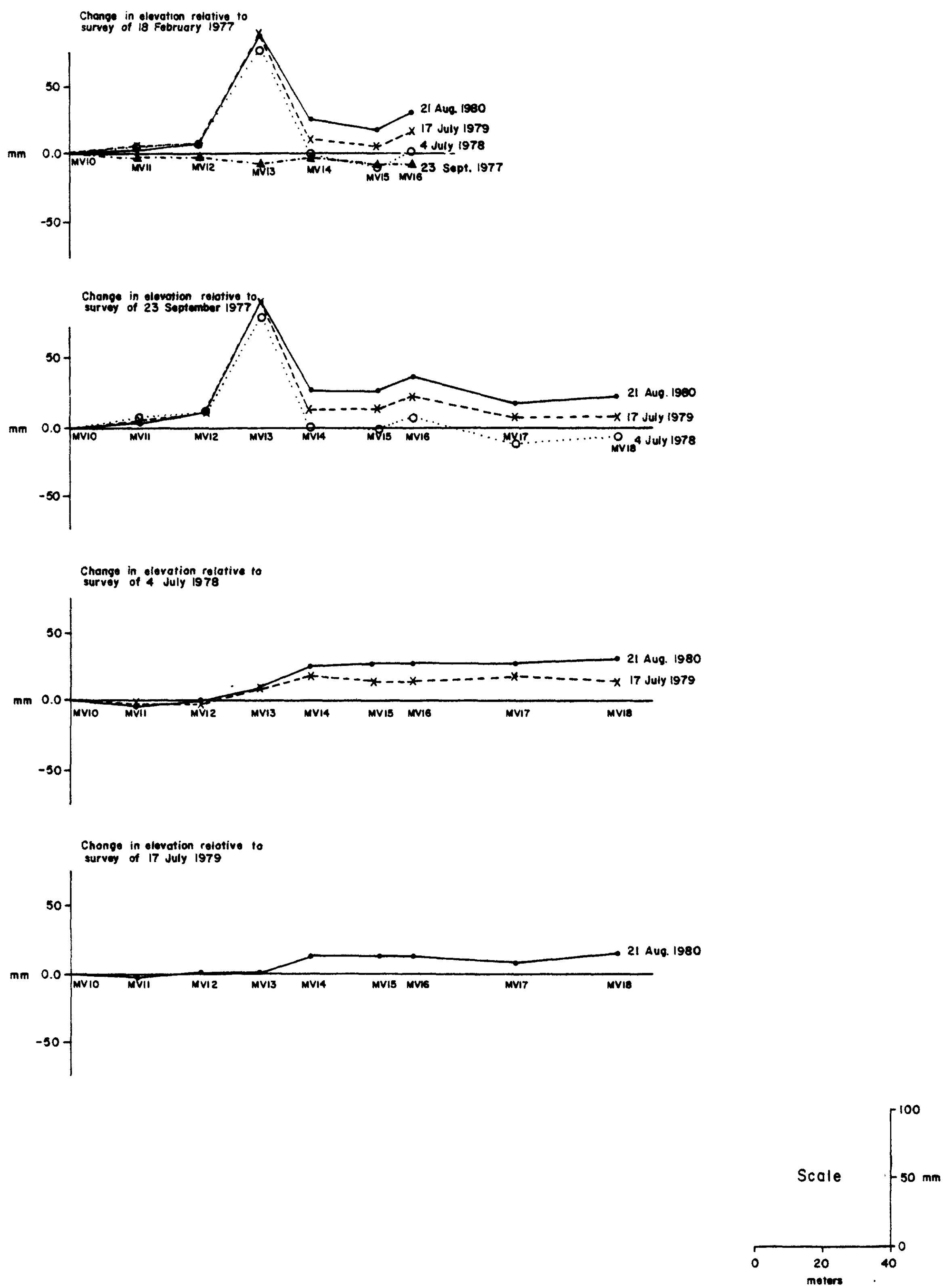


Fig. 14

47TH ST. EAST ALIGNMENT ARRAY

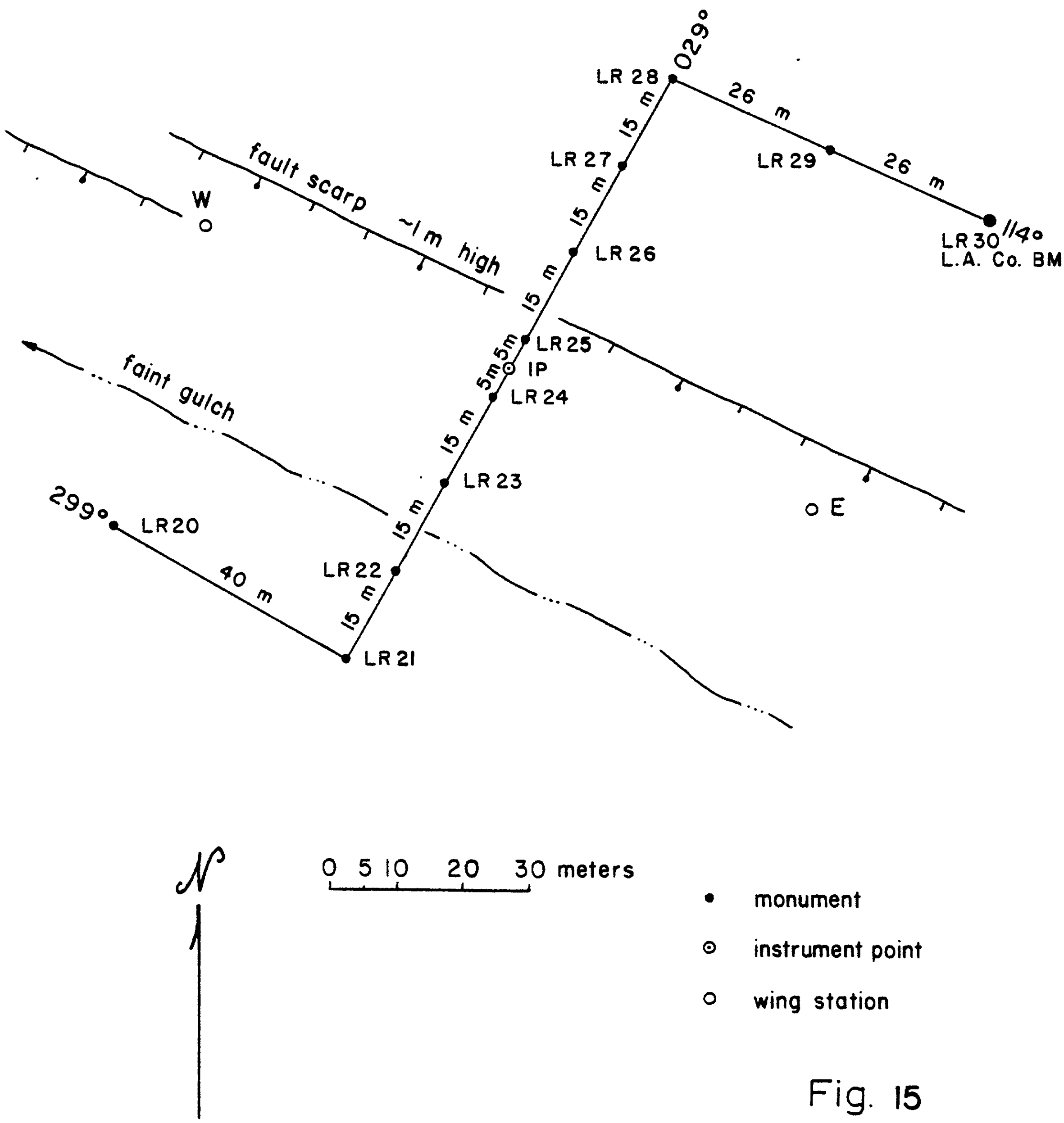


Fig. 15

SANTA CRUZ ISLAND FAULT CROSSING ARRAY

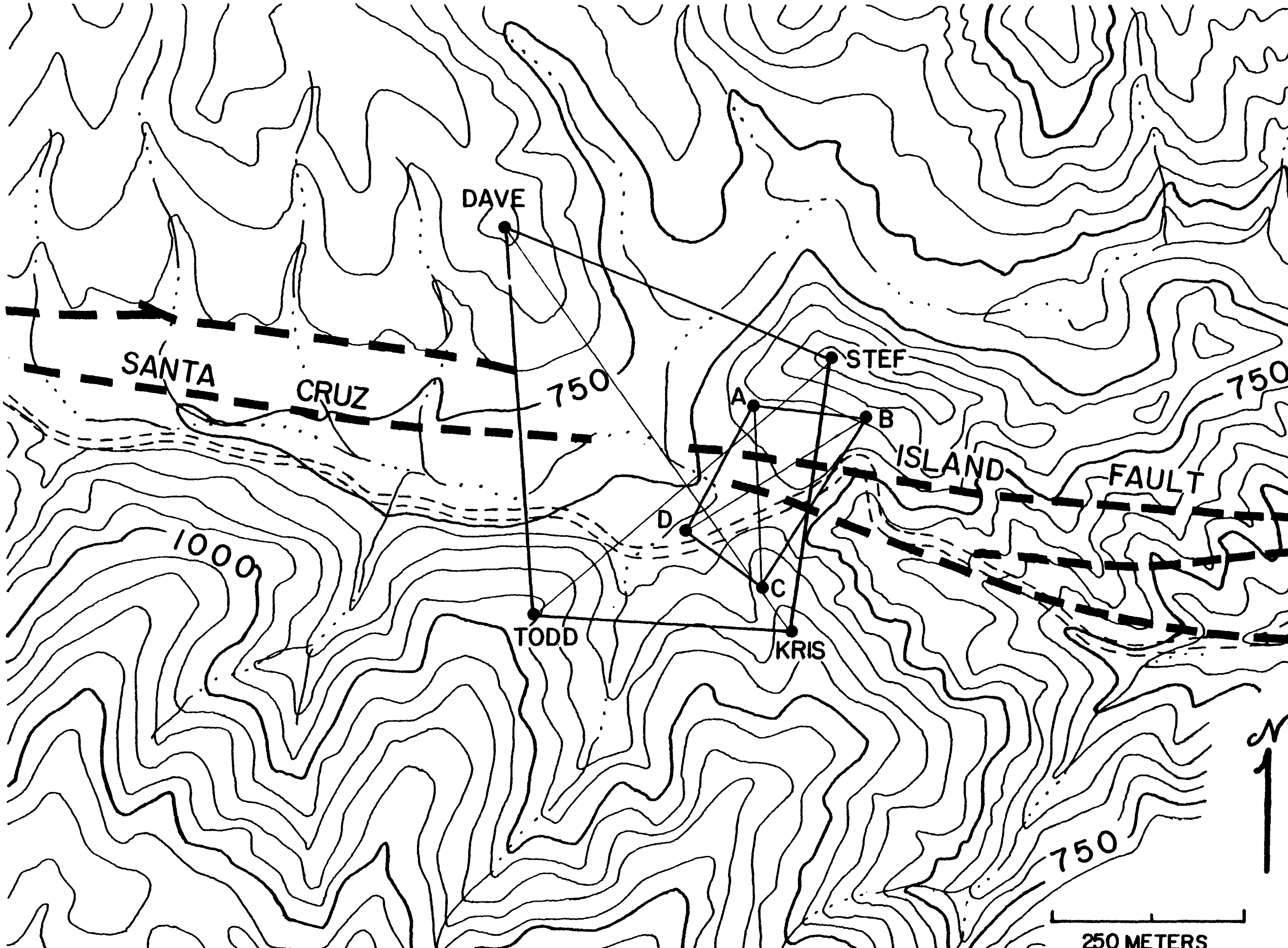


Fig. 16

APPENDIX I

Component North/Component East vs Time dry tilt records, including rainfall (1978-1980 only) and local earthquake records. Each dry tilt site is identified by its name and site number which is coded to the location map (Fig. 1) and to the survey data (Table I). Scale in microradians varies among the graphs.

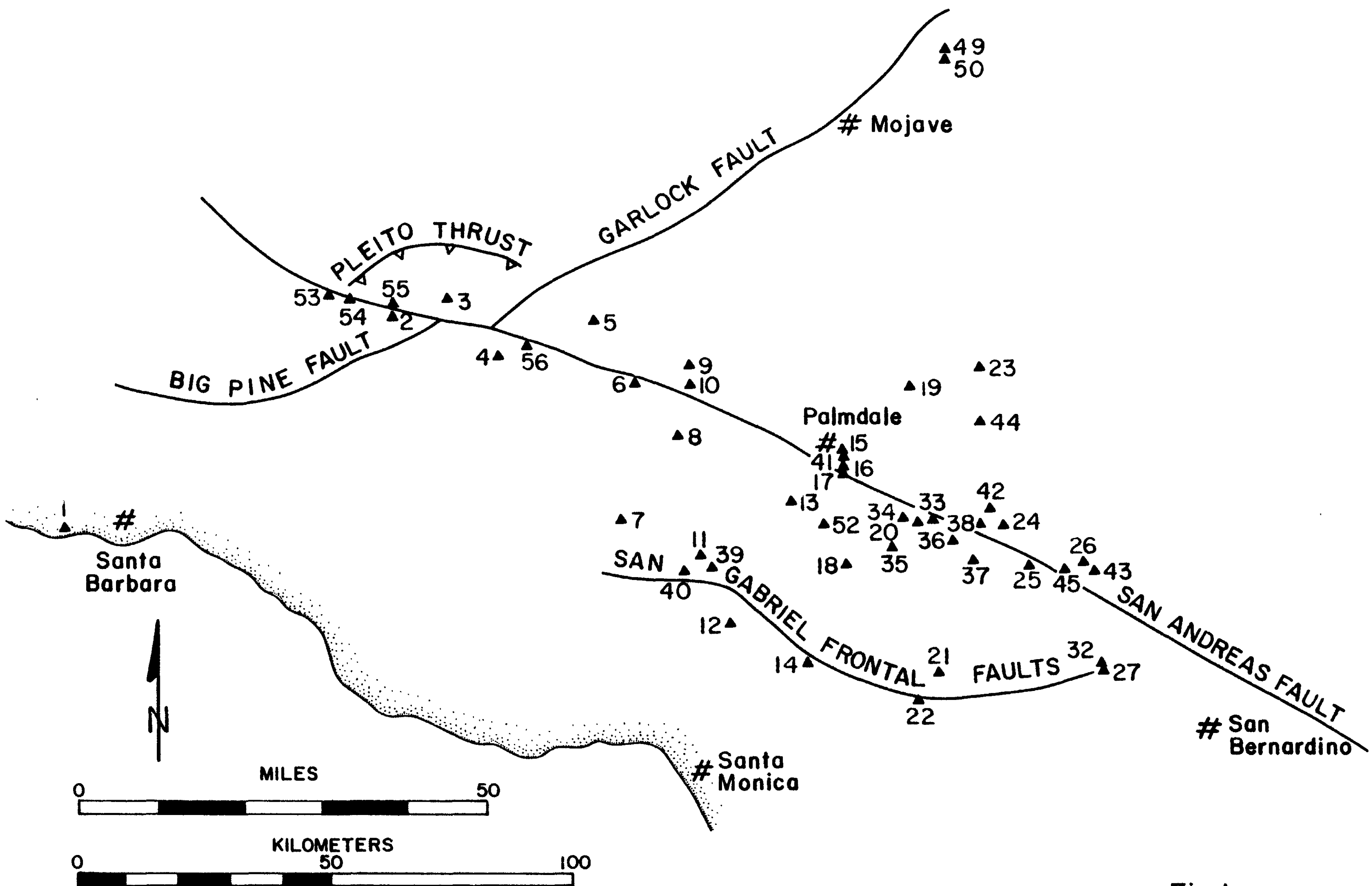
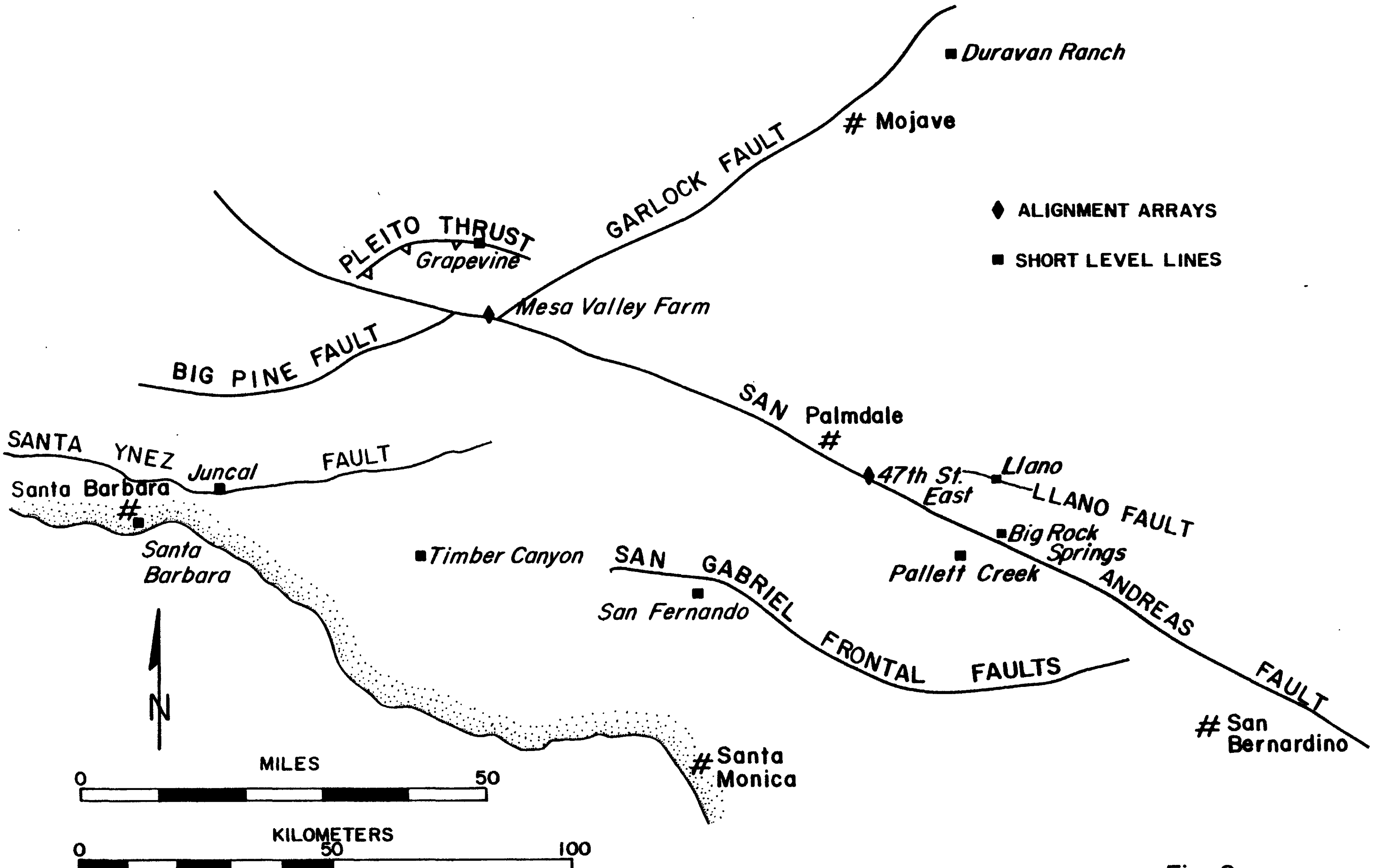

PLEITO THRUST
GARLOCK FAULT
BIG PINE FAULT
SAN ANDREAS FAULT
SAN GABRIEL FRONTAL FAULTS
Mojave
Palmdale
Santa Barbara
Santa Monica
San Bernardino
N
MILES
0
50
KILOMETERS
0
50
100
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
32
33
34
35
36
37
38
39
40
41
42
43
44
45
49
50
52
53
54
55
56

Fig. I



Duravan Ranch
Mojave
GARLOCK FAULT
ALIGNMENT ARRAYS
SHORT LEVEL LINES
PLEITO THRUST
Grapevine
Mesa Valley Farm
BIG PINE FAULT
SAN ANDREAS FAULT
Palmdale
47th St. East
Llano
LLANO FAULT
Big Rock Springs
Pallett Creek
SANTA YNEZ FAULT
Juncal
Santa Barbara
Santa Barbara
Timber Canyon
SAN GABRIEL FRONTAL FAULTS
San Fernando
San Bernardino
Santa Monica
N
MILES
0
50
KILOMETERS
0
50
100

Fig. 2

UCSB Level Lines and Leveled Alignment Arrays, Vicinity of Palmdale

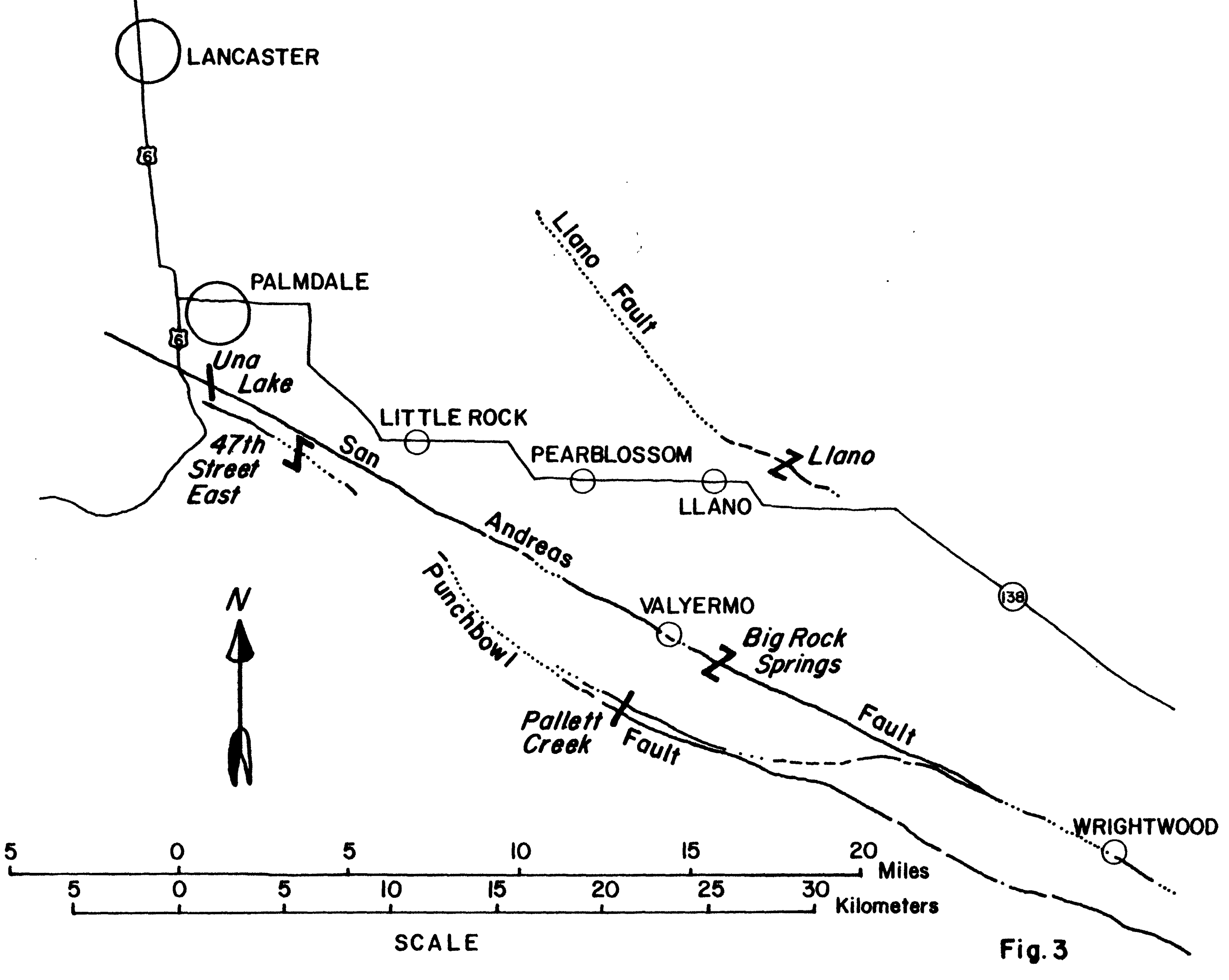


Fig. 3

PALLETT CREEK LEVEL LINE

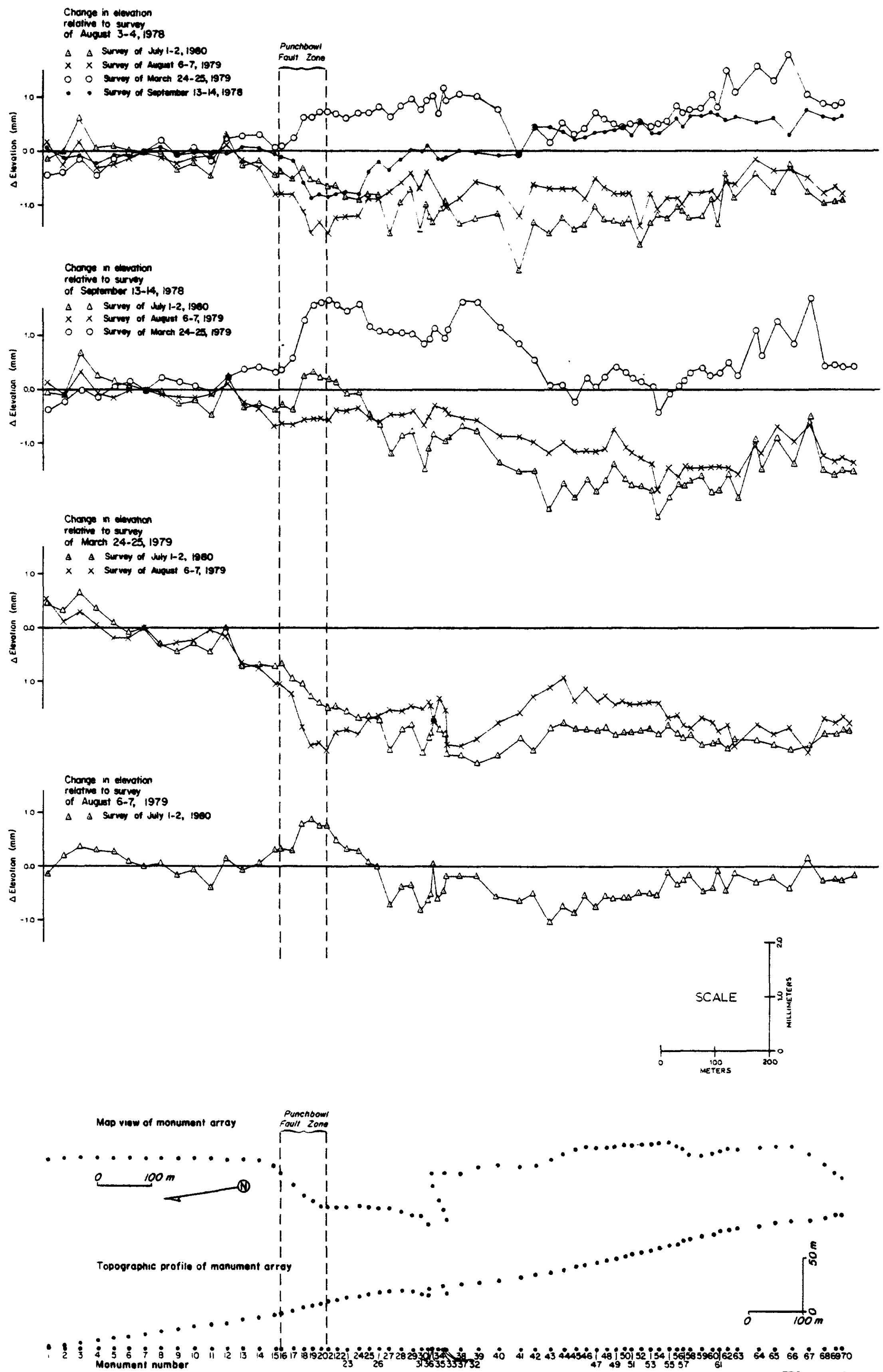
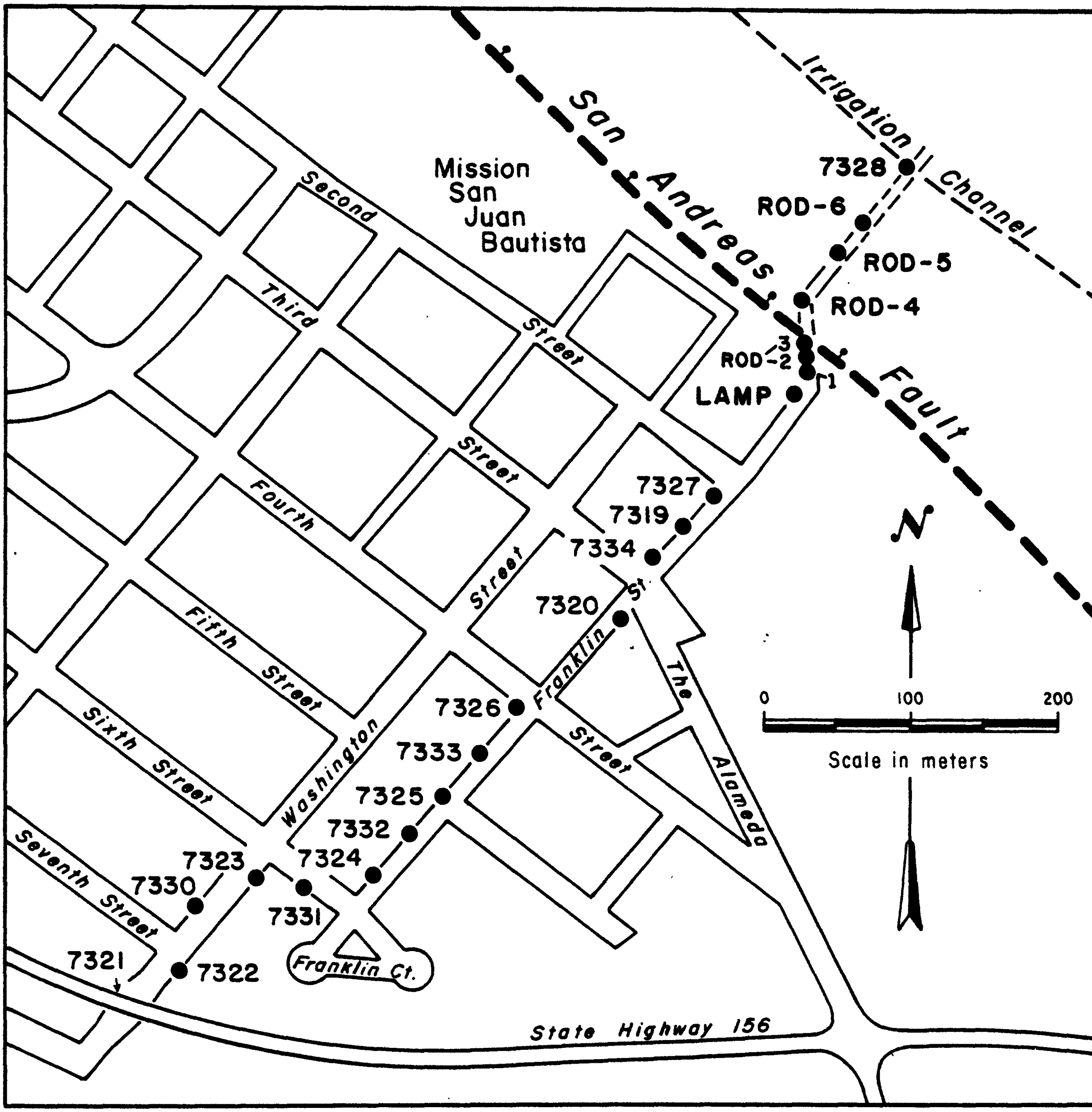


Fig. 4



dgc 1976

Fig. 5

SAN JUAN BAUTISTA LEVEL LINE

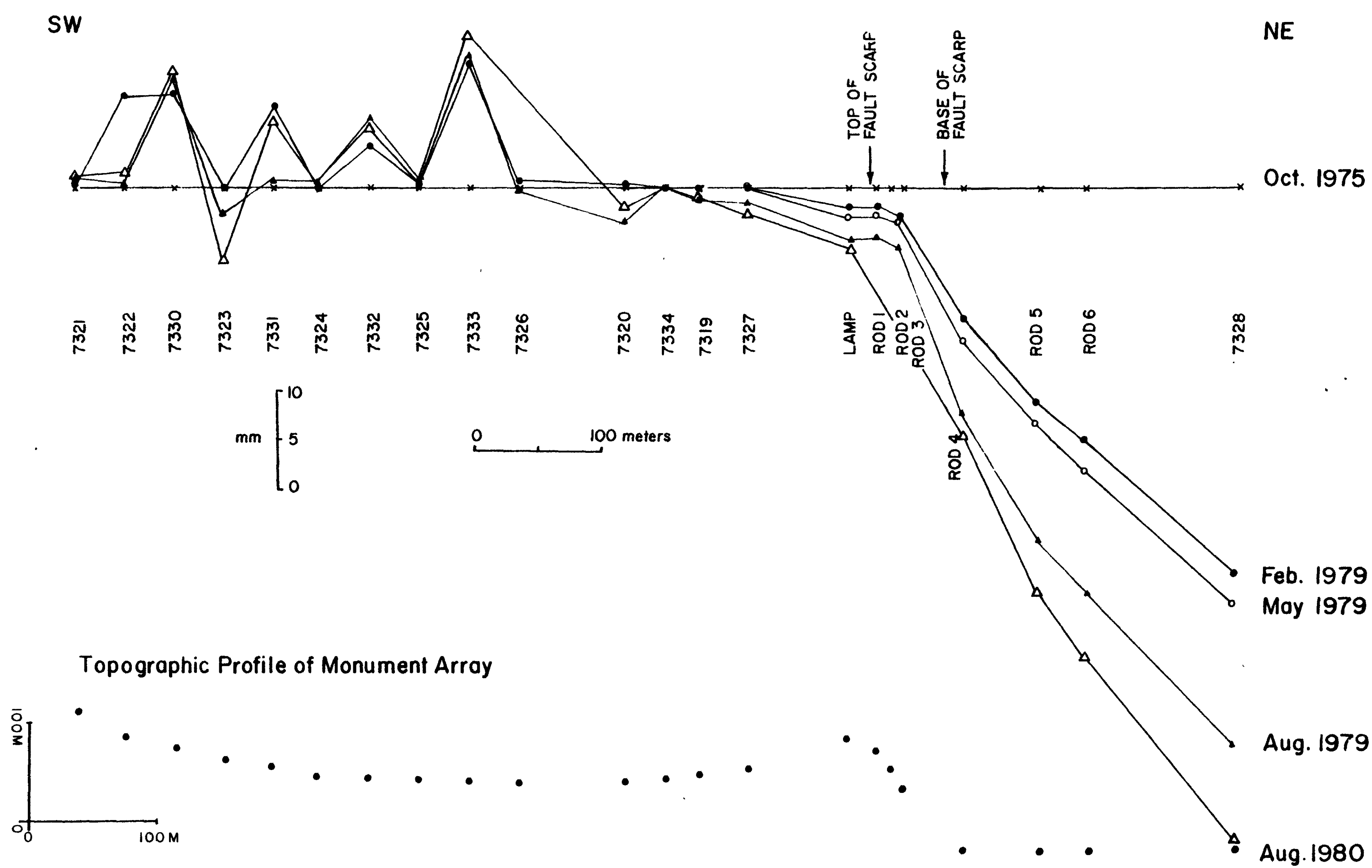


Fig. 6

CAPTIONS FOR FIGURES

1. Index map of UCSB dry tilt arrays.

2. Index map of UCSB short level lines and leveled alignment arrays.

3. Location of Pallett Creek level line acorss the Punchbowl fault.

4. Elevation change data (August 1978-July 1980), plan geometry and topographic profile for Pallett Creek level line. Benchmark PC7 is arbitrarily held fixed.

5. Location of San Juan Bautista level line across the San Andreas fault.

6. Elevation charge data (1975-1980) and topographic profile for San Juan Bautista level line. Only surveys done in 1979 and 1980 are shown for clarity. Benchmark 7334 is arbitrarily held fixed.

7. Site map of Duravan Ranch level line across unnamed fault scarp.

8. Elevation change data (1974-1980) for Duravan Ranch level line. Benchmark RRT is arbitrarily held fixed.

9. Site map of Grapevine level line across the Pleito thrust.

10. Elevation change data (1979-80) for Grapevine level line. Benchmark G1 is arbitrarily held fixed.

11. Site map of Big Rock Springs level line across the 1857 scarp of the San Andreas fault.

12. Site map of the Llano level line across the Llano fault.

13. Site map of the Mesa Valley Farm leveled alignment array across the San Andreas fault.

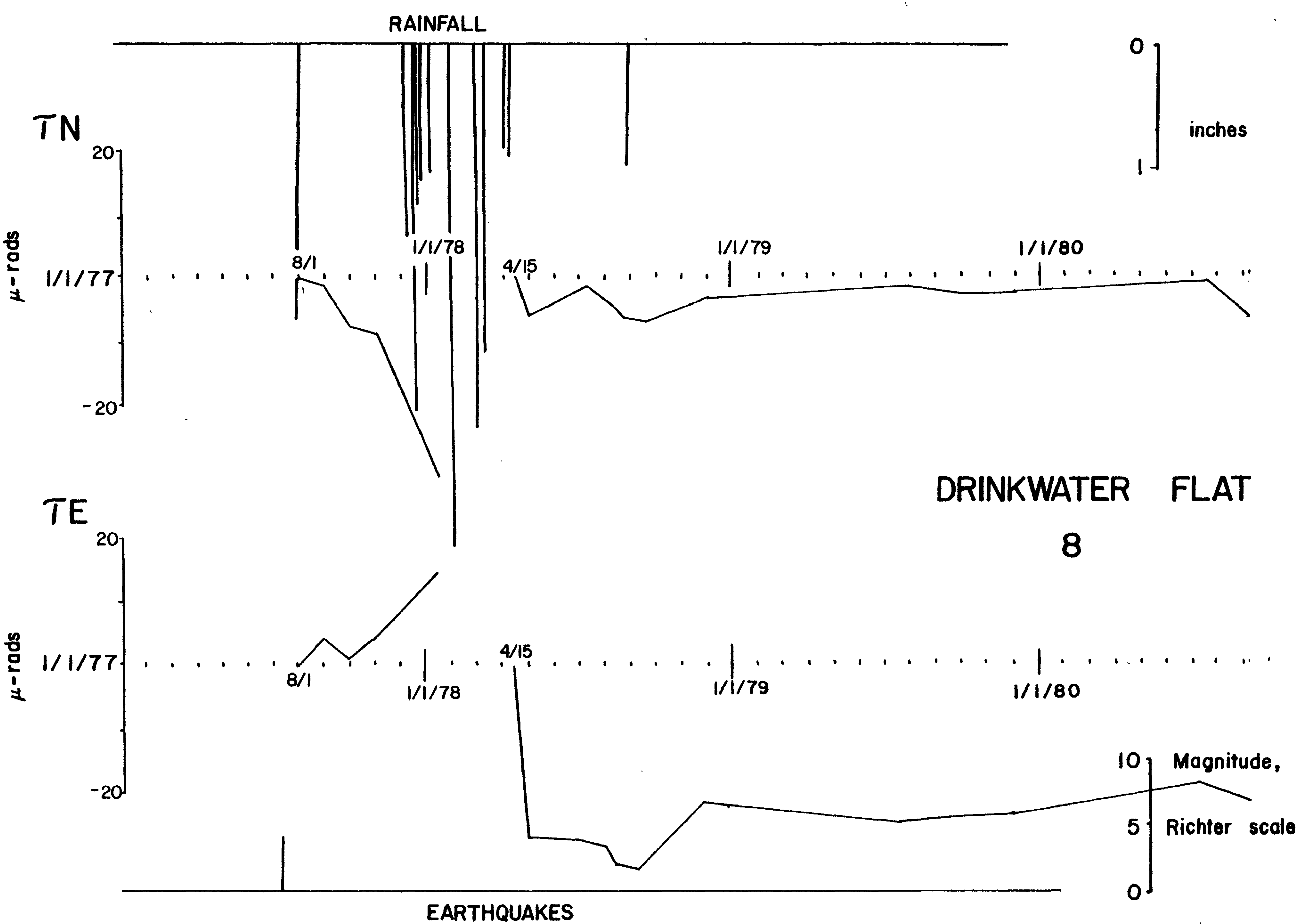
14. Elevation change data (1976-1980) for Mesa Valley Farm leveled alignment array. Benchmark MV10 is arbitrarily held fixed.

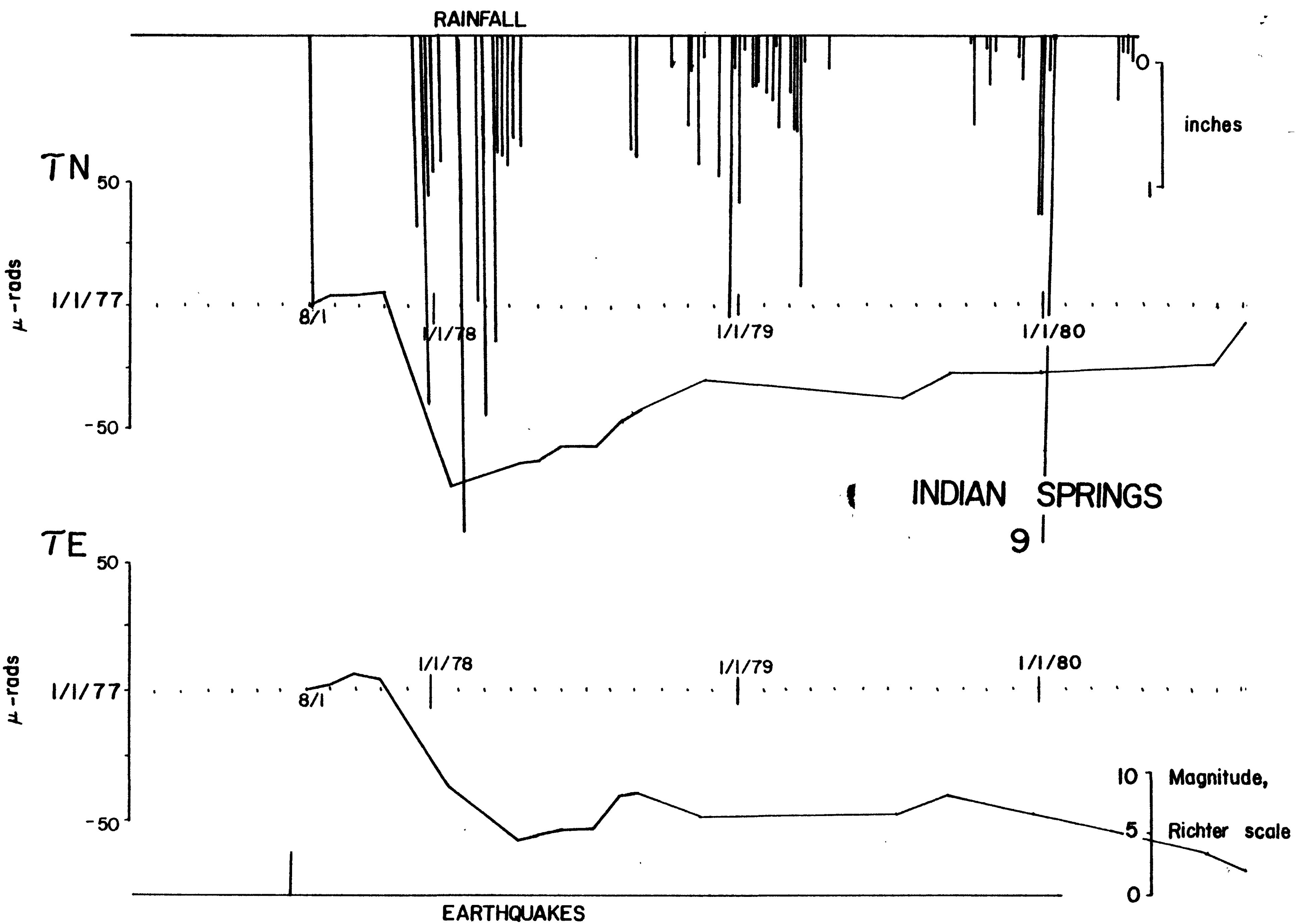
15. Site map of 47th St. E leveled alignment array across the Nadeau fault.

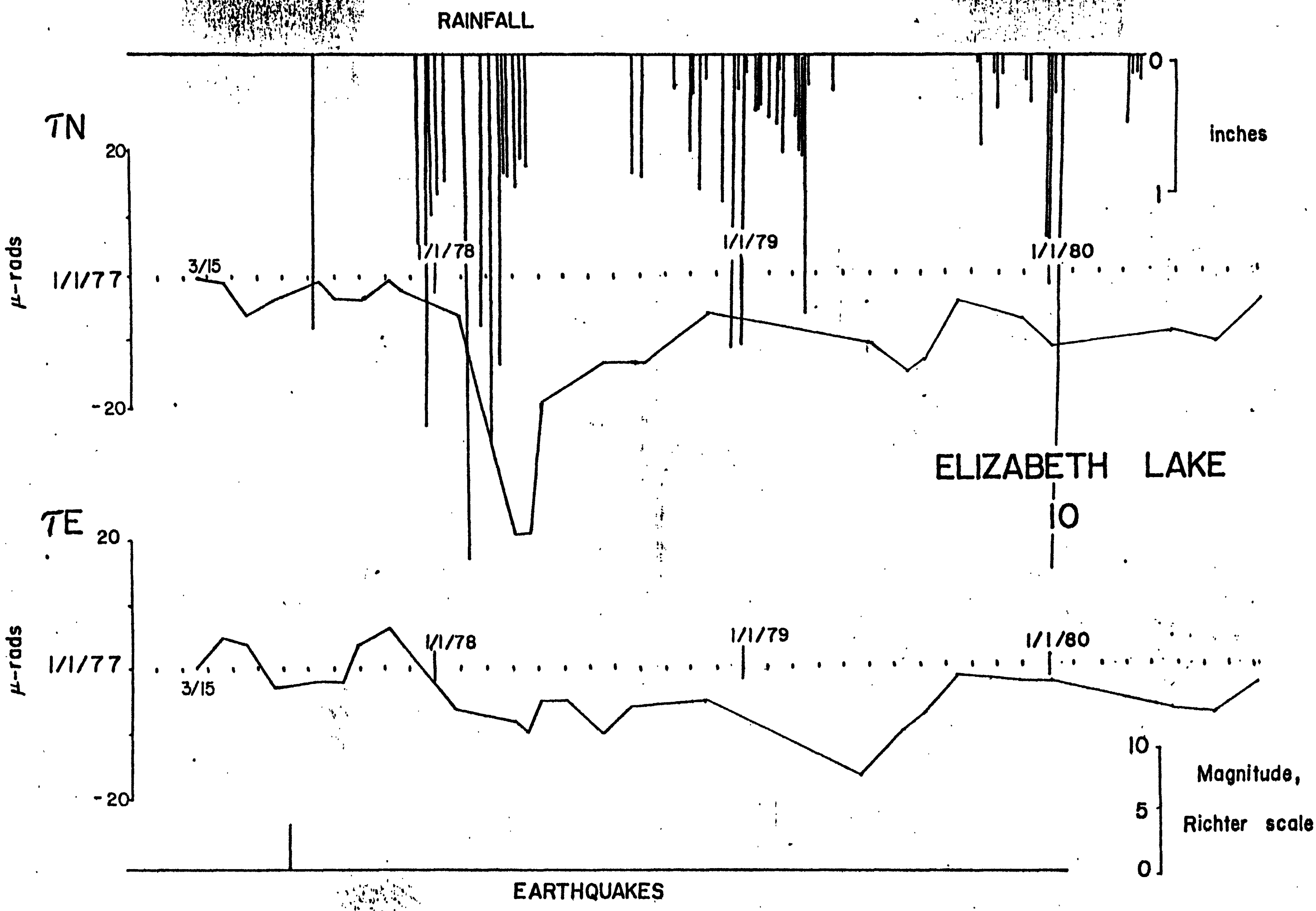
16. Site map of UCSB trilateration/triangulation arrays across the Santa Cruz Island fault zone.

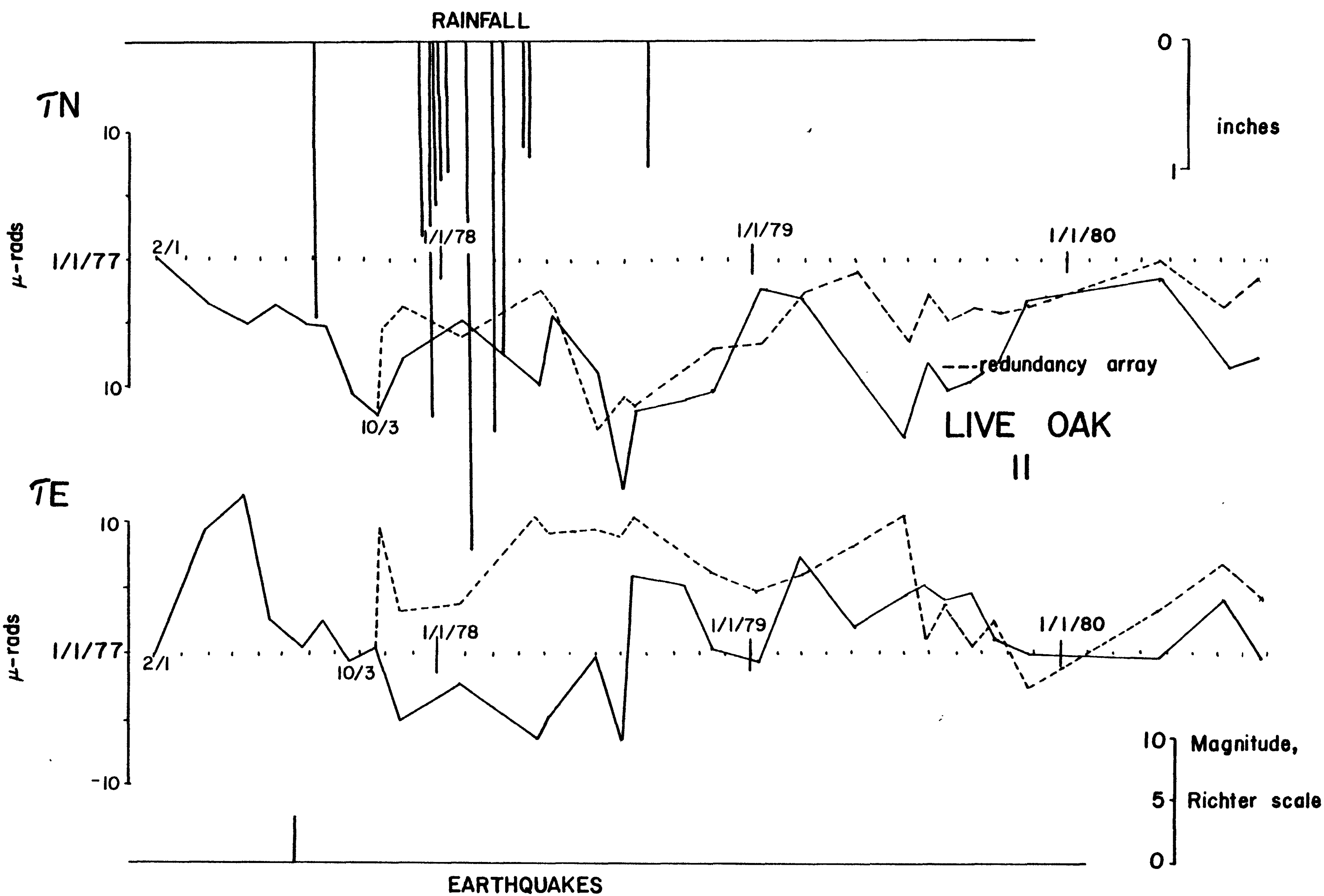
TABLE III. ALIGNMENT ARRAYS

LOCATION	LATITUDE	LONGITUDE	QUANDRANGLE	INITIAL SURVEY	MOST RECENT SURVEY	TOTAL # SURVEYS
Mesa Valley	34°48'46"	118°54'20"	Frazier Mtn.	2/77	9/80	6
47th St. East	34°31'03"	118°02'47"	Palmdale	12/76	8/80	7

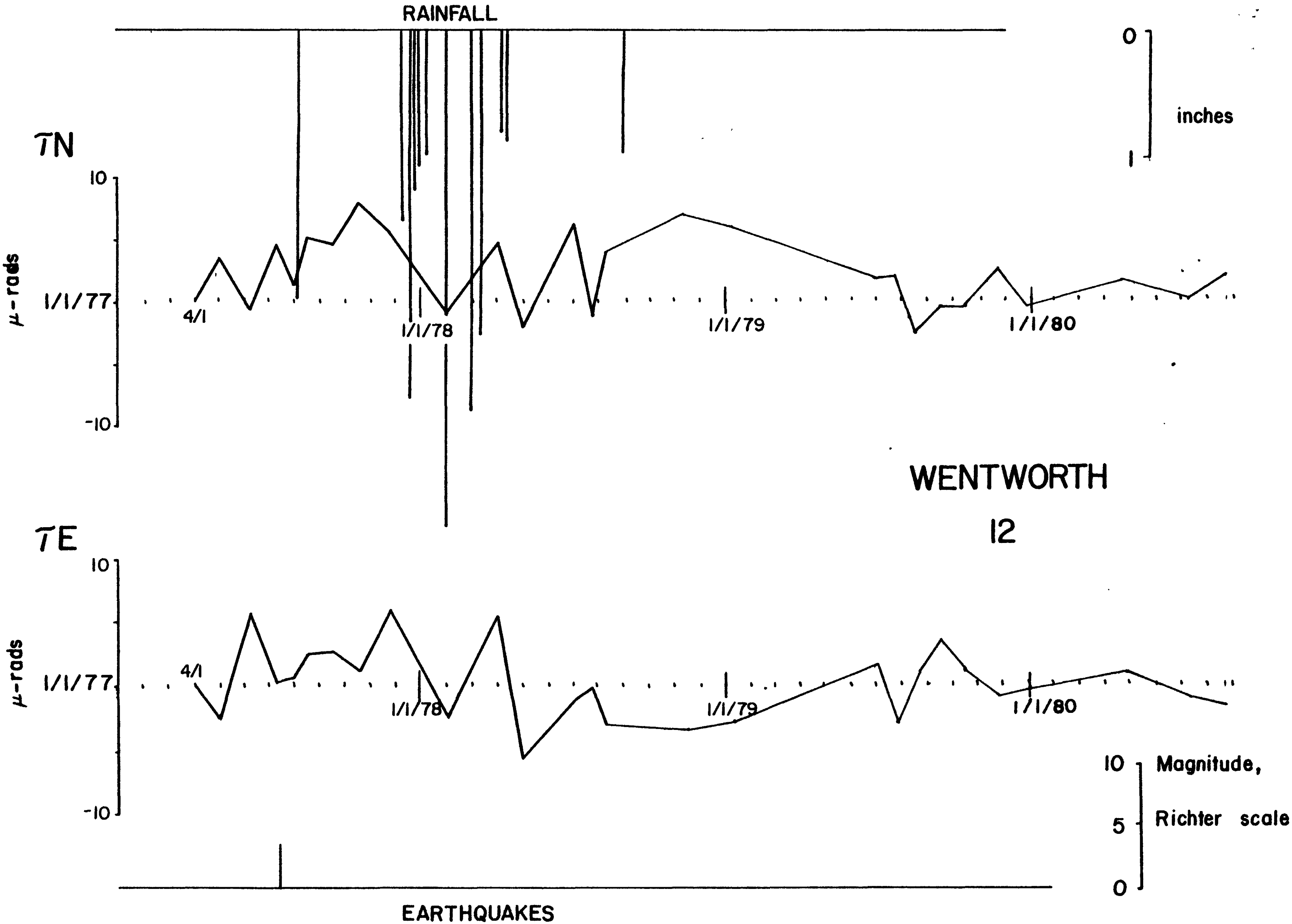

RAINFALL
0
1
inches
TN
20
μ-rads
1/1/77
-20
8/1
1/1/78
4/15
1/1/79
1/1/80
TE
20
μ-rads
1/1/77
-20
8/1
1/1/78
4/15
1/1/79
1/1/80
DRINKWATER FLAT
8
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

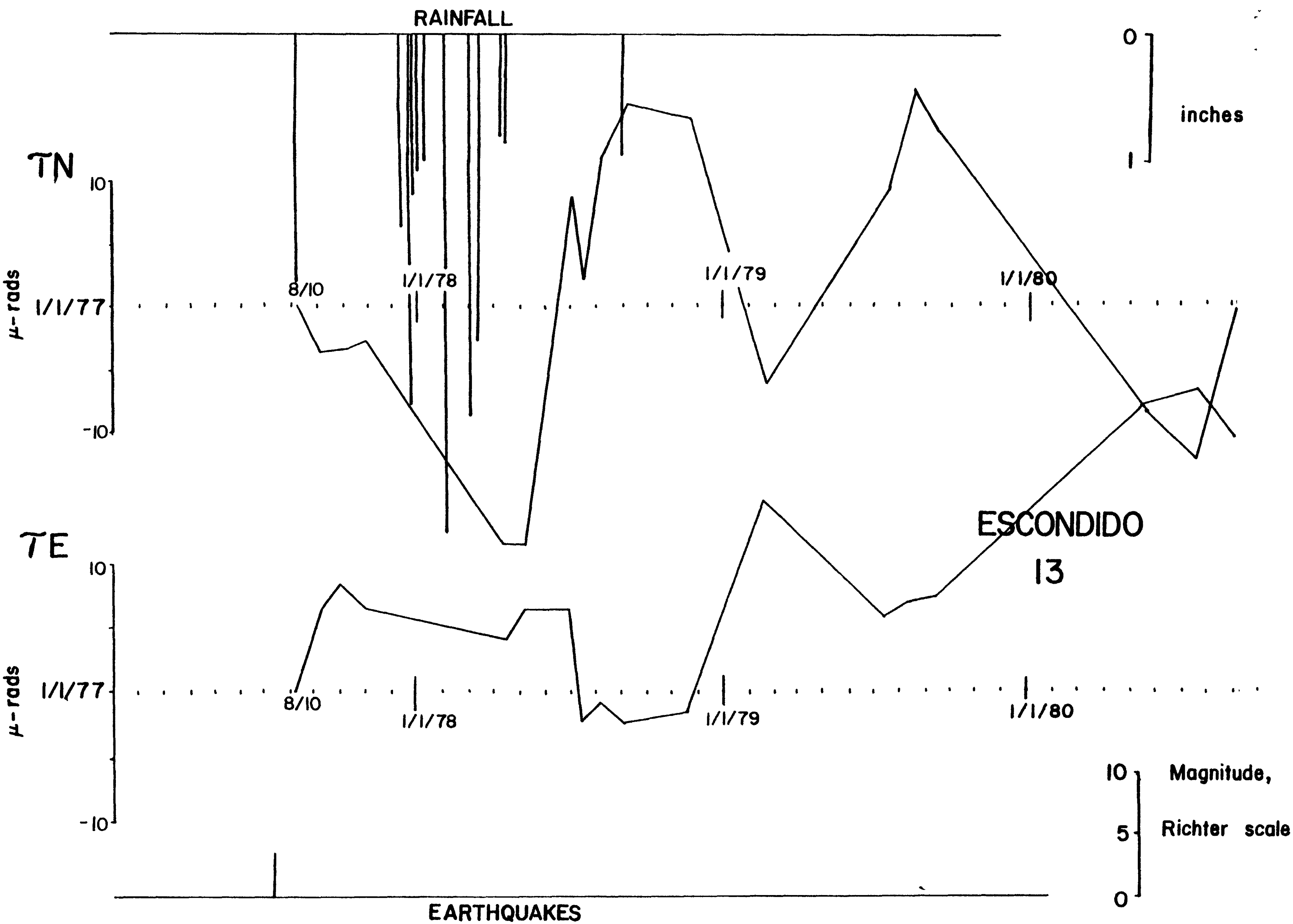

RAINFALL
inches
0
1
TN
50
μ-rads
1/1/77
-50
8/1
1/1/78
1/1/79
1/1/80
INDIAN SPRINGS
9
TE
50
μ-rads
1/1/77
-50
8/1
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

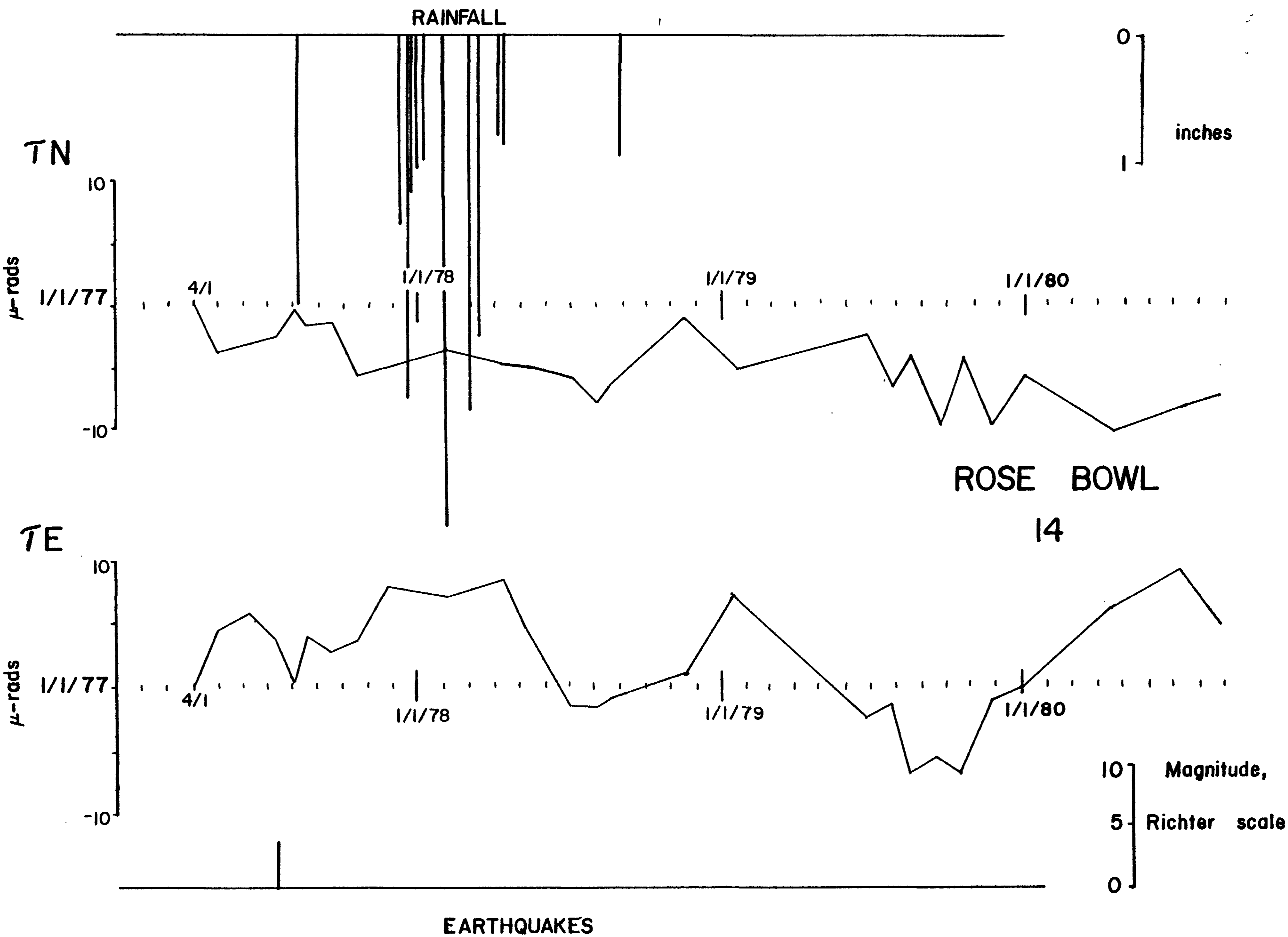

RAINFALL
0
1
inches
τN
20
1/1/77
-20
μ-rads
3/15
1/1/78
1/1/79
1/1/80
ELIZABETH LAKE
10
τE
20
1/1/77
-20
μ-rads
3/15
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

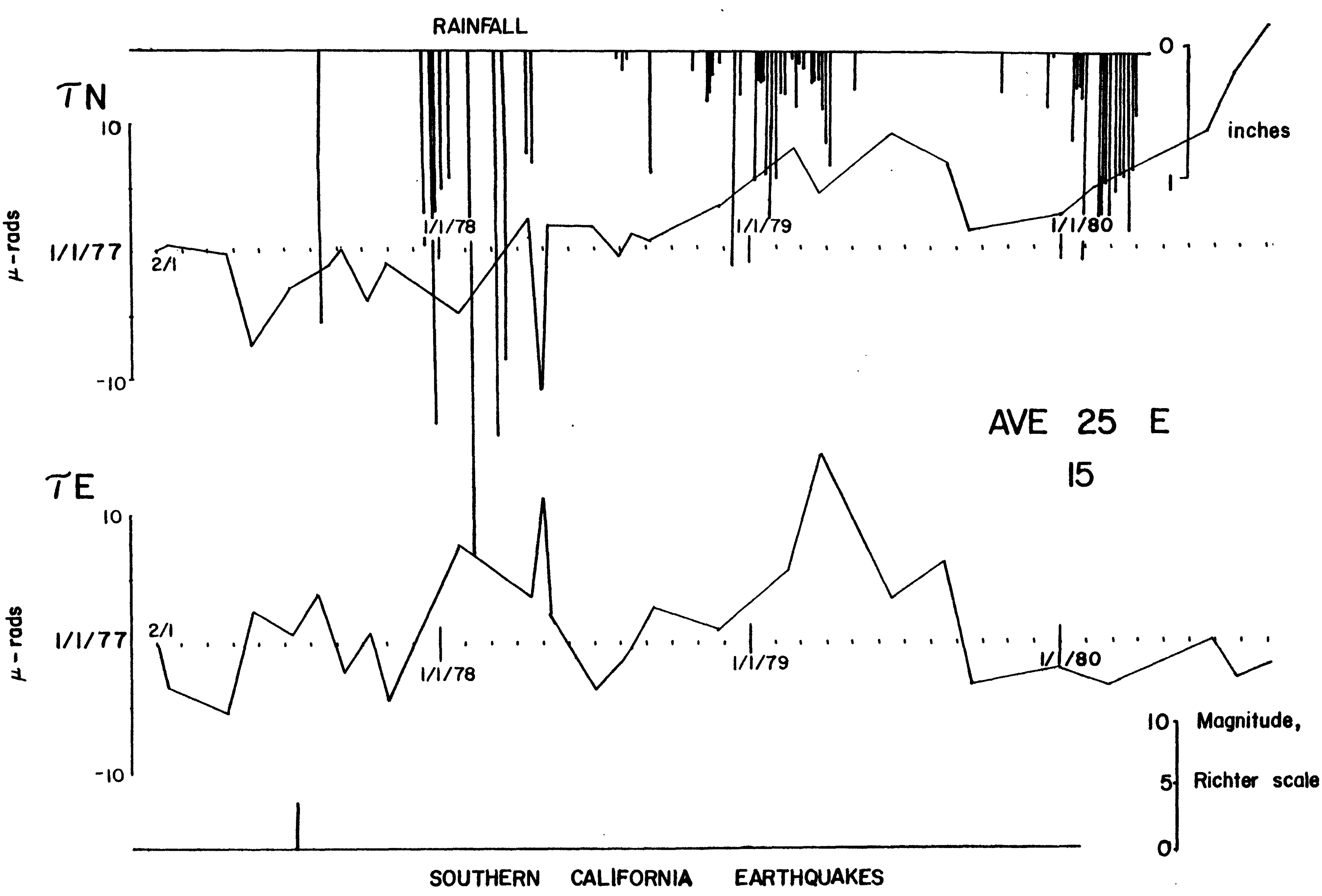


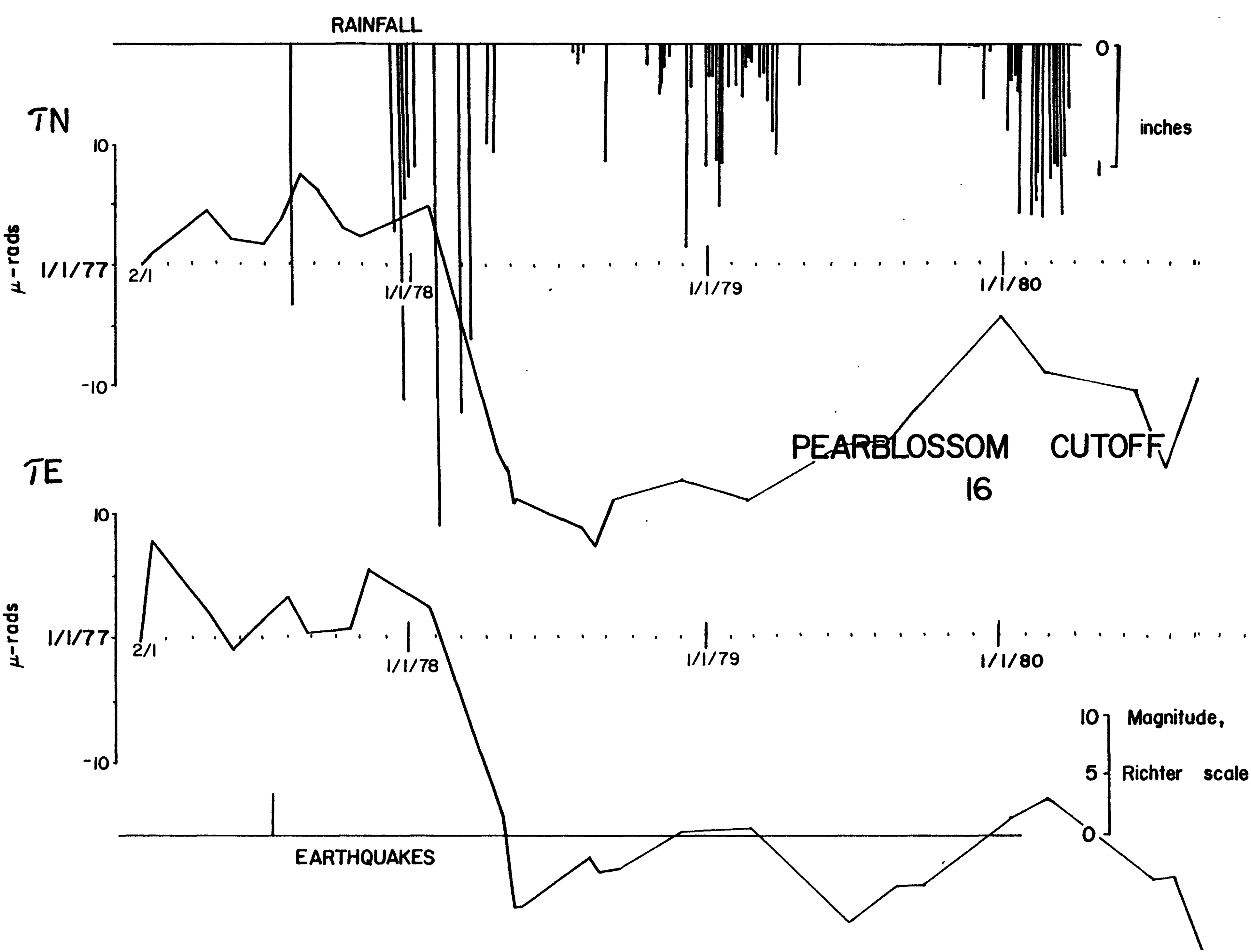
RAINFALL
0
inches
1
τN
10
1/1/77
10
μ-rads
2/1
10/3
1/1/78
1/1/79
1/1/80
---redundancy array
LIVE OAK
II
τE
10
1/1/77
-10
μ-rads
2/1
10/3
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

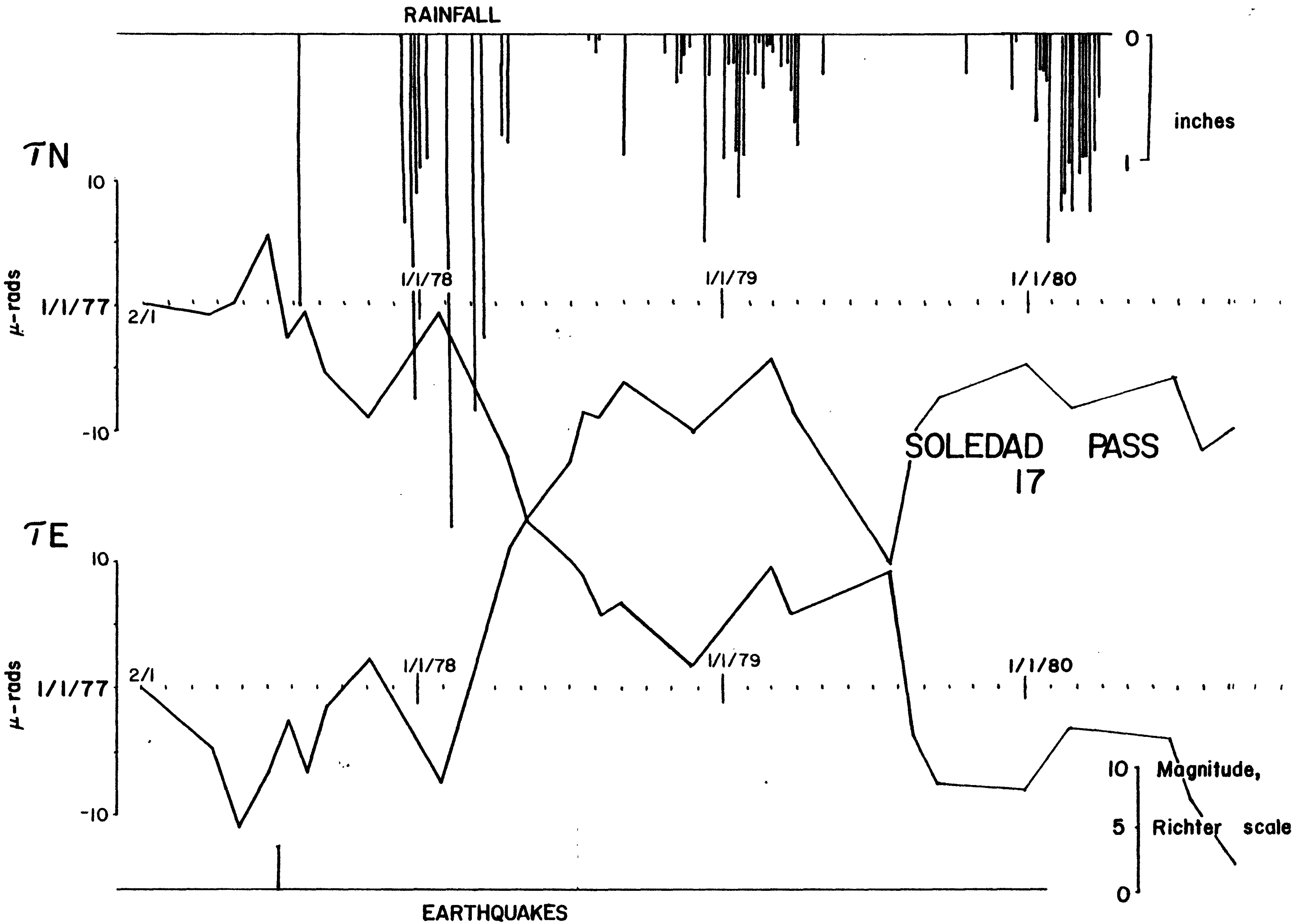

RAINFALL
0
inches
1
τN
10
μ-rads
1/1/77
-10
4/1
1/1/78
1/1/79
1/1/80
WENTWORTH
12
τE
10
μ-rads
1/1/77
-10
4/1
1/1/78
1/1/79
1/1/80
10
Magnitude,
5
Richter scale
0
EARTHQUAKES

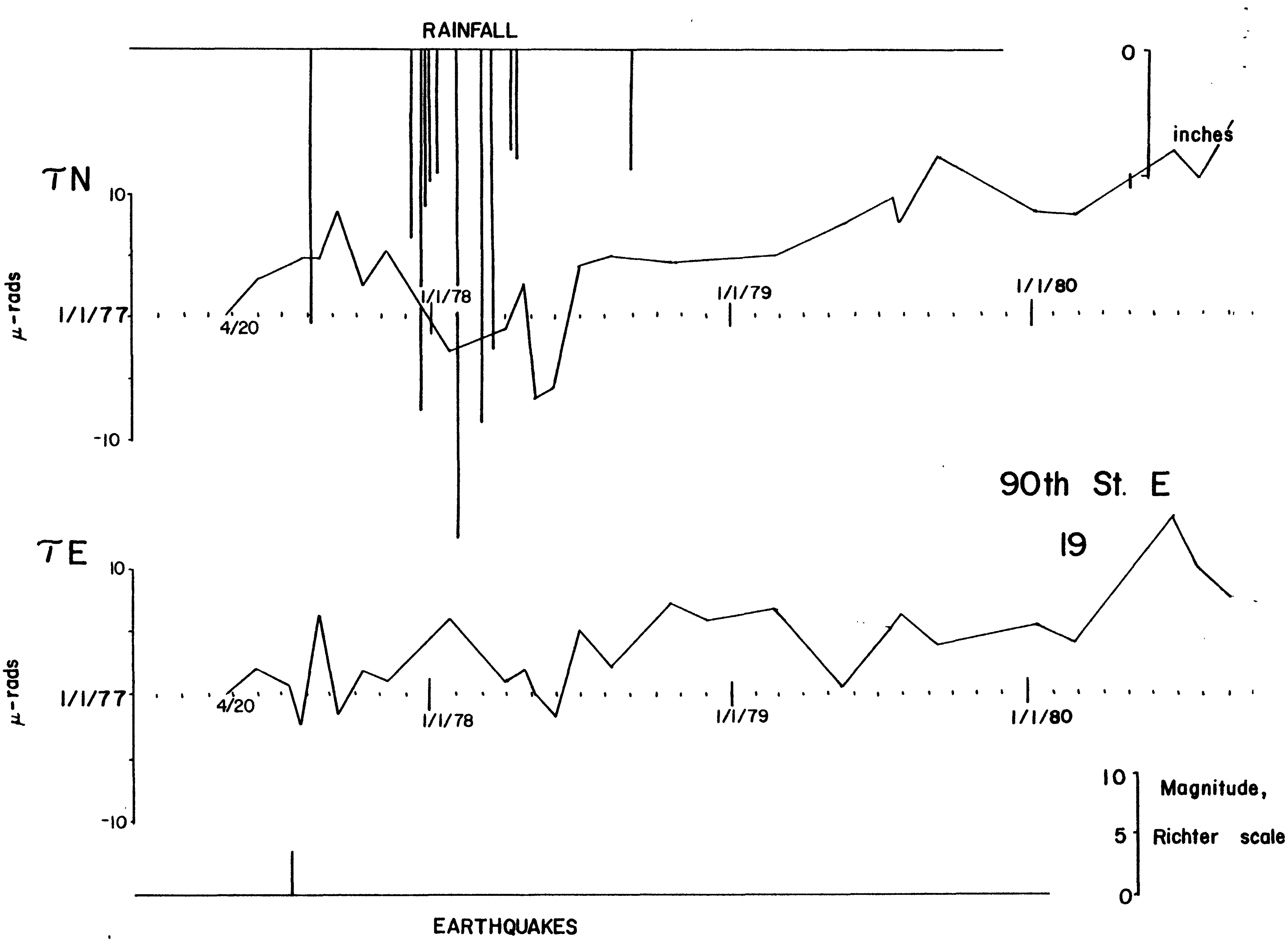

RAINFALL
0
inches
1
TN
10
μ-rads
1/1/77
-10
8/10
1/1/78
1/1/79
1/1/80
TE
10
μ-rads
1/1/77
-10
8/10
1/1/78
1/1/79
1/1/80
ESCONDIDO
13
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

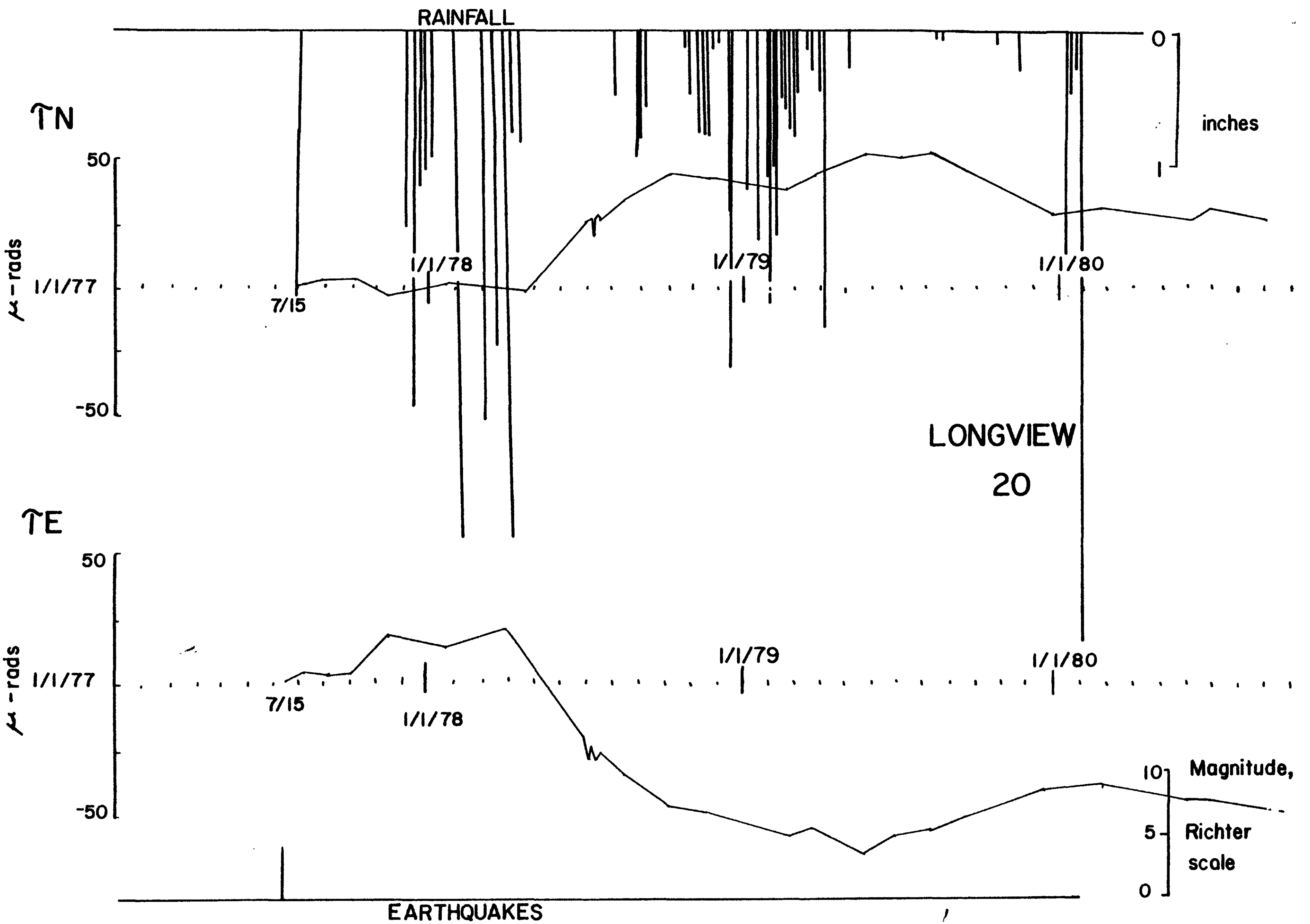

RAINFALL
0
1
inches
τN
10
1/1/77
-10
μ-rads
4/1
1/1/78
1/1/79
1/1/80
ROSE BOWL
14
τE
10
1/1/77
-10
μ-rads
4/1
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES


RAINFALL
τN
10
1/1/77
-10
μ-rads
2/1
1/1/78
1/1/79
1/1/80
0
1
inches
AVE 25 E
15
τE
10
1/1/77
-10
μ-rads
2/1
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
SOUTHERN CALIFORNIA EARTHQUAKES

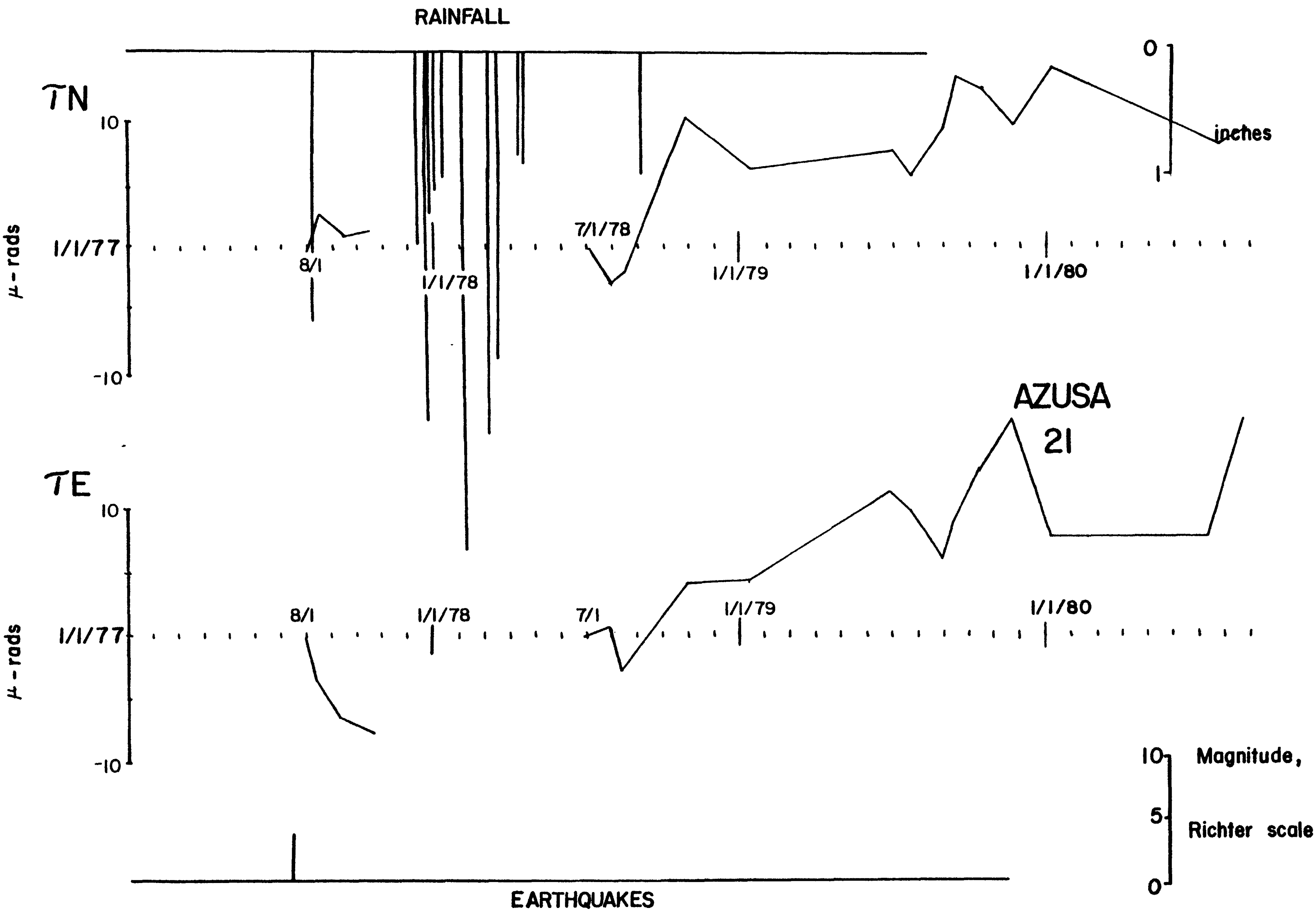

RAINFALL
0
1
inches
τN
10
1/1/77
-10
μ-rads
2/1
1/1/78
1/1/79
1/1/80
PEARBLOSSOM CUTOFF
16
τE
10
1/1/77
-10
μ-rads
2/1
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES


RAINFALL
0
inches
1
τN
10
μ-rads
1/1/77
-10
2/1
1/1/78
1/1/79
1/1/80
SOLEDAD PASS
17
τE
10
μ-rads
1/1/77
-10
2/1
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

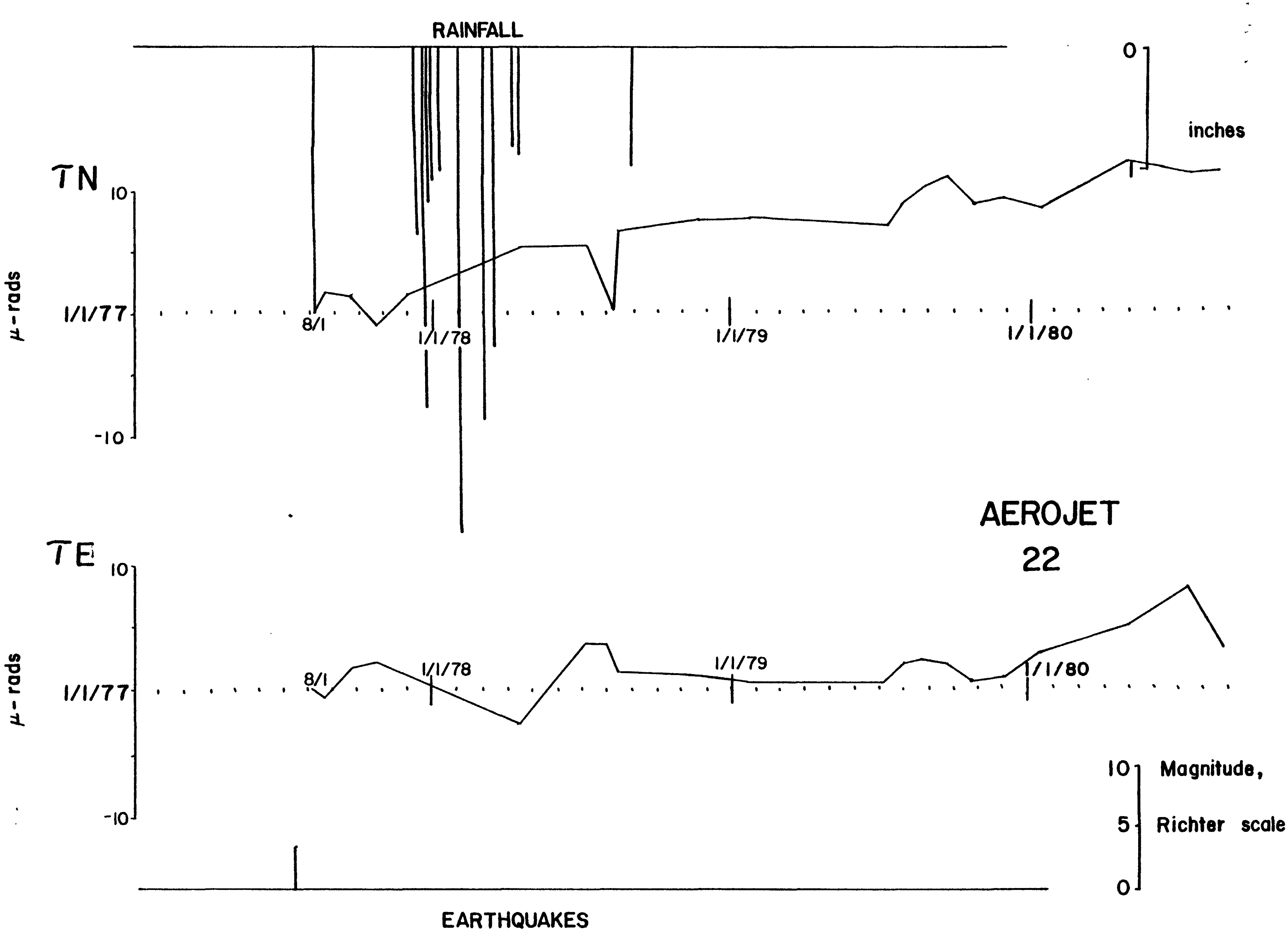

RAINFALL
0
inches
τN
10
1/1/77
-10
μ-rads
4/20
1/1/78
1/1/79
1/1/80
90th St. E
19
τE
10
1/1/77
-10
μ-rads
4/20
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

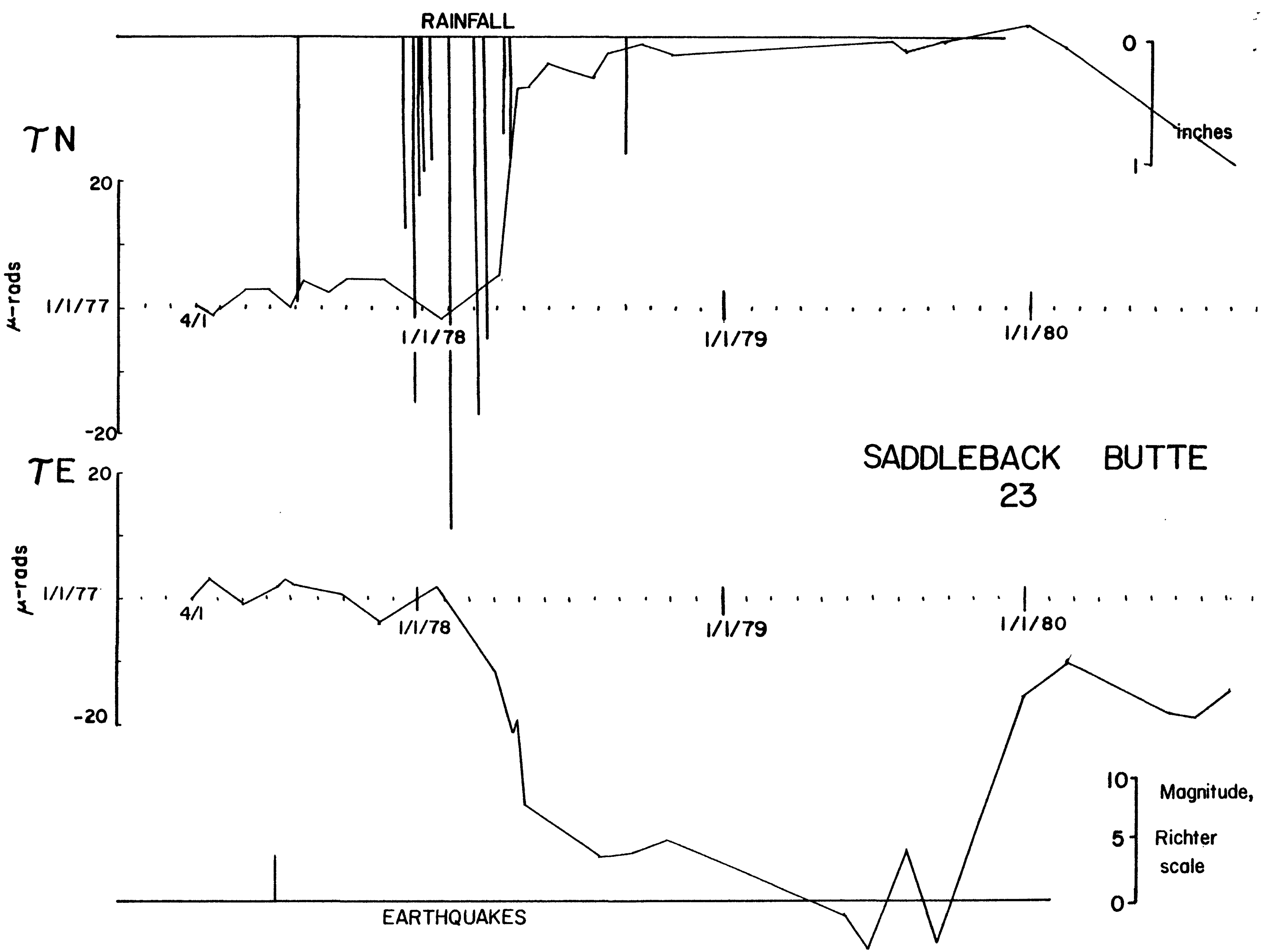


RAINFALL
0
1
inches
τN
50
μ-rads
1/1/77
-50
7/15
1/1/78
1/1/79
1/1/80
LONGVIEW
20
τE
50
μ-rads
1/1/77
-50
7/15
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter
scale
EARTHQUAKES

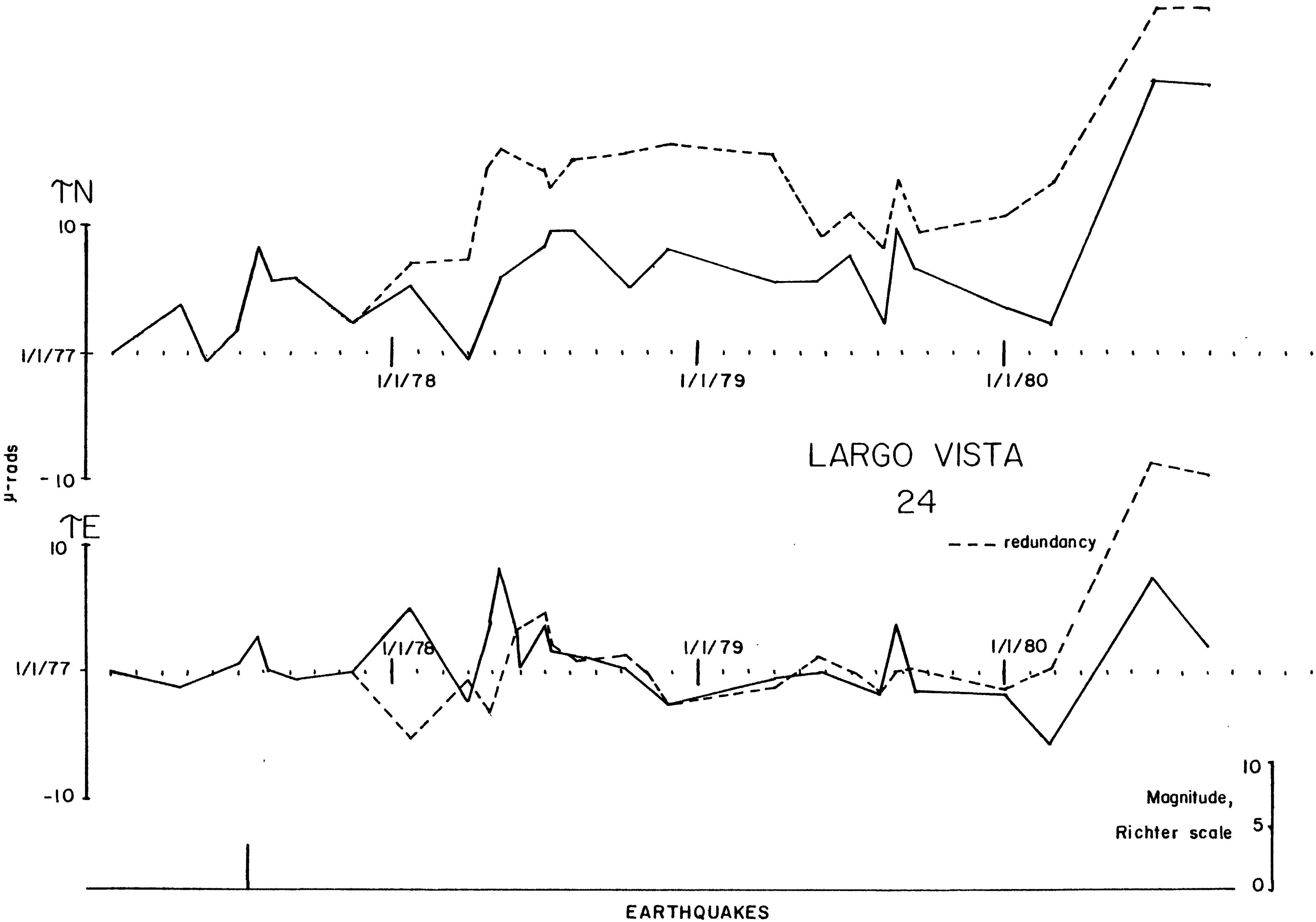


RAINFALL
τN
10
1/1/77
-10
μ - rads
8/1
1/1/78
7/1/78
1/1/79
1/1/80
0
1
inches
AZUSA
21
τE
10
1/1/77
-10
μ - rads
8/1
1/1/78
7/1
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

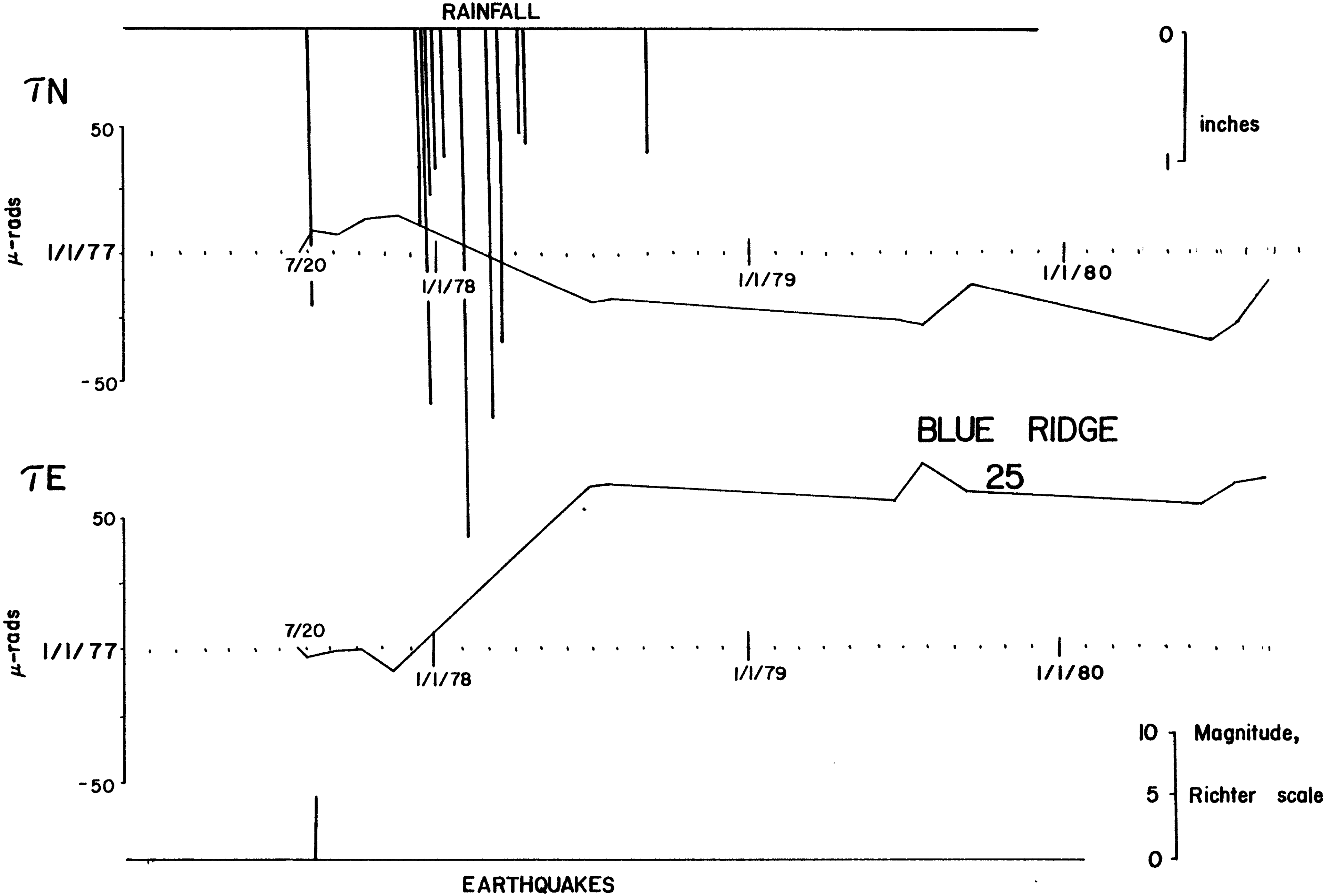

RAINFALL
0
inches
TN
10
μ-rads
1/1/77
8/1
1/1/78
1/1/79
1/1/80
-10
AEROJET
22
TE
10
μ-rads
1/1/77
8/1
1/1/78
1/1/79
1/1/80
-10
10
Magnitude,
5
Richter scale
0
EARTHQUAKES

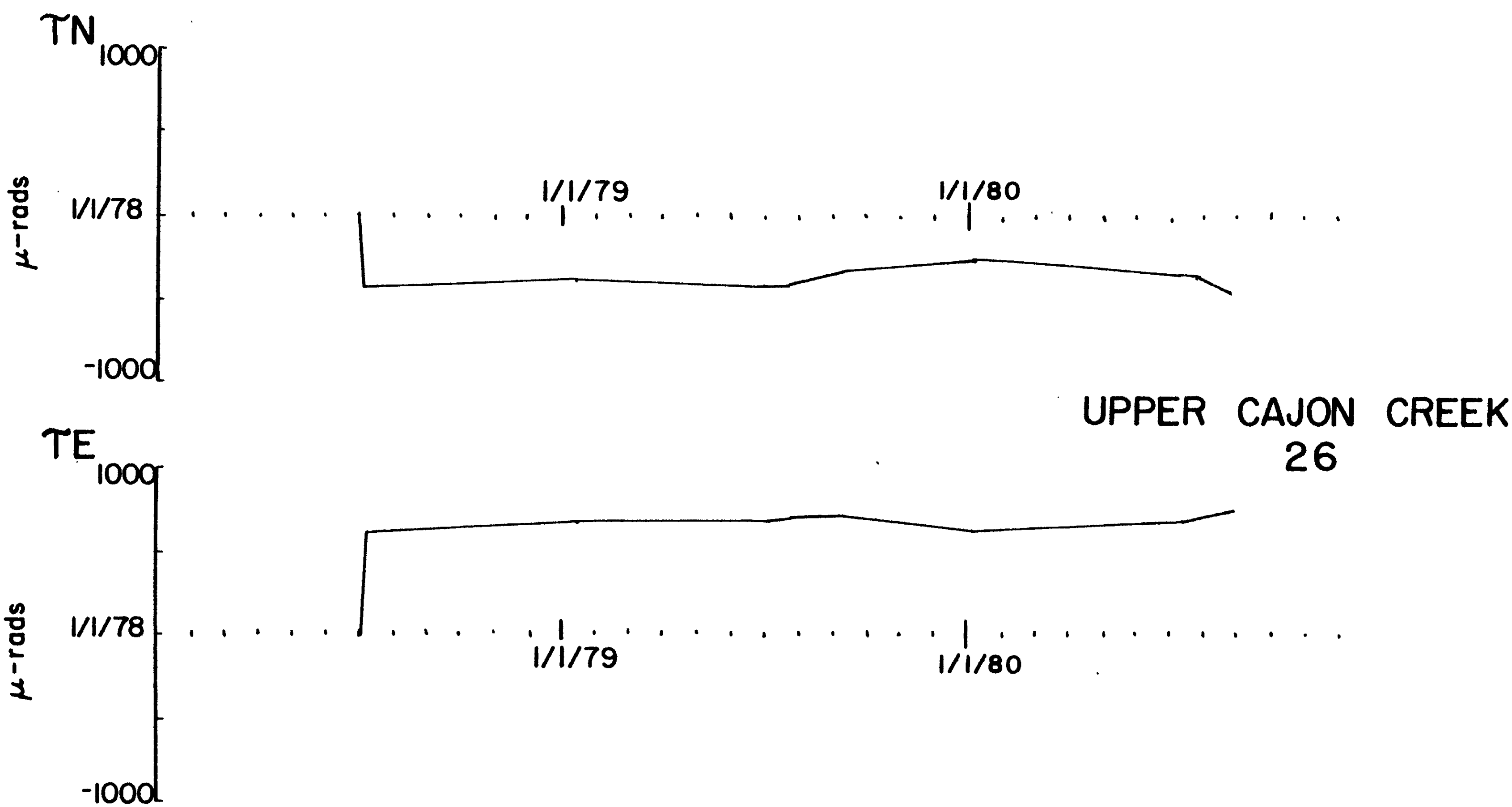


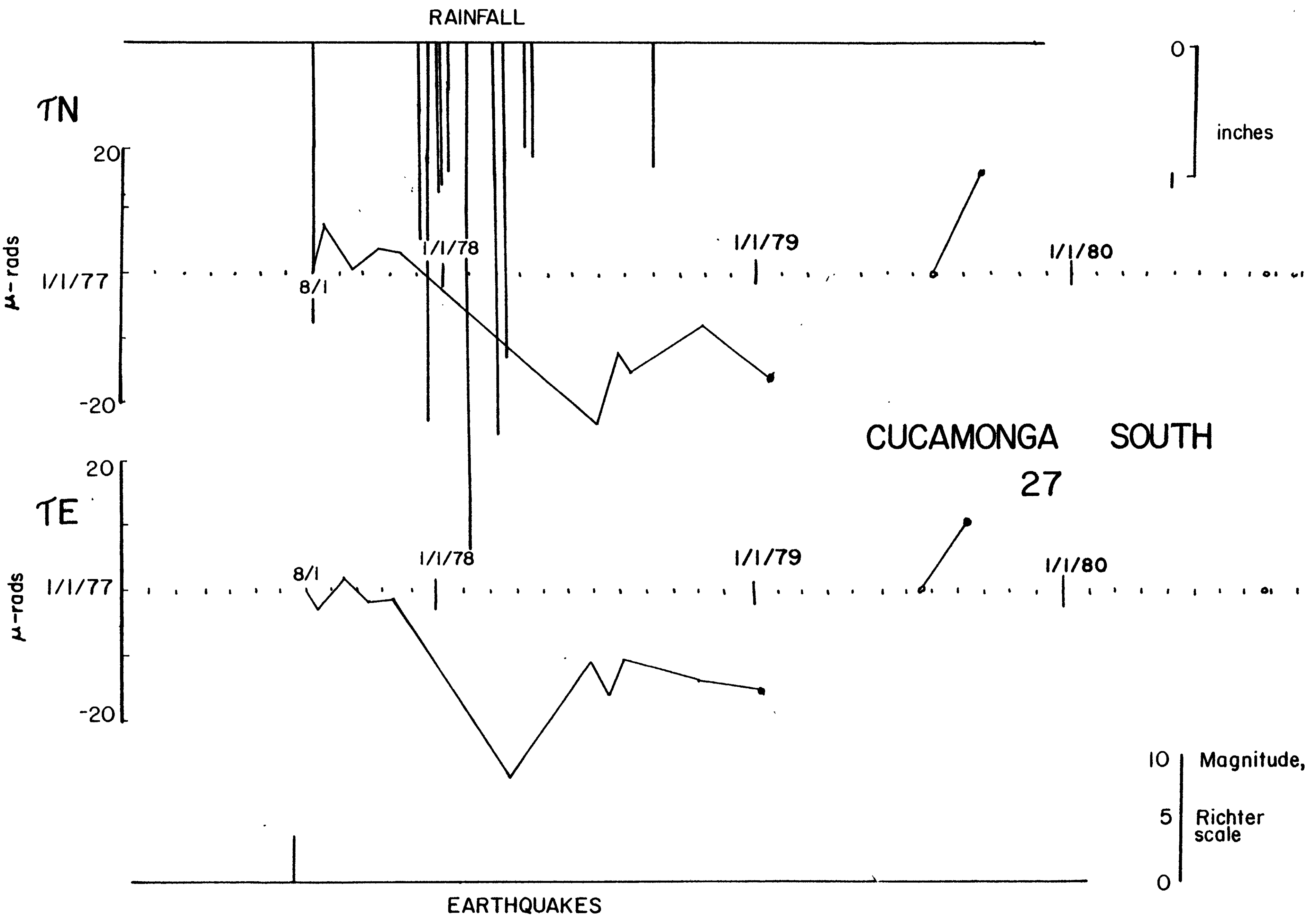
RAINFALL
0
inches
1
τN
20
μ-rads
1/1/77
4/1
1/1/78
1/1/79
1/1/80
-20
SADDLEBACK BUTTE
23
τE
20
μ-rads
1/1/77
4/1
1/1/78
1/1/79
1/1/80
-20
10
5
0
Magnitude,
Richter
scale
EARTHQUAKES

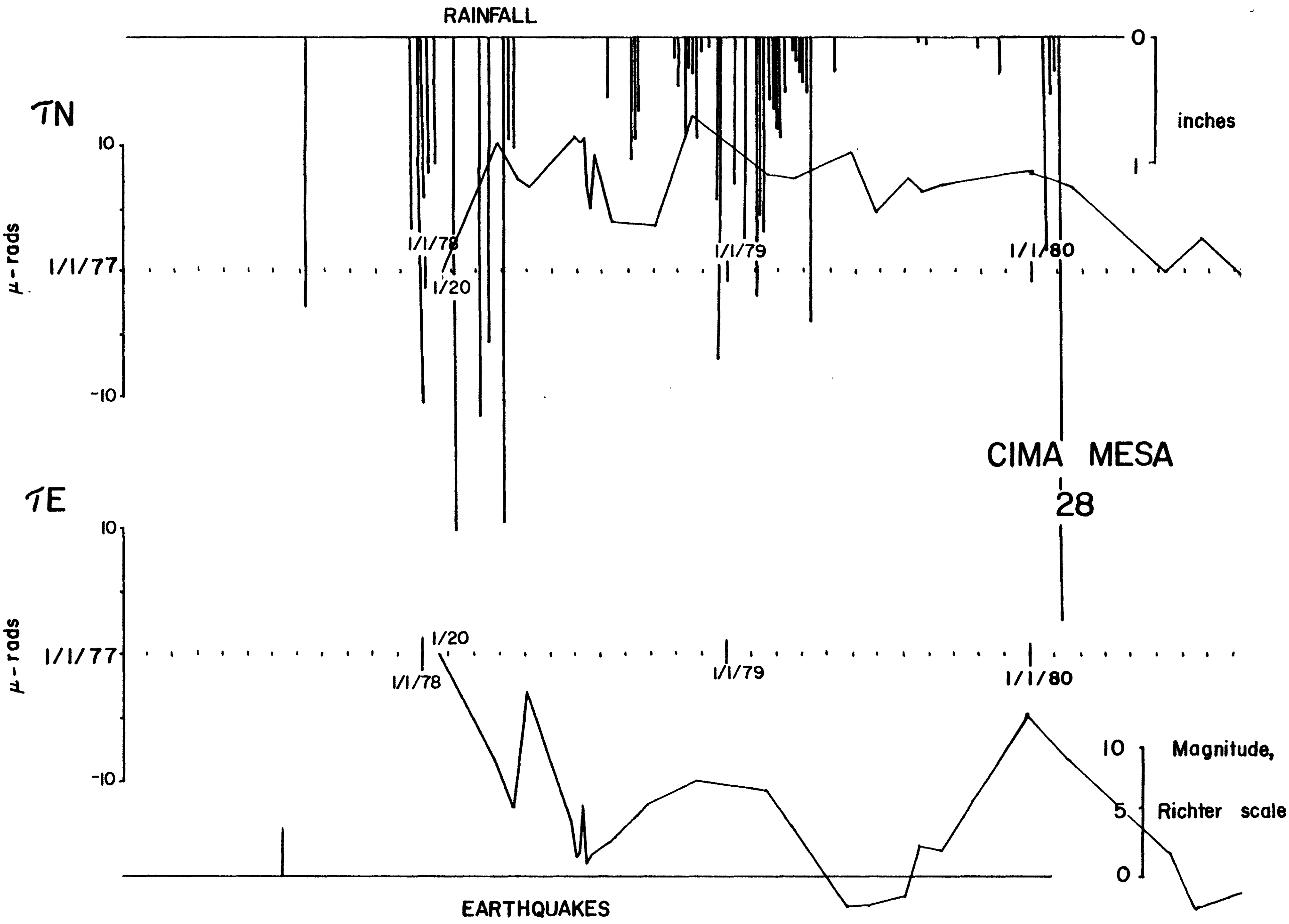


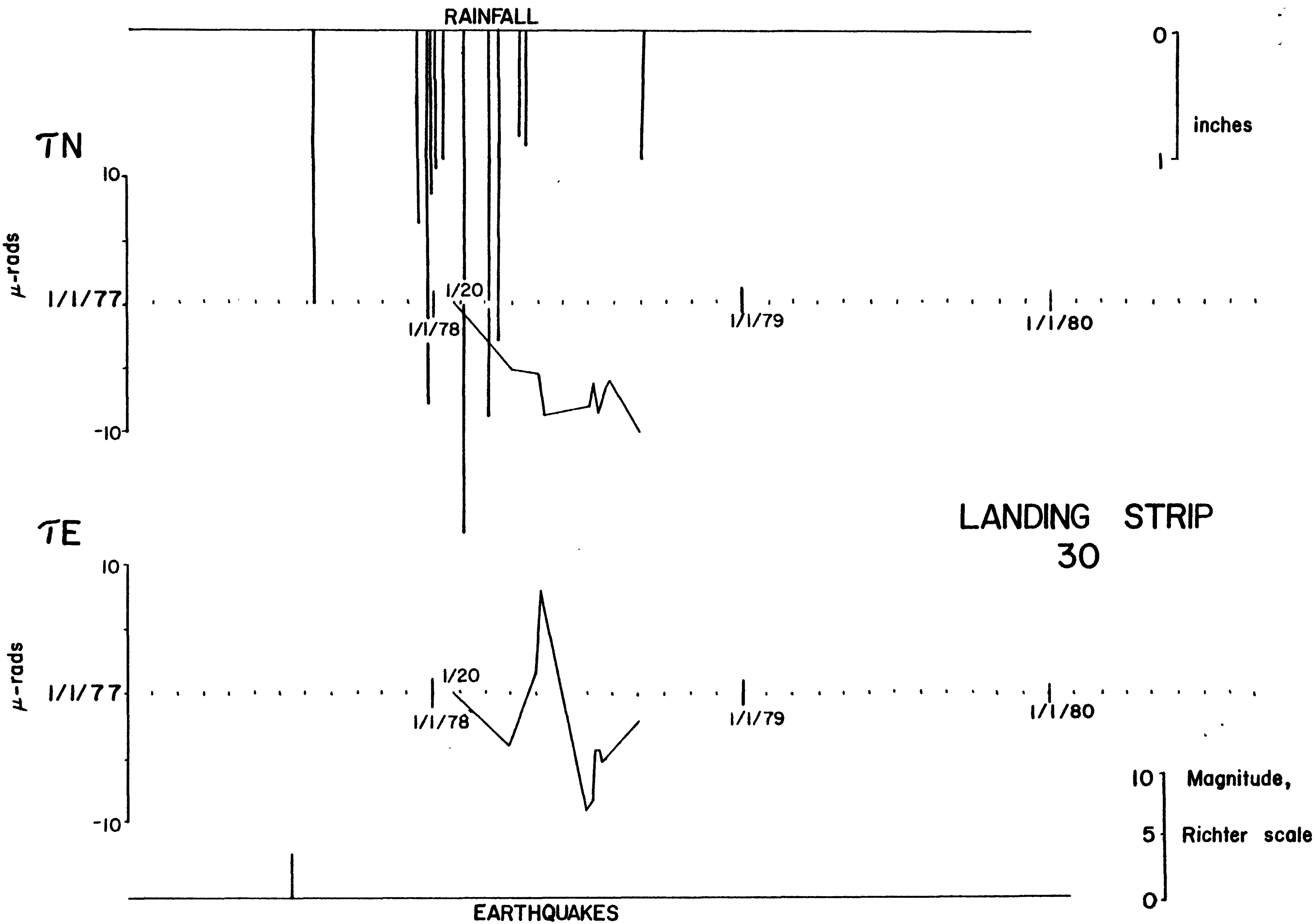
LARGO VISTA
24
τN
τE
10
-10
1/1/77
1/1/78
1/1/79
1/1/80
μ-rads
redundancy
Magnitude,
Richter scale
0
5
EARTHQUAKES

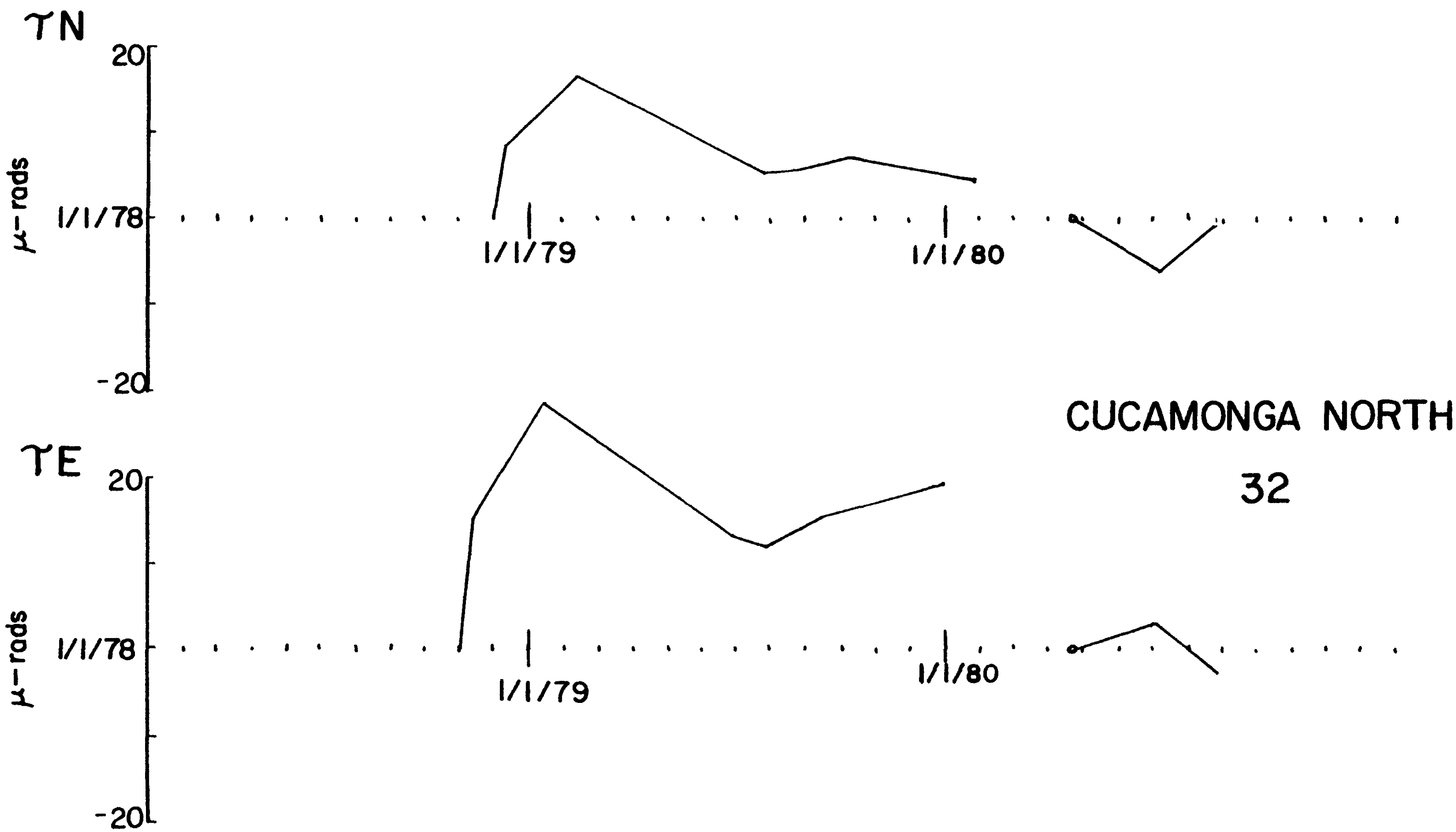

RAINFALL
0
inches
1
τN
50
μ-rads
1/1/77
-50
7/20
1/1/78
1/1/79
1/1/80
BLUE RIDGE
25
τE
50
μ-rads
1/1/77
-50
7/20
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES


TN
1000
1/1/78
-1000
μ-rads
1/1/79
1/1/80
TE
1000
1/1/78
-1000
μ-rads
1/1/79
1/1/80
UPPER CAJON CREEK
26

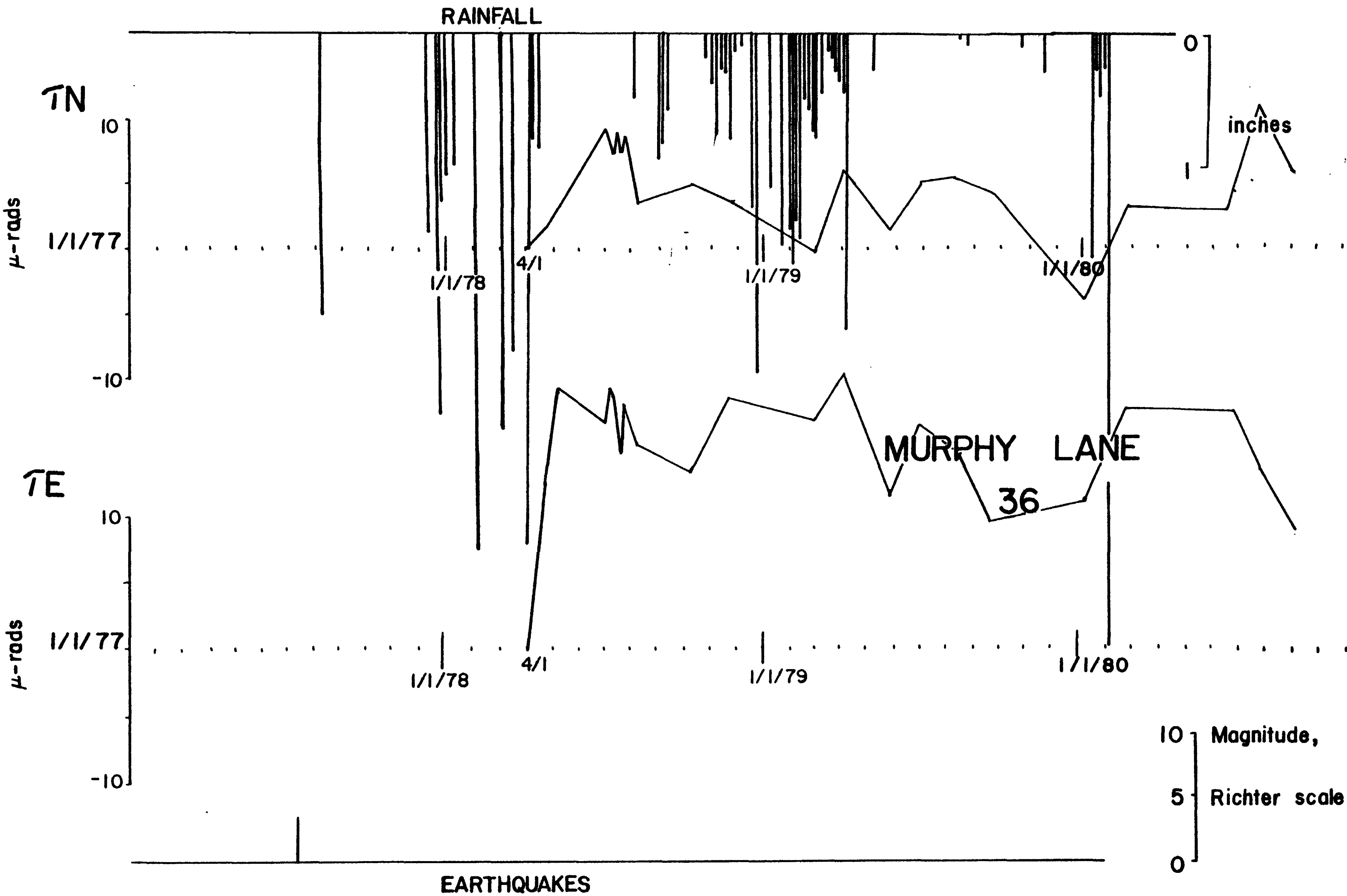

RAINFALL
τN
20
1/1/77
-20
μ-rads
8/1
1/1/78
1/1/79
1/1/80
0
1
inches
CUCAMONGA SOUTH
27
τE
20
1/1/77
-20
μ-rads
8/1
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

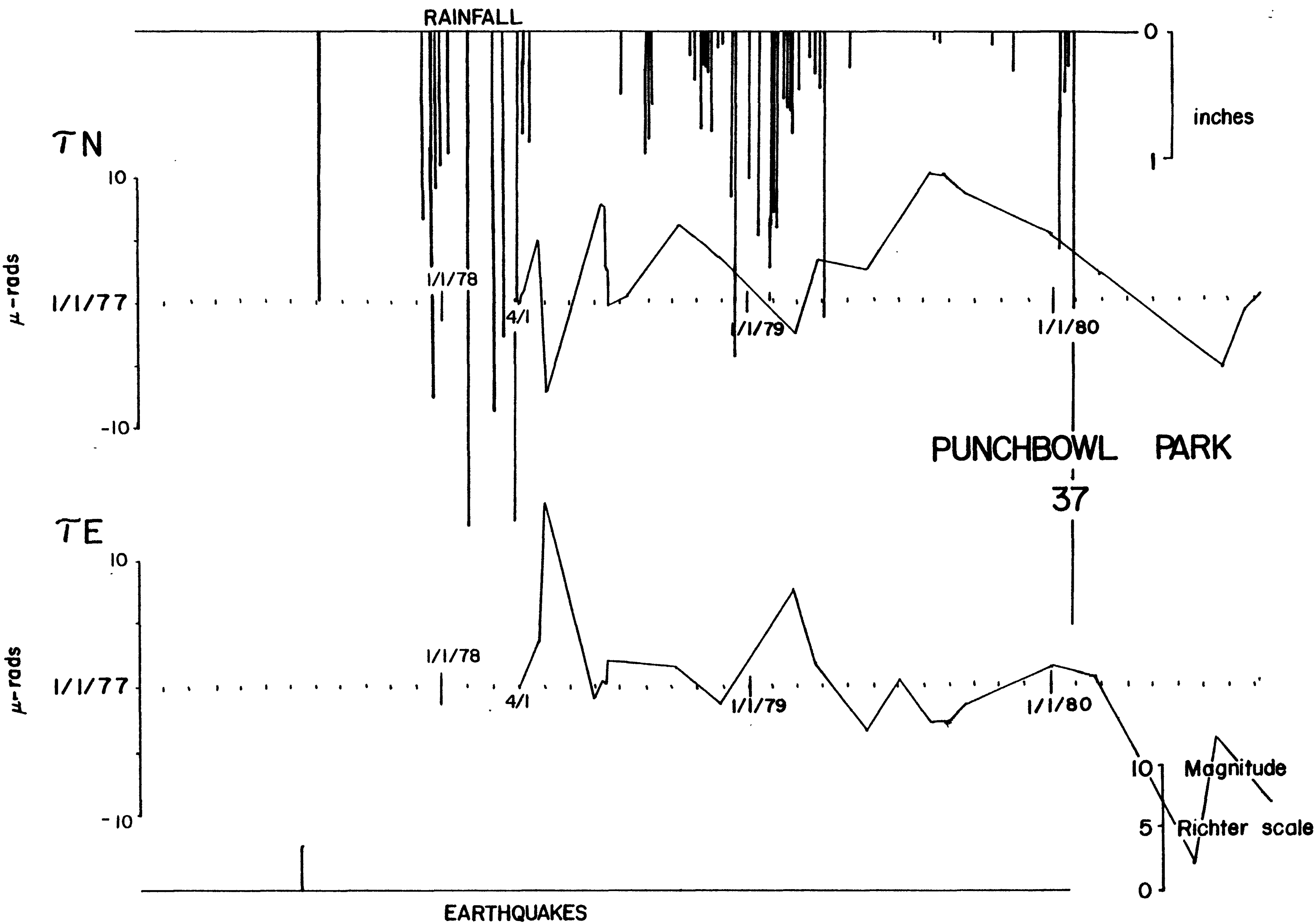

RAINFALL
0
inches
1
τN
10
μ-rads
1/1/77
-10
1/1/78
1/20
1/1/79
1/1/80
CIMA MESA
28
τE
10
μ-rads
1/1/77
-10
1/20
1/1/78
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES


RAINFALL
inches
0
1
τN
μ-rads
10
1/1/77
-10
1/20
1/1/78
1/1/79
1/1/80
LANDING STRIP 30
τE
μ-rads
10
1/1/77
-10
1/20
1/1/78
1/1/79
1/1/80
EARTHQUAKES
Magnitude, Richter scale
10
5
0

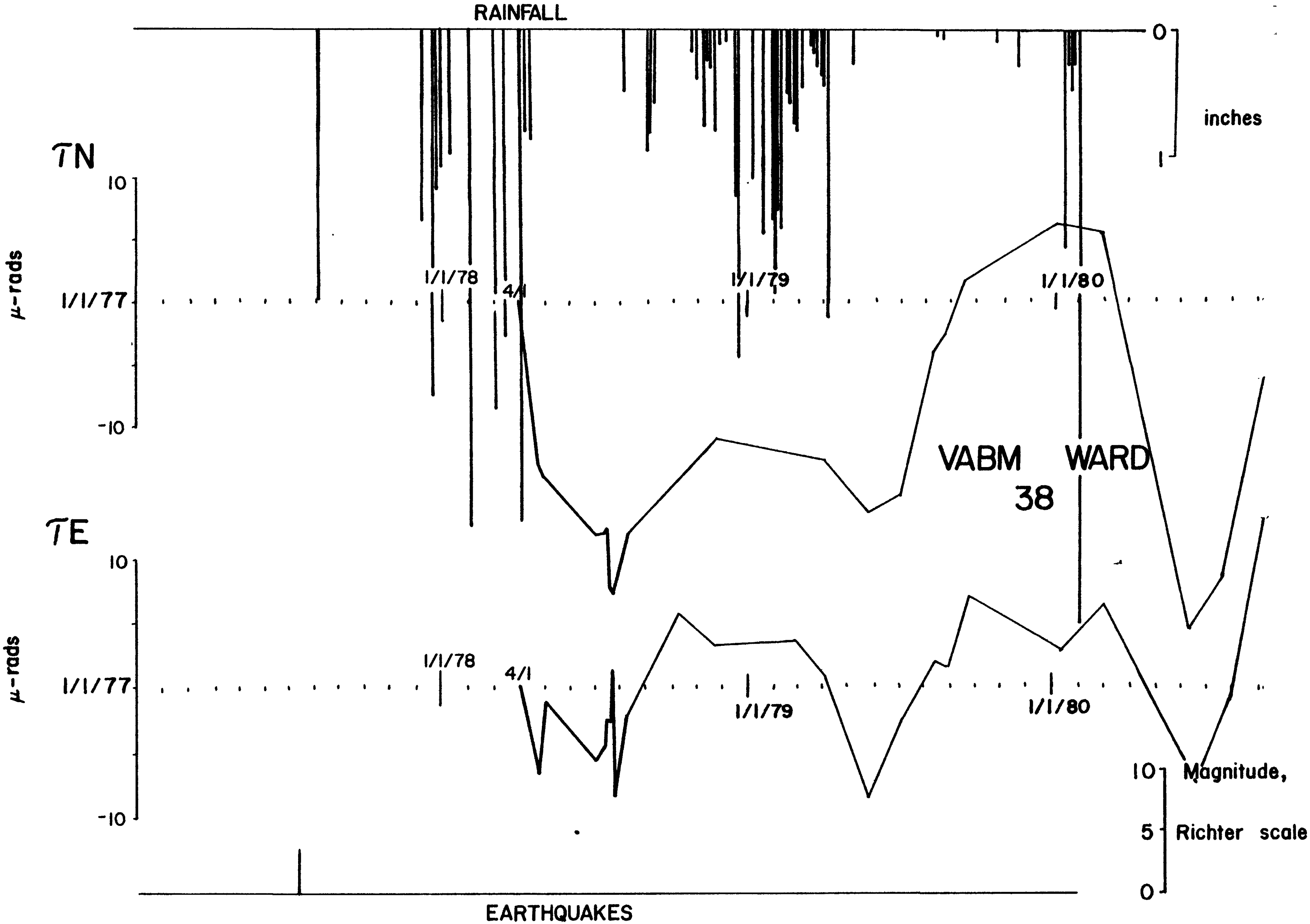


CUCAMONGA NORTH
32
τN
τE
μ-rads
20
-20
1/1/78
1/1/79
1/1/80

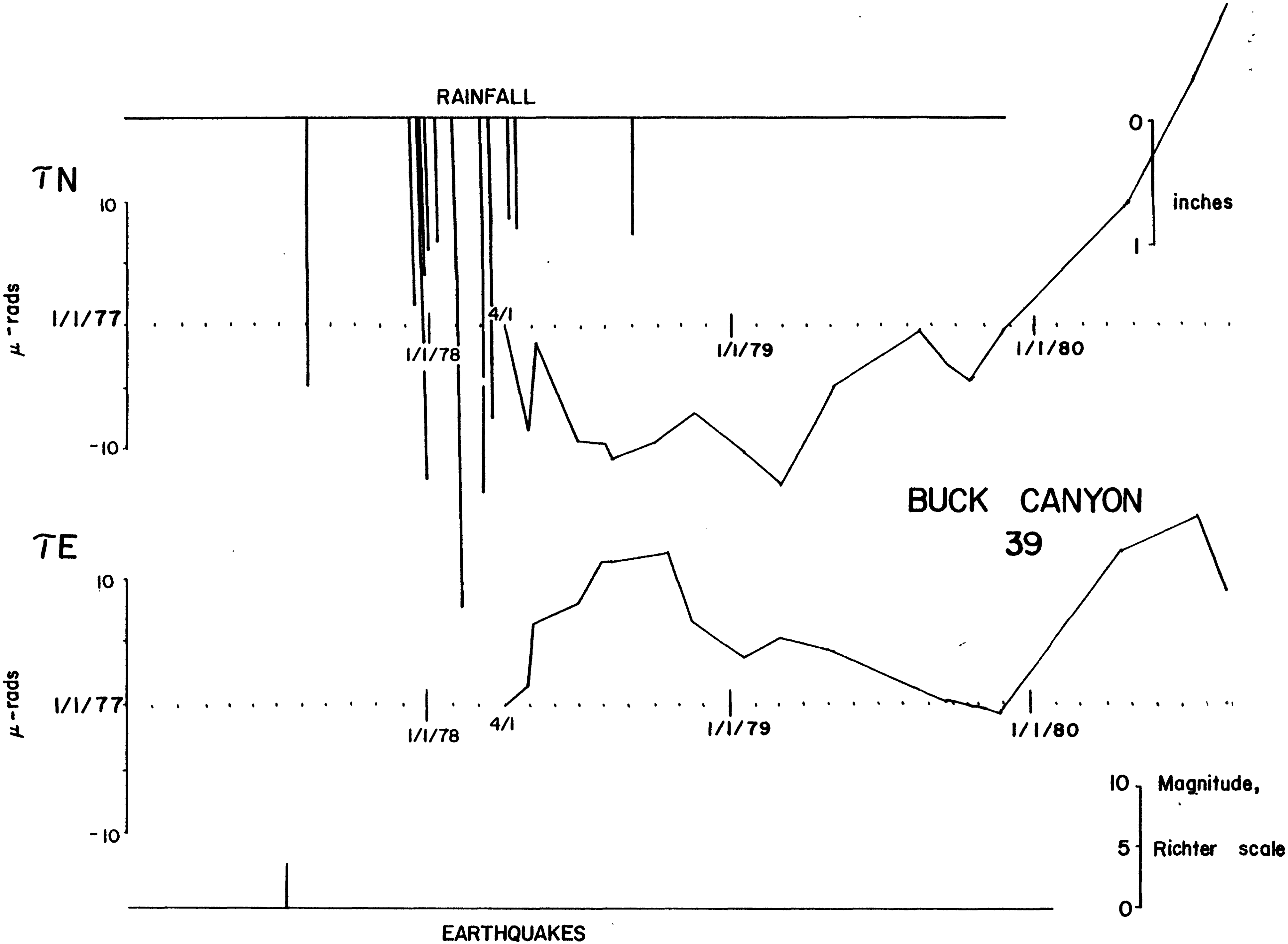

RAINFALL
τN
μ-rads
10
1/1/77
-10
τE
μ-rads
10
1/1/77
-10
1/1/78
4/1
1/1/79
1/1/80
0
1
inches
MURPHY LANE
36
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

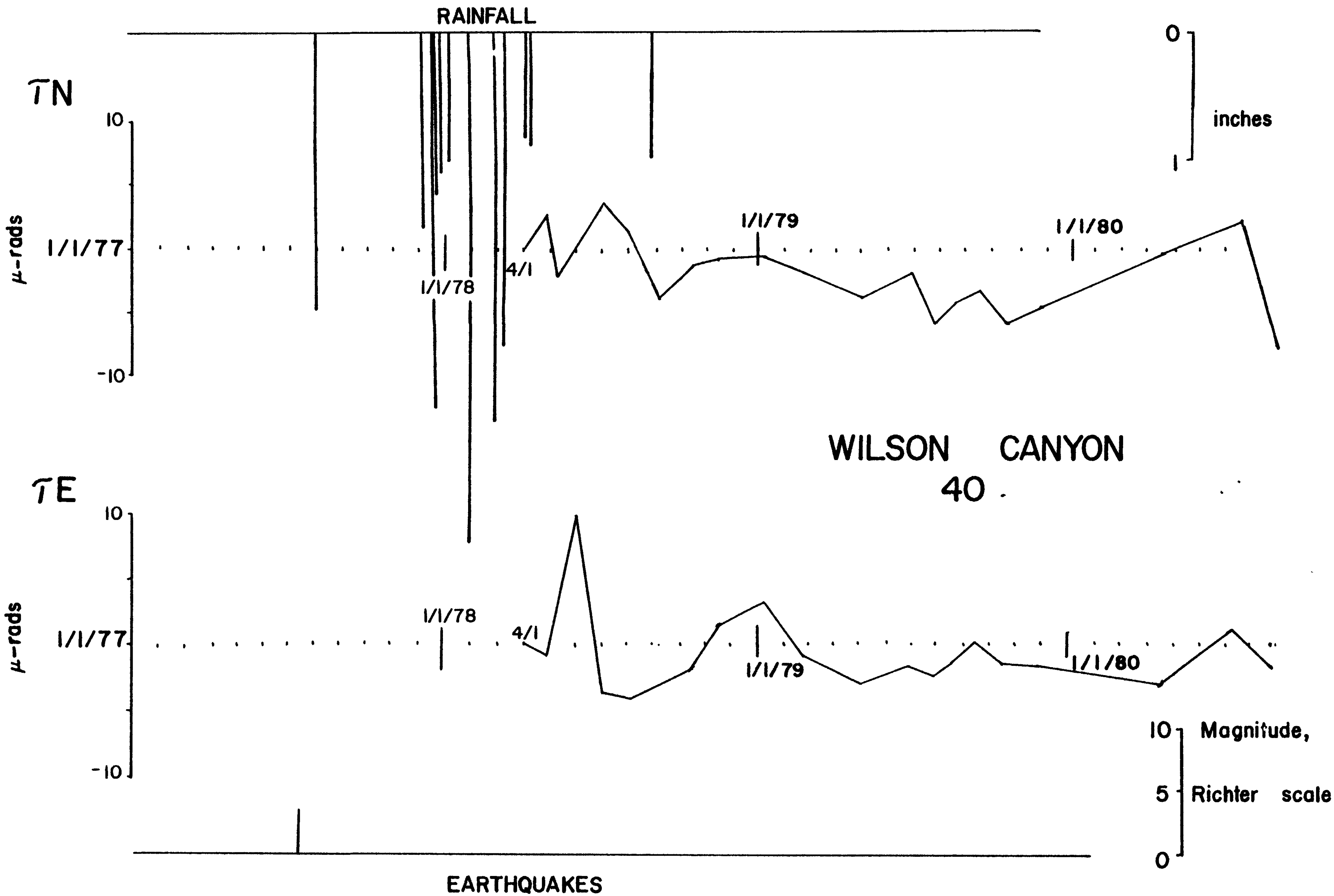


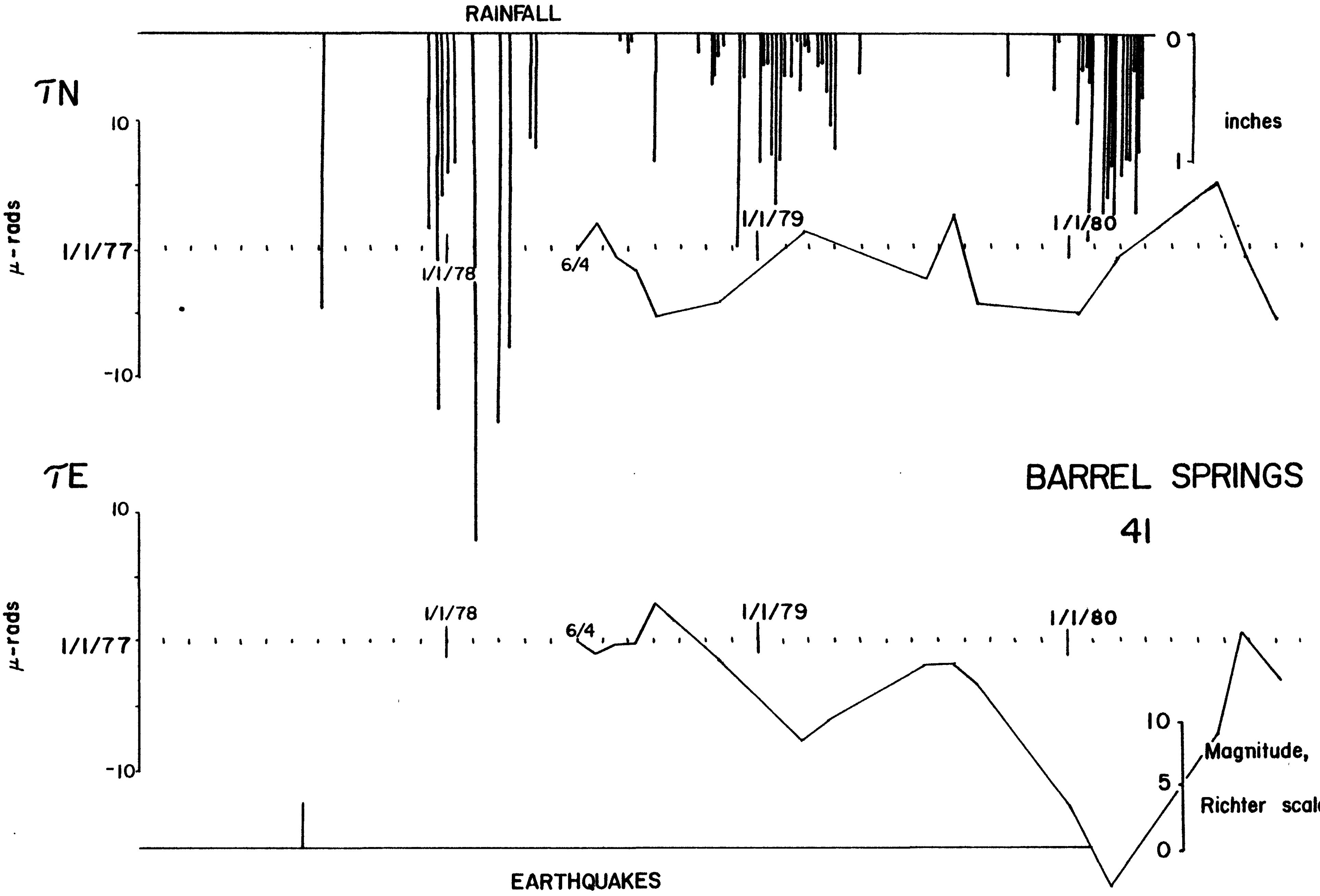
RAINFALL
0
1
inches
TN
10
1/1/77
-10
μ-rads
1/1/78
4/1
1/1/79
1/1/80
PUNCHBOWL PARK
37
TE
10
1/1/77
-10
μ-rads
1/1/78
4/1
1/1/79
1/1/80
10
5
0
Magnitude
Richter scale
EARTHQUAKES

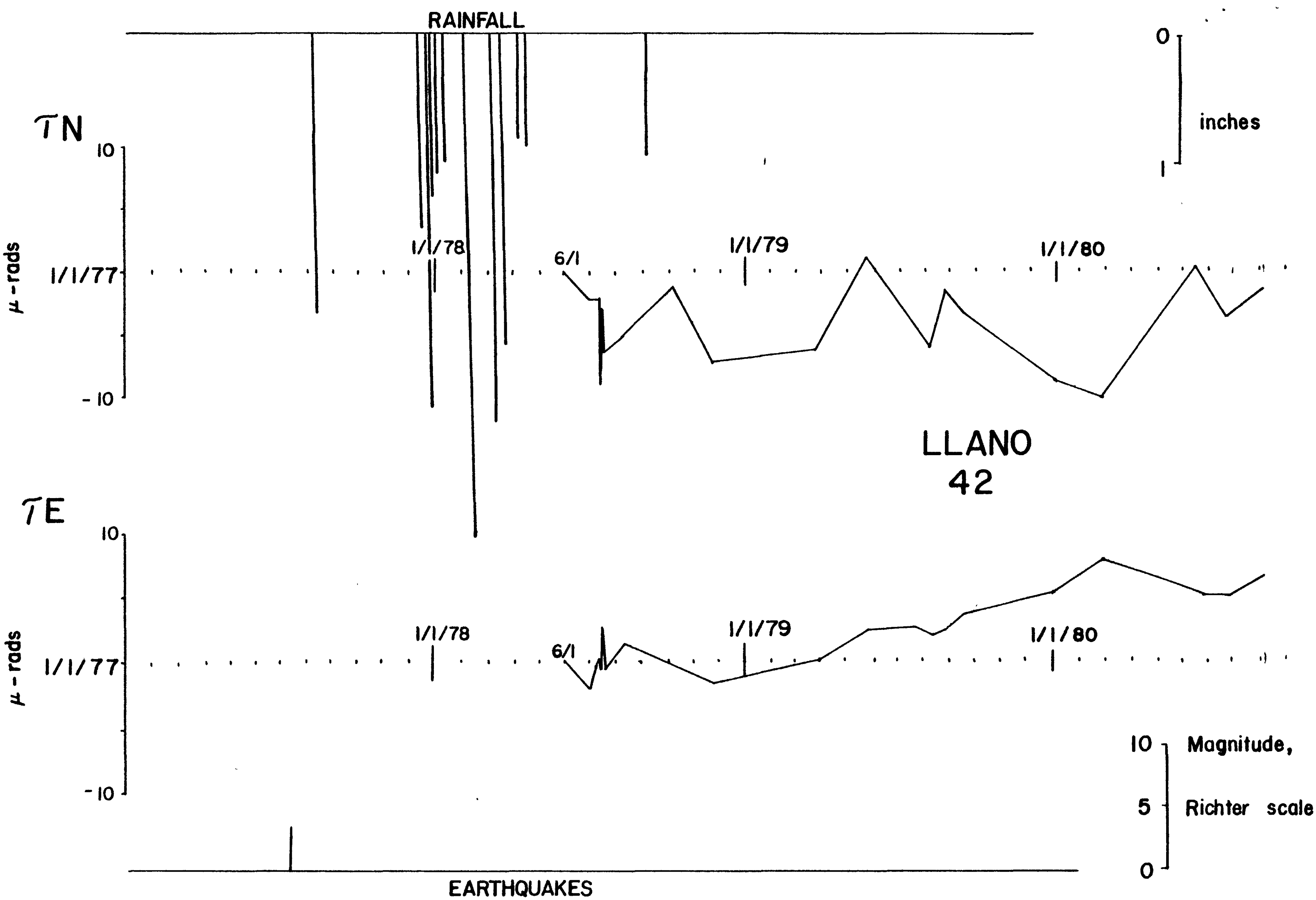


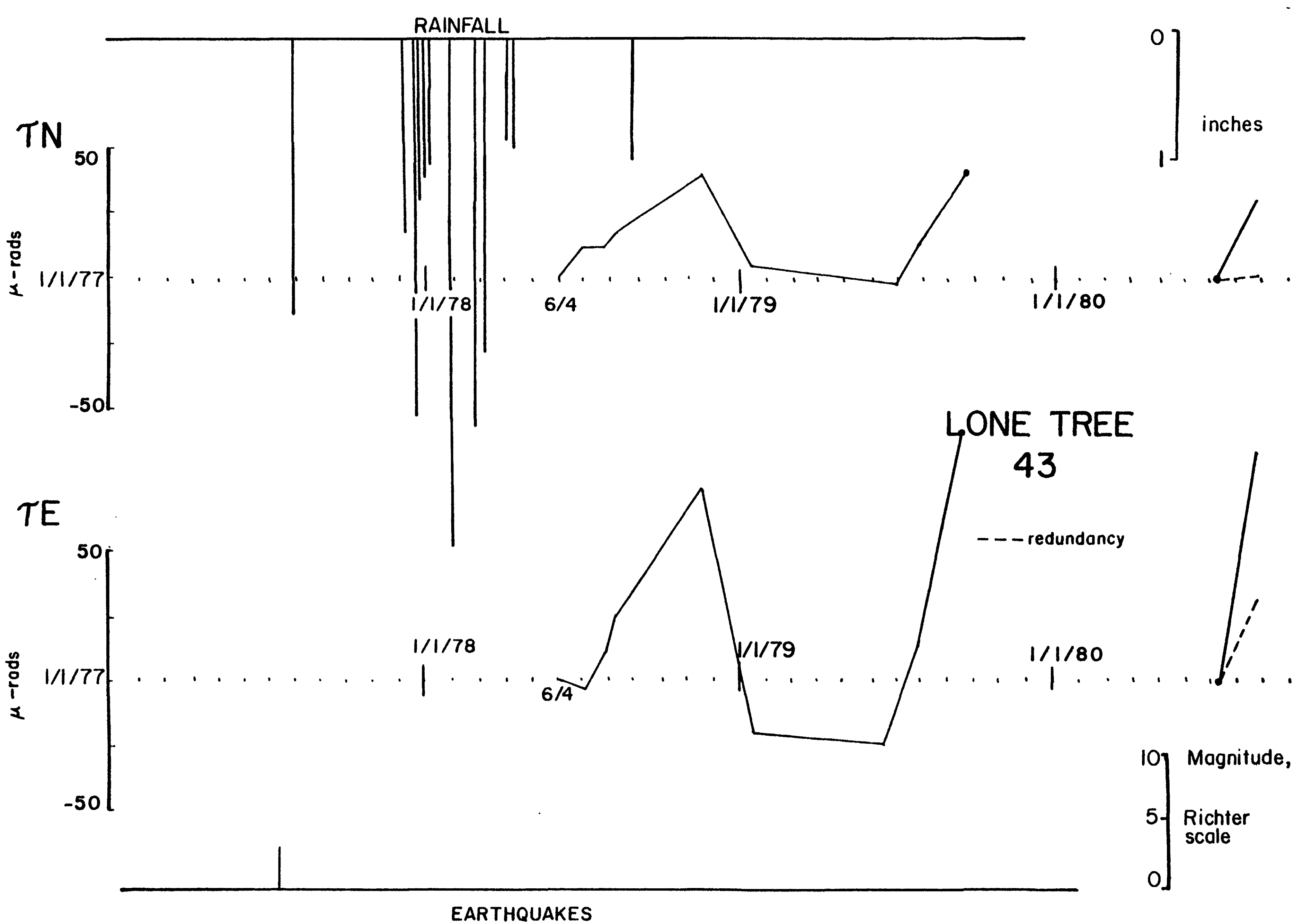
RAINFALL
0
inches
1
TN
10
μ-rads
1/1/77
-10
1/1/78
4/1
1/1/79
1/1/80
VABM WARD
38
TE
10
μ-rads
1/1/77
-10
1/1/78
4/1
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

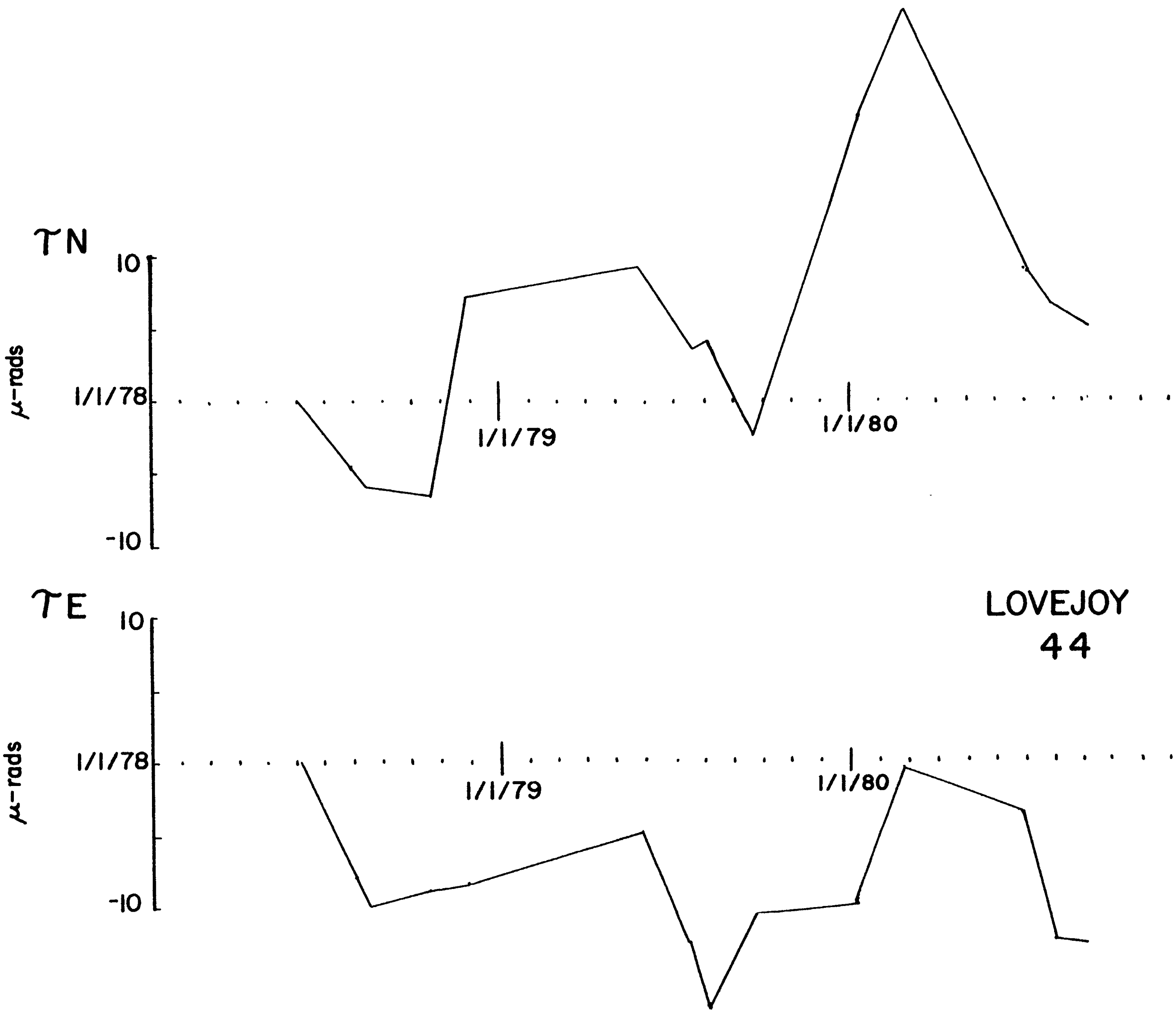

RAINFALL
τN
10
-10
μ-rads
1/1/77
1/1/78
4/1
1/1/79
1/1/80
0
1
inches
BUCK CANYON
39
τE
10
-10
μ-rads
1/1/77
1/1/78
4/1
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

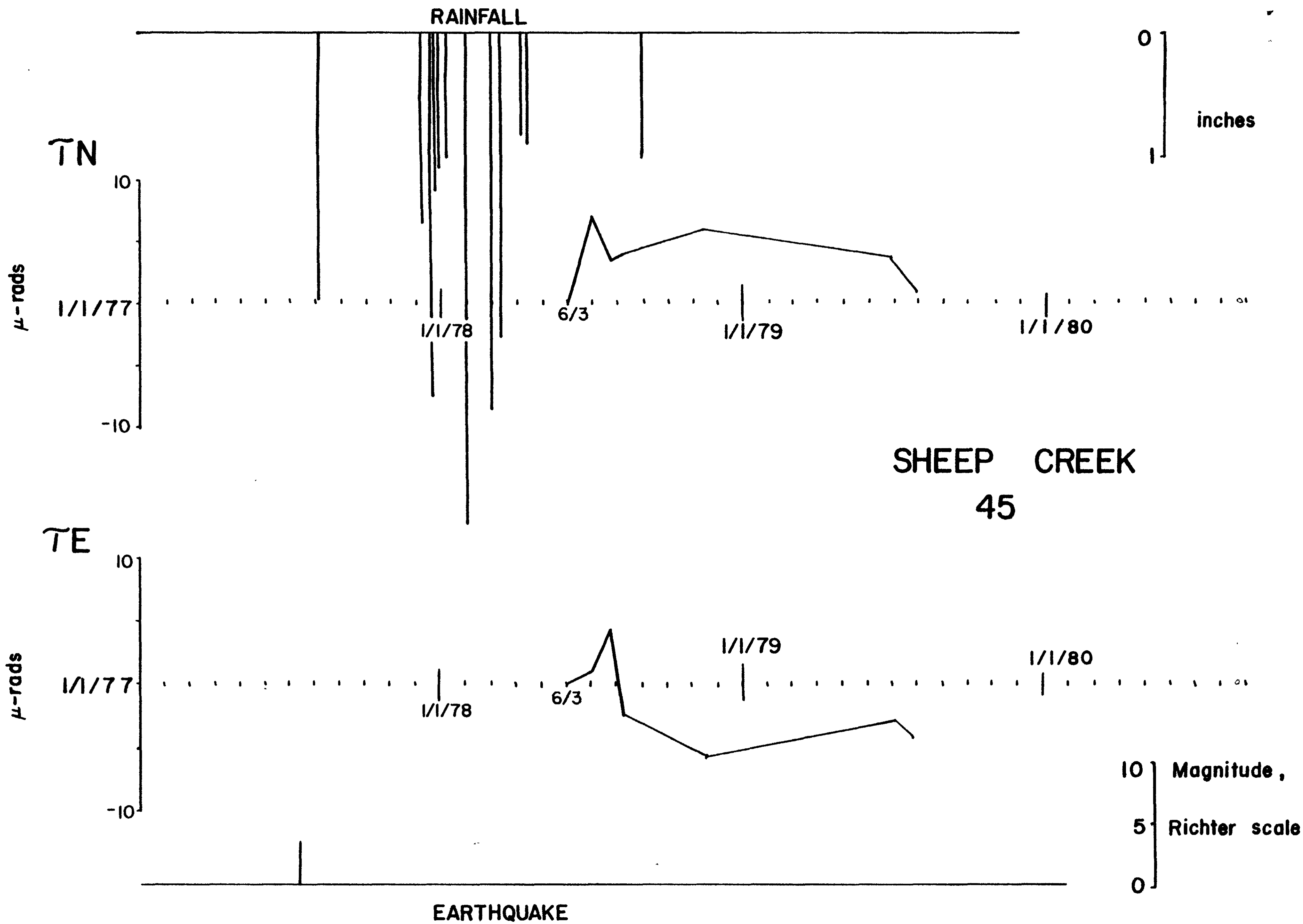

RAINFALL
0
inches
1
τN
10
1/1/77
-10
μ-rads
1/1/78
4/1
1/1/79
1/1/80
WILSON CANYON
40
τE
10
1/1/77
-10
μ-rads
1/1/78
4/1
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

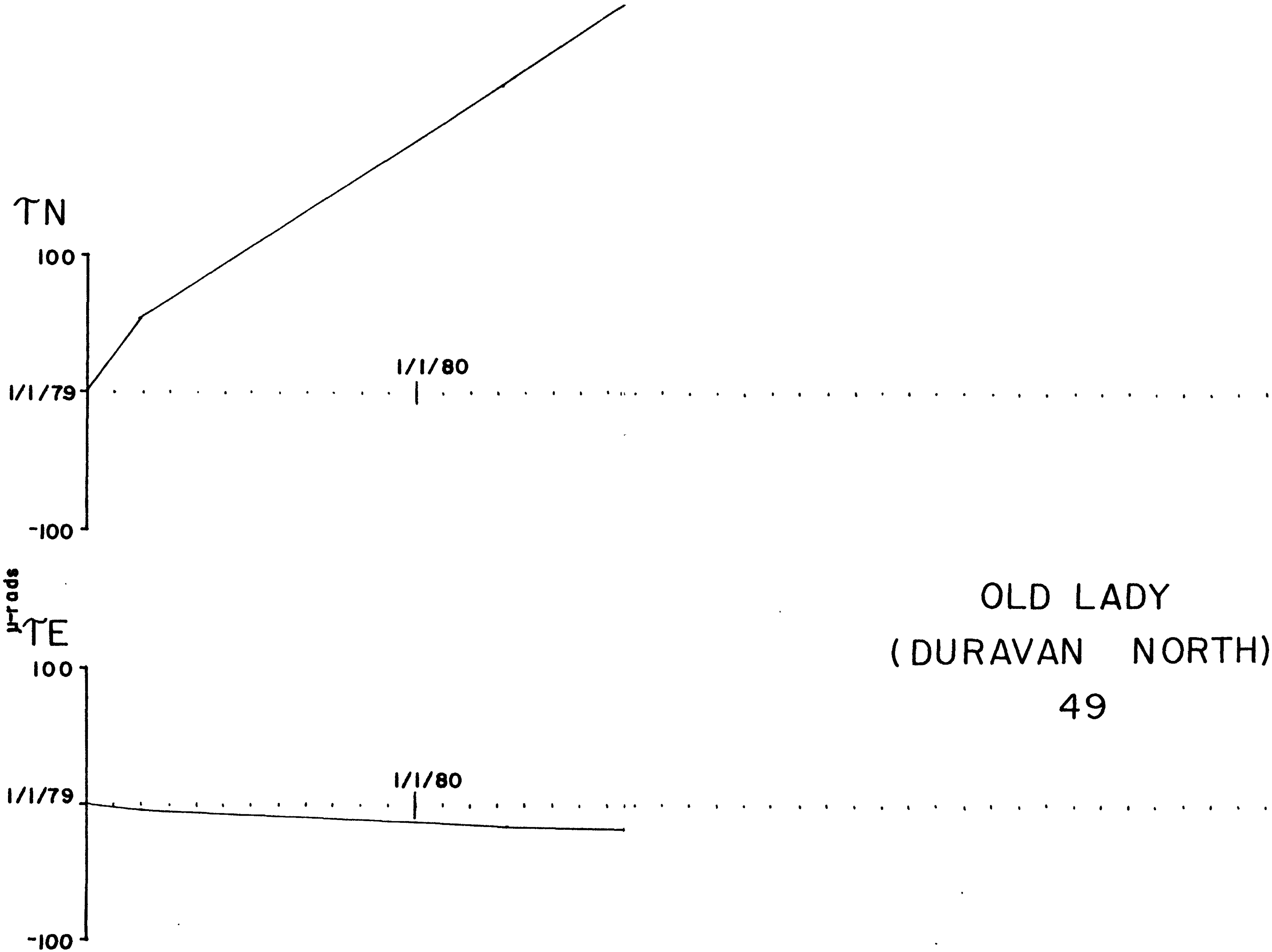

RAINFALL
inches
0
1
τN
10
μ-rads
1/1/77
-10
1/1/78
6/4
1/1/79
1/1/80
BARREL SPRINGS
41
τE
10
μ-rads
1/1/77
-10
1/1/78
6/4
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES

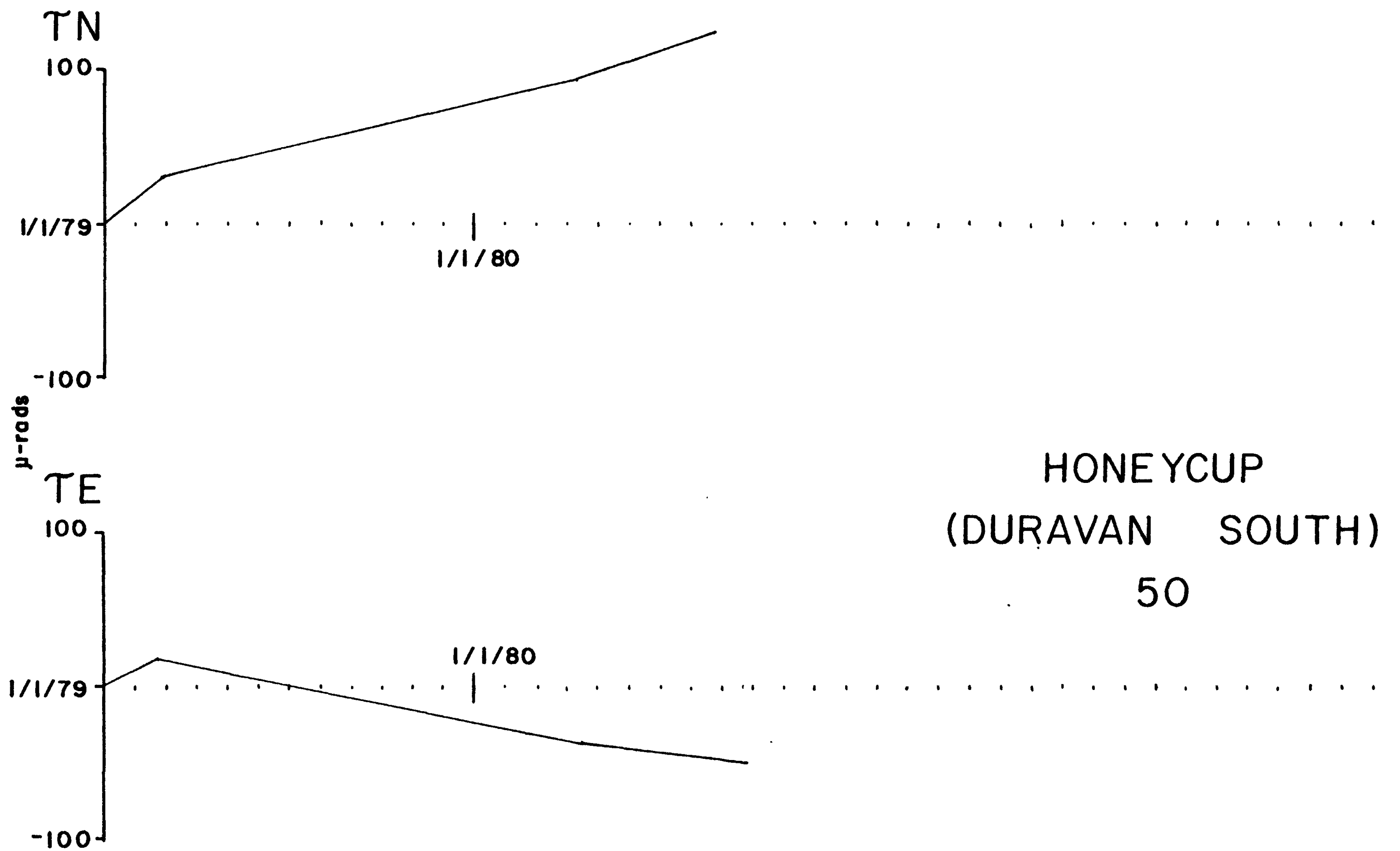

RAINFALL
0
inches
1
τN
10
μ-rads
1/1/77
-10
1/1/78
6/1
1/1/79
1/1/80
LLANO
42
τE
10
μ-rads
1/1/77
-10
1/1/78
6/1
1/1/79
1/1/80
10
5
0
Magnitude,
Richter scale
EARTHQUAKES


RAINFALL
0
inches
1
TN
50
1/1/77
μ-rads
-50
1/1/78
6/4
1/1/79
1/1/80
LONE TREE
43
--- redundancy
TE
50
1/1/77
μ-rads
-50
1/1/78
6/4
1/1/79
1/1/80
10
Magnitude,
5
Richter scale
0
EARTHQUAKES

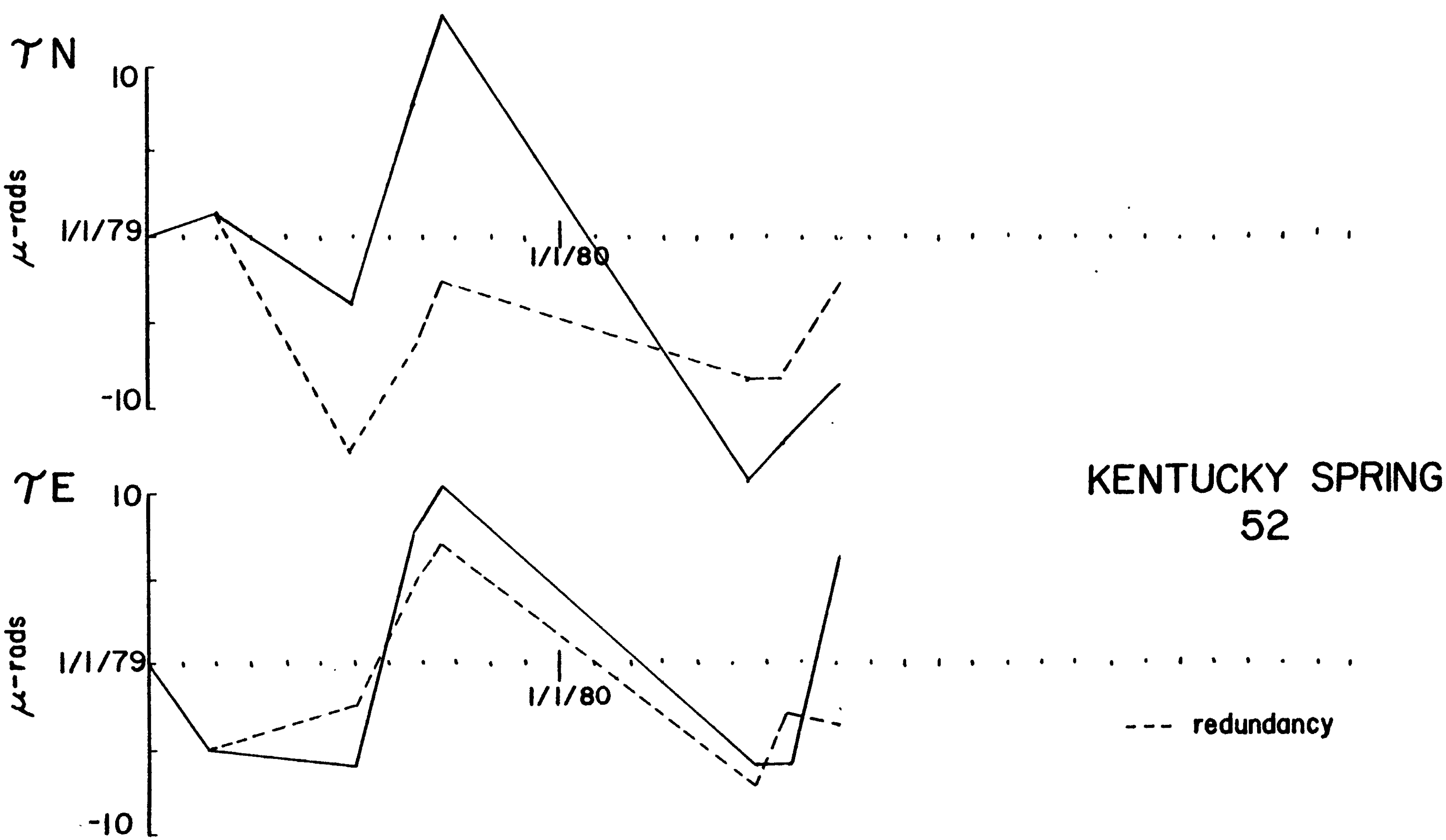

τN
10
1/1/78
-10
μ-rads
1/1/79
1/1/80
τE
10
1/1/78
-10
μ-rads
1/1/79
1/1/80
LOVEJOY
44

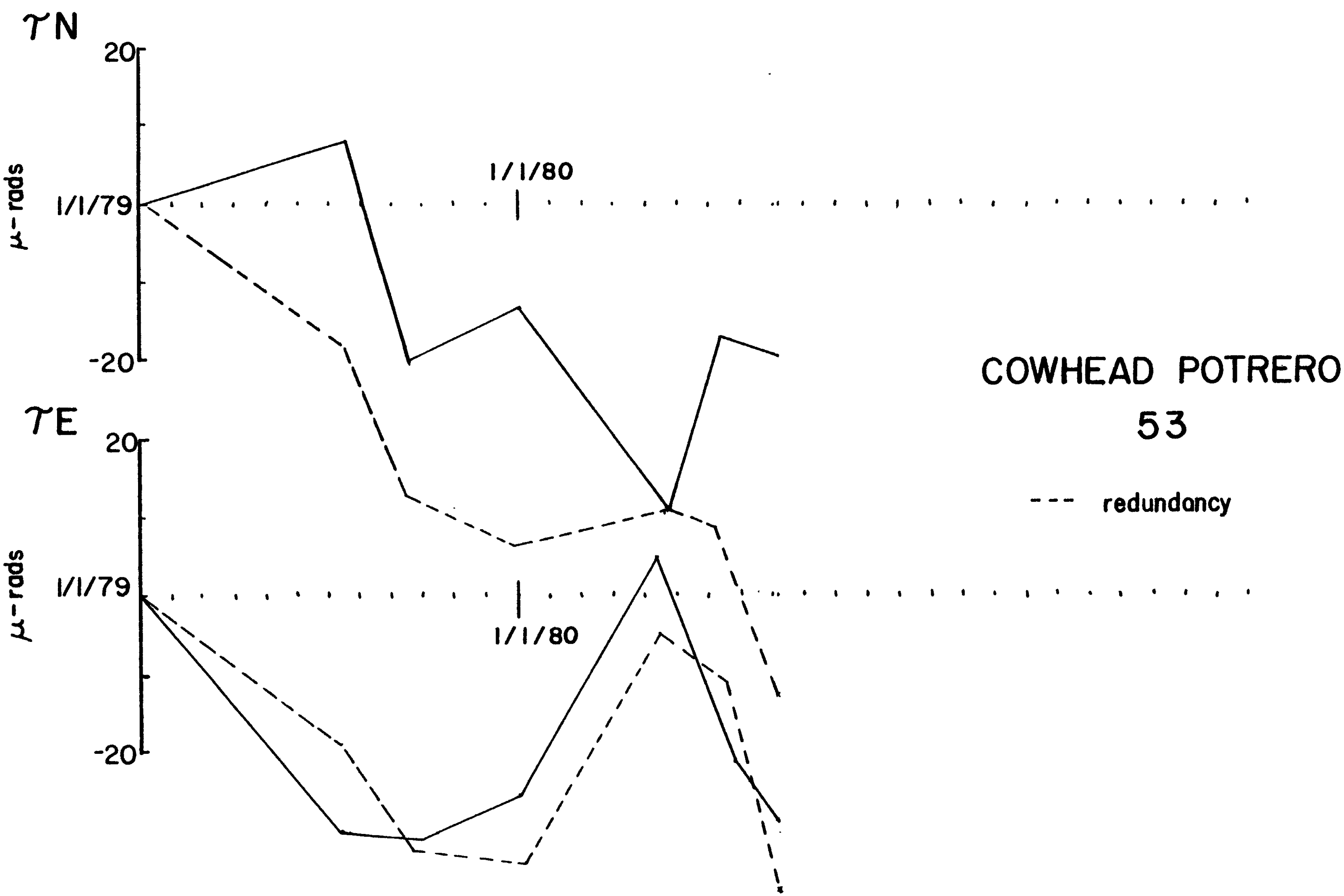

RAINFALL
0
inches
1
TN
10
μ-rads
1/1/77
-10
1/1/78
6/3
1/1/79
1/1/80
SHEEP CREEK
45
TE
10
μ-rads
1/1/77
-10
1/1/78
6/3
1/1/79
1/1/80
10
Magnitude,
5
Richter scale
0
EARTHQUAKE


τN
100
1/1/79
1/1/80
-100
μ-rads
τE
100
1/1/79
1/1/80
-100
OLD LADY
(DURAVAN NORTH)
49

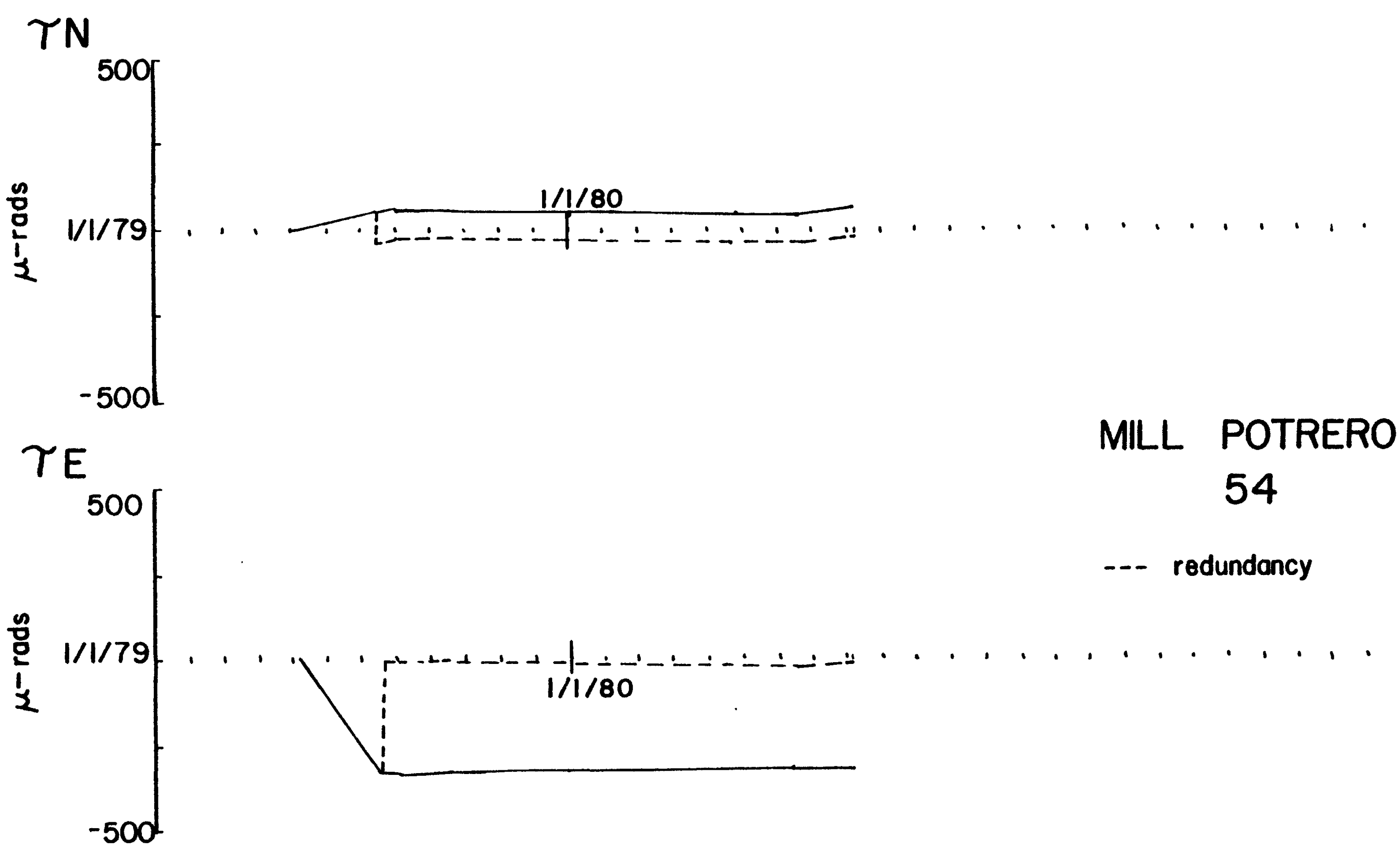


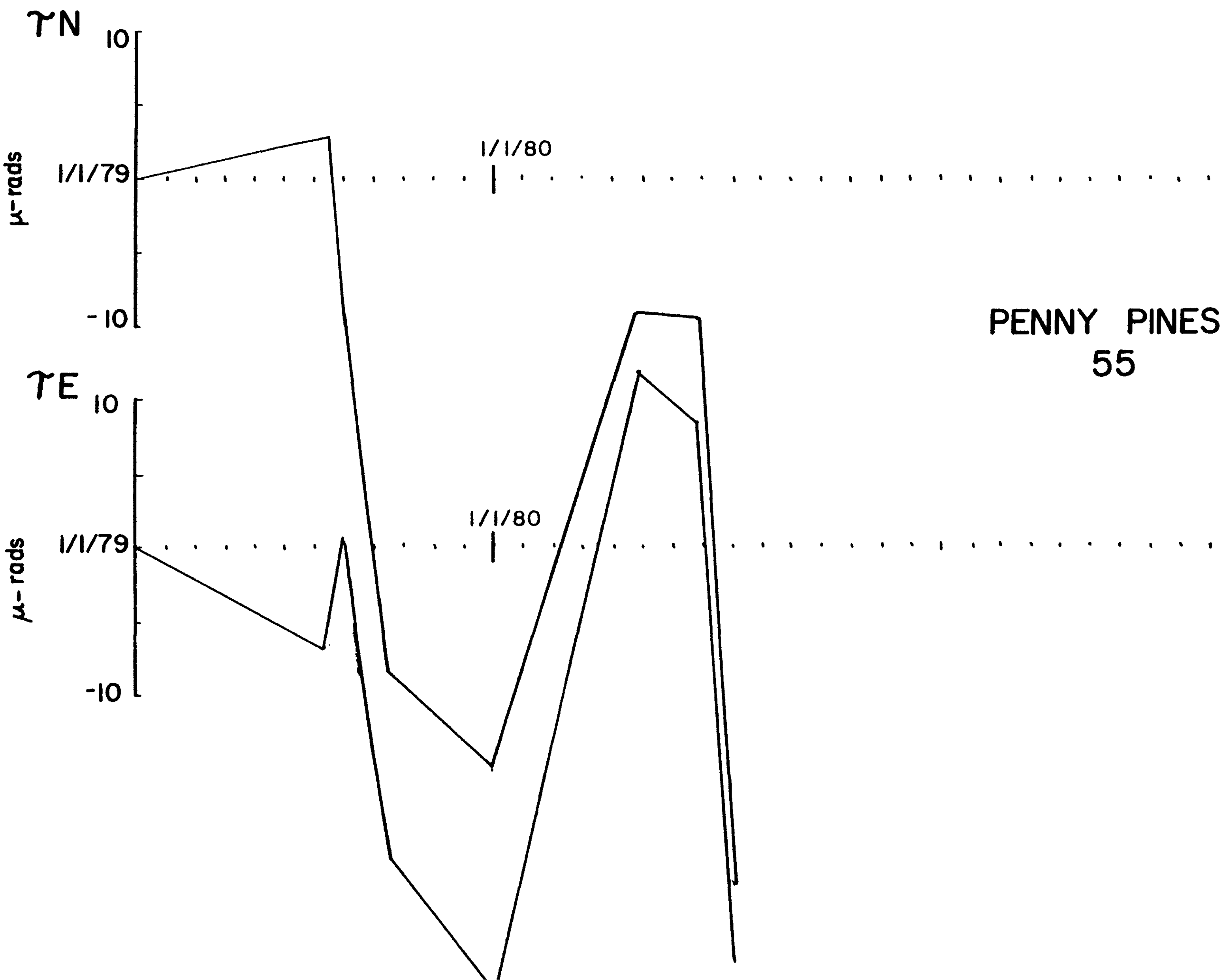
HONEYCUP
(DURAVAN SOUTH)
50


γN
10
1/1/79
-10
μ-rads
1/1/80
γE
10
1/1/79
-10
μ-rads
1/1/80
KENTUCKY SPRING
52
--- redundancy

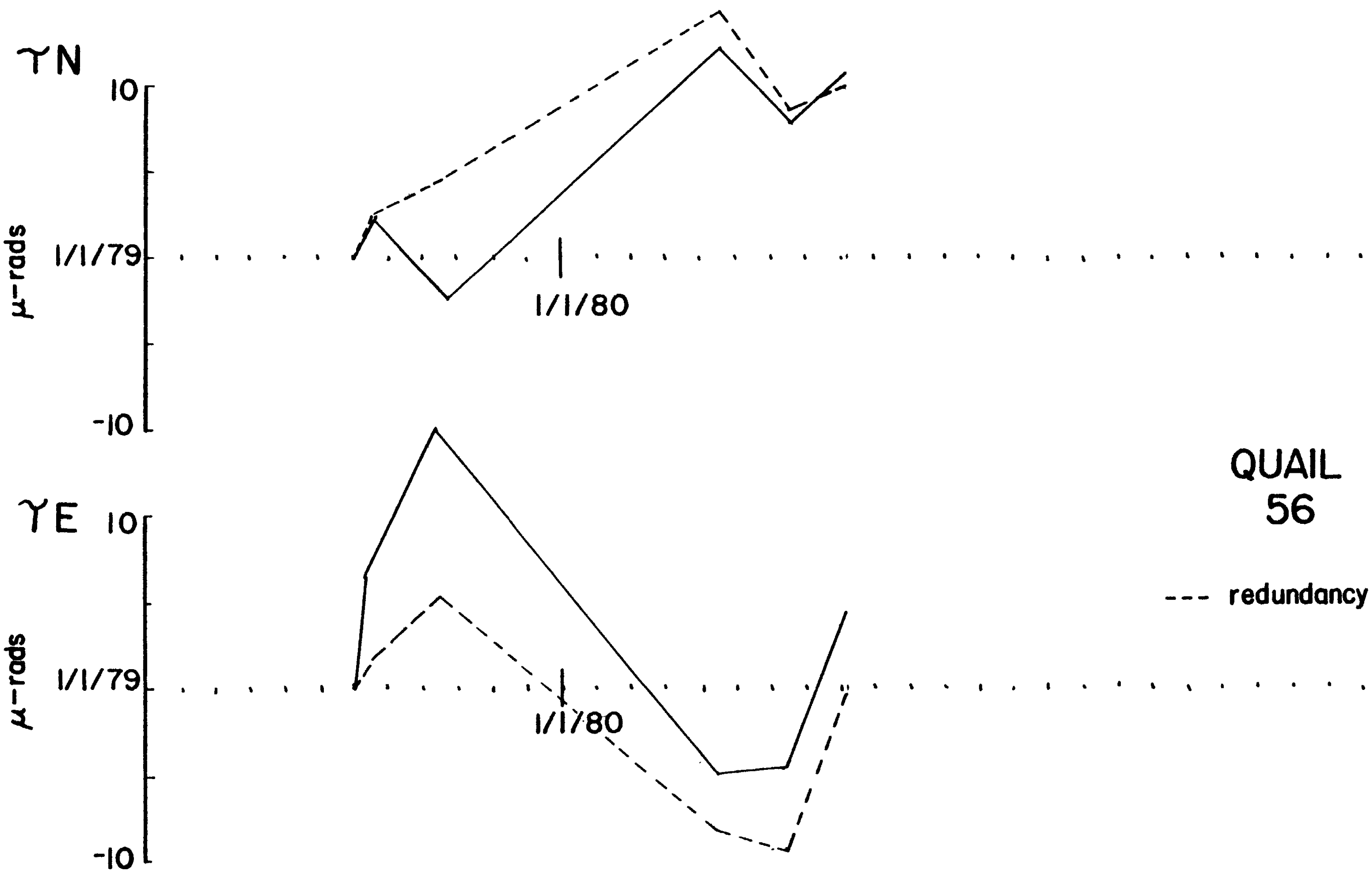


τN
20
1/1/79
-20
μ-rads
1/1/80
τE
20
1/1/79
-20
μ-rads
1/1/80
COWHEAD POTRERO
53
--- redundancy

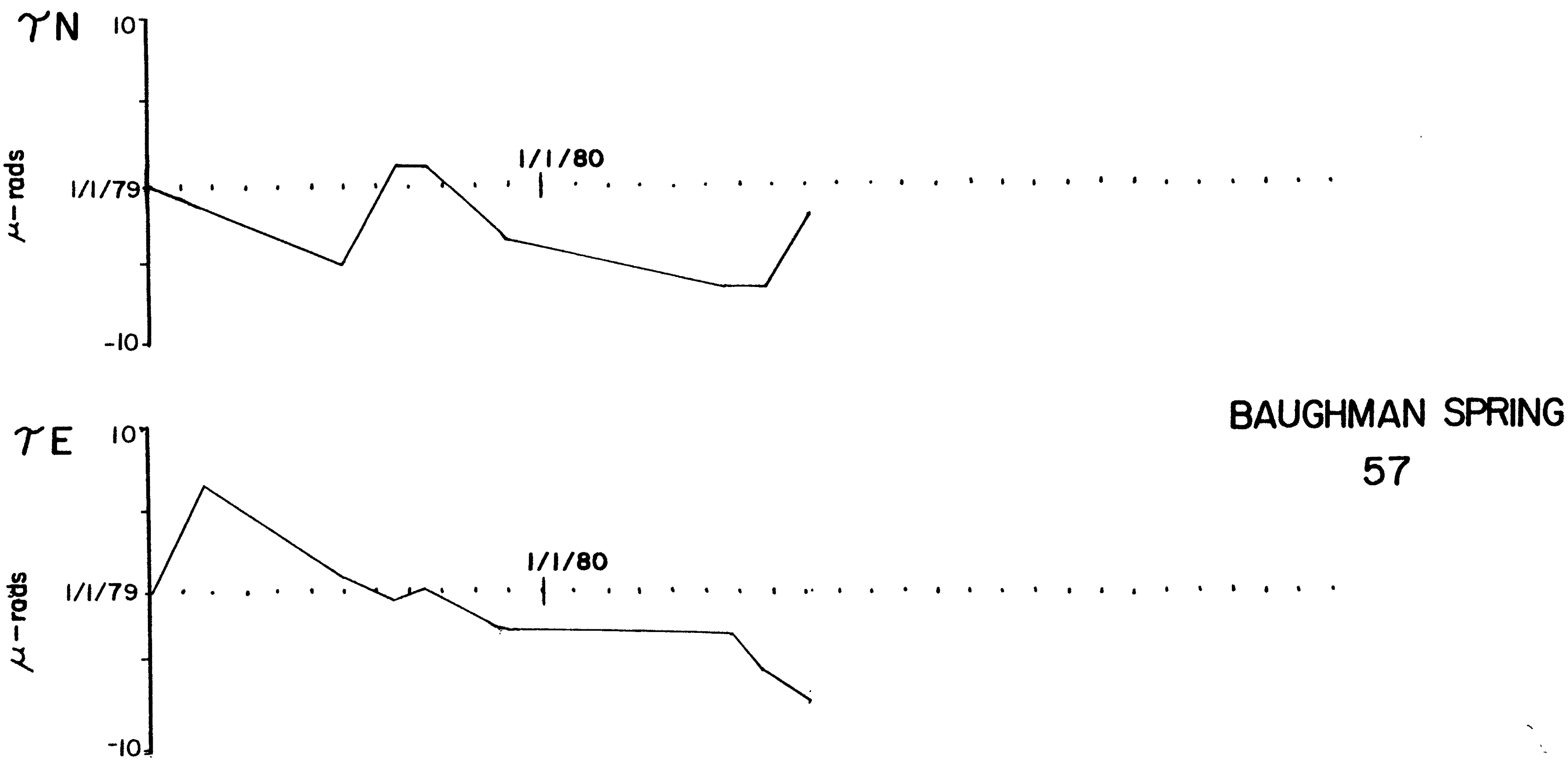

γN
500
1/1/79
-500
μ-rads
1/1/80
γE
500
1/1/79
-500
μ-rads
1/1/80
MILL POTRERO
54
--- redundancy

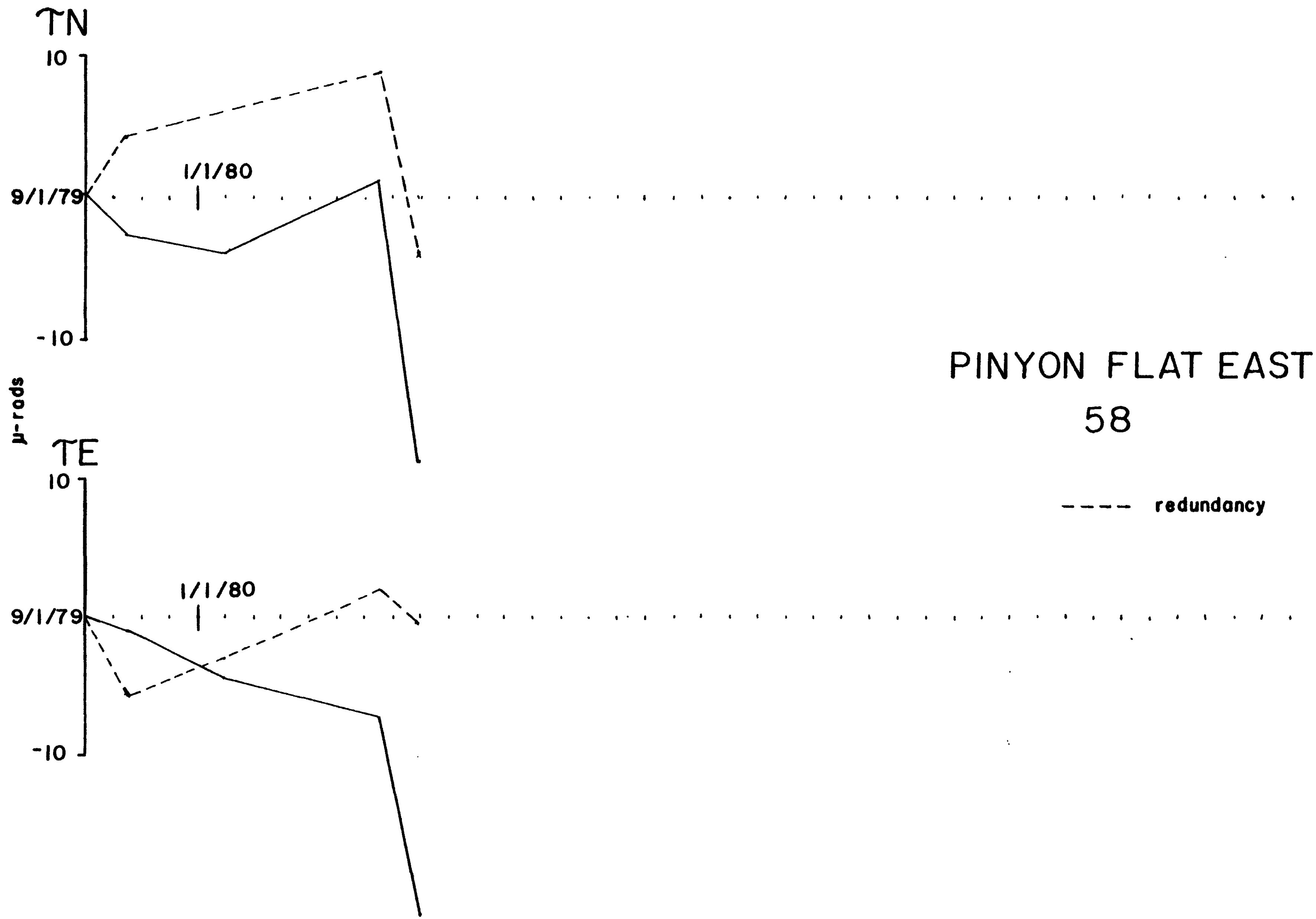


PENNY PINES
55
τN
10
1/1/79
-10
μ-rads
1/1/80
τE
10
1/1/79
-10
μ-rads
1/1/80

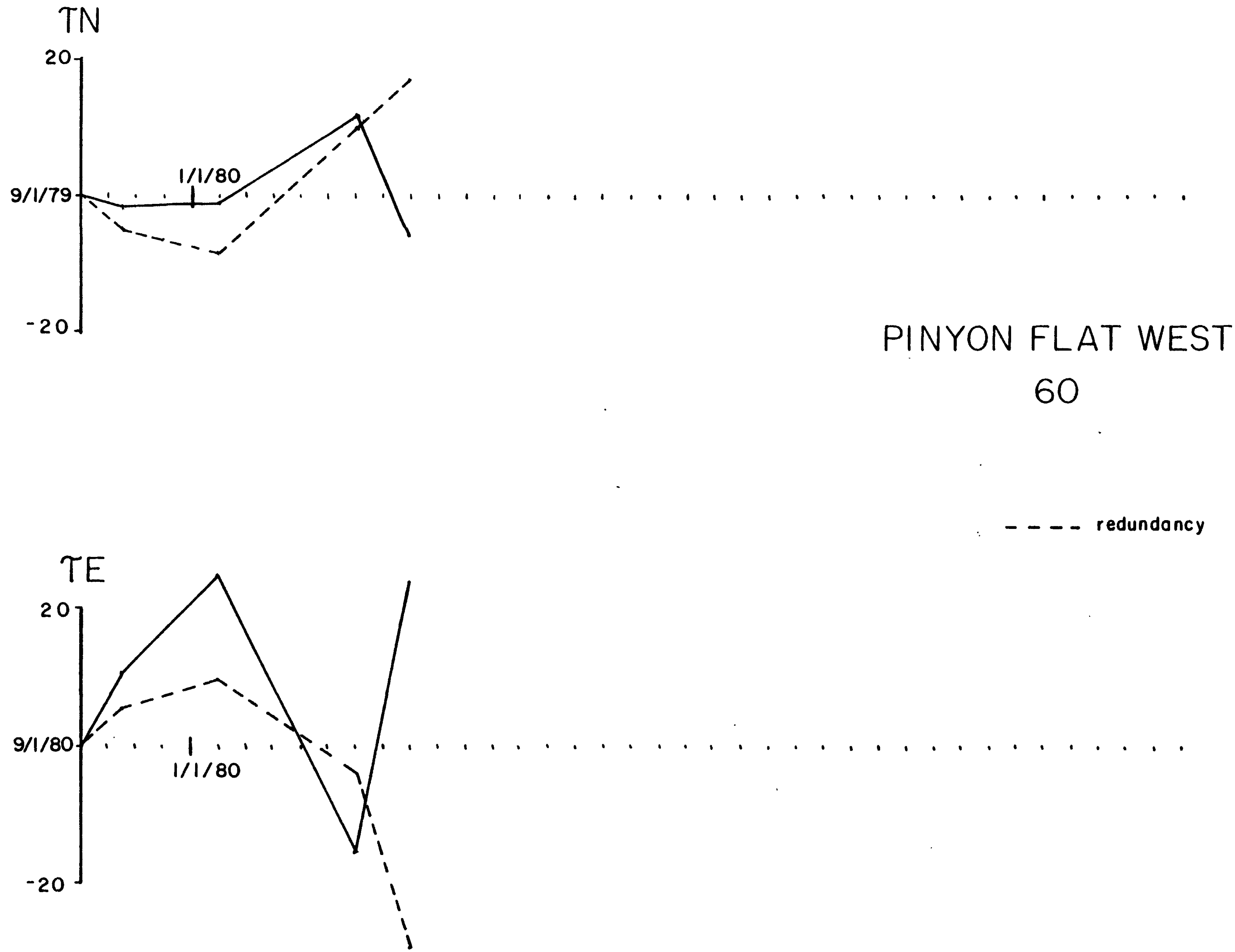


γN
10
1/1/79
μ-rads
-10
1/1/80
γE
10
1/1/79
μ-rads
-10
1/1/80
QUAIL
56
--- redundancy


γN
10
1/1/79
-10
μ-rads
1/1/80
γE
10
1/1/79
-10
μ-rads
1/1/80
BAUGHMAN SPRING
57



PINYON FLAT EAST
58
redundancy
TN
10
9/1/79
1/1/80
-10
μ-rads
TE
10
9/1/79
1/1/80
-10


PINYON FLAT WEST
60
redundancy
TN
20
9/1/79
1/1/80
-20
TE
20
9/1/80
1/1/80
-20