

COALINGA EARTHQUAKE RECORDED GROUND MOTION

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INTRODUCTION

The origin of the Coalinga earthquake of May 2, 1983 ($M_L = 6.7$) was approximately 13 km northeast of the city of Coalinga at a depth of about 10 km (Fig. 1). No surface rupture was observed. This earthquake was the largest to occur in California since the San Fernando earthquake of 1971 and it caused major damage to old buildings in downtown Coalinga and to old homes elsewhere in the city. During the three months following the mainshock six aftershocks of magnitude 5 and greater occurred.

Permanent strong-motion stations operated by the California Division of Mines and Geology (CDMG) in the region surrounding Coalinga are shown in Figs. 1 and 2. Fig. 2 shows the detailed station locations and local geology of the strong-motion array near Parkfield described by McJunkin and Shakal (1983). The USGS maintains a permanent station at the Pleasant Valley Pumping Plant (Fig. 3). Temporary CDMG stations were placed in the epicentral area after the mainshock to augment permanent stations as shown in Figure 3.

Nearly 100 strong-motion instruments were triggered by the Coalinga earthquake mainshock and the films collected represent the largest number of records from a single event since the San Fernando earthquake of 1971. Most of the records were obtained from ground level triaxial accelerographs. Sixty of the records were from CDMG stations and the coordinate locations, accelerations, and reproductions of the records are included in a report by Shakal and McJunkin (1983). Records from the USGS stations are similarly reported by Maley et al., (1983).

GROUND MOTION NEAR COALINGA

The permanent ground motion instruments at the Pleasant Valley Pumping Plant and Cantua Creek stations shown in Fig. 3 were the stations nearest the city of Coalinga during the mainshock. The USGS reported a peak horizontal ground acceleration of 0.54g at the Pleasant Valley Pumping Plant (Maley et al., 1983) and the CDMG instrument at Cantua Creek recorded a peak acceleration of 0.28g.

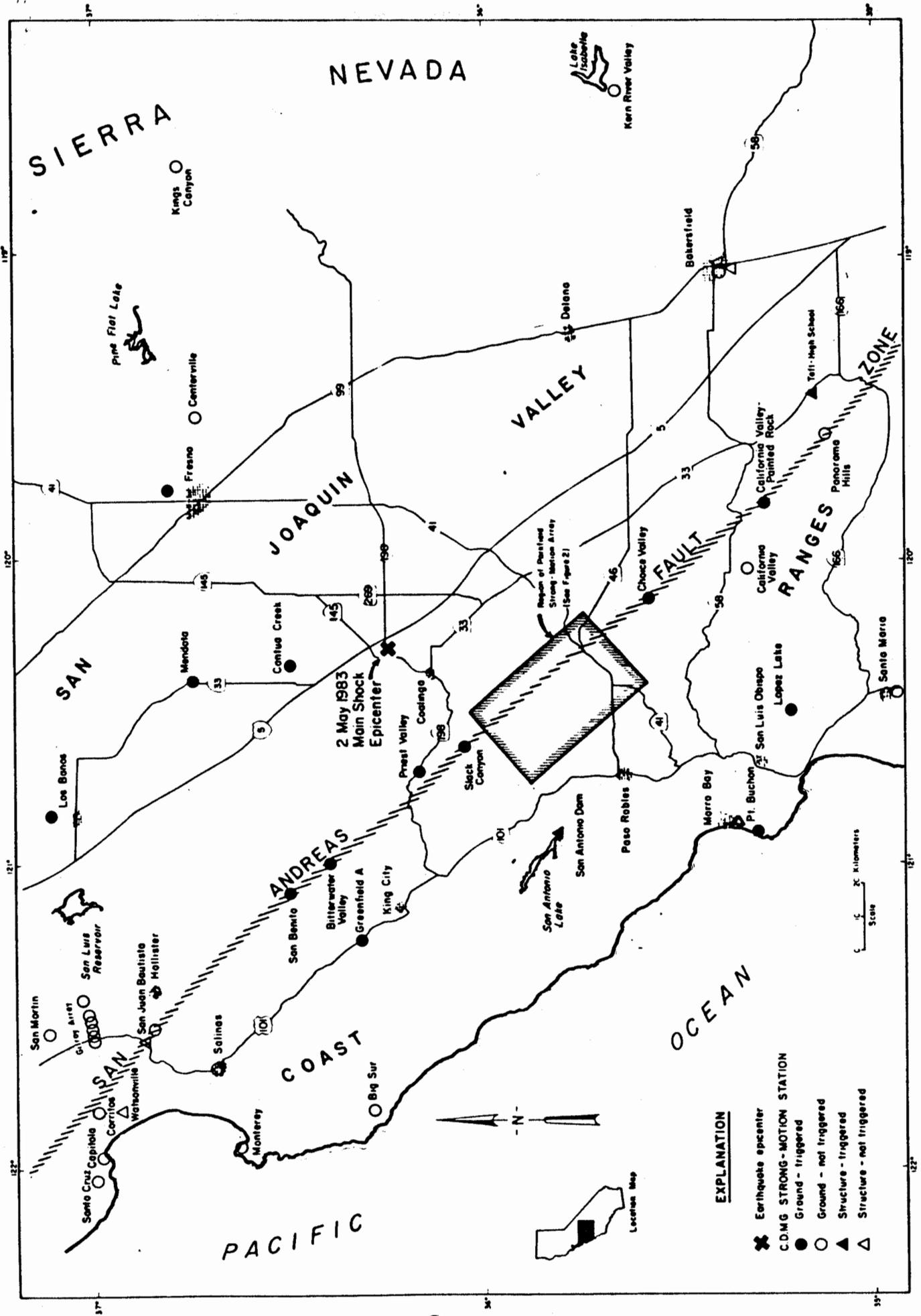


Figure 1 CDMG strong-motion stations in the region of the 2 May 1983 Coalinga earthquake. Parkfield array stations are shown by larger-scale map in figure 2. (From Shakal and McJunkin, 1983)

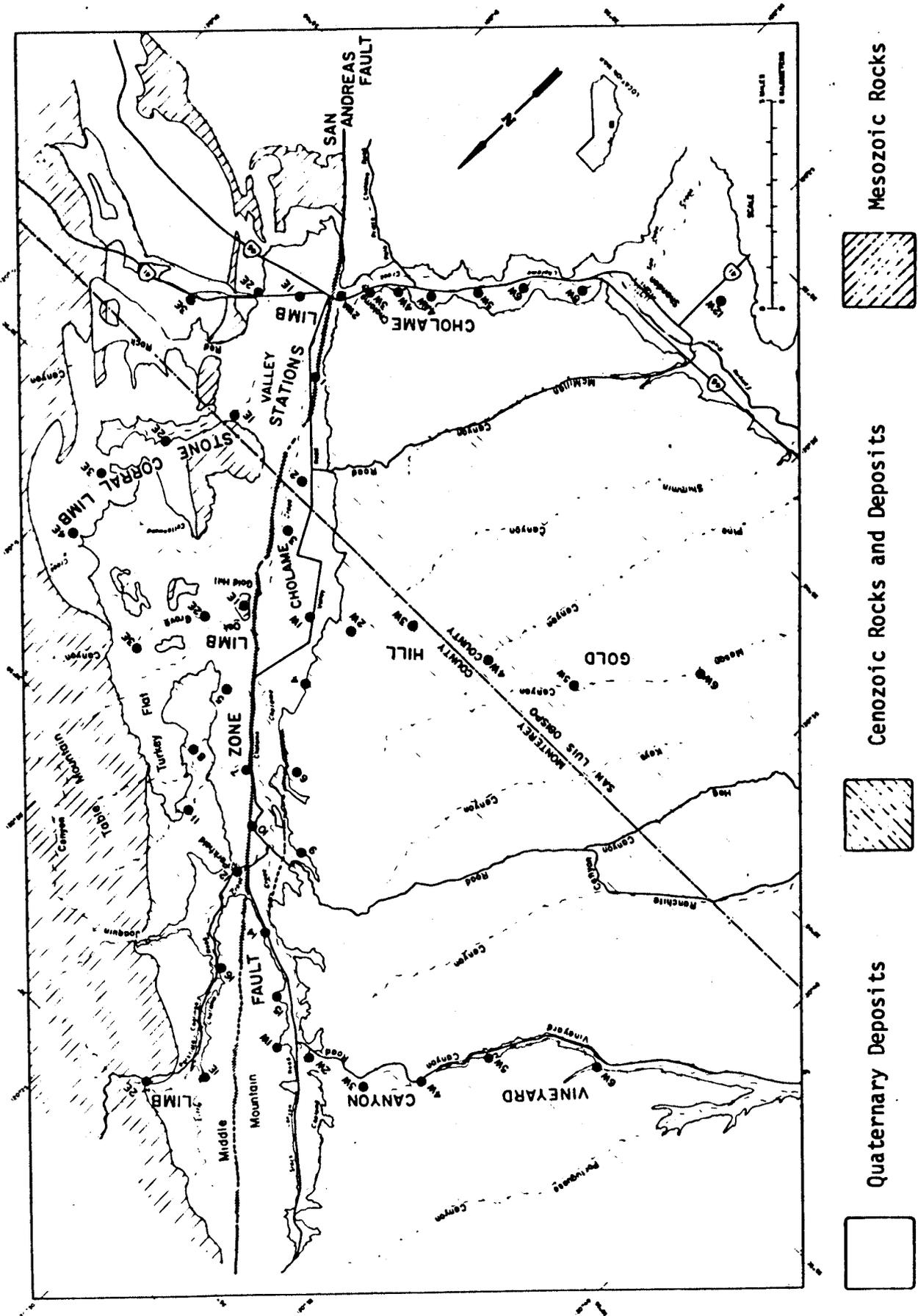


Figure 2 CDMG Parkfield strong-motion array and generalized geology. The array configuration forms four limbs (Cholame, Stone Corral, Gold Hill, Vineyard Canyon) oriented perpendicular to the San Andreas and a central zone of stations paralleling the fault. Fault trace (diagrammatically shown) is of ground rupture in the 1966 Parkfield earthquake. (From McJunkin and Shakal, 1983)

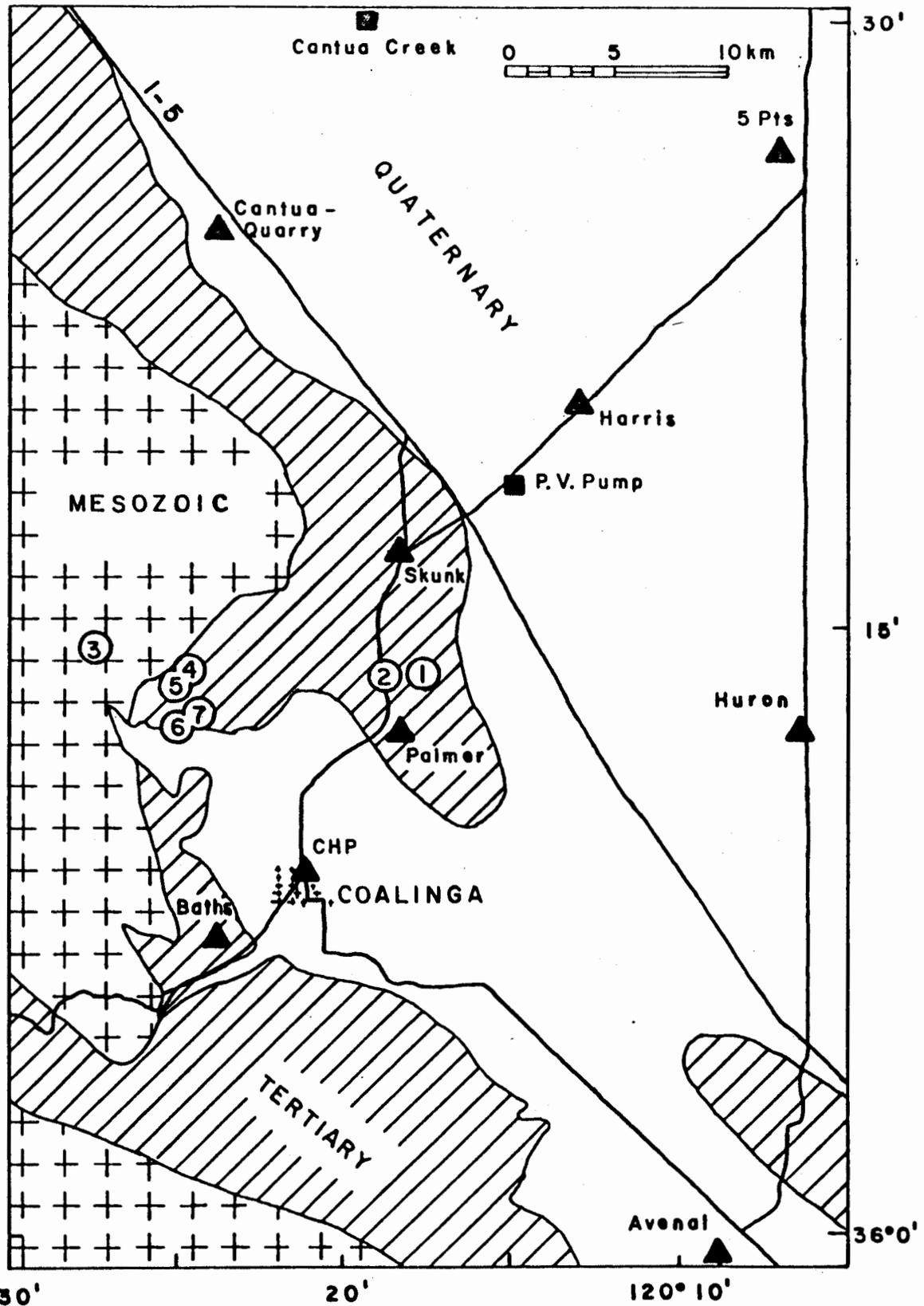


Figure 3 Stations, epicenters and local geology near Coalinga (geology simplified from Jennings and Strand, 1958). Temporary stations (triangles) augment permanent stations (squares) at Cantua Creek (CDMG) and Pleasant Valley Pump Plant (USGS). The epicenters (circles) are numbered 1 (mainshock) through 7. (After Shakal and Ragsdale, 1983)

Soon after the mainshock, CDMG and several other organizations placed additional instruments in the epicentral region. Records were recovered from two CDMG accelerographs located in and near Coalinga during the six principal aftershocks (magnitude 5 and greater). These records provide valuable information on the general character of ground motion in Coalinga. The accelerographs were located at the California Highway Patrol (CHP) station in Coalinga and at the Sulphur Baths about 3 km southwest of the city (Fig. 3). Coalinga overlies an alluvial valley while the Baths station is located on rock. At the CHP station the peak horizontal accelerations recorded were 0.53g in Event 5 (M =5.9) and 0.71g in Event 7 (M =5.1). These were the highest accelerations recorded during the aftershocks and more damage was caused by Event 7 than by any of the other aftershocks. Fig. 4 shows the accelerograms recorded at both stations during these events. These and other aftershock records from this pair of stations indicate peak amplitudes approximately three times higher at the CHP station on alluvium than at the Baths station on rock. From the Event 7 record and the damage reports, the implication of these records is that the peak acceleration at the CHP station was probably 0.7g or higher during the main shock. Note that the motion at the CHP station shows the highest energy at periods from 0.1 to 0.2 seconds, which is near the fundamental period of many of the low rise buildings damaged in the earthquake. Digitization and analysis of the aftershock records will provide further information on the spectral characteristics of the ground shaking.

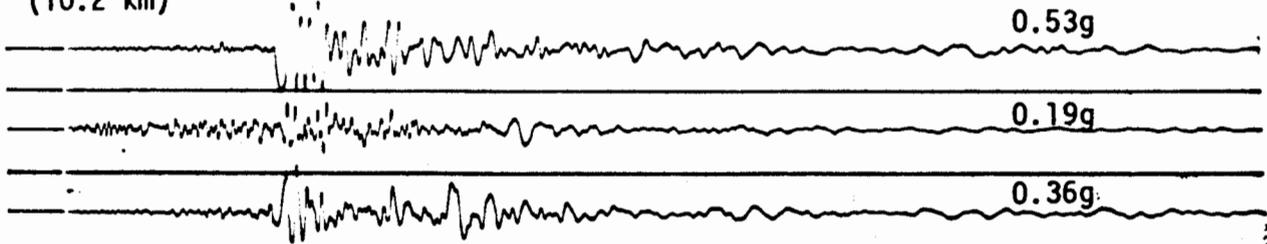
PEAK ACCELERATION versus DISTANCE

The Coalinga earthquake peak acceleration data are plotted against epicentral distance and are compared with corresponding data from the 1971 San Fernando earthquake (Maley and Cloud, 1973) in Fig. 5. Both earthquakes had similar magnitudes, both had thrust mechanisms and the predominance of data from both were recorded at epicentral distances of 30 - 80 km. Epicentral distance is used for initial comparisons since both earthquakes have similar source mechanisms and earthquake-station geometries. More detailed studies of the Coalinga data will be made and analyses have begun (Boore et al., 1983) incorporating the distance to a postulated surface of rupture.

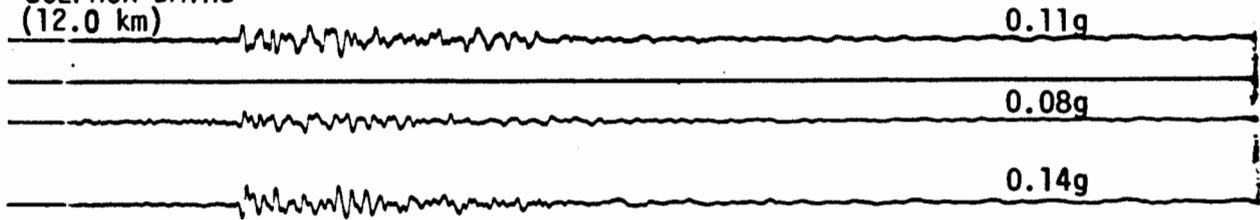
The similarity of the data sets shown in Fig. 5 is apparent. For both events, the highest acceleration for a given distance is four to five times larger than the lowest. The accelerations from the Coalinga event appear to be somewhat higher than those from the San Fernando event. This may be due in part to differences in the structures in which the records were obtained. Most of the Coalinga records were obtained from instruments located in small shelters (McJunkin and Shakal, 1983) while the San Fernando data were generally recorded in moderate to large structures.

EVENT 5 22 July 1983 0240 UTC 5.9 M_L

COALINGA CHP
(10.2 km)

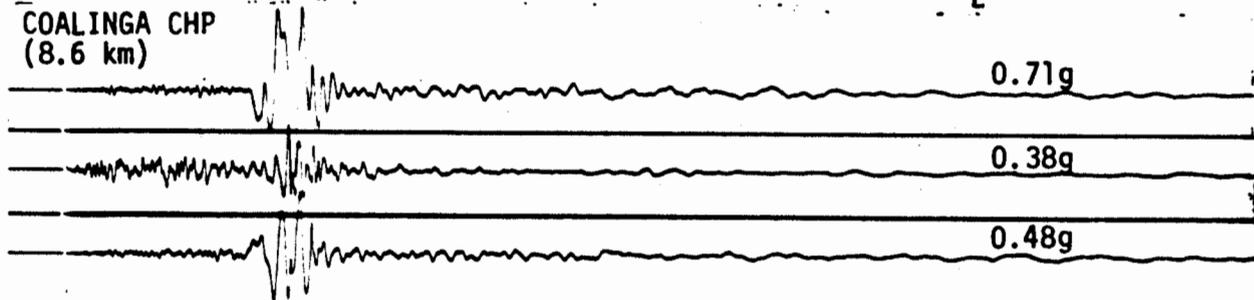


SULPHUR BATHS
(12.0 km)



EVENT 7 25 July 1983 2232 UTC 5.1 M_L

COALINGA CHP
(8.6 km)



SULPHUR BATHS
(10.6 km)

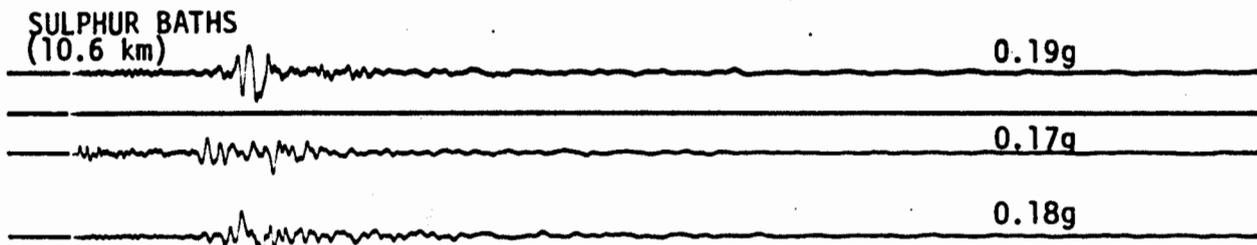


Figure 4 Coalinga aftershock accelerograms recorded at a station in Coalinga (CHP) and at a station on rock at the edge of the valley (Sulphur Baths).

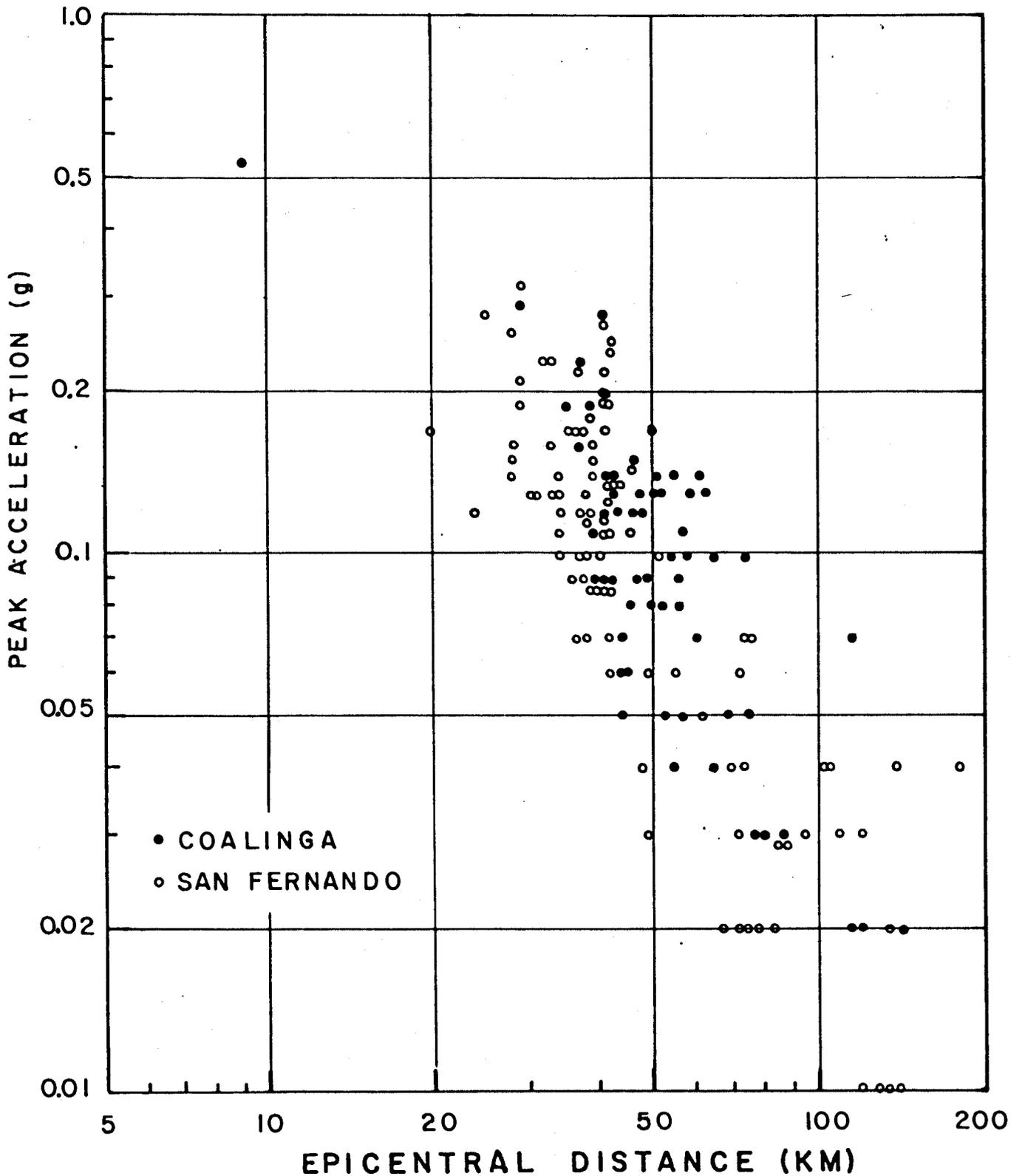


Figure 5 Peak acceleration data from the 2 May 1983 Coalinga earthquake with data from the 1971 San Fernando earthquake included for reference. This plot is preliminary and does not include the Coalinga data from the distant (over 75 km) stations mentioned by Maley et al. (1983). (From Shakal and Ragsdale, 1983)

GROUND MOTION at the PARKFIELD ARRAY

The CDMG Parkfield array of strong motion instruments recorded the ground shaking at 46 stations in a 20 km by 30 km area during the Coalinga earthquake (Fig. 2). This array was designed to record close-in ground motion during future earthquakes on the San Andreas fault (McJunkin and Shakal, 1983). The Coalinga earthquake, located approximately 50 km northeast of the center of the array, provided an unusual set of records from stations closely spaced relative to the source distance. Thus, the site geologic conditions and topography are expected to be the principal cause for the differences in motion at adjacent stations.

Fault-Zone stations 9, 14 and 15 are less than 3 km apart and located on the same side of the fault. Records from these stations are shown in Fig. 6. The station 14 record is significantly higher in amplitude (peak acceleration = 0.28g) than the adjacent station 9 record (peak acceleration = 0.05g). The high amplification at station 14 may be due to low velocity materials at depth at this station which are not present at station 9. Spectra for the stations (Fig. 7) show that the station 14 record is two to five times higher than the station 9 record in the period range from 0.5 to 2 seconds. Full understanding of these differences will require further information on the nature of the materials underlying the sites.

The amplitude of the peak accelerations (east component) at each station in the array is shown schematically on the map in Fig. 8. The stations located along the fault are generally in alluvial valleys while the other stations located in the surrounding hills are on older (higher velocity) materials. The depth of alluvium under the valley stations probably varies greatly. Peak accelerations at valley stations are generally higher than those in the hill area. The data from the Parkfield array and the Coalinga CHP and Baths stations show peak accelerations higher on alluvium than on rock. Note that many ground motion prediction equations do not predict significant differences in peak acceleration between rock and soil.

The pattern of peak velocities and peak displacements for the east component of records that have been processed in the array are shown in Figs. 9 and 10. The peak velocities and displacements are generally higher in the valley area than in the hills. The differences in peak velocity and displacement between valley and hill stations appear to be greater than the differences in peak acceleration. This is consistent with many velocity prediction relationships (e.g., Boore et al., 1980) which do indicate a significant dependence of velocity on site geology.

The pattern of spectral values of effective peak acceleration (EPA) and effective peak velocity (EPV) for the records that

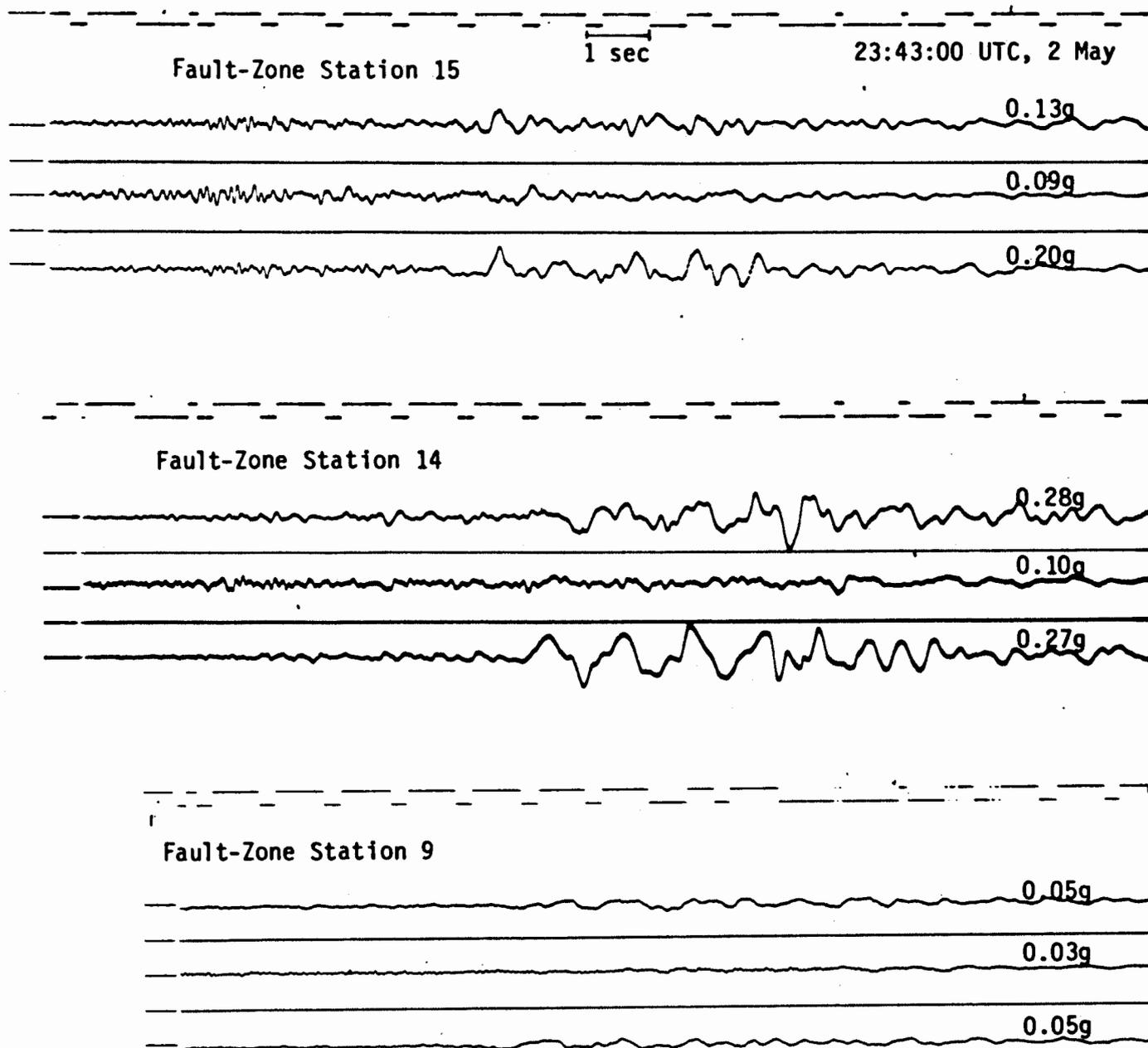


Figure 6 Accelerograms recorded at three neighboring stations in the Parkfield array during the 2 May 1983 Coalinga earthquake. The components are East, Up, and North, respectively. (After Shakal and Ragsdale, 1983)

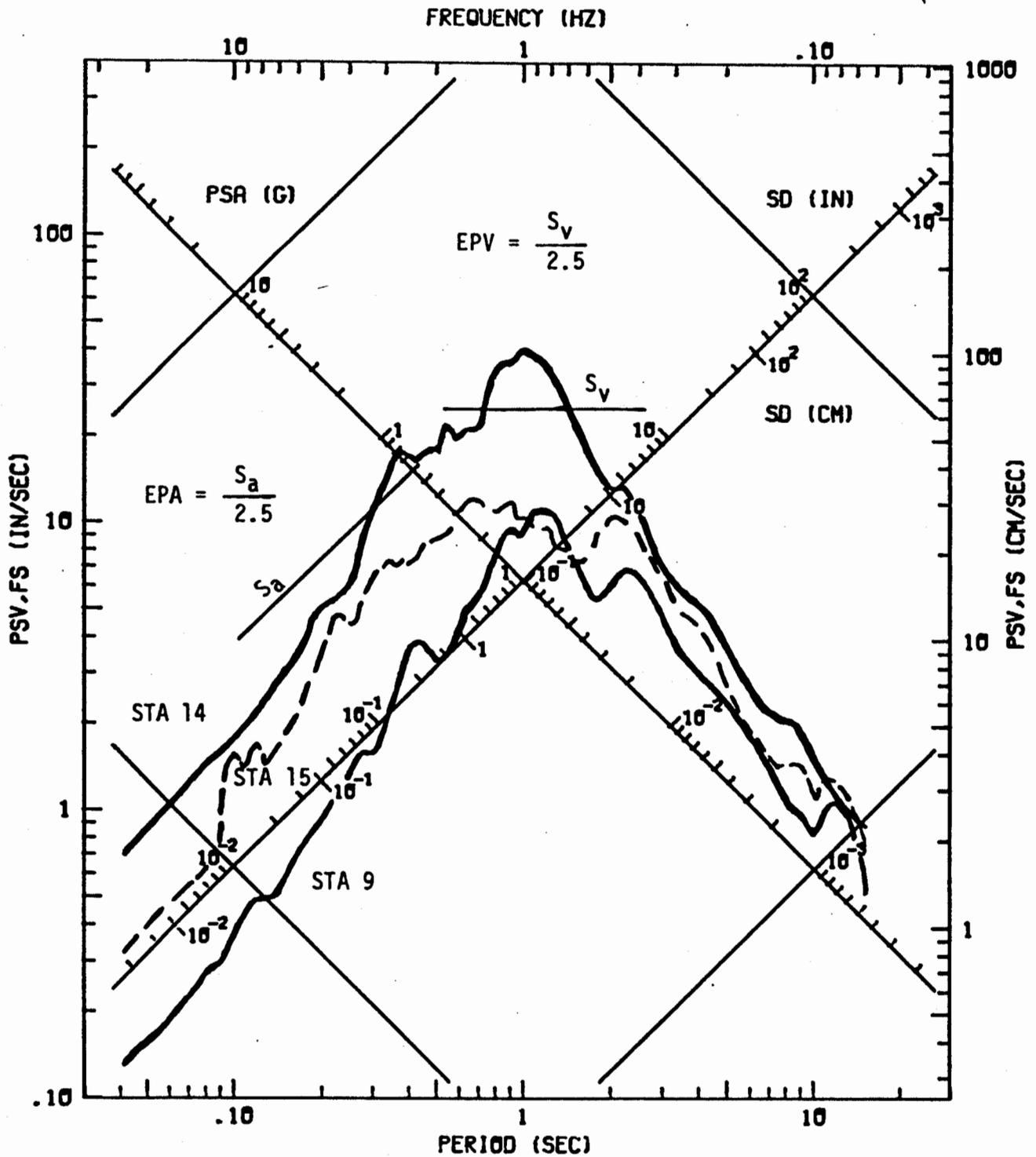


Figure 7 Response spectra (5% damping) for the accelerograms of Fig. 6, East Component. The ATC-3 procedure for estimating EPA and EPV is indicated schematically.

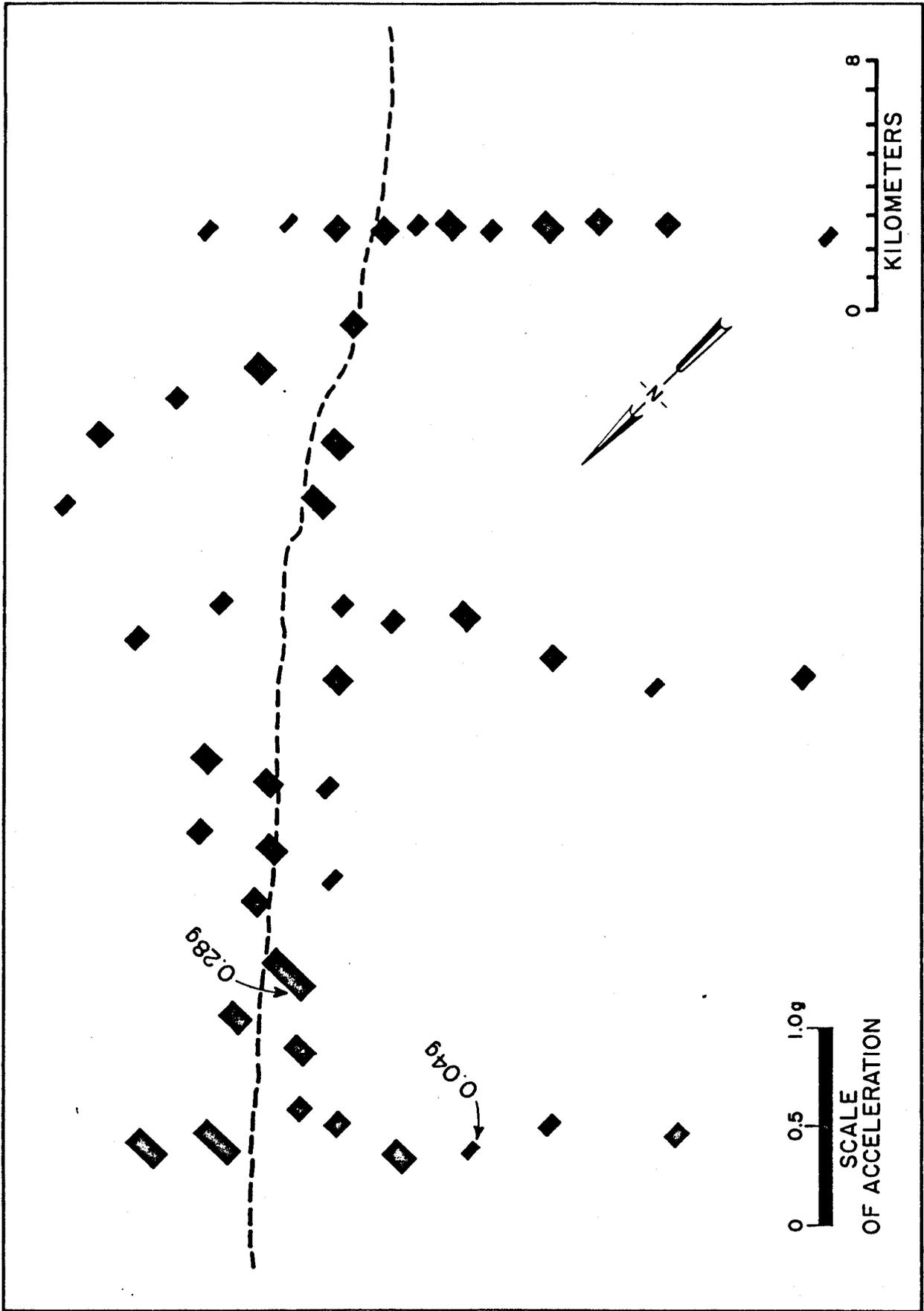


Figure 8 Peak Acceleration (East Component). Locations correspond to stations shown in Fig. 2

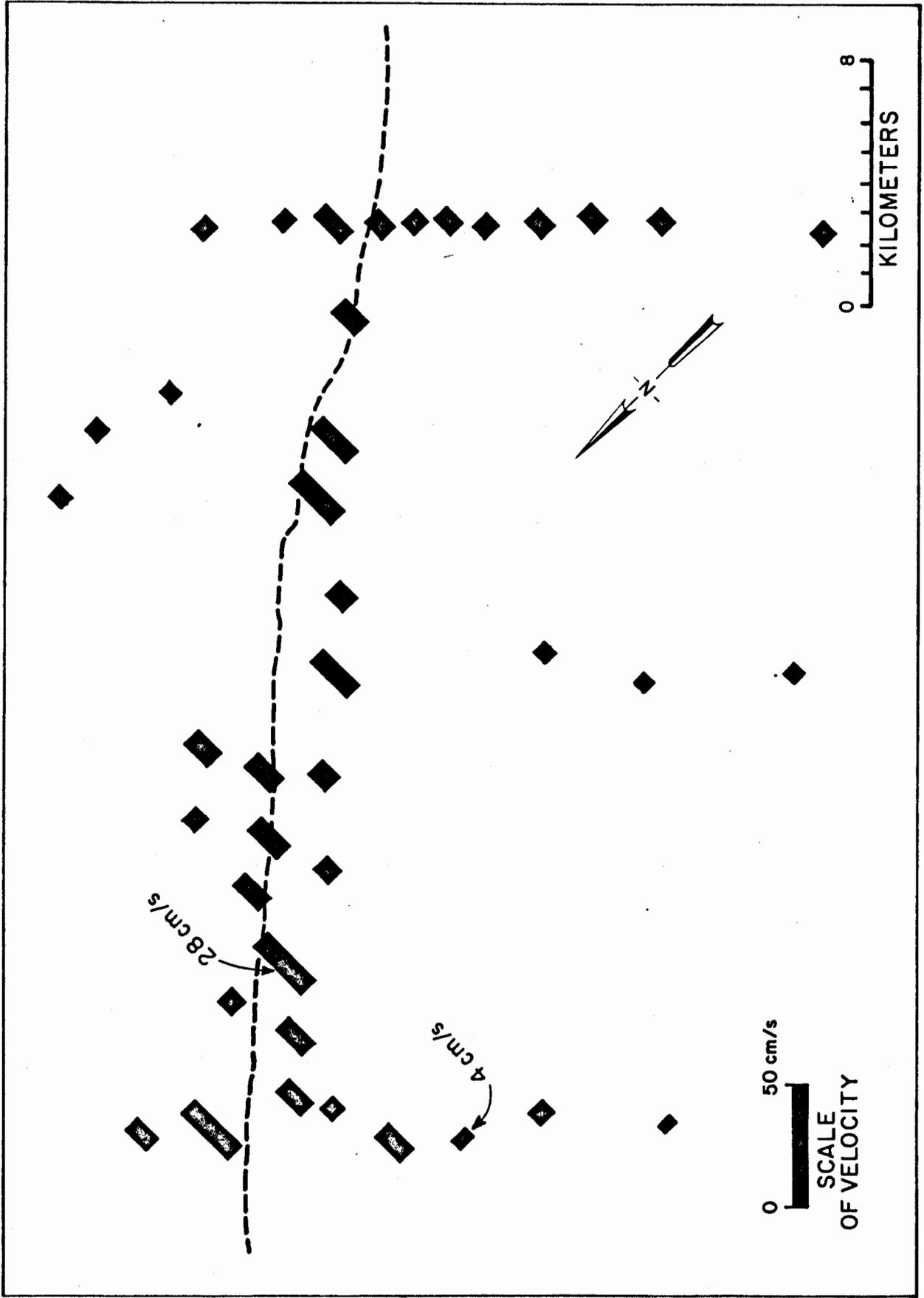


Figure 9 Peak Velocity (East Component). Locations correspond to stations shown in Fig. 2

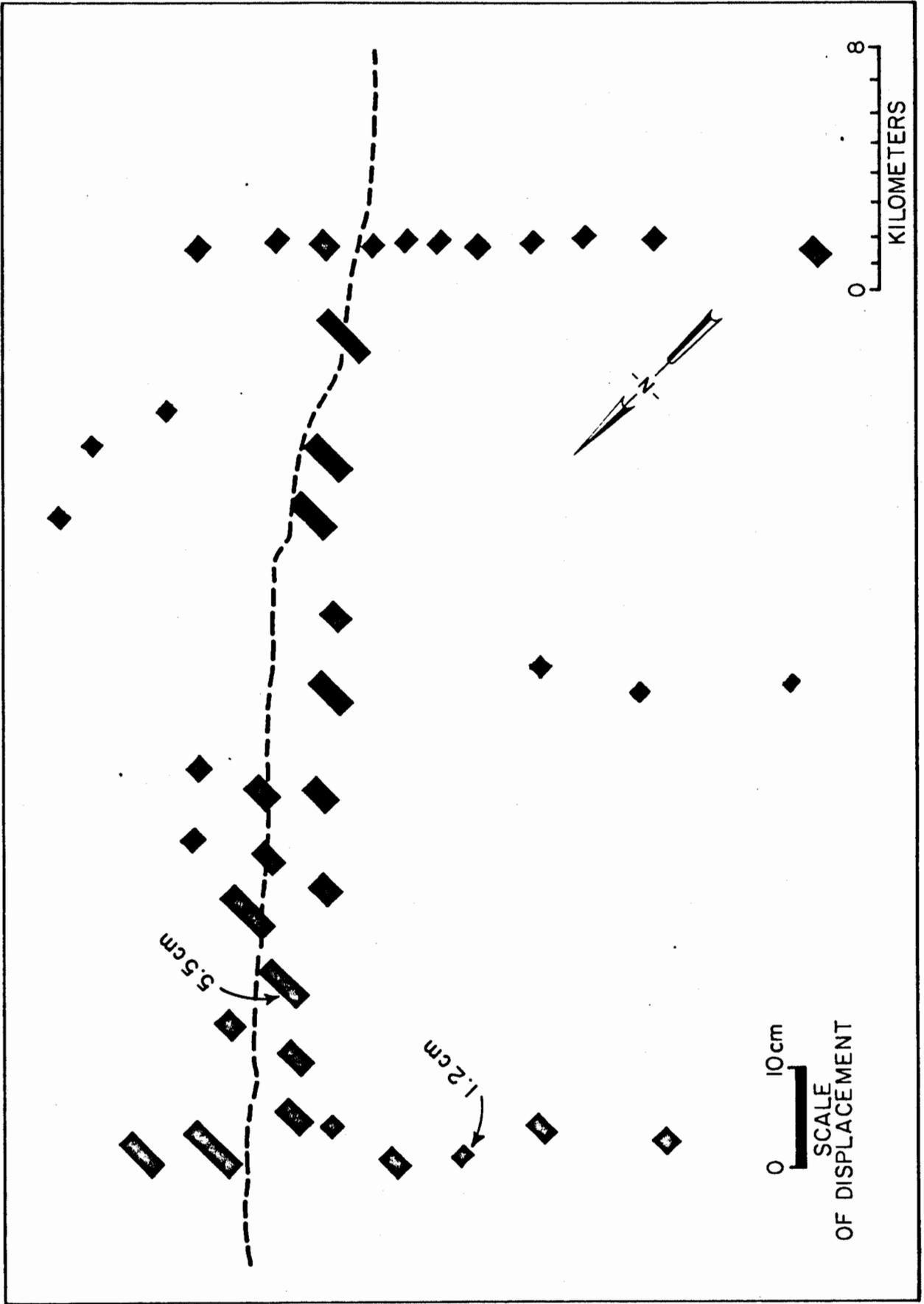


Figure 10 Peak Displacement (East Component). Locations correspond to stations shown in Fig. 2

have been processed are shown in Figs. 11 and 12. As indicated in Fig. 7, the values of EPA and EPV were estimated from spectral accelerations in the period range of 0.1 to 0.5 seconds and the values of EPV were estimated from spectral velocities near the period of 1 second (using 5% damping spectral plots as outlined in Applied Technology Council Report ATC-3-06, 1978). The patterns show that the spectral values of EPA and EPV are in reasonable agreement with the instrumental peak acceleration and peak velocity values. Thus, the spectral values also follow the pattern of being generally higher in the alluvial valley.

In summary, the data presented show that for this earthquake, ground shaking (as represented by peak and spectral values of acceleration and velocity) at alluvial valley sites near Parkfield is considerably higher than at sites in the adjacent hills. This is consistent with ATC-3 provisions that recommend higher lateral force design values for buildings values on soil than for those on rock. Preliminary studies indicate that the valley sites are underlain by relatively low velocity materials. Further investigation of conditions at these sites will contribute to our understanding of local variations in ground motion.

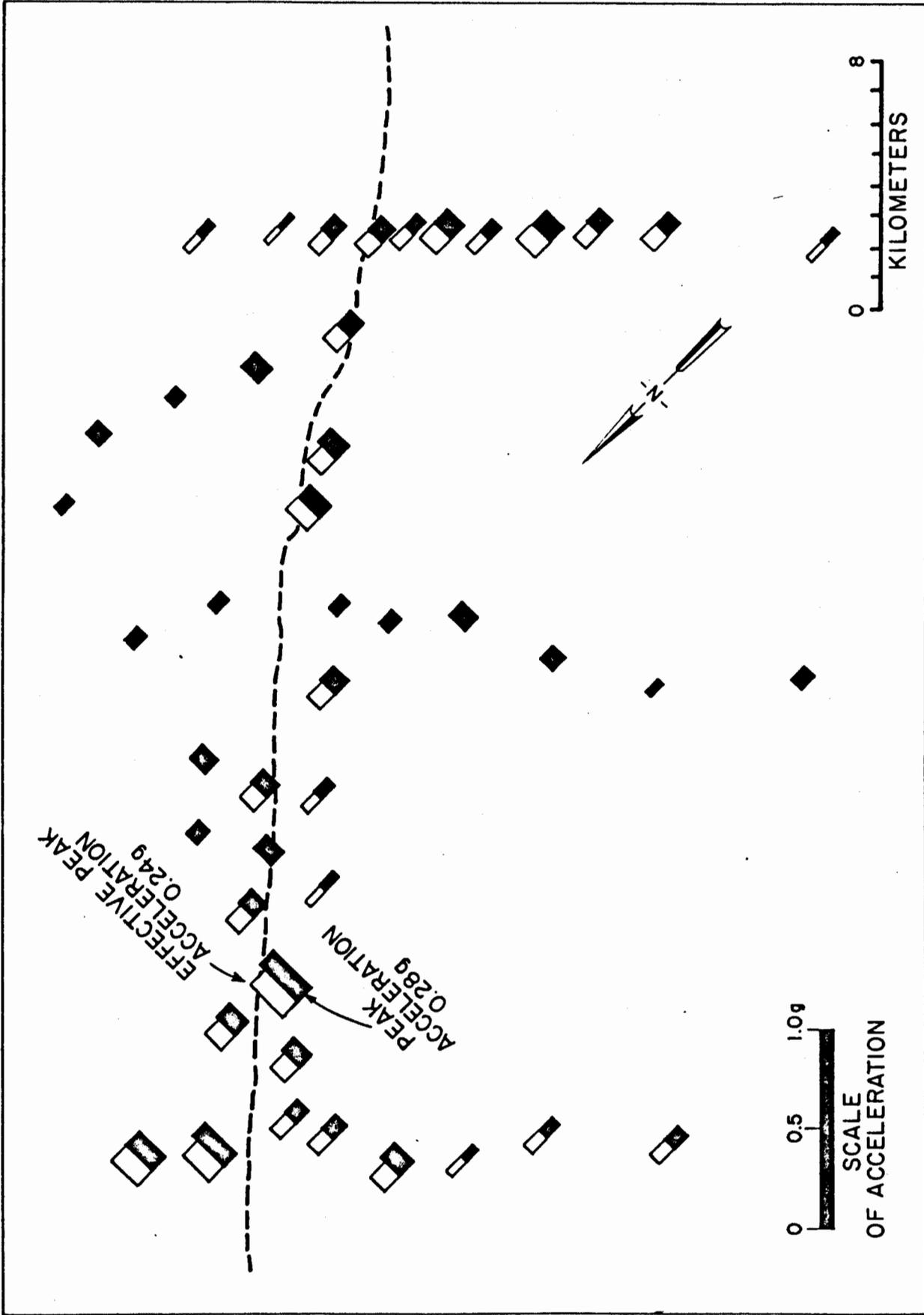


Figure 11 Effective peak acceleration and peak acceleration

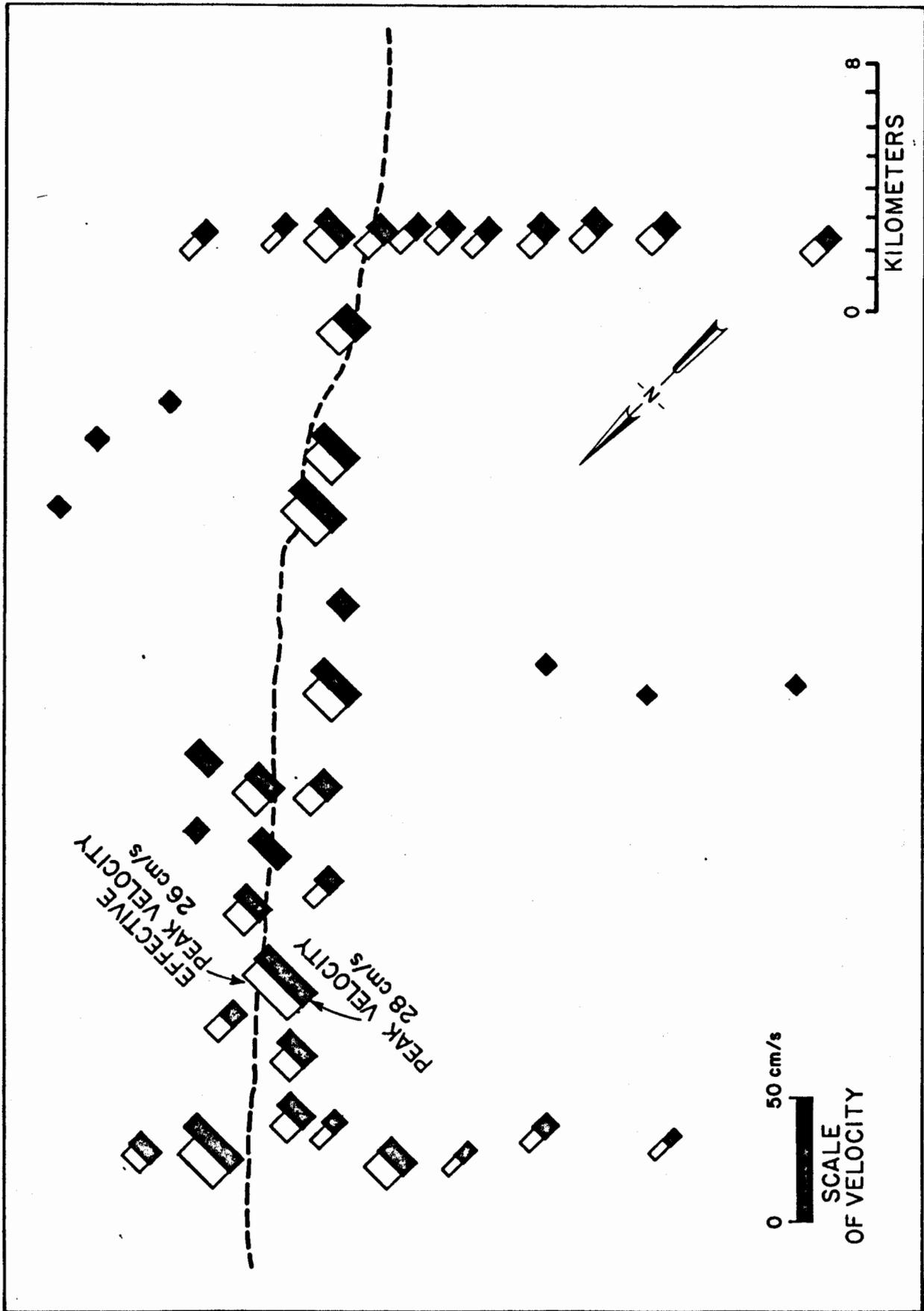


Figure 12 Effective peak velocity and peak velocity

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