AFTERSHOCKS IN THE FIRST 32 HOURS FOLLOWING OAXACA EARTHQUAKE OF 29 NOVEMBER, 1978 DETERMINED FROM SISMEX NETWORK

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RESUMEN

Se han localizado 15 réplicas ($3.5 \lesssim M \lesssim 4.5$) ocurridas durante las primeras 32 horas del temblor principal de Oaxaca a partir de los datos de la red SISMEX. El área estimada de estas réplicas corresponde al 60% del área estimada para las réplicas registradas en el campo del 1o. al 12 de diciembre de 1978; esta discrepancia se puede explicar si se toma en cuenta la posibilidad de aumento del área de las réplicas con el tiempo.

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Aftershocks beginning 32 hours after the main event of 29 November 1978, Oaxaca, Mexico earthquake are well located from portable field seismographs. The local network of portable seismographs, which was operating in the epicentral region for 3 weeks prior to the earthquake, was, however, only partially operational in the first 32 hours following the mainshock (L. Ponce, personal communication, 1978. Since the PDE (Preliminary Determination of Epicenters) aftershock locations for the Oaxaca earthquake are known to be in error by as much as 60 km (Singh *et al.*, 1980) we decided to calibrate the SISMEX (Sistema de Información Sismotelemétrica de México) network to locate the aftershock epicenters for first 32 hours. The early aftershock locations are important since the rupture area of the mainshock is expected to be equal to this aftershock area (Kanamori, 1977).

The SISMEX network consists of 5 short-period and 9 strongmotion stations in and around the Valley of Mexico (Fig. 1) telemetering FM coded signals to the Instituto de Ingeniería. Here the signals are recorded on analog tape and helicorder drums. Important events are digitized and stored on magnetic tapes. The SISMEX array forms an aperture of about 20° at an approximate distance of 500 km with respect to the Oaxaca aftershock area (Fig. 1).

Six aftershocks which are well located by the portable field array were chosen for calibration. P and S phases were read on the SISMEX records plotted on a scale of 5 mm/sec. Seismograms are generally very complicated showing several refracted and reflected phases. The phases used in this study were the direct phases Pg and Sg which are often the phases with the largest amplitudes although not the first to arrive. Identification of these phases was not unambiguous; to distinguish between different possibilities the arrival times were plotted against the average distance to the aftershock area. As can be seen from Fig. 1, 4 of the 5 stations form a near straight line towards the epicentral area. The differential distances between these stations for any point within the aftershocks area are nearly constant. Thus the plot of arrival times vs. average differential distances should fall approximately on a straight line; the slope of this line would give the apparent velocity. Readings with

abnormal velocities could then be rejected. Using the origin times and the epicenters of the 6 calibrations events, the average P and S velocities to the 5 SISMEX stations were calculated. No significant difference between the stations were observed indicating that no station corrections should be applied. Average values for P were velocity (α) and S wave velocities (β) were found to be 6.1 km/sec and 3.5 km/sec, respectively. Using a half-space model with the above velocities the 6 aftershocks were recalculated with the SISMEX readings. Six additional well located aftershocks were recalculated using SISMEX readings. Fig. 2 shows that the locations of these 12 events as obtained from the field data and the SISMEX data. This rather simple method gives epicenters from SISMEX which differ from those obtained from the field network by 5 to 25 km. Since the errors seems random, SISMEX epicenters would give a larger aftershock area.

Fifteen events with magnitudes from 3.5 to 4.5, which occurred in the first 32 hours after the main shock, were selected for analysis. Events with $M < 3.5$ did not have clear P arrivals whereas events with $M > 4.5$ saturated the system making it impossible to read S. The locations of these 15 aftershocks are shown in Fig. 3. Table 1 gives the data on these events. Also shown in Fig. 3 are PDE locations for 3 of these events. The aftershock area as defined by these 15 events is about 3700 km^2 which is 40% smaller than the area defined by the following 12 day aftershocks (Singh *et al.*, 1980). Since SISMEX locations are likely to increase the area, the first 32 hour aftershock area as defined by these 15 events is probably even smaller than 3700 km^2. The difference in the aftershock areas for the first 32 hours and the next 12 days may be due to growth of this area with time. If this is the case the horizontal projection of the rupture area associated with the main event is probably closer to 3700 km^2. It is also probable that a different aftershock area may have resulted if all the events with $M > 4.5$ which occurred in the first 32 hours could have been located using the SISMEX stations.

It seems that SISMEX array, after simple calibration, is capable of yielding better epicentral locations for events occurring in or near Mexico than the PDE locations.

TABLE 1

Epicenters determined by SISMEX

DATE	ORIGIN TIME	LAT.	LONG.
29-11-78	22 28 06	15.73	96.83
29-11-78	22- 32 13	16.07	96.95
30-11-78	00 01 13	15.75	96.81
30-11-78	01 31 04	15.76	96.72
30-11-78	02 20 56	15.50	96.86
30-11-78	03 03 43	15.86	96.74
30-11-78	05 09 57	15.45	96.78
30-11-78	07 23 52	15.91	97.08
30-11-78	07 48 52	15.53	96.75
30-11-78	10 42 46	16.07	97.13
30-11-78	12 03 06	15.61	97.06
30-11-78	17 47 49	15.59	96.66
30-11-78	21 21 21	15.44	96.82
30-11-78	23 54 10	15.66	96.77
01-12-78	03 01 00	15.69	97.15

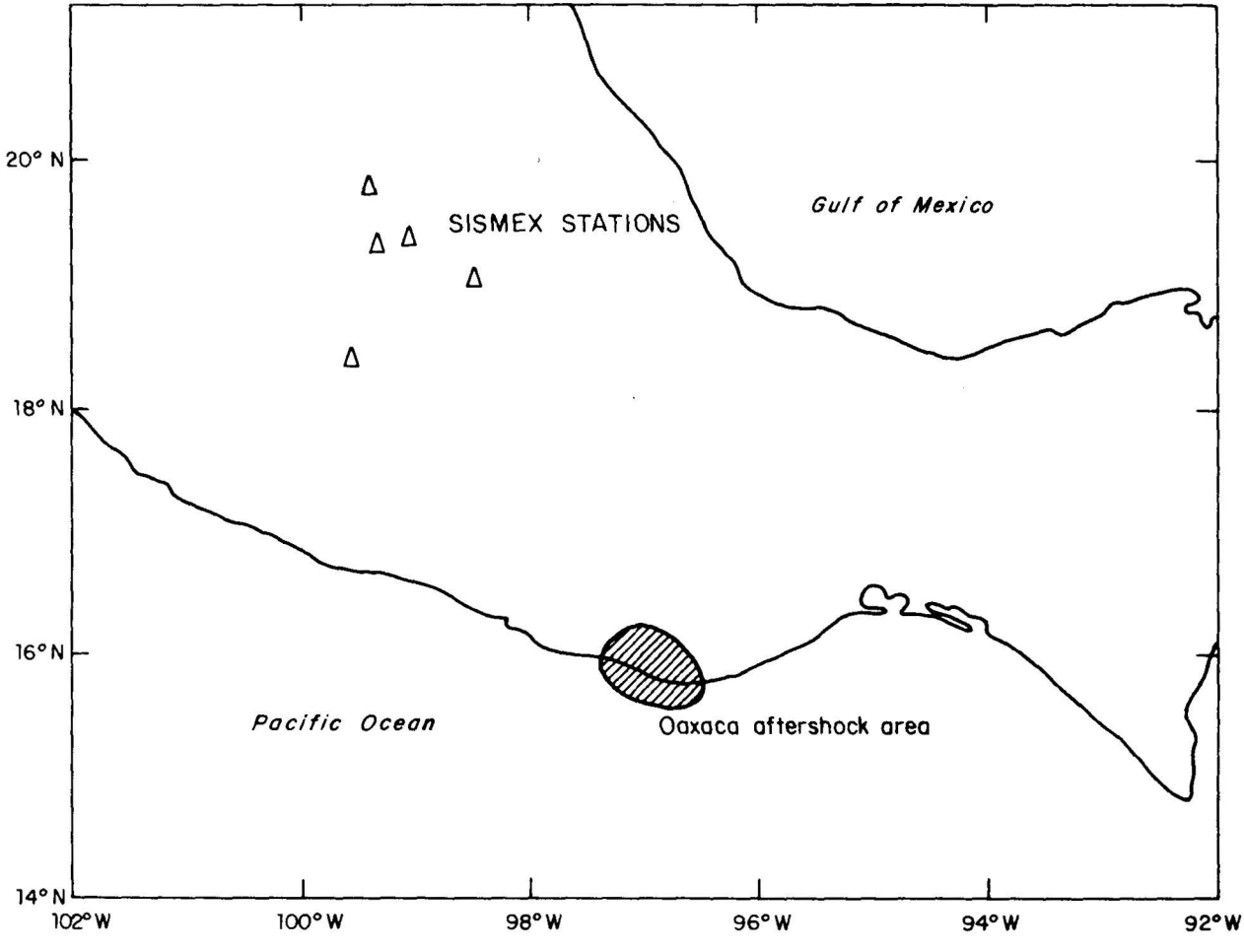

Figure 1. Locations of the SISMEX seismic stations (triangles) and the Oaxaca earthquake aftershock area (hatched).

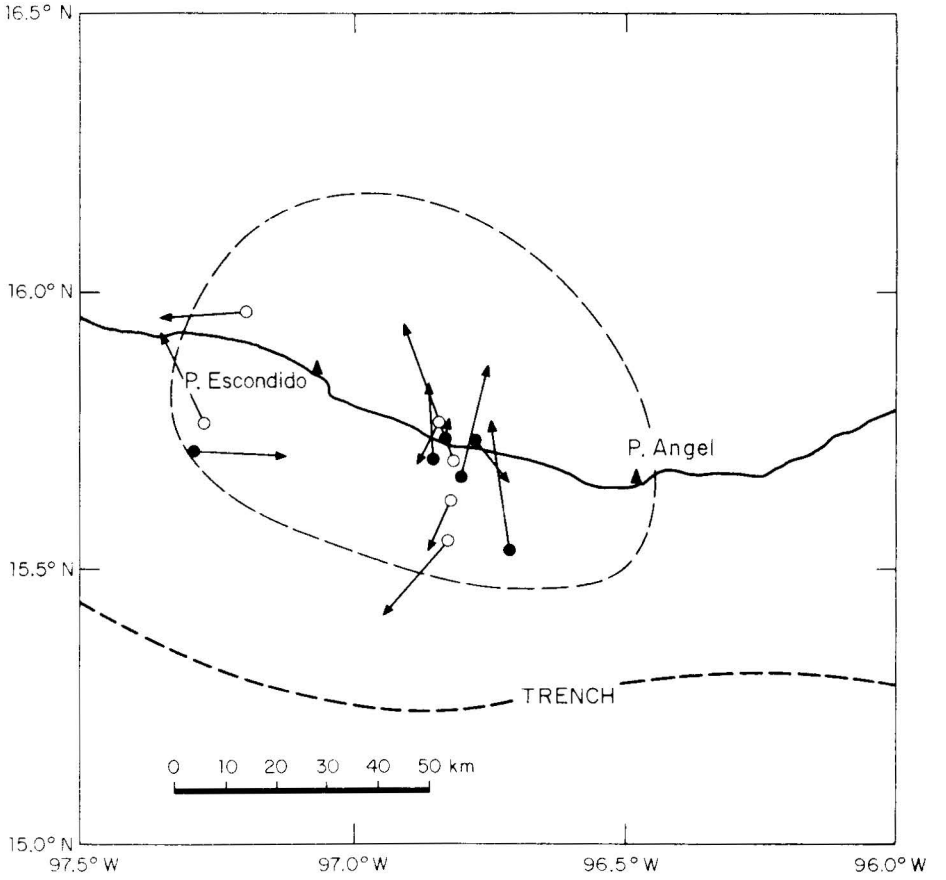

Figure 2. Calibration and test events. The dashed outline shows the aftershock area as determined from the local field seismographs (Singh *et al.*, 1979). Open and solid circles are the locally determined epicenters of the calibration and test events, respectively. The corresponding arrowheads give the locations determined by SISMEX.

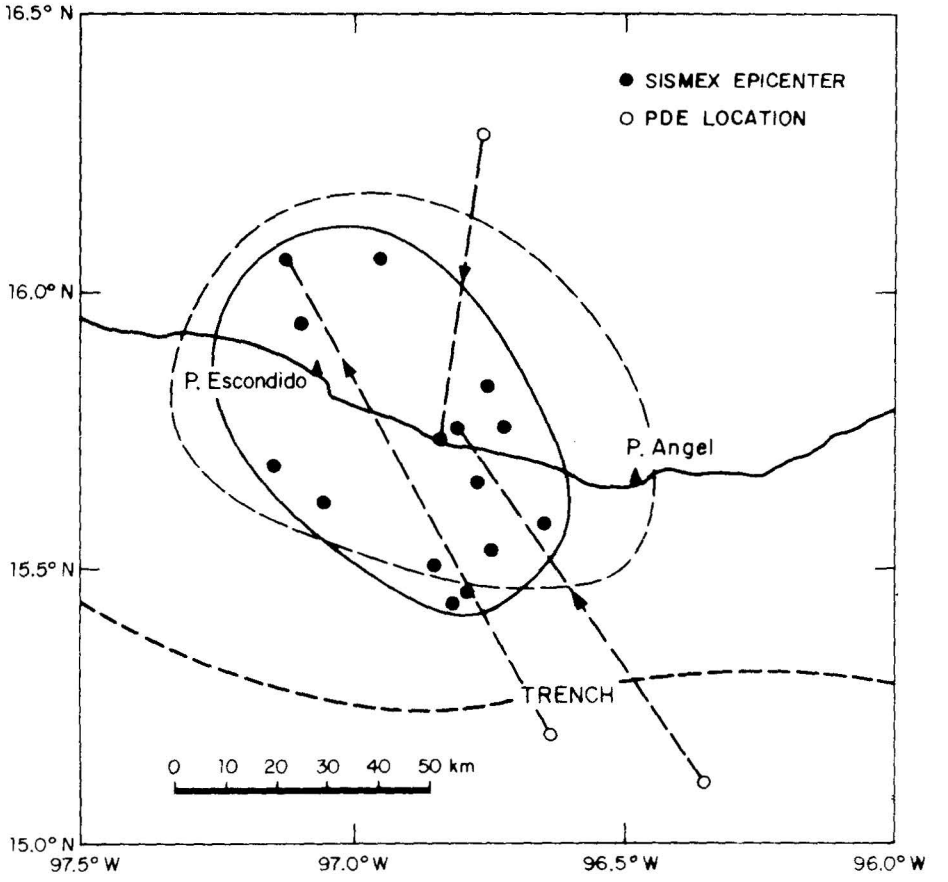

Figure 3. SISMEX epicenters (solid circles) for the first 32 hours of aftershocks. The continuous and dashed lines show the aftershocks areas as determined for the first 32 hours (SISMEX) and the next 12 days (field seismographs), respectively. Open circles show the corresponding PDE locations

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