OAXACA, MEXICO, EARTHQUAKE OF NOVEMBER, 1978: A PRELIMINARY REPORT ON SEISMIC ACTIVITY FOR PERIOD 20 JANUARY-20 APRIL 1979

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RESUMEN

Entre el 20 de enero y el 18 de abril de 1979, el Instituto de Geofísica, UNAM y el Laboratorio Sismológico, CALTECH operaron conjuntamente una red local de estaciones sismológicas portátiles al sur del Estado de Oaxaca, con el objeto de observar las réplicas del temblor de Oaxaca ($M_S = 7.8$) ocurrido el 29 de noviembre de 1978. Aquí se presentan las localizaciones epicentrales para 139 temblores ($M_L \geqslant 3.0$). Los principales resultados son los siguientes: (1) el área epicentral alcanza el valor de 9000 km^2, valor que coincide con determinaciones según la fórmula de Utsu-Seki para temblores de $M_S = 7.8$; sin embargo el área determinada para el período del 1o. al 12 de diciembre de 1978 (Singh *et al.*, 1978, 1979) es de sólo 6000 km^2 y la determinada para las primeras 32 hrs de réplicas (Havskov *et al.*, 1979) es de 3700 km. (2) La actividad sísmica de mayor magnitud se concentra en dos regiones pequeñas; una, en la parte sur central de la zona de réplicas, sugiriendo un lineamiento N-S y la otra, en la parte noroeste del área de réplicas. (3) La región suroeste del área de réplicas presenta escasa actividad sísmica y de baja magnitud; esto sugiere que esta región define un bloque "rígido" que después de ocurrir el temblor se reacomoda liberando su energía elástica a lo largo de sus fronteras con las unidades tectónicas circundantes. Estas observaciones sugieren que la determinación del área de ruptura del temblor principal, a partir del área de réplicas, debe ser realizado luego de un análisis detallado y multidisciplinario de los factores que pudieran controlar la ocurrencia de las réplicas en espacio, tiempo y energía.

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During a period of 3 months from 20 January to 18 April, 1979, the Institute of Geophysics, UNAM, and the Seismological Laboratory, CALTECH, installed in Southern Oaxaca, Mexico a local array of 5 portable smoke paper seismographs. Each station used a MEQ-800 Sprengnether microearthquake recorder along with vertical SS-1 Kinemetrics seismometer, To = 1 sec. The selected sites are shown in figure 1 (black triangles) and they are located as close possible to sites occupied previously, before and after the occurrence the mainshock (Ponce *et al.*, 1978 a, b; Singh *et al.*, 1978). Time was controlled every 24 hrs recording the WWV radio signal; P-waves first arrival times were read with an accuracy of ± .1 sec and S-waves arrival times with ± .2 sec. The purpose of the project was to observe the evolution of aftershock seismic activity in space, time, and energy in order to compare it with preceding and first aftershock activities. Here we will point out only some evident patterns of the observed seismicity and we compare it with the aftershock seismic activity reported for the period of 1st December to 12 December, 1978 (Singh *et al.*, 1978).

In Figure 1 we show the epicenter location for 139 earthquakes ($M_L \geqslant 3.0$) that occurred in southern Oaxaca (96°W – 98°W; 15° – 17°V) from 20 January to 18 April 1978. Hypocenters were determined using HYPO-71, additional data from a short-period permanent seismic station operated in Oaxaca City (VHO) by the Institute of Geophysics, were also used. Delays for this station were calculated using 7 large well recorded aftershocks (Ponce *et al.*, 1978 a, b). Magnitudes (m) are relative and were determined using the formula suggested by Lee *et al.* (1973). In Figure 1 we delineate the aftershock area determined for the first period of aftershocks (Singh *et al.*, 1978, 1979). This area is of the order of 6000 km^2. Using the same criteria we delineate a new aftershock area valid for the whole period of observation (1st December 1978-18 April, 1979). This new area is of the order of 9000 km^2, 50% greater than the previous one. This new value agree quite well with the size of aftershock area determined with the relation log A = 1.02 M_S – 4.01 obtained from data on 21 japanese earthquakes (Utsu and Seki, 1955): for a M_S = 7.8 earthquake this relation give an area of

8831 km^2, approximately equal to the 9000 km^2. For the first 32 hrs following Oaxaca earthquake the aftershock area has been estimated to be 3700 km^2 (Havskov *et al.*, 1978). The differences in the aftershock areas suggest the growth of this area with time. The significance of this result is due to the fact that aftershock area is used to estimate the rupture area. This suggest that for Oaxaca region the probable rupture area might be only 40% of the area defined according to the Utsu-Seki equation.

From Figure 1 is observed that large events cluster in two small regions: (1) at the south of the aftershock area defining a N-S direction; this is also observed for aftershocks (Singh *et al.*, 1978, 1979) located from 1st to 12 December, 1978, and has also been discussed in relation to preceding seismic activity (Ponce *et al.*, 1978 a, b). (2) at the northwestern region of the aftershock area; this region was relative quite from 1st to 12 December, 1978. From Figure 1 is observed that at the southern half of the aftershock area most of the strain energy is liberated along a narrow band with N-S direction; at both sides of this band the activity is scarce and of relative lower magnitudes. This is also observed from 1st to 12 December (Singh *et al.*, 1978, 1979). This suggest that at least for these periods the south western zone of relative quietness —bounded on its western flank by aftershock activity—, could constitute the bulk of a tectonic block that moves as a "rigid" unit after the occurrence of the mainshock, liberating most of its strain energy along its boundaries in contact with surroundings blocks. Unfortunately we did not observed the seismic activity from 19 December, 1978 to 19 January 1979 to support more strongly this hypothesis; however morphostructural analysis of Oaxaca region support the existence of tectonic units whose limits correlate enough well with the preceding and large aftershock seismic activities (Ponce *et al.*, 1978 a, b; Sumín de Portilla, 1978) and support the suggested hypothesis.

In Figure 2 we show the seismicity projected on a profile along the direction N23°E (A-A, Figure 1). Large earthquakes ($M_L \geqslant 3.5$) suggest two clusters of events: (1) along a plane dipping 14° to the N23°E interface that is almost coincident with the plane of fracture of the mainshock (Stewart and Chael, 1978); (2) along a plane dipping 72° to the S 23°W; this plane reach the surface at Loxicha region, half way from Miahuatlán to the coast line. We should note that the Loxicha region suffered the greatest damage during the occurrence of the mainshock; probable this active "fault" delineated from aftershock activity, experienced also some displacement during the occurrence of the mainshock affecting mainly the Loxicha region.

The fluctuation of seismic activity (number of events per unit time), not shown here, indicate that energy is liberated according to type 2.c. defined by Utsu (1969). For Japan this type correspond to shallow earthquakes associated to subduction boundaries; the Oaxaca earthquake is indeed one of the same type.

In conclusion, we point out that the occurrence of aftershocks for Oaxaca earthquake, and maybe for others subduction boundaries, reflect the complexities of the tectonic units of the continental plate. In view of that, the aftershocks areas should not be used as a measurement of fracture areas without a more detailed and multidisciplinary analysis.

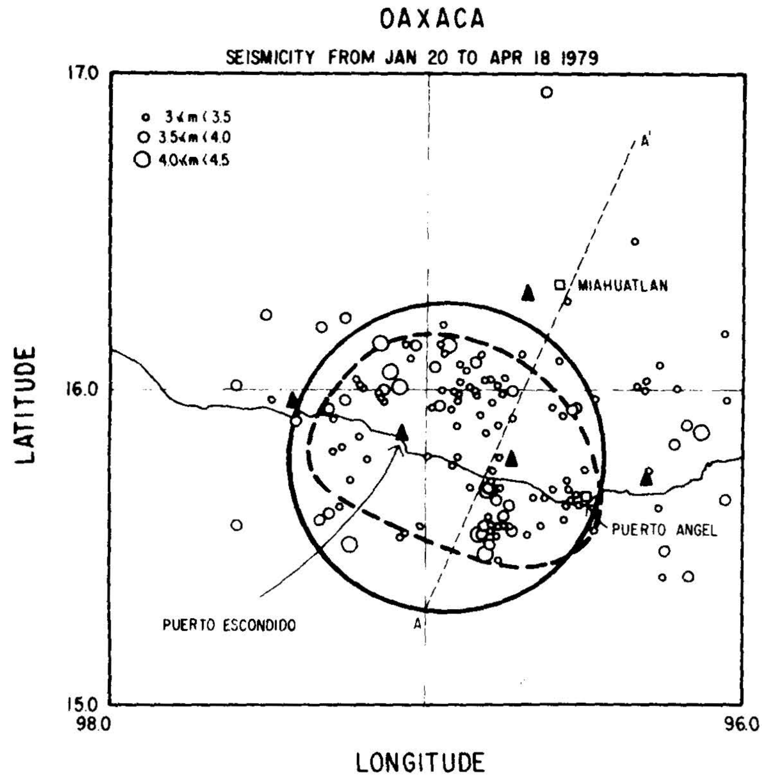

FIG. 1

Figure 1. Epicenter location for 139 earthquakes for the period from 20 January to 18 April, 1979. Triangles show the observation sites; circles represent epicenters; segment line delineate aftershock area defined for period from 1st to 12 December, 1978 (Singh *et al.*, 1978); continuos line delineate aftershock area for the whole period of observation (30 Nov. to 17 Dec., 1978; 20 Jan. to 18 April, 1979); straight line show the direction of projection (see Figure 2).

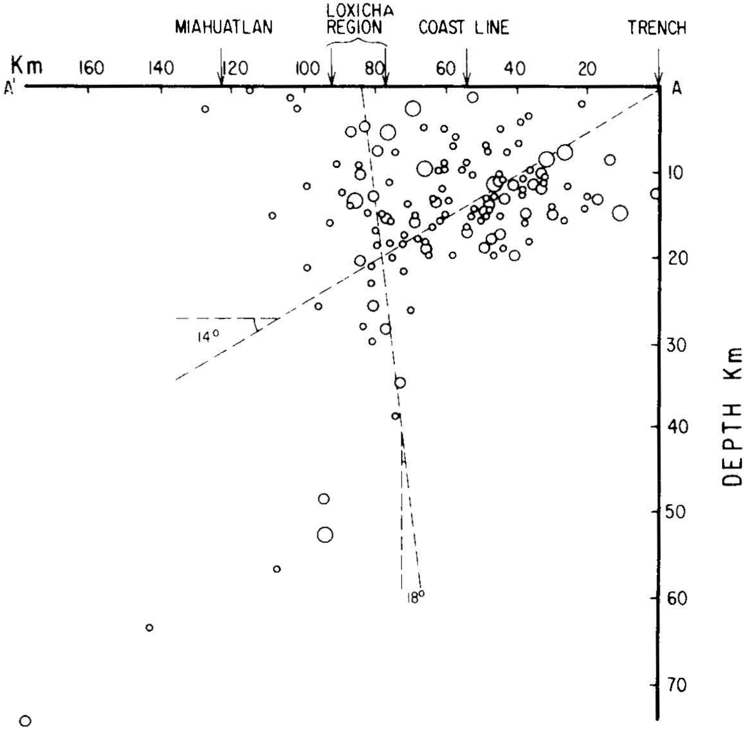

FIG 2

Figure 2. Projection of hypocenters along profile A-A' (see Figure 1); dashed lines delineated the two suggested directions of clustering of events.

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