THE 1978 OAXACA EARTHQUAKE
SOURCE MECHANISM ANALYSIS FROM DIGITAL DATA

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RESUMEN

Los temblores de Oaxaca de 1978 (Ms = 7.8), de Colima de 1973 (Ms = 7.5) y de Petatlán de 1979 (Ms = 7.6) ocurrieron a lo largo de la trinchera centroamericana y tienen mecanismos focales similares (fallas inversas de bajo ángulo de buzamiento). El momento del temblor de Colima fue determinado a partir de ondas Rayleigh del manto.

La comparación de las ondas del manto indica que el temblor de Oaxaca tiene un momento de $1.5 - 3.0 \times 10^{27}$ dinas-cm, un poco menor que el de Colima; el momento para el temblor de Petatlán $1.5 - 2 \times 10^{27}$ dinas-cm. Usando el área de réplicas como una estimación del área de ruptura, se obtiene que la caída de esfuerzos para el temblor de Oaxaca es de 10 - 20 bares, similar al de Colima (18 bares); para el temblor de Petatlán se obtiene una caída de esfuerzo de 20 - 30 bares. Registros de instrumentos de período largo de estaciones SRO y WWNSS fueron utilizados para inferir sobre la complejidad de la fuente. Los sismogramas sintéticos se calculan por medio del programa de Chapman basado en la teoría de rayos según el método de WKBJ. Resultados preliminares sugieren que el terremoto de Oaxaca se inició en una pequeña área ($r = 10$ km) con una caída de esfuerzos alta ($\Delta \sigma \geq 1,000$ bares) que se expandió a una área mayor con una caída de esfuerzos menor en promedio.

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Digital data from SRO, IDA, and U. Nevada at Reno stations have been used, with WWSSN data, to study the source mechanism of the 29 November, 1978, Oaxaca, Mexico earthquake ($M_S = 7.8$). To estimate the seismic moment, a comparison of long period mantle surface waves recorded on the Pinon Flat strainmeter between the Oaxaca event and the 1973 Colima earthquake ($M_S = 7.5$) is shown in Figure 1. Reyes et al. (1979) determined the seismic moment for the Colima event, $3 \pm 1 \times 10^{27}$ dyne/cm, and a stress drop of 10 bars. Without taking into account possible small differences in source mechanisms or focusing due to rupture propagation, the seismic moment of the Oaxaca earthquake, estimated from a direct comparison of amplitudes, is $1.5 \times 3 \times 10^{27}$ dyne/cm, slightly smaller than Colima. Also shown in Figure 1 is the record from the 14 March 1979 ($M_S = 7.6$) Petatlán, Guerrero, Mexico earthquake, with a seismic moment of $1.5 - 2 \times 10^{27}$ dyne/cm. Using the aftershock area determined by Reyes et al. (about 3300 km$^2$), the calculated stress drop for the Oaxaca earthquake is 10–20 bars, similar to that of Colima. For the Petatlán earthquake, we have determined an aftershock area of about 2000 km$^2$, giving a stress drop of about 20–30 bars.

The fault plane solution provides control on the auxiliary plane only. The slip vector has a dip of about 15° and a strike of 35°, in good agreement with estimates of relative motion between the American and Cocos Plates. Analysis of long period mantle Rayleigh waves recorded at the IDA stations suggests a fault strike of around 270°, and a rake angle of −70° (a left lateral thrust fault).

Further refinement of the source mechanism of the Oaxaca earthquake can be obtained from an analysis of teleseismic body waves. We use the Chapman WKBJ synthetic seismogram program to generate Green's functions for the moment tensor, including rays for P, pP and sP, using the upper mantle structure, T7, of Burdick and Helmberger (1978). Analysis is still underway and our results are very preliminary. Two results are illustrated in Figures 2 and 3. Figure 2 shows the effect of fault dip on synthetics calculated for the SRO station ZOBO. The data is the top seismogram. Gamma is the rake angle. Synthetics were calculated for a pure thrust ($\gamma = -90$), but are not sensitive to the actual rake. $h$ is the source depth and $f_c$ is the corner frequency of the
Brune far-field source model. Since ZOBO is close to a node, the first P motion is very sensitive to the fault dip. A dip of about 6° best fits the data. Figure 3 shows the effect of variations in corner frequency. The top line and the dotted lines show the data. A corner frequency of 0.25 Hz fits the data quite well. For a Brune far-field source function, this corresponds to a source radius of only about 10 km. Amplitude of the SRO data suggest a body-wave seismic moment of about $3 \times 10^{27}$ dyne/cm. close to that derived from long period mantle surface waves. If these preliminary numbers are correct, they imply a stress drop of over a kilobar in the area which generated the relatively simple body wave pulse, in constrast to the stress drop of 10 bars determined from the aftershock area and the long period mantle waves. This strongly suggests that the Oaxaca earthquake initiated as a high stress drop event in a small area, and spread into a larger area with lower average stress.
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Figure 1

0 SEC 500
\( \gamma = -90^\circ \quad h = 25 \quad f_c = 0.25 \)

Figure 2
$ZOB0$

$f_c = 0.25$

$0.125$

$0.083$

$0.063$

$s = 6^\circ \quad \gamma = -90^\circ \quad h = 25$

Figure 3