

**GEOMETRY OF THE BENIOFF ZONE IN THE TEHUANTEPEC  
AREA IN SOUTHERN MEXICO**

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**RESUMEN**

Mediante el uso de datos de las estaciones VHO, COM y una red sísmica local que operó durante 1979 en Chiapas, en el sureste de México, la geometría de la zona de Benioff más allá de los 60 km de profundidad ha sido bien delimitada en el área de Tehuantepec. Los hipocentros se encuentran confinados en un estrato de 45 km de espesor, rumbo N45E y echado de 45°. El volcán Chichón está situado a 225 km sobre el centro de la zona de Benioff.

**ABSTRACT**

Using data from a local seismic network operating in Chiapas, Southern Mexico, in 1979 plus two permanent stations VHO and COM, the geometry of the Benioff zone below 60 km depth was accurately mapped in the Tehuantepec area. The hypocenters were found to be confined within a slab of thickness 45 km, dip 45° and strike N 45°E. The only active volcano in the area, The Chichón, is situated about 225 km above the center of the Benioff zone.

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## INTRODUCTION

A local seismic network, installed in connection with hydroelectric projects, was operating in Chiapas in 1979 enabling us to make good locations of deep earthquakes in the Tehuantepec area. These new data take on added significance because few details are known of the regional tectonics and because the subduction of the Cocos plate in the area might be related to the activity of Chichonal volcano, which erupted in March-April, 1982.

## DATA

Data from a local network operating in the first 9 months of 1979 plus the permanent stations VHO and COM (Fig. 1) were used in locating about 300 earthquakes in the magnitude range 3-5. This data set included only events within about 250 km epicentral distance from the local network. Locations were made with the HYPO71 program (Lee and Lahr, 1978) and in general both S and P times were used. The following model for Chiapas (Novelo, 1980) was used:

Velocity (km/sec)	Depth to interface (km)
3.0	0
5.0	3
6.0	8
7.6	28
8.3	38
8.4	80
8.5	150

Only events which had HYPO71 standard errors of location less than 10 km and RMS residuals  $\leq 0.5$  sec were used in this study. Thus the data set was reduced to 76 deep events in the Tehuantepec area (Fig. 1). It is to be expected that the deeper inland events are better located since the network provides poor depth control for the many shallow events near or off the Pacific Coast.

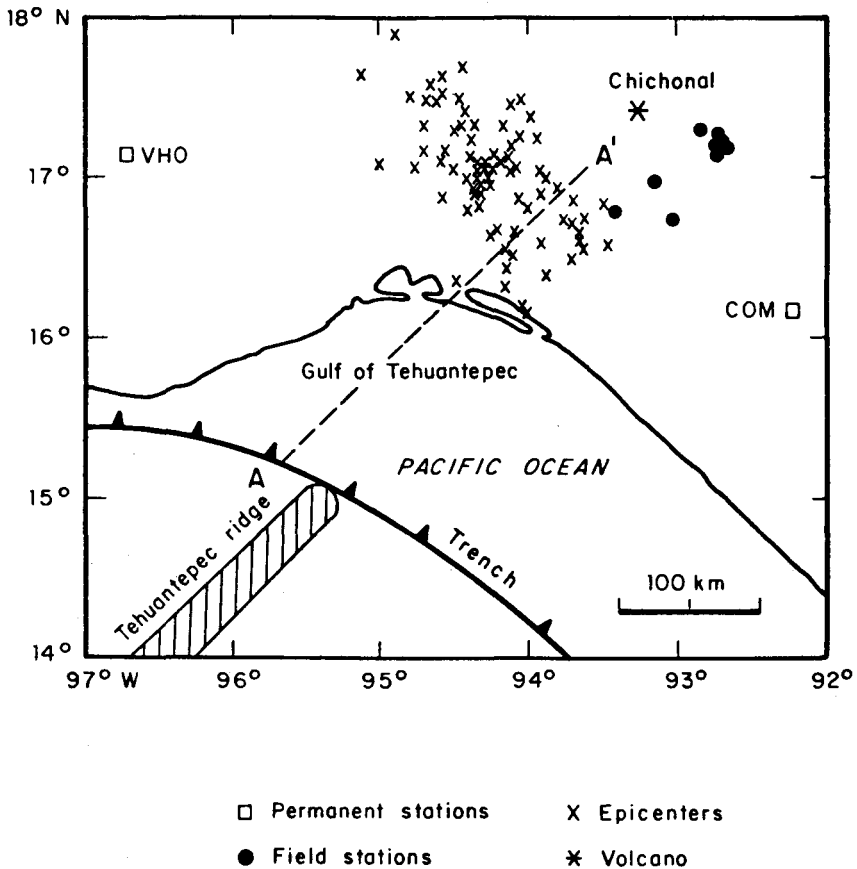


Fig. 1. The area studied. Data shown in Fig. 2 are projected along AA'.

The hypocenters were projected onto various sections with different azimuths and the least scatter was found when they were confined to a slab of dip  $45^\circ$ , strike  $N45^\circ E$  and thickness 45 km, see section AA' in Fig. 1 and profile in Fig. 2a.

#### QUALITY OF THE DATA

Studies by Barazangi and Isacks (1979) indicate that events deeper than 50 km in a Benioff zone can be systematically mislocated in depth, in amounts up to 50 km, when using a local network and a flat layered earth model. Selected teleseismic data were shown to give better results. A comparison is therefore made with data reported by Preliminary Determination of Epicenters (PDE) over the period 1962-

76. A total of 63 events from the same area were plotted on the same section as used above (Fig. 2b). A comparison of Fig. 2a and 2b seems to indicate that there is no systematic difference in the location of the Benioff zone, although the PDE data show considerable scatter. Thus the Benioff zone is probably accurately defined in the Tehuantepec area.

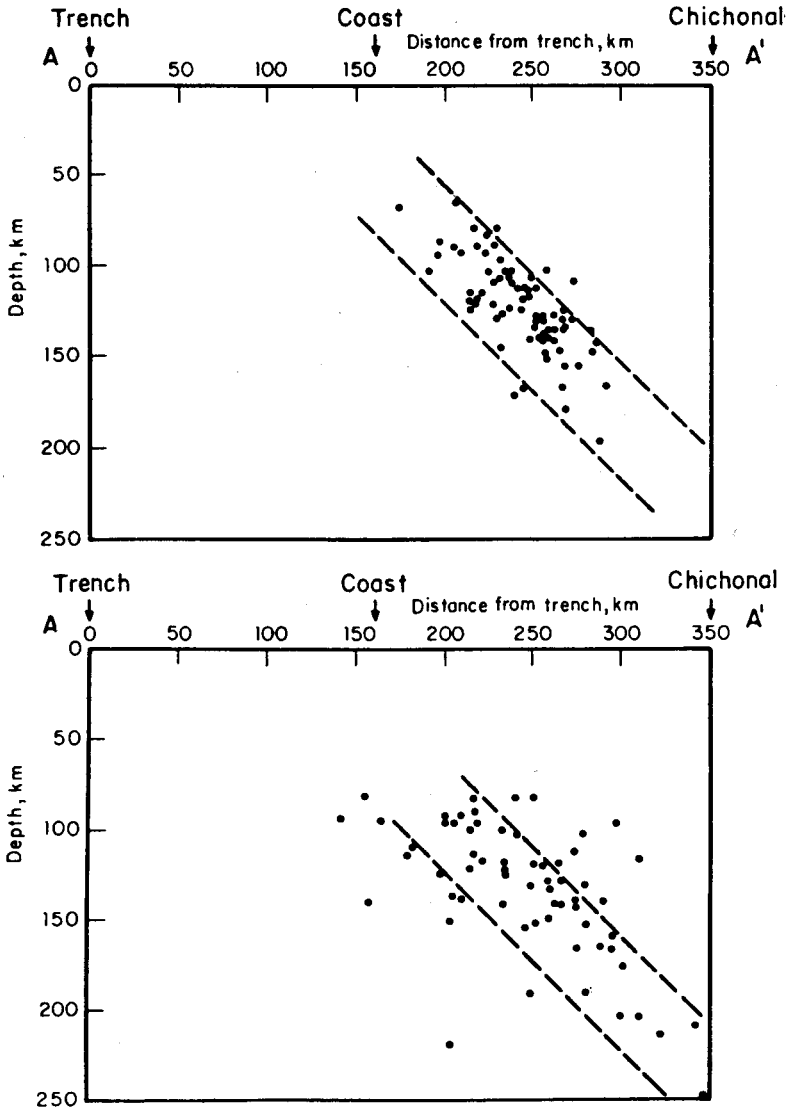


Fig. 2. (a) Section of hypocenters from this study. (b) Section of hypocenters given by PDE for the period 1964-76. Both Sections are projections along line AA' as shown in Fig. 1.

## DISCUSSION

Previous studies from the area were published by Molnar and Sykes (1969) and Hanuš and Vaněk (1979). They find a Benioff zone of about 100 km thickness with a dip between  $30^{\circ}$  and  $40^{\circ}$ . However their sections were made in directions N  $30^{\circ}$ E to N  $15^{\circ}$ E which results in a smaller dip as compared to using the optimum direction N  $45^{\circ}$ E found in this study. It thus seems that our result is an improvement over previous published results.

The present data set seem to indicate that the plate is subducting at a  $45^{\circ}$  angle below 60 kms depth. The trench is curved in the Gulf of Tehuantepec (Fig. 1) and far from parallel to the strike of the Benioff zone, as mapped below 60 kms depth, indicating that the plate could be strongly flexed between the trench and 60 kms depth.

From Fig. 2 it is seen that the center of the Benioff zone is about 225 km below the Chichonal volcano, which generates andesites (Medina, 1982). This distance seems reasonable considering that andesites have been observed in volcanos around the Pacific situated 80-270 km above the Benioff zone (Dickinson and Hatherton, 1967). Most of the seismicity is above 175 km depth and is very scarce directly below the volcano. This was also observed in the studies by Molnar and Sykes (1969) and Hanuš and Vaněk (1979). Similarly below many active volcanos worldwide there is little or no intermediate depth seismic activity (Carr and Stoiber, 1974). This has been interpreted as an indication of the existence of partially melted areas in the Benioff zones directly below the volcanos. It could also be the case below the Chichonal volcano.

The Tehuantepec ridge is being subducted near the southern end of the area under study. Within  $\pm 2^{\circ}$  the ridge is parallel to the direction of dip of the Benioff zone (N  $45^{\circ}$ E) as mapped below 60 kms depth. The direction of plate motion, calculated from the pole of rotation given by Minster and Jordan (1978), is N  $36^{\circ}$ E.

This  $9^{\circ}$  difference is small compared to what has been observed in other subduction zones such as the Aleutians where a difference of up to  $45^{\circ}$  has been observed between the direction of plate motion and the direction of dip of the Benioff zone (Davies and House, 1979). The strike of the Tehuantepec ridge is parallel to the direction of dip of the Benioff zone below 60 kms depth suggesting that the stiffness of the ridge may guide the direction of subduction. To further test this hypothesis, an accurate mapping of the Benioff zone between the trench and 60 kms depth should be made. With the new stations being planned in the area this should be possible in the near future.

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