COMMUNICATION

SHALLOW CRUSTAL STRUCTURE BELOW MEXICO CITY

J. HAVSKOV*
and S. K. SINGH**

RESUMEN

A partir de perfiles directos de refracción sísmica, usando como fuente explosiones de una cantera, se obtuvo una estructura cortical superior de dos capas bajo la Ciudad de México: para la primera capa (2 km de espesor) la velocidad de la onda compresional $\alpha_1 = 2.9$ km/seg y para la segunda capa $\alpha_2 = 4.7$ km/seg. Estos valores corresponden bastante bien a los valores obtenidos anteriormente en el lago de Texcoco, usando perfiles cortos de refracción invertidos.

ABSTRACT

From unreversed seismic refraction profiles, using quarry blasts as source, a 2-layer upper crustal structure below Mexico City is obtained: for the first layer (2 km thick) α_1 (the compressional wave velocity) = 2.9 km/sec, for the second layer $\alpha_2 = 4.7$ km/sec. These values compare reasonably well with the values obtained in the lake of Texcoco from short reversed refraction profiles.

* *Instituto de Ingeniería, UNAM.*
** *Instituto de Geofísica, UNAM.*

Quarry explosions in the South of Mexico City have been recorded by portable smoked-paper seismographs and the permanent seismic network around the Valley of Mexico (SISMEX) operated by the Instituto de Ingeniería (UNAM). From these non-reserved seismic refraction profiles, we have estimated the compressional (P) wave velocity structure in the upper few kilometers of the crust below Mexico City.

The site of the quarry explosions is shown in Fig. 1 by a solid star. The quarry, operated by Secretaría de Obras y Servicios del Departamento del Distrito Federal to produce building materials, carries out explosions once every two days or so. The solid triangles in Fig. 1 show the SISMEX permanent stations where these explosions are routinely recorded. The data from these stations are telemetered to Ciudad Universitaria, Station IIM, which keeps an accurate central clock. The travel time of P wave between the explosion site and IIM was established, with the help of a smoked-paper seismograph left operating near the site for 3 successive explosions, to be 0.7 second. Since during the period of observations the explosions were carried out nearly at the same place (within ± 70 m), the origin times of all other explosions were computed by substractig 0.7 second to the P reading at IIM.

We attempted to occupy as many stations as possible along the lines A and B (Fig. 1) to record the first arrivals using portable smoked-paper seismographs. In spite of many attempts, at different filter settings and gains, we could obtain usable data only at the stations shown in Fig. 1; at all other stations signal to noise ratio was too low.

Travel time-distance plots of the first arrivals along the lines A and B are shown in Fig. 2. The readings at the SISMEX stations have been averaged over 10 explosions. Lines A and B are 52 km and 27 km long, respectively. For the line A, the slope of the line corresponding to direct arrival of P wave through the first layer is well defined; it gives a velocity $\alpha_1 = 2.9$ km/sec for the first layer. The refracted arrivals are controlled by essentially 2 points. Assuming a flat layer model we obtain the P wave velocity $\alpha_2 = 4.7$ km/sec for the second layer and a thickness $h_1 = 2.0$ km for the first layer. Line B has only 2 data points. Assuming that α_1 is the same as for the line A and that these 2 points correspond to the refracted arrival from the top of the second layer, we obtain $\alpha_2 = 6.0$ km/sec and $h_1 = 2.6$ km. This implies rather large difference in α_2 along the lines A and B. Alternatively, we can assume that the second layer along the line B has the same α_2 as along the line A ($\alpha =$ 4.7 km/sec) but dips at an angle of about 9° towards the explosion site. This would give a thickness of 2.9 km for the first layer below the explosion site.

It is interesting to compare our results with the results obtained from short reversed refraction profiles conducted in the lake of Texcoco (Marsal and Graue, 1969). The location of these profiles are shown in Fig. 1 (lines T-1, T-2 and T-3). The results from Texcoco at the intersection of lines T-1, T-2 and T-3 can be summarized with a 3-layer model: $\alpha_1 \simeq 1.7$ km/sec, $h_1 \simeq 0.52$ km; $\alpha_2 = 2.9$ km/sec. $h_2 \simeq 1.0$ km; $\alpha_3 = 4.5$ km/sec. These results are comparable to our results for the line A. For central plateau of Mexico, Meyer *et al.* (1961) have reported a 1 km thick layer with $\alpha_1 = 3$ km/sec overlying a layer with $\alpha_2 = 4.95$ km/sec.

Until more extensive seismic refraction data or data from well recorded local earthquakes become available, we suggest that an average 2-layer model of $\alpha_1 = 2.9$ km/sec, $h = 2$ km and $\alpha_2 = 4.7$ km/sec be used for the upper crust of Mexico City. The second layer probably corresponds to lower to middle tertiary rocks (Mooser, 1961; Marsal and Graue, 1969) whereas the first layer probably consists of a series of andesites and deposits of volcanic tuffs intermixed with sands, shales, sandstones, lacustrine limestones, breccias, conglomerates, etc., as revealed from the boreholes of Texcoco (Marsal and Graue, 1968). As is well known a highly compressible, saturated clay of about 30 m thickness overlies this 2-layer model in most part of the valley of Mexico. Sinking of the City due to water withdrawal and high amplification of seismic waves in the city are atributed to this layer of clay.

ACKNOWLEDGEMENTS

We thank L. Astiz, E. Mena, D. Novelo and A. Uribe for help in data collection. We are very grateful to Ing. E. Wuest of Planta de Asfaltos del D.D.F. for advising us of the approximate time of the explosions so that the seismographs could be moved to the field, and to Dr. C. Lomnitz for helpful suggestions on the original manuscript.

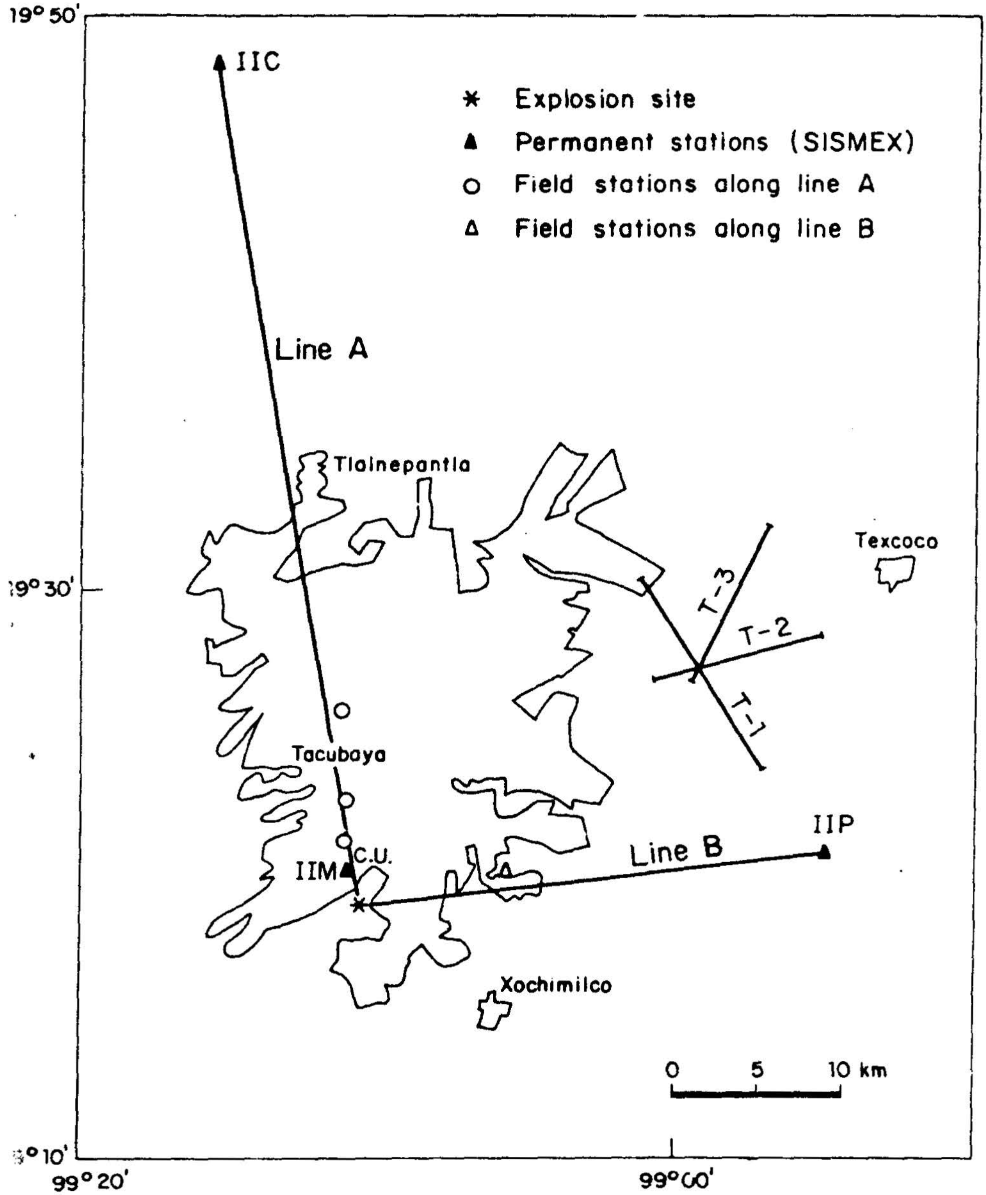
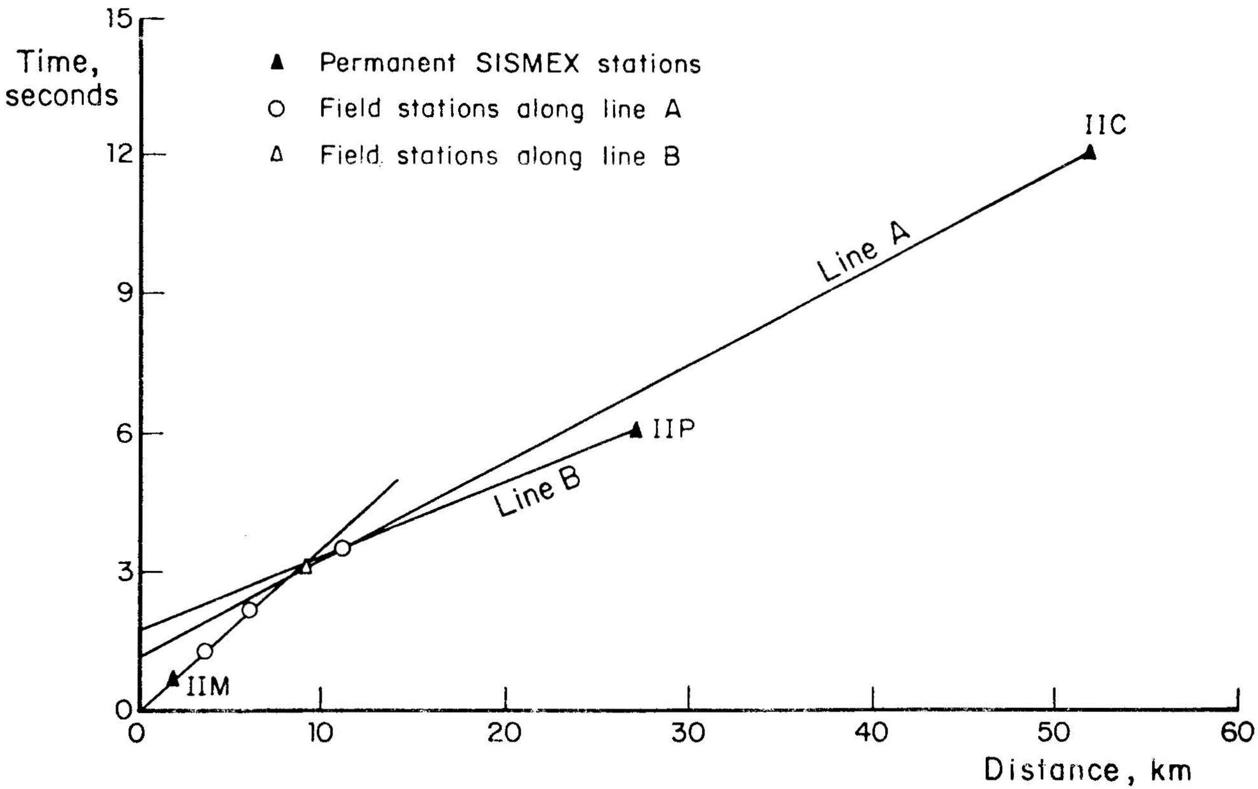


Figure 1. Location map. Lines A and B are 52 km and 27 km long, respectively. Solid star shows the explosion site. Solid triangles, open circles and open triangle are the permanent SISMEX stations, the field stations along line A and along line B, respectively. Lines T-1, T-2, and T-3 are the seismic refraction profiles made in the lake of Texcoco (Marsal and Graue, 1969).



e 2. Travel time – distance plot along lines A and B (Fig. 1).

BIBLIOGRAPHY

MARSAL, R. and R. GRAUE, 1969. El subsuelo del lago Texcoco, in *El Hundimiento de la Ciudad de México y Proyecto Texcoco* (Nabor Carrillo Volume). 167-202.

MEYER, R. P., J. S. STEINHART and G. P. WOOLLARD Central plateau of Mexico, 1957. In *Explotion Studies of Continental Structure*, Carnegie Institution of Washington, Pub. No. 622, Washington D. C., pp. 199-225.

MOOSER, F., 1961. Informe sobre la geología de la Cuenca del Valle de México y zonas colindantes, Secretaría de Recursos Hidráulicos, Comisión Hidrológica de la Cuenca del Valle de México, 99 p.