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Crustal thickness variations in northern Venezuela from deep seismic observations

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Introduction

Interdisciplinary geophysical and geological studies are being carried out within the framework of the BOLIVAR (Broadband Ocean-Land Investigations of Venezuela and the Antilles arc Region) and GEODINOS (Geodinámica reciente del límite norte de la placa Sudamericana) projects in order to investigate the geodynamics of the complex Caribbean-South America (CAR-SA) plate boundary zone. Here, we focus on the land based active seismic observations done in 2004 in northern Venezuela between 63°W and 70°W (Figure 1), which provide information from the Caribbean Mountain System in the north to the related foreland basins in the south.

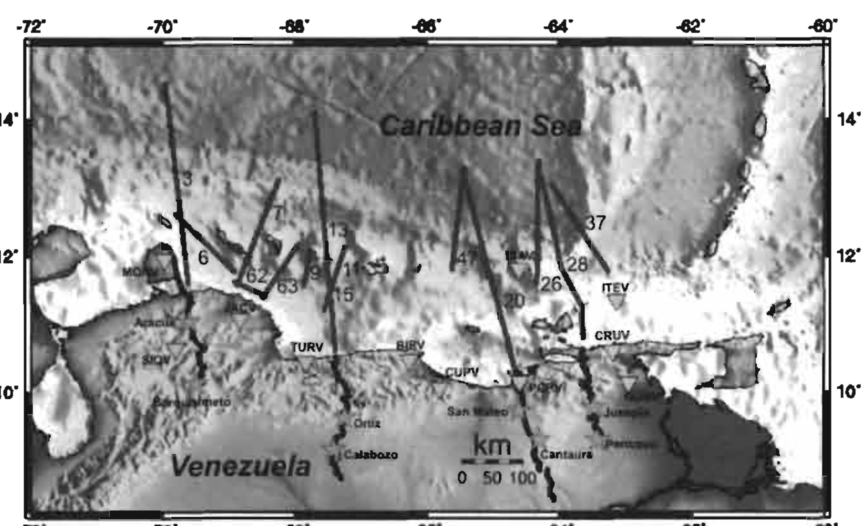

Figure 1. Location map with airgun lines (straight lines with line numbers), seismological stations used for recording (inverted triangles with station codes) and land shots (stars with shot point name) with the respective recording lines (black).

Up to now, little has been known about the crystalline crustal structure and Moho depths in Venezuela (e.g. Mooney et al., 1998). Results of deep wide-angle seismic measurements are available at the east coast of Maracaibo Lake (Gajardo et al., 1986), on the Guayana Shield (Schmitz et al., 2002), in the central offshore area (Guédez, 2003) and in the Oriental Basin (Schmitz et al., 2005), the more recent ones using airgun shots and borehole blasts as energy sources, respectively. In this contribution, we present examples of the seismic data and a preliminary map of the crustal thickness in northern Venezuela.

Seismic data

A combined seismic refraction/wide-angle reflection study was conducted in April/May 2004 (Levander et al., 2004) with airgun sources at sea and land shots as energy sources. In this paper, we analyze the recordings of the airgun blasts at the stations of the Venezuelan Seismological Network (Guralp CMG-40T, 30 s seismometers), as well as the recording of the land blasts done with temporary stations (a total of 550 REFTEK 125-01 recorders connected to 4.5 Hz vertical geophones; courtesy of IRIS-PASSCAL Instrument Center) along profiles perpendicular to the coastline (Figure 1).

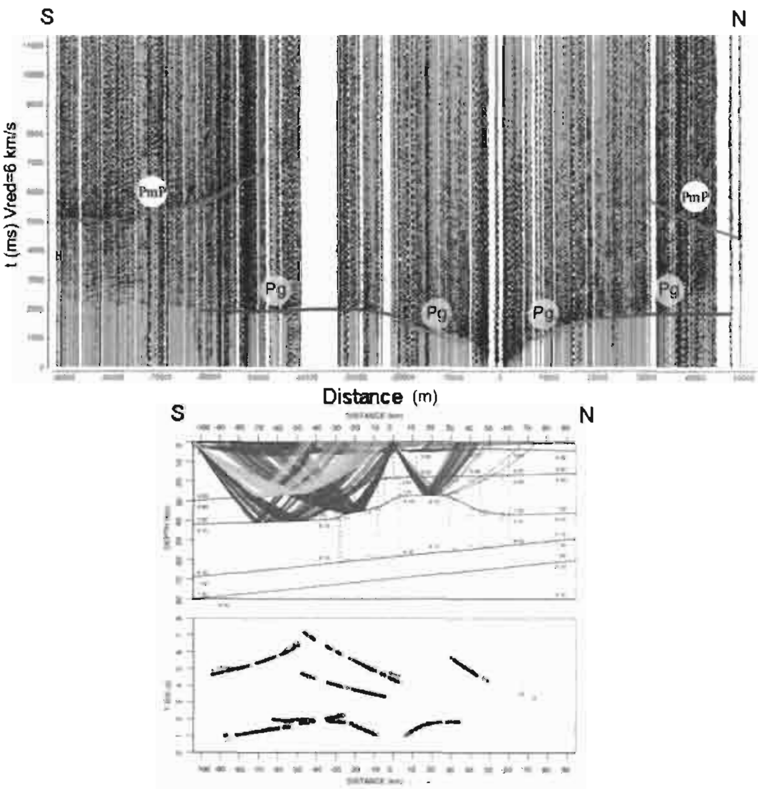

Figure 2. Seismic section of Aracua shot point (top), raytracing (center) and observed and calculated travel times (bottom). Pg arrivals are observed up to 40 km to the north and 60-70 km to the south. To the south, Moho reflections are observed between 100 and 55 km distance, whereas to the north, arrivals between 100 and 32 km are interpreted as Moho reflections, resulting in a crustal thinning to about 27 km. Location in figure 1.

Shot point spacing for the airgun pulses was 50-100 m and the receiver spacing for the land shots (2 shots along each profile with explosive charges between 0.6 an 1 ton; spacing of 50-100 km) was generally 300 to 500 m. Positioning was done using Garmin GPS V handhold units with an accuracy of about 10 m. The data were sampled with a frequency of 100 Hz. The seismograms were bandpass filtered with corner frequencies between 1 and 30 Hz and plotted in trace normalized form with a reduction velocity of 6 km/s.

The data quality is good for the recordings of the land shots, as well as for the recordings of the airgun sources at the seismological stations. An as example for both types of data we present the record sections from shot point Aracua in western Venezuela (Figure 2) and the recordings of the airgun line BOL37 at the seismological station "Isla Testigos" (ITEV) in eastern Venezuela (Figure 3), respectively.

Modelling and conclusions

The picks obtained from the seismic phases were correlated, and for the Moho reflections, the crustal thickness and the average crustal velocity was estimated using the Z_{max} formula (Giese, 1976). The 1-D estimates were taken as input for 2-D forward modelling using the ray tracing program RAYINVR (Zelt and Smith, 1992) in an iterative procedure starting with the structure of the sedimentary basin and the upper crust, and then including the Moho reflections in order to model the whole crust (Figures 2 and 3).

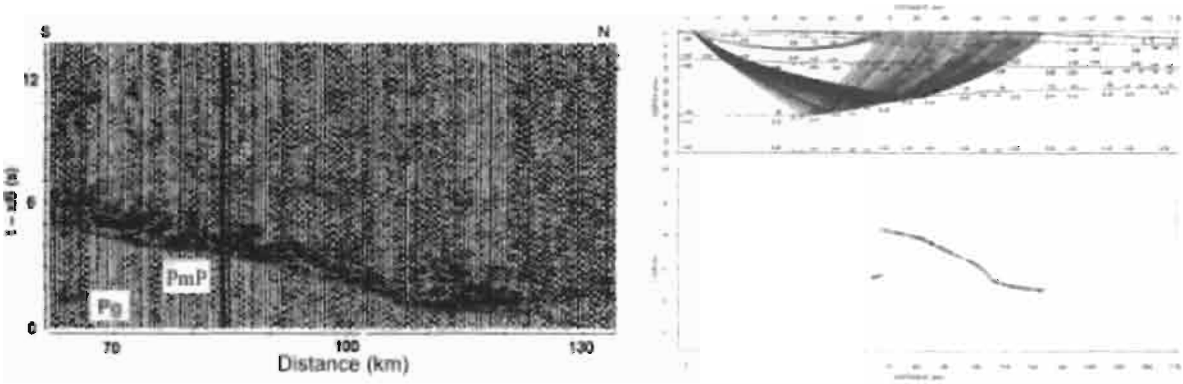

Figure 3. Seismic section with the recordings of the airgun shots along line Bol 37 at station ITEV (left), raytracing and observed and calculated traveltimes (right). Pg arrivals are observed up to 70 km distance, whereas Moho reflections are observed between 120 and 65 km distance.

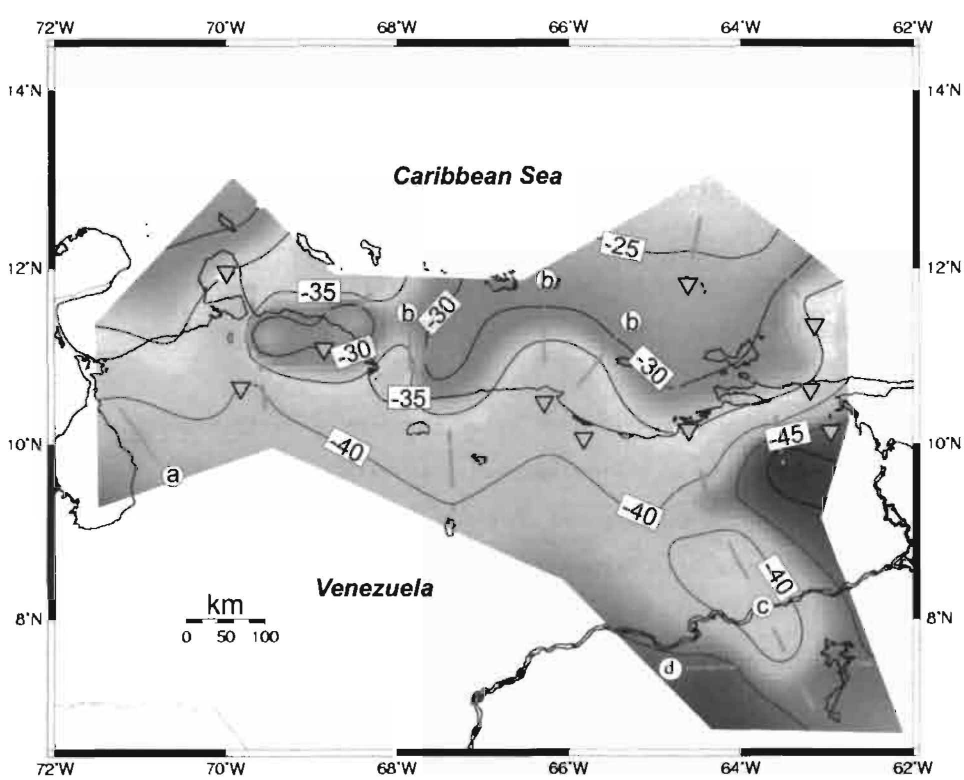

Figure 4. Preliminary map of crustal thickness in northern Venezuela derived from seismic wide angle observations. The surface gridding algorithm (Wessel and Smith, 1991; tension factor T=0.07) is used for the interpolation of Moho depths. The bold lines indicate the portion of the profiles that are modelled with Moho reflections; a-d = results from previous studies (see text).

The crustal thickness in northern Venezuela is mapped (Figure 4) including the results from this study and from previous deep seismic refraction studies for the east coast of Maracaibo Lake (a) (Gajardo et al., 1986; Guédez, 2003), the central offshore area (b) (Guédez, 2003), the Oriental Basin (c) (Schmitz et al., 2005) and the Guayana Shield (d) (Schmitz et al., 2002).

In general, the crustal thickness in northern Venezuela decreases from about 40 km south of the Caribbean Mountain System to less than 35 km along the coastline, whereas it exceeds 35 km in the central Costal Cordillera (Guédez, 2003). A pronounced crustal thinning is observed in the Falcón basin at 70°W (Figure 2; see also Rodríguez and Sousa, 2003). On the other hand, there is strong evidence for a deep (50 km) crustal root east of 64°W in the Eastern Basin, based on late Moho reflections. This deep crustal root might be interpreted as lower crustal material, underplated during processes related to the subduction of the Atlantic slab.

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