STRUCTURE OF THE SUBDUCTION CHANNEL AT THE ECUADOR CONVERGENT MARGIN FROM WIDE-ANGLE SEISMIC MODELING AND INVERSION

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INTRODUCTION

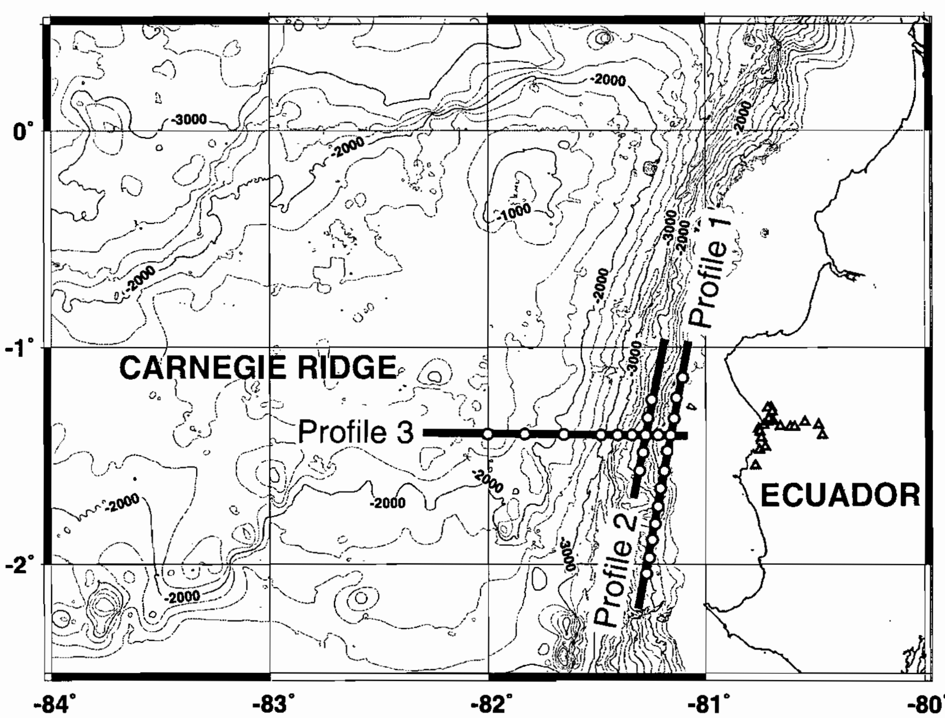

***Figure 1**: bathymetric map of the study area. Locations of the wide-angle seismic lines shot during the Sisteur experiment are shown: black lines stands for the shooting line; open circles for OBSs and open triangles for land seismometers.*

The North Andean convergent margin located at the boundary between the Nazca and South American plates has remained poorly studied, although since 1901, six great subduction earthquakes have ruptured the plate boundary between 3°S and 3°N. Several factors have been proposed as controlling inter-plate coupling and tectonic regime of the margin including reactivation of seafloor relief when subducted, and the subduction or accretion of sediment [*Cloos and Shreve*, 1996].

A major east-west trending bathymetric feature, the Carnegie Ridge (Figure 1), characterizes the Nazca plate. This ~200-km wide volcanic ridge, related to the interaction between the Galápagos hotspot and the

Galápagos spreading center to the west, is subducting beneath the Ecuador convergent margin. The frontal subduction of the Carnegie Ridge, has produced a segmentation of the upper plate expressed in lateral variations of uplift, seismicity, deformation, arc magmatism as well as sediment distribution along the margin [*Collot et al.*, 2002; *Gutscher et al.*, 1999].

Seismic investigations at convergent margins are critical to understanding the mechanics of the interplate seismogenic zone. During the SISTEUR experiment (Sept.-Oct. 2000) conducted by our group on board the French research vessel *Nadir* (IFREMER) and the Ecuadorian research vessel *Orion* (INOCAR), we collected deep multichannel seismic reflection and wide-angle seismic data recorded by ocean bottom seismometers (OBSs) and land seismometers on the Nazca-north Andean plate boundary. The objectives of this cruise were to study the crustal structure and its possible correlation with the occurrence of great subduction earthquakes in the area of the Ecuador and southern Colombia margin. We focus in this paper on imaging the geometry and the properties of the subduction channel in front of the subduction of the Carnegie Ridge (Figure 1).

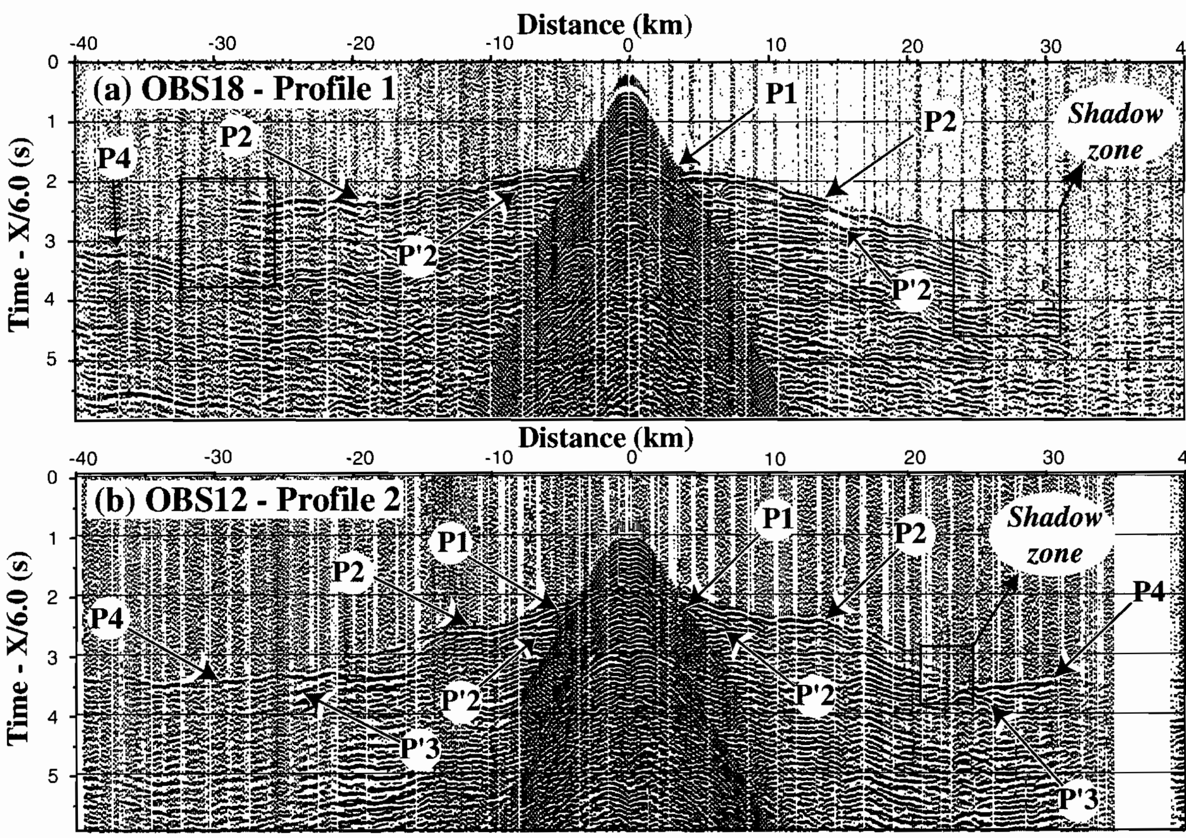

***Figure 2**: Wide-angle seismic record sections from OBS 18 (Profile 1) and OBS 12 (Profile 2). The reducing velocity is 6.0 km/s. Data were bandpass filtered between 3 and 18 Hz and amplitude scaled proportional to offset. Main arrivals used for modeling and inversion: P1 refraction in the sedimentary cover; P2 refraction in second layer (upper plate); P4 refraction in fourth layer (subducting plate); P'2 reflection from the base of layer 2, P'3 reflection from the base of layer 3. On both sections a clear shadow zone is interpreted as related to a low-velocity layer 3. It reaches ~1 s delay along profile 1 and only ~0.3 s along profile 2.*

Data acquisition and modeling

Three seismic lines were shot on the Ecuador margin over a network of 24 OBSs and 10 land stations (Figure 1). 350-km of in-line shots were recorded providing a unique set of high quality data (Figure 2). Profiles

1 and 2 were shot parallel to the trench respectively on the top of the continental platform and in the middle of the slope. One of the striking characteristics of the wide-angle record sections is the presence of a clear shadow zone between arrival P2, refracted in the upper plate and phase; P3, refracted in the top of the plunging plate.

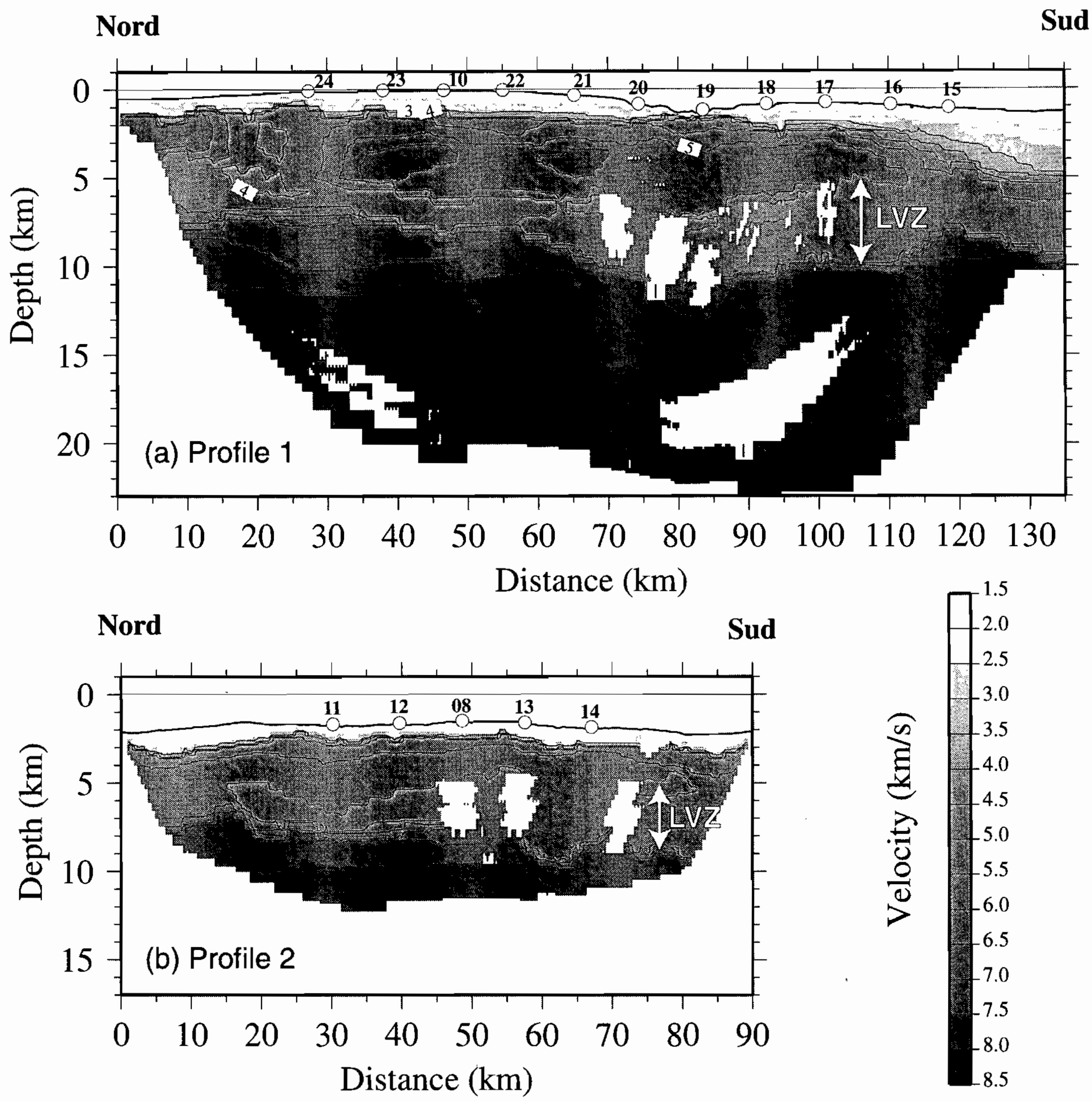

Figure 3*: Velocity models obtained from the inversion of the travel time of the first arrival [Korenaga and et al., 2000]. The starting model was based on forward modeling of wide-angle and coincident multichannel reflection data [Zelt and Smith, 1992]. (a) Model along profile 1. (b) Model along profile 2. The low velocity channel is indicated on both models. It reaches 3 km along profile 2 and 5 km along profile 1.*

CONCLUSIONS

Along profile 2 the top and the base of low velocity layer are underlined by reflections visible at wide-angle and at vertical incidence as well. The average velocity in this layer, constrained by the wide-angle reflection at its base, is 4.0 to 4.5 km/s, only slightly lower than in the basement of the upper plate (5.0 km/s). The thickness of this layer varies from zero to the north of the profile to approximately 3 km to the south.

Along profile 1 the low velocity channel is thicker (3 to 5 km) and there is clear reflection at its base. Seismic velocities, as high as 6.0 km/s, determined in the overriding plate are possibly related to the Piñon formation composed of mafic rocks [e.g., *Reynaud et al.*, 1999]. Beneath this profile, the uppermost part of the down-going plate could be part of the low velocity layer and the actual subduction channel is not clearly defined.

On the contrary, the low velocity layer is clearly related to the subduction channel beneath profile 2 as the top of the down-going plate is clearly defined. The sedimentary cover of the Carnegie Ridge consists of a ~1 km thick layer of material with an average seismic velocity of ~2.5 km/s. This preclude that the subduction channel consists only of sediments of the down-going plate dragged along in the subduction. Several hypotheses could explain the velocity models: material possibly comes from both the down-going and the overriding plates, material of the subduction channel should be compacted as it is buried beneath ~ 2 km of rocks and because of the deformation, material should be accreted between the 2 plates to explain the thickness of the subduction channel.

Amplitude modeling and waveform inversion will provide additional constrains on the geometry and characteristics of the subduction channel.

REFERENCES

Cloos, M., and R.L. Shreve, Shear-zone thickness and seismicity of Chilean- and Marianas-type subduction zones, *Geology*, *24* (2), 107-110, 1996.

Collot, J.-Y., P. Charvis, M.-A. Gutscher, S. Operto, and the SISTEUR scientific Party, Exploring the Ecuador-Colombia active margin and inter-plate seismogenic zone, *EOS, Transaction, American Geophysical Union*, *in press*, 2002.

Gutscher, M.A., J. Malavieille, S. Lallemand, and J.Y. Collot, Tectonic segmentation of the North Andean margin: impact of the Carnegie Ridge collision, *Earth and Planetary Science Letters*, *168*, 255-270, 1999.

Korenaga, J., and et al., Crustal structure of the southeast Greenland margin from joint refraction and reflection seismic tomography, *Journal of Geophysical Research*, *105*, 21591-21614, 2000.

Reynaud, C., E. Jaillard, H. Lapierre, M. Mamberti, and G.H. Mascle, Oceanic plateau and island arcs of southwestern Ecuador: their place in the geodynamic evolution of northwestern South America, *Tectonophysics*, *307*, 235-254, 1999.

Zelt, C.A., and R.B. Smith, Seismic traveltime inversion for 2-D crustal velocity structure, *Geophysical Journal International*, *108*, 16-34, 1992.

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