Geophysical Research Abstracts
Vol. 13, EGU2011-12432-1, 2011
EGU General Assembly 2011

1992 Nicaragua tsunamigenic slow earthquake: Geophysical constraints from seismic modelling

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We present a 2D model of the Nicaragua convergent margin obtained by travel-time inversion of WAS data recorded in two perpendicular profiles. The first, which is ~280 km long and perpendicular to the trench, is the sum of two shorter profiles, NIC20 and P50, acquired separately during the cruises EW-0005 (2000) and SO173-1 (2003) respectively. It was recorded by a total of 28 OBHs and 7 land stations. The second profile (NIC125) was acquired during EW-0005 (2000). It is located ~50 km landwards from the trench and runs perpendicular to it. It is 190 km long and was recorded by 12 OBHs. Both wide-angle seismic profiles have been combined with coincident MCS and gravity data to further constraint the inverted models.

For the travel-time inversion we followed a top-to-bottom layer stripping strategy aimed to determine the position of a single reflector and the velocity distribution above it. This process allows us to keep velocity contrasts across sharp geological interfaces. Subsequently, a Monte Carlo-based mean deviation analysis was performed to estimate the uncertainty of the model parameters.

The velocity model shows three different areas in the overriding plate: the sedimentary cover on top of the basement which is in turn divided into western and eastern bodies. Upper continental mantle velocities are found at ~10 km below a >5 km thick sedimentary basin, which indicates the presence of very thin (5-6 km) crust that thickens to ~20 km toward the trench. The mantle wedge shows relatively low seismic velocity (7.0-7.5 km/s) and density, indicating a high degree of serpentinization. Under the lower slope, there is a low velocity zone (less than 6 km/s at the base) that is also observed at the crossing point of the perpendicular profile. The interplate reflector fits well with that of coincident MCS data, except for a segment under the low velocity zone, where the misfit is up to 1s. The same misfit is also observed along the whole perpendicular profile. The presence of a low velocity zone benath the middle slope is a relatively common feature that has been observed in different convergent settings. We show here that the misfit between MCS and WAS reflectors can be easily explained by a ~15 % seismic velocity anisotropy in the upper plate. Both the presence of low velocities and the velocity anisotropy strongly suggest that this is a segment of the upper plate where the frame rock is highly fractured allowing fluids to easily escape from the subduction channel and/or the incoming plate.

Eventually, the velocity model helps to understand the geological structures involved in the 1992 slow earthquake. The hypocentre seems to be located close to the limit between crust and mantle wedge of the overriding plate. This limit can be approximately defined in our model by a sharp velocity gradient from 6 km/s to 7 km/s separating crustal basaltic rocks from the serpentinized mantle wedge. Furthermore, a number of aftershocks occurred in the serpentinized mantle wedge. Consequently, we speculate that the rupture of the main shock may have extended along the interface between subducting slab and mantle wedge. The frictional properties of serpentinized material might then explain the slow character of the earthquake.