Subduction channel, inherited crustal structures and the 1958 (Mw 7.7) Ecuador subduction earthquake

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In Northern Ecuador, seismological studies showed that the seaward limit of the rupture zone of the1958 subduction earthquake ceased ∼25 km landward of the trench. A multichannel seismic reflection (MCS) line was interpreted to show that a splay fault provided a seaward boundary to rupture during the 1958 event. Reprocessing of the line through Prestack Depth Migration using MCS and OBS data show variable sediment input to the subduction channel (SC), complex structures in the SC, and intra-margin physical heterogeneities that support the splay fault and reveal a major fossil strike-slip fault system. These features help understanding the seismogenesis at oceanic, non-accretionary margins. (1) Sediment input to the SC consists of a 3-km-thick, trench fill overlaying a 1-1.5 km–thick graben-fill, whereas beneath the deformation front, the SC thins to less than 0.5 km due to subduction of a 2.5-km-high, buried seamount. Landward, the SC velocity increases from 3.0 to 4. 8 km/s and its thickness decreases irregularly from 1.5 to ∼ 0.3 km between 6 and 15-km-depths, where its seismic structure shows evidence for tectonic shearing. (2) The splay fault zone, ∼ 30 km east of the trench, is characterized by two major high-amplitude, landward-dipping reflectors that cut through the basement and sole out onto the SC at depths of 10 and 12 km. These reflectors sharply separate margin rock bodies with contrasting velocities revealing a landward-dipping low velocity zone (4.0-4.5 km/s) squeezed between seaward rocks with velocities of 5.0-5.5 km/s and landward rocks with velocities of 6.0 km/s. The splay fault zone correlates with an upward bulging of the basement and seafloor, and with a summit graben, thus supporting active shallow extension associated with deep-seated compression. (3) The fossil strike-slip fault system, located ∼ 55 km landward of the trench, is sealed by neogene fore-arc basin deposits. This fault system is characterized by a basement-involved flower structure showing upward diverging, reverse-separation faults that juxtaposed rocks of contrasting reflectivity. The strike-slip fault, which links at a ∼10 km-depth with low-angle landward-dipping faults, does not show direct connection with the plate interface. The splay fault and strike-fault zones are tentatively interpreted as inherited structures resulting from reactivation of pre-existing seaward-verging, listric, normal faults. These faults were established during a period of extension that affected the Gorgona terrane prior to its oblique docking at the north Andean margin. The strike-slip fault zone is not reactivated in the present-day stress field, whereas the splay fault zone is involved in active deformation, possibly during great subduction earthquakes.