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Constraints on the plate interface at the Alaska-Aleutian subduction zone from MCS and OBS data of the ALEUT Project

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In summer 2011, the Alaska Langseth Experiment to Understand the megaThrust (ALEUT) program acquired deep penetration multichannel seismic (MCS) reflection and ocean bottom seismometer (OBS) data along a part of the Aleutian-Alaska subduction zone that exhibits the full spectrum of coupling, from locked to freely slipping. The aim of this program is to characterize variations in the geometry and properties of the plate interface and relate them to downdip and along-strike changes in slip behavior and seismogenesis. Our study encompassed 1) the freely slipping Shumagin Gap; 2) the locked Semidi segment, which last ruptured in 1938, and 3) the locked western Kodiak asperity, the western extent of the 1964 M9.2 rupture. We acquired 3700 km of MCS data with the R/V Langseth along a series of strike and dip profiles that span the entire locked zone on the megathrust, its updip and downdip transitions to stable sliding and bending of the downgoing plate. MCS Data were acquired with a 6600 cu.in. airgun array and two 8-km-long streamers. Refraction data were acquired using the same source and short period OBS spaced at ∼15 km along two ∼400-km profiles coincident with MCS data across the Shumagin Gap and Semidi segment.

Here we present results from MCS and OBS data regarding the plate interface reflectivity, geometry and dimensions as well as the structure and hydration of the downgoing plate. MCS data from all the dip profiles reveal reflections from the interplate interface from the trench, at ∼7-8 s twtt or 5.5-6.0 km depth, to 120 km landward of the trench, at 10-12s twtt or 30-40 km depth, with high variation in its reflection response with depth. The downdip transition from the potentially locked region to stable sliding seems to be marked by a change in the plate interface reflection signature itself from a single reflection at shallower depth to a wide zone of reflectivity of up to a few seconds twtt at greater depth. Accretionary prism structure varies along strike but is quite narrow (∼ 15-25 km) on all the profiles suggesting an erosive character of the margin before it became an accretionary margin. Above, or seaward of the transition from coupling to stable sliding, the decollement is not characterized by a continuous single reflection but rather consists of several strong reflection sections, especially within the Shumagin gap. Other reflections in the overriding plate appear to delineate one or more large faults are observed 75 km back from the trench and appear to connect to the plate interface within this gap at ∼11 s twtt. These faults are associated with a large basin and appear to have accommodated primarily normal motion, although folding of sediments near the fault and complicated fault geometries in the shallow section may indicate that this fault has accommodate other types of motion during its history.Seaward of the trench, MCS data exhibit significant along-strike variations in the structure of the downgoing plate. Pronounced bending faulting, thin sediments (∼0.5 km), rougher basement topography and clear Moho reflections are observed in oceanic lithosphere subducting in the weakly coupled Shumagin Gap, while less bending-related deformation and Moho reflectivity and thicker sediment thickness (∼1.25 km) is associated with the subducting plate in the Semidi segment. The change in sediment thickness appears to be related to changes in the thickness of sediment being carried into the subduction zone near the plate boundary and in the style of deformation of the accretionary prism. These structural variations between the Shumagin gap and Semidi segment are accompanied by differences in the velocity structure of the downgoing plate based on OBS data. Reduced mantle velocities and altered crustal velocities in the oceanic plate are observed in the Shumagin Gap as it bends and subducts possibly due to hydration. Preliminary analysis suggests more modest decreases in mantle velocities in the Semidi segment, where less bending related faulting is observed. These along-strike variations in the structure of the downgoing plate can impact the conditions at the megathrust and the delivery of water and other volatiles to the seismogenic zone and to deeper levels of the subduction zone, where they may influence arc magmatism and intermediate depth seismicity.