Deciphering the mechanics of an imaged fault system in the over-riding plate at the Shumagin Seismic Gap, Alaska subduction zone using MCS waveform tomography

Details

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Abstract

The 2011 ALEUT program acquired 3500 km of multichannel seismic (MCS) data along a part of the western Alaska subduction zone, from the freely slipping Shumagin Seismic Gap to the locked regions in the Semidi segment and the western Kodiak asperity. The MCS profiles were acquired on the R/V Langseth using two 8-km-long streamers and span the entire locked zone on the megathrust, including the updip and downdip transitions to stable sliding. The primary goal was to characterize variations in the geometry and properties of the megathrust and the downgoing plate and relate them to downdip and along-strike changes in slip behavior and seismogenesis. The images capture the targeted megathrust reflectivity and its spatial variation. Notably, the two westernmost profiles show reflections arising from a major fault in the overriding plate within the Shumagin Seismic Gap located

75 km from the trench, which can be followed from the seafloor to the megathrust. The imaged normal fault bounds the seaward end of the Sanak forearc Cenozoic basin, formed after the Early Eocene reorganization of the Alaska subduction zone. The new reflection images also show that the seaward pair of the previously interpreted growth faults, thought to indicate deposition contemporaneous with basin subsidence, is a part of the imaged fault system. The unexpected imaging of this major fault system in the over-riding plate raises important questions: Has this fault been active during the most recent nearby megathrust earthquakes, such as the 1946 and 1948 earthquakes? Was the Sanak basin formed as a result of slip on the imaged normal fault system or is it a result of growth faulting that predates the formation of this fault? The timing and style of deformation on this fault has significant implications for both coupling on the megathrust seaward and landward of where the normal fault roots and tsunamigenesis. To complement constraints on the geometry and reflection characteristics of this structure from MCS [Bécel et al., this session] we have applied full waveform tomography to the prestack MCS data with the goal to form high-resolution velocity profiles for the shallow sections of the normal fault. The starting velocity model for waveform inversion was formed by traveltime tomography on picked refracted arrivals found at offsets from ~5-8 km. The preliminary, phase-only results along one profile show velocities reducing laterally across the shallow end of the normal fault by 200 m/s (from 2200 to 2000 m/s). We interpret this reduction in velocities to indicate that the fault system is active and that fluid flow may be involved. Some authors suggest that low or zero friction is a required mechanical condition to allow slip on such a normal fault system [McKenzie and Jackson, 2012]. Consequently, the obtained results could prove important to re-assessing both the tsunami risk and the plate interface coupling in the Shumagin Seismic Gap area.

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