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Characterization of geometry, properties and coupling of the Alaska subduction zone by means of reflection images and traveltime tomography

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In 2011, the Alaska Langseth Experiment to Understand the megaThrust (ALEUT) program acquired a total length of ∼3700 km of deep penetrating multi-channel seismic (MCS) reflection lines as well as two coincident 350 km-long profiles of wide-angle ocean bottom seismometer (OBS) refraction data south west of Kodiak Island in the Gulf of Alaska. The investigated region of the Alaska Subduction Zone encompasses segments that have ruptured in megathrust earthquakes in the past, and segments, that are suspected to be less coupled, and therefore have a lower probability for great earthquakes to occur. Kodiak asperity ruptured during the Good Friday earthquake of 1964 (M9.2), Semidi Segment ruptured last time in a great earthquake in 1938 (M8.3), and Shumagin Gap has not been ruptured by a major earthquake for at least 150 years and is considered to slip freely. The coupling degree of imaged section of the plate interface appears to at places vary strongly over a remarkably short distance of just tens of kilometers. We present new seismic reflection images that resulted from analyzing profiles crossing the northeastern half of the study area, from the middle of the Semidi Segment to the southwestern tip of the Kodiak Asperity. We also discuss the methodology used to analyze the collected controlled source seismic data and the results obtained. Processing steps for MCS data include amplitude compensation for spherical spreading, noise removal with the LIFT method, surface consistent amplitude balancing, multiple attenuation with both SRME method and radon transformation, predictive deconvolution and Kirchhoff time migration. The formed reflection images complete the picture on the subducting plate geometry in the study area as a whole and allow us to make an attempt to estimate both the downdip limit of the seismogenic zone and the lateral variations in subduction coupling by means of evaluating the seismic reflection signature of the interplate interface. Reflection images across the Pacific Plate approaching the trench provide means to estimate the extent of faulting and hydration on this subducting plate and relate this formation to the historical intraslab seismicity in the region. To constrain the geometry and depth of the subduction interface, as well as rock properties, a smooth tomographic trench-normal 2D velocity model is derived from OBS refraction data. Because this profile is the southward continuation of the 1994 Aleutian Seismic Experiment OBS profile (BA3) that runs from Bristol Bay to just north of the Alaska Peninsula, we show a combined ca. 1000 km long tomographic image (with a gap across the Alaska Peninsula) showing oceanic-continental plate subduction.