Seismic Constraints on the Structure of Alaska: A Review

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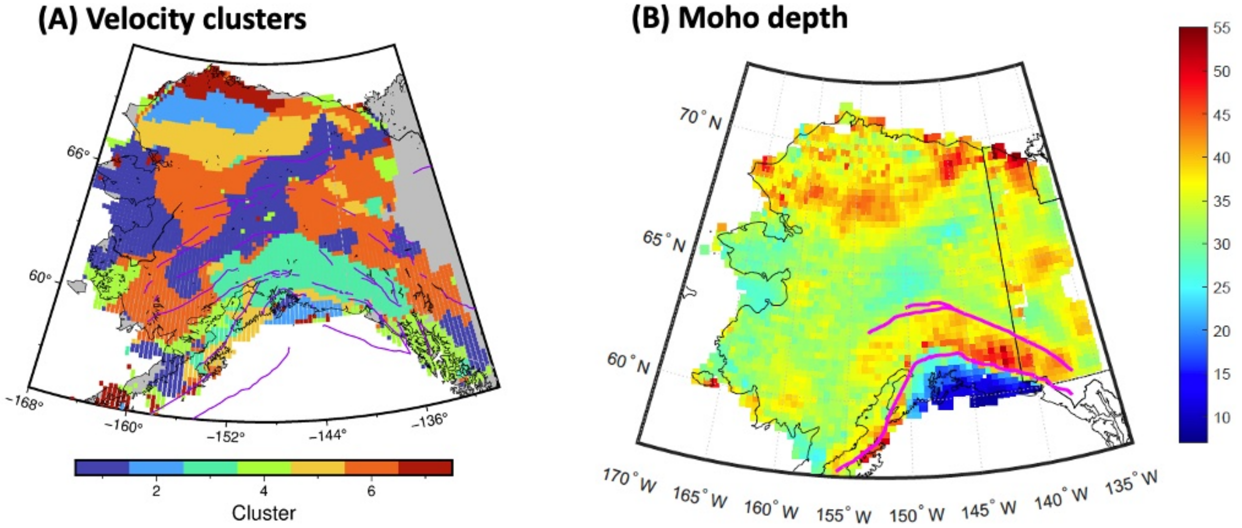
Significant advances in seismic imaging of Alaska have been made with the recent seismic deployments of the USArray Transportable Array (TA) and several Flexible Arrays. In this study, we assembled available seismic velocity models centered on the TA deployment area and analyzed their collective information about the structure of the subducting upper (North American) lithospheres. Differences in-depth resolution of different imaging methods led us to separately consider velocity models in two groups: (1) velocity models constrained by body waves that are parameterized by velocity permutations, and (2) models created with surface waves and/or ambient noise correlations that estimate absolute P and/or S velocity, with some in concert with converted wave information. Models in the first group provide estimates of velocity to a depth of 800 km while the second group models can only resolve structure to depths up to around 100-150 km. Our analysis and comparison are focused on two components: 1) structure of the continental lithosphere and 2) slab geometry and mantle velocity structure. Regarding the first component, we applied a series of complementary methods to appraise the implications of the existing data on crustal structure through clustering of velocity depth profiles and compilation of crustal thickness results. The velocity clustering analysis revealed the regionalization of structural domains from the southern accretionary boundary, through the interior of Alaska, to the Brooks range area. An analysis of both individual-station and areal upper plate crustal thickness measurements, which explicitly accounts for the subduction zone across southcentral Alaska, revealed regionalization of crustal thickness to the subduction zone region, the Wrangellia terrane, the interior, and beneath the Brooks Range. The regionalization is split into two forms north of the subduction zone region: 1) thicker (~40-55 km) crust beneath the Brooks Range and the Wrangellia terrane, and 2) thinner (~20-30 km) crust of the interior; the plate interface depth was used as the upper plate crustal thickness in the subduction zone region where the subducting crust is in contact with the upper crust. For the upper mantle structure associated with the subducting slabs, we developed a vote map from the body wave models that when used with 3D visualization provided a valuable tool for appraising the geometry of the subducting slab. A new discovery is that these TA-based models resolve long-standing questions about the geometry of the subducting Yakutat lithosphere, indicating a slab tear and a southward bending in the deep upper mantle.

(A) Velocity clusters

(B) Moho depth



(C) 3-D vote map

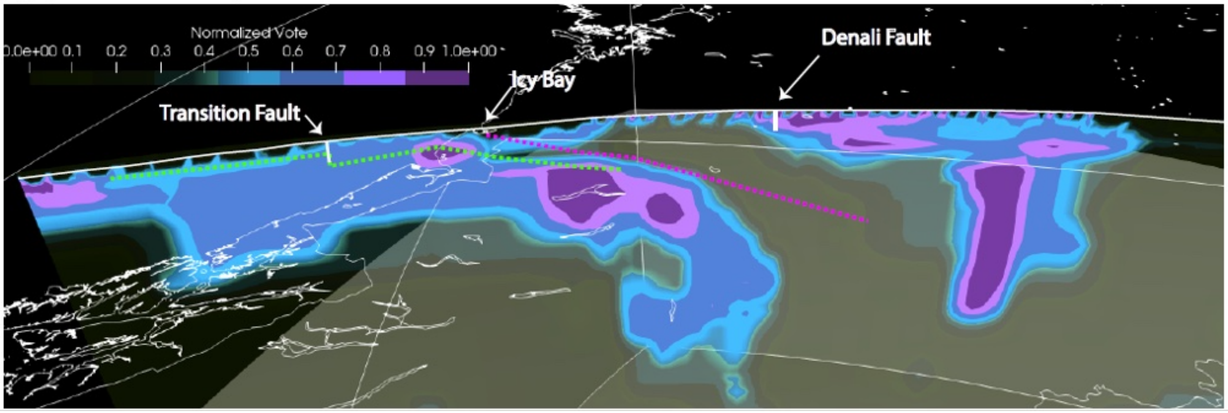


Figure 1. Examples of compiled seismic models, including (A) clustering of velocity depth profiles, (B) compilation of Moho depth models, and (C) vertical cross-section of the 3-D vote map of velocity perturbations. The colors in (A) label different velocity clusters using the velocity model by Berg et al. (2020), with the purple lines showing major faults. (B) shows the Moho depth of the overriding plate (north of the southern purple line) and the subducting plate (south of the southern purple line). Major structural features are labeled in (C) for reference. The cross-section runs from the southwest (left) to the northeast (right) viewing toward the northwest.