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The lowermost mantle beneath Bering Sea – Geodynamic and mineral physical implications from seismic data

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Seismic array data are used to study a region of approximately 90x35 degrees beneath the Bering Sea and Alaska. We use P and S wave reflections off the core-mantle-boundary (CMB) and D" reflector with source-receiver combinations spanning a distance range from 60 to 85 degrees. More than 100 earthquakes originating in the Japan, Kuril-Kamchatka or Izu-Bonin-Mariana trench are used. These events of magnitudes from 5.7 to 7.3 were recorded by several seismic networks and arrays in Canada and the United States, often at temporary stations of the Earthscope project (US-Array). Array methods such as vespagrams or slowness-backazimuth analysis are used to determine travel time differences, slowness and backazimuth of P, PdP and PcP. Comparing amplitudes, waveforms and polarities of processed data with synthetic seismograms, we aim to determine the thickness of the reflector and the impedance contrast between lower mantle and D" layer.

The western part of our studied region shows the clear existence of a sharp D" reflector with steep sides and a discontinuity width of about 90km. The central area lacks D" reflections, while further east weak signals of PdP are detected. In an area in which, according to tomography, there is a transition from a low velocity region to a high velocity region according to tomography, observed phases show contradictory results: both clear PdP signals and clear evidence for an absent PdP are repeatedly observed within the Fresnel zone. Strong topography variations within a short lateral range could cause such annihilated or weakened reflected signals due to interference. Nonetheless, the observed lateral variations in P reflector depths correlate with results of former S wave studies in this region, indicating a very heterogeneous lowermost mantle beneath the Bering Sea.

Different models exist to account for a strong topography of D" discontinuity with a varying thickness and topography:

- upwelling of warm material above the CMB resulting in solid-melt phase change,
- a transition from an upwelling to a downwelling producing a steep slope,
- accumulation of folded, old subducted MORB material, in combination with a phase transition from perovskite to post-perovskite within the chemically different material, or
- a chemically isolated region with different iron and aluminum content relative to the average mantle.

We aim to distinguish between these possibilities, using mineral physical and geodynamical modelling, respectively, to describe the sharpness of the discontinuity, the velocity contrast across it and the steepness of its lateral topography in terms of feasible temperature and chemical variations.

The combination of high data coverage and complex structural properties makes the D" beneath Alaska and Bering sea an interesting case study. It also suggests that D" is characterized by a multitude of features, which may be unique for different locations on Earth.

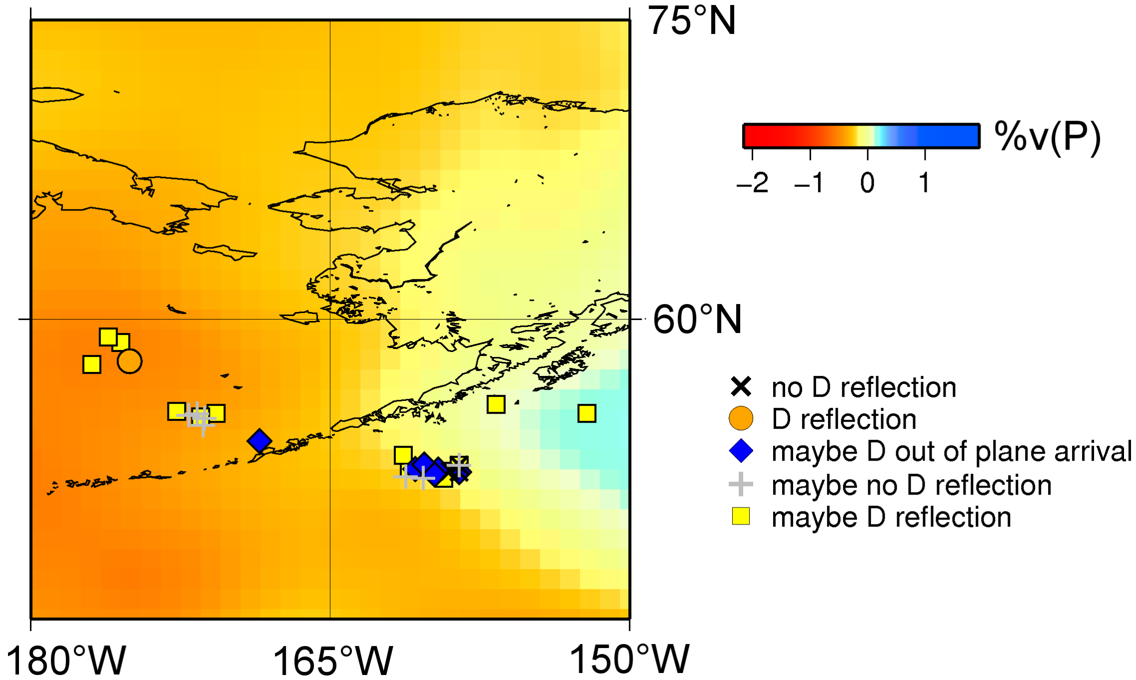

Figure 1: Contradictory data in transition from a low velocity region to a high velocity region in tomographic P wave model in D” beneath the Bering Sea and the Gulf of Alaska.