A Global Veneer of Subducted Materials along the Earth's Core-Mantle Boundary

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The absolute change in physical properties from the mantle to the core is greater than that between solid rock and air. As such, Earth's core-mantle boundary (CMB) is host to a variety of phenomena, including thin (5-50 km), enigmatic regions with strongly reduced seismic wave velocities (10-50%), dubbed ultra-low velocity zones (ULVZs). A wide range of ULVZ characteristics has been previously inferred, leading to many questions regarding their origin, and associated uncertainties are exacerbated by limited sampling since less than 20% of the CMB has been surveyed for ULVZ presence. Here we investigate the CMB beneath the previously unsampled southernmost hemisphere. This region is unique because it is far from the two large low velocity provinces (LLVPs) in the Earth's lower mantle as well as from areas of recent or current subduction. Using a new analysis approach based on historical earthquake data patterns, we show widespread and geographically variable ULVZ structure across the CMB south of 35°S latitude. Mantle convection simulations demonstrate the feasibility of distributed heterogeneities along the CMB from past subduction, consistent with our ULVZ observations. These results support a compositional component to ULVZs in our study region, as well as globally. Variable accumulation volume (and thus seismic detectability) due to a diversity in subduction and mantle flow histories across the planet, coupled with lateral temperature variations along the CMB, can explain a ubiquitous ULVZ possessing variable properties.

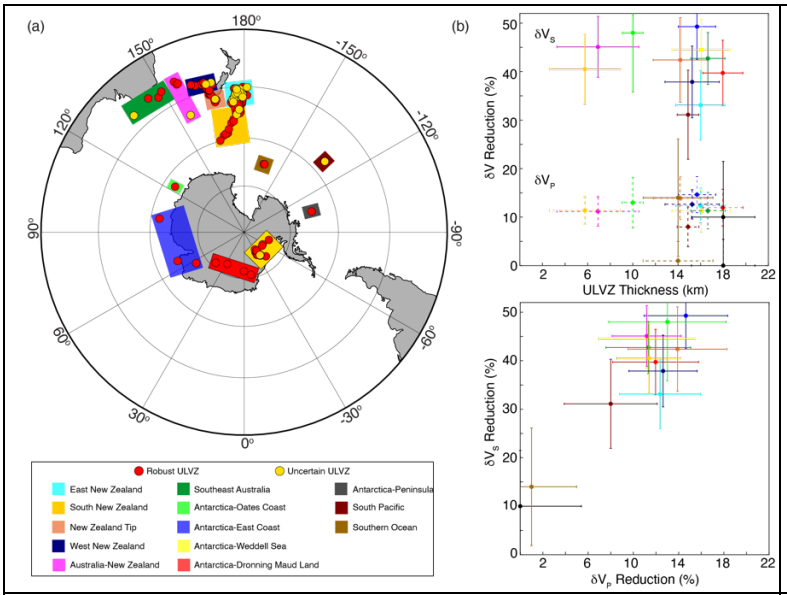

Figure 1. ULVZ results beneath the southernmost hemisphere. (a) Average PcP CMB bounce points for examined events. Red dots indicate events showing robust ULVZ evidence; yellow dots are those with uncertain evidence. Colored rectangles denote geographic families. (b) ULVZ parameters averaged by geographic family with corresponding standard deviations.

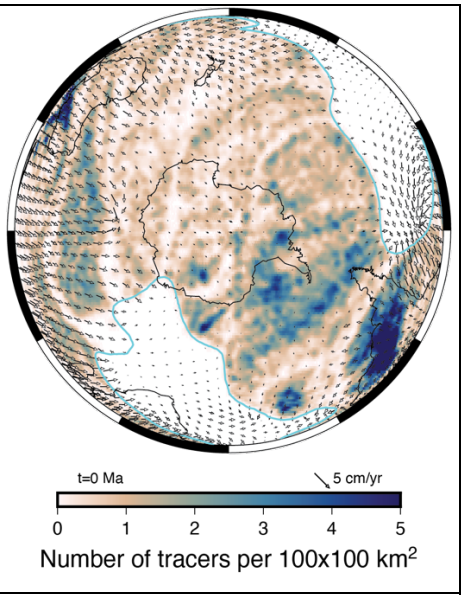

Figure 2. Distribution of subducted materials in the lowermost 300 km of the mantle, viewed from South Pole. Cyan lines mark the boundaries of thermochemical piles that simulate the LLVPs.