Seismic evidence for a 1000 km mantle discontinuity under the Pacific

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Seismic discontinuities in the mantle are indicators of its thermo-chemical state and offer clues to its dynamics. Ray-based seismic methods, though limited by the approximations made, have mapped mantle transition zone discontinuities in detail, but have yet to offer definitive conclusions on the presence and nature of mid-mantle discontinuities. We developed a wave-equation-based imaging method, reverse-time migration of precursors to surface-reflected seismic body waves, to uncover both mantle transition zone and mid-mantle discontinuities, and interpret their physical nature. Using USArray data, we observe a thinned mantle transition zone southeast of Hawaii, and a reduction in impedance contrast around 410 km depth in the same area, suggesting a hotter-than-average mantle in the region. We furthermore reveal a 4000–5000 km-wide reflector in new images of the mid mantle below the central Pacific, at 950–1050 km depth. This deep discontinuity exhibits strong topography and generates reflections with polarity opposite to those originating at the 660 km discontinuity, implying an impedance reversal near 1000 km. We link this mid-mantle discontinuity to the upper reaches of deflected mantle plumes upwelling in the region. Reverse-time migration full-waveform imaging is a powerful approach to imaging Earth's interior, capable of broadening our understanding of its structure and dynamics and shrinking modeling uncertainties.

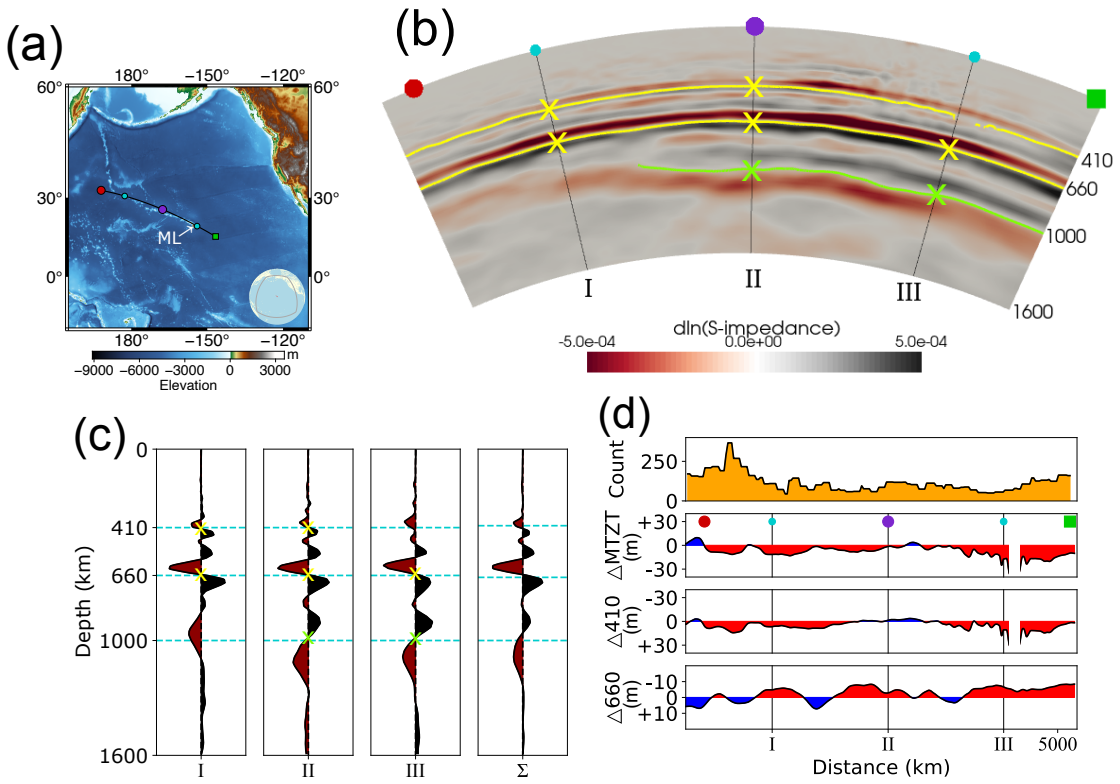

Figure 1: *Reverse-time migration image of mantle transition zone and mid-mantle discontinuities along the Hawaiian seamount chain. (a) Geographical situation. (b) Vertical slice through the imaged impedance contrasts. Traced 410, 660 and 100 km discontinuities are drawn in yellow. Three vertical profiles through this section are plotted in (c). Their stacked profile is in the last panel. (d) Topography of the mantle transition zone discontinuities. The first row shows bounce point counts along the Hawaiian seamount chain.* `http://doi.org/10.1038/s41467-023-37067-x`