Waveform modeling of the seismic response of a mid-ocean ridge axial melt sill

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Seismic reflections from axial magma lens (AML) are commonly observed along many mid-ocean ridges, and are thought to arise from the negative impedance contrast between a solid, high-speed lid and the underlying low-speed, molten or partially molten (mush) sill. The polarity of the AML reflection ($P_{AML}P$) at vertical incidence and the amplitude versus offset (AVO) behavior of the AML reflections (e.g., $P_{AML}P$ and S -converted $P_{AML}S$ waves) are often used as a diagnostic tool for the nature of the low-speed sill. Time-domain finite difference calculations for two-dimensional laterally homogeneous models show some scenarios make the interpretation of melt content from partial-offset stacks of P- and S-waves difficult. Laterally heterogeneous model calculations indicate diffractions from the edges of the finite-width AML reducing the amplitude of the AML reflections. Rough seafloor and/or a rough AML surface can also greatly reduce the amplitude of peg-leg multiples because of scattering and destructive interference. Mid-crustal seismic reflection events are observed in the three-dimensional multi-channel seismic dataset acquired over the RIDGE-2000 Integrated Study Site at East Pacific Rise (EPR, cruise MGL0812). Modeling indicates that the mid-crustal seismic reflection reflections are unlikely to arise from peg-leg multiples of the AML reflections, P-to-S converted phases, or scattering due to rough topography, but could probably arise from deeper multiple magma sills. Our results support the identification of Marjanovic et al. (2014) that a multi-level complex of melt lenses is present beneath the axis of the EPR.

Keywords: East Pacific Rise, Axial melt lens, Waveform modeling, Mid-crustal seismic reflection event, Multiple-sill model