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Structure of the ultraslow-spreading Southwest Indian Ridge at 64°30’E from coincident multichannel and wide-angle seismic data

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Ultraslow-spreading oceanic ridges (<20 mm/yr) constitute about 35% of the global ridge system and yet the lithospheric structure that accretes at these spreading rates is little understood. At these ridges, the interplay between plate- and mantle-driven processes produces complex relationships between intermittent volcanic seafloor and extensive non-volcanic seafloor domains, with a subsurface structure that differs significantly from the traditional 3-layer crust topping the uppermost mantle that forms at faster-spreading rates. We present new constraints on the velocity and reflectivity structure of the oceanic lithosphere at the ultraslow-spreading Southwest Indian Ridge (SWIR) at 64°30’E. The eastern SWIR has a full-spreading rate of <14 mm/yr and represents a magma-poor endmember. In this area, broad serpentinized mantle domains are exposed with little interference of igneous rocks that can make their identification and geophysical characterization challenging. We use coincident wide-angle ocean bottom seismometer (OBS) and multichannel seismic (MCS) data collected during the SISMOSMOOTH 2014 survey along two long (~150 km) orthogonal profiles, one along the ridge valley (EW direction) and one across it (NS direction). We first run traveltime tomography using picks of first arrivals recorded by 16 OBS placed on the NS profile and 16 OBS on the EW profile. The computed models show that seismic velocities increase rapidly with depth, changing from 3.5-4 km/s at the seafloor to 7 km/s at 2-5 km and that the vertical gradient reduces for velocities greater than 7 km/s. We suggest that the changes in velocity with depth are related to changes in the degree of serpentinization and interpret the subsurface structure to be composed of highly fractured and fully serpentinized peridotites at the top with a gradual decrease in pore space and serpentinization to unaltered peridotites at depth. The NS velocity model shows greater lateral velocity variations than the EW profile, which indicates a more complex structure for the former. Next we perform MCS data analysis to produce reflection sections for the two profiles. Time-migrated sections are converted to depth using the velocities derived from the tomographic models. We observe steep south-dipping reflections around the highest topographic feature on the NS profile, coincident with a sharp lateral change in the velocities and a high vertical gradient in the velocity model, which we interpret as the seismic expression of an active axial detachment fault. Clear Moho arrivals are not identified either in the OBS or the MCS record sections, consistent with our interpretation of the subsurface being composed of a gradual transition from serpentinized peridotites to fresh mantle peridotites.