Evolution of the lithosphere in the Indian Ocean from combined earthquake and ambient noise tomography

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Rayleigh wave dispersion extracted from ambient seismic noise has been widely used to image crustal and uppermost mantle structure. Applications of this approach in continental settings are abundant, but there have been relatively few studies within ocean basins. By cross-correlating ambient noise recorded at broadband seismic stations around the Indian Ocean, we demonstrate the feasibility of extracting high-quality, long-period (10–30 mHz) Rayleigh waves that traverse the entire ocean basin. High-quality Rayleigh wave cross-correlation functions can be obtained from stacking waveforms over less than 2 years at land stations and less than 4 years at island stations. We show that adding the dispersion information extracted from ambient noise to a global earthquake data set can improve the resolution of phase velocity maps by about 20% in the northern Indian Ocean, where the station distribution is the best. We find that a plate cooling model with a potential temperature of 1450˚C and plate thickness of 125 km can fit both the seismic observations and seafloor topography. The Seychelles-Mascarene Plateau is characterized by anomalously slow velocity at 30 mHz. The inclusion of ambient noise data in the tomographic inversion shifts the slow velocity anomaly into better agreement with the topographic relief, allowing us to estimate its crustal thickness and confirm that the plateau's elevation is supported by thick crust. The 10 and 20 mHz phase velocity maps show a strong asymmetry across the Central Indian Ridge that is best explained by eastward asthenospheric flow emanating from nearby hot spots.

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