An Ocean-Bottom View of Mantle Convection Beneath the Pacific Basin

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The Pacific basin provides an outstanding natural laboratory for studying a wide range of tectonic and upper-mantle dynamic processes, including seafloor spreading, hotspots and other midplate melting and volcanism, and multiscale thermal convection. Historically, direct geophysical constraints on these processes were limited to lowresolution, long-wavelength imaging due to the restriction of most geophysical instrumentation on the surrounding continents and isolated islands. Here we present emerging results from the Pacific ORCA (OBS Research on Convecting Asthenosphere) project, consisting of two year-long seismic arrays deployed on relatively young (~40 Ma) and old (~100 Ma) seafloor in the central and south Pacific. ORCA is designed to image upper-mantle seismic wavespeeds in two regions where satellite-derived gravity variations display linear structures suggestive of small-scale convection in the upper mantle. At YoungORCA, body-wave tomography captures linear blobs of fast and slow material in the mantle beneath the oceanic plate, parallel to the gravity features. We interpret these as cold sinking and warmer rising material, revealing a highly dynamic convective system underneath the plate. Surface-wave constraints on absolute shear velocity and attenuation suggest that the asthenosphere in this region may be anomalously slow and weak, enhancing the likelihood of small-scale convection. Seismic anisotropy in both regions deviates from the canonical predictions of seafloorspreading fabric in the lithosphere and absolute plate motion in the asthenosphere, suggesting that smaller-scale dynamics are active over a variety of length scales in both ridge and mid-plate environments. By combining these findings with previous and emerging results from US and international partners in the grass-roots PacificArray initiative, we are gaining an improved understanding of the processes controlling the formation, modification, and evolution of the ocean plates and the underlying convection system.

