Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)
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SIT040-17 Room: 101 Time: May 27 10:00-10:15

Origin of the South Pacific Superswell constrained by tomographic models

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The South Pacific region is a unique area, characterized by numerous geophysical anomalies: a) a long wavelength (several thousands km) positive depth anomaly, qualifying this region as Superswell; b) a depression in the geoid for spherical harmonic degrees 7 through 12; c) slow seismic velocities in the mantle below and d) a high concentration of volcanism. All these anomalies may be explained by the buoyant uplift of a large plume (several hundreds km wide), called 'Superplume', although the dynamics of its uplift and the characteristics of the mantle involved in this process are not well constrained yet. Recently, the precision of the tomography models describing this region has been significantly improved, owing to long-term broadband seismic observations on islands and on the deep seafloor in the French Polynesia region, thus providing an accurate image of the mantle beneath the South Pacific. We use these tomography models to conduct geodynamic modeling of the Superplume. We convert the seismic velocity anomalies into density anomalies. We then compute the instantaneous mantle flow driven by the density anomalies by solving the conservation equations of mass and momentum in regional three-dimensional spherical shell geometry. The result indicates that the shorter-wavelength dynamic topography is supported largely by upper mantle flow towards hotspots, and that the longer-wavelength dynamic topography is supported in large part by upwelling of a gigantic anomalous body in the lower mantle, with its top at depths around 1000 km. As our model allows depth and lateral viscosity variations, we also present the mantle rheology which best reproduces the surface observations.

Keywords: mantle dynamics, tomography models, mantle rheology, South Pacific, mantle plumes/ superplumes