Future geophysical observation on oceanic lithosphere and asthenosphere study: Hawaii-Emperor Bend (HEB) Project

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We introduce a future geophysical observation project planned under collaboration between Japan and Germany, which can be regarded as one of the regional arrays of the Pacific Array Initiative (http://eri-ndc.eri.u-tokyo.ac.jp/PacificArray/). This project aims to constrain the viscosity of oceanic asthenosphere through passive electromagnetic (EM) and seismological observations on the seafloor, based on a unique view point focusing on the geometry of the Hawaii-Emperor Bend and plume-plate interaction.
For the plume-plate interaction, once the plume material, which can be hotter and richer in volatile composition than the ambient mantle, reaches below the lithosphere, it can reheat the base of the lithosphere and the plume material itself can spread laterally mainly in the direction of the overlying plate motion dragged by the lithosphere. We can suppose two extreme scenarios about the fate of the plume material. If the mechanical coupling between the lithosphere and plume material is enough strong, i.e, the viscosity contrast between them is relatively small, the plume material (and ambient asthenospheric mantle material) would move laterally with a similar speed as the overlying lithosphere. While if the coupling is weak (the viscosity contrast is large), the asthenosphere moves slower than the lithosphere and hence the plume material would be left behind the lithosphere. If this is the case for the Emperor chain, because it is oblique to the current plate motion, the plume material is expected to locate in the east of the Emperor Chain, at a distance depending of the coupling between the lithosphere and asthenosphere.
The ocean bottom EM and seismological observations have succeeded to image the upper mantle structure around the hotspots in terms of electrical conductivity structure and seismic velocity structures. Both properties and viscosity in the mantle are dependent on the temperature, volatile composition, and partial melt if it exists, but in different ways. The plume material is thought to be hotter and richer in the volatile composition than the ambient mantle, and therefore, it is expected that the plume material can be imaged as high conductivity and low velocity anomalies. This study can provide more direct evidence to distinguish the scenarios mentioned above. Moreover, joint interpretation of the electrical conductivity and seismic velocity can give more quantitative discussion about the temperature, volatiles, and melts, and give suggestions about the viscosity of the asthenosphere with support of petrological and laboratory experiment, and geodynamic modeling studies.
We have carried out geodynamic simulations that reconstruct mantle flow in the central Pacific area since 100 Ma, including the Hawaii plume –a hot upwelling from deep in the mantle, the plate motion change at 47 Ma, and global mantle flow. The simulations show that a hot anomaly representing the plume material distributes in the asthenosphere beneath east of the Emperor chain and its horizontal location is dependent on the assumed viscosity profile (more east if the asthenosphere has a thin low-viscosity layer) as expected. The results encourage us to put the marine EM and seismological observations into practice. We further plan to conduct feasibility studies to examine how well the plume material can be resolved as the anomalies in electrical conductivity and seismic velocity from the observations.

Keywords: Hawaii-Emperor Bend, Oceanic lithosphere and asthenosphere, Plume and plate interaction, Marine electromagnetic and seismic observations