Magnetic dipole anomalies as tracers of mantle wedge serpentinization

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Recent geological surveys that have sampled both land and seafloor material report the existence of serpentinized material between the trenches and their volcanic front [e.g., Fryer et al., 1992]. This material is thought to come from the shallow mantle wedge as a diapir [e.g., Fryer and Fryer, 1987; Maekawa et al., 1993] because of its low density [Toft et al., 1990], the result of reactions with aqueous fluids supplied by the subducting slab [e.g., Tatsumi, 1989]. In some regions, these serpentine diapirs form a chain of small seamounts parallel to the trench [Fryer et al., 1992]. Since the serpentinization process accompanies magnetite production [O'Hanley, 1996], serpentine diapirs are expected to have a relatively high susceptibility [Toft et al., 1990; Nazarova, 1994]. This enables us to observe them as a series of magnetic dipole anomalies. Southwest Japan is an ideal area for these observations, because a fine-scale airborne magnetic data set is available [Geological Survey of Japan (GSJ), 1996] and no significant magnetic source other than the diapirs exists in the region of interest. By estimating the aspects of the magnetic source both through inversion and from paleomagnetic properties of field samples, we can discuss the tectonic framework of this region.

Results of magnetic inversion to several dipole anomalies, we can determine the magnetic source to be a spheroidal shape parallel to the tectonic zone of the central Shikoku and slightly inclined southward in three of five magnetic dipole areas. The source of them are magnetized roughly in the same direction as the current geomagnetic field. This implies that induced magnetization is the dominant component rather than remanent magnetization.

There are several examples of serpentine outcrops exposed as a large amount of volume. In the California Coast Ranges, the New Idria body is obviously diapir which has a pipe that has been traced 10 km below the main body associated with magnetic anomaly dipoles (Jachens et al., 1995; Coleman, 2000). At the Ocean-continent boundary, off the Iberian margin has other example of serpentine diapir emplaced west of the Galicia bank (Boillot et al., 1980). It seems to be devoid of magnetic anomalies, whereas the Cretaceous quiet zone close to the passive margin. Diapiric scenario may be the same as: the serpentinization resulted from hydrothermal processes have been associated with the accretion of the oceanic crust, then the serpentinites have initiated their diapiric ascent along fractures (Boillot et al., 1980). The reason why so small number of magnetic anomaly observed in this Iberian margin's and Izu-Bonin-Mariana forearc examples, that the surface alteration of serpentines to clay minerals occurred further than that of our Shikoku samples when the diapir was in contact with seawater.

During subduction, oceanic lithosphere, capped by variably hydrated uppermost mantle, oceanic crust, and sediments, undergoes progressive metamorphism and devolatilization. The mantle wedge serpentinization and serpentine diapir process might be a global phenomena. The California Coast Ranges and Shikoku are better geophysical sites to be found a tracer of a serpentine diapir than other marine margins.