Magnetization of the oceanic lithosphere around the outer-rise off the Japan Trench

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The oceanic lithosphere, born at a mid-ocean ridge, subducts at an oceanic trench, and is recycled in the deep earth. A study of the modification and alteration of the lithosphere beneath the seafloor is great significant to understand one aspect of the earth evolution. Marine magnetic anomaly lineation contains information of the structure and physical properties of crust and uppermost mantle when the lithosphere is created, and the subsequent alteration and modification, in addition to the plate tectonics and the paleo-geomagnetic field intensity variations. We examine magnetic anomaly around the outer-rise off the Japan Trench (38-41N). The seafloor has a series of parallel magnetic anomalies (Japanese Lineation Set) due to magnetization of the Cretaceous Pacific Plate (Chrons M11-M7 (135-127 Ma) in the study area (e.g. Nakanishi et al., 1989)). The anomalies are well lineated and have high-amplitudes of 500-1000 nT. Moreover a few large seamounts exist, thus the area is one of the best subduction zones toward above scientific objectives. The outer-rise is a swell of seafloor near an oceanic trench, where the oceanic plate begins to flex and is bent upwards by stresses. Normal faulting related to plate bending results in horst-graben structure. Thus, this study intends to examine whether the magnetic anomaly varies caused by such the tectonic phenomenon.

Because of limited areas of existent data in the seaward of the Japan Trench, we newly collected magnetic data aboard JAMSTEC R/V Kairei cruises conducted in 2003-2007. A magnetic anomaly map was made by compilation of our data, data published by Geological Survey of Japan (GSJ, 1996), and data from NGDC. Equivalent magnetization was calculated from the obtained magnetic anomaly. We used a three-dimensional inversion method of Parker and Huestis (1974). Uniform thickness of the magnetic source layer of 1 km, and constant direction of magnetization within the source layer are assumed. Upper surface of the magnetic source layer is assumed to be the surface of igneous oceanic crust. In the seaward slope, the surface is estimated by removing the sedimentary layer from the seafloor topography. The thickness of sedimentary layer is more or less 500 m indicated by ocean drillings and seismic reflection profiles. Meanwhile, the surface of the subducting oceanic crust in the landward of the trench is determined using seismic refraction and reflection profiles (Fujie et al., 2002; Ito et al., 2000; Miura et al., 2003; Nakanishi et al., 2001; Takahashi et al., 2004; Tsuru et al., 2000; Tsuru et al., 2003). Swath bathymetry was employed for the topography, and JTOPO30 were merged with the swath bathymetry to extend coverage to areas where no shipboard data were available. The inclination of magnetization in the source layer was assumed to be around 0 because the Pacific Plate was believed to be created near the equator (e.g. Larson and Chase, 1972). The ambient geomagnetic field are referred from IGRF.

Along-lineation variation of absolute values shows that magnetization in the seaward trench slope from the trench axis to a distance of ca. 70 km is lower than that in the further seaward seafloor. The location, where the low magnetization appears, corresponds to areas where the horst-graben structure is developed and large steps grow on the seafloor. This result would suggest that the lower magnetization relates to formation of the horst-graben structure associated with plate bending and normal faulting. The apparent decay in magnetization would reflect some kind of destruction and mechanical disorganization of the magnetic layer by faulting, resulting in progressive randomization of bulk remanent magnetization in the original layer configuration. The faulting may allow seawater to infiltrate deep into the crust and perhaps uppermost mantle. Otherwise, chemical demagnetization by low temperature hydrothermal circulation is possible for reducing the magnetization.