Secular Variations of the Geomagnetic Vector Field Revealed by Long-term Seafloor Observation in the Northwest Pacific

Hiroaki Toh[1]; Yozo Hamano[2]

[1] Dept Earth Science, Toyama Univ; [2] Dept. Earth & Planetary Physics, Univ. of Tokyo

http://www3.toyama-u.ac.jp/~toh

A SeaFloor ElectroMagnetic Station (Toh et al., 2004; SFEMS) in the Northwest Pacific has been operated for approximately four years to date. The SFEMS is now installed at a site called NWP whose acoustically determined coordinate is (41 05.9211 N, 159 56.9093 E, 5570m). It is situated on the seafloor as old as 124 Ma. The SFEMS yielded two-year long time-series up to now, which consists of the absolute geomagnetic total force, 3-component geomagnetic field and 2-component horizontal geoelectric field. In addition to the temporal electromagnetic variations, precise attitude data, viz., the instrument's orientation and horizontal two components of tilt were also recorded by a fiber optical gyro and a high-resolution tiltmeter.

The precise attitude data allowed us to resolve the smooth temporal changes of the Earth's main field, i.e., the geomagnetic secular variations, even for the seafloor vector field ranging from JUL/2002 through MAY/2003. It turned out that the increase of the absolute geomagnetic total force at NWP mainly stemmed from the increase of the vertical geomagnetic component at a rate of +28 nT/y. Comparison of the observed secular variations with those estimated by the Oersted satellite (Olsen, 2002) showed very good agreement, which implied that the incremental tendency of the vertical geomagnetic component can be reproduced by the westward drift of the equatorial dipole of internal origin. This was further confirmed by taking differences of the geomagnetic vector field between Kakioka Magnetic Observatory and NWP, assuming that the external secular variations, if any, are common at both sites.

It is well-known that the non-dipole components are small enough to be negligible compared with the dipole component in the Northwest Pacific. However, this does not necessarily mean that temporal variations of the non-dipole components are also negligible. In fact, the revealed secular variation for the vertical geomagnetic component was proved to be a sum of decrease of the axial dipole moment, increase of non-dipole contribution and the westward drift of the equatorial dipole. As for the secular variations of the tangential geomagnetic components, it turned out that the dipole and the non-dipole secular variations had opposite signs, namely, they tended to cancel out with each other, which resulted in relatively smaller observed secular variations of +5 nT/y and -5 nT/y for the northward and eastward geomagnetic components, respectively. This suggests that a significant eastward flow component is present on the core-mantle boundary beneath the Northwest Pacific.

To know precise distribution of the geomagnetic secular variations for the vector field is important in the sense that core surface flow models can be constructed from that information assuming the frozen flux nature for the geodynamo (e.g., Olsen and Holme, 2003). This implies that a combination of ground-based geomagnetic observation network including seafloor sites and satellite geomagnetic measurements of extremely high spatial resolution is indispensable in order to reveal dynamics in the Earth's outer core.