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Release Note for Long-term Seafloor Geomagnetic Data Observed in the West Philippine Basin

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Since June of 2006, long-term geomagnetic observation has been conducted at a site hereafter referred to as 'WPB' in the West Philippine Basin. The seafloor observation is based on the collaboration among Data Analysis Centre for Geomagnetism and Space Magnetism, Kyoto University and Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology. Almost continuous record of approximately 6 years has been obtained so far. The 1.7 years of the raw record up from June, 2009 through February, 2011 has been further processed/corrected to be ready for public release on and after June 1, 2014. The intent of this short note is to briefly outline the contents of the seafloor geomagnetic data.

Table 1 summarizes information of the seafloor site and the observed geomagnetic data.

Table 1 Outline of the seafloor site and data

Site Location: 19.324N, 135.110E, Depth=5700m (WGS84)
Site Code: WPB (West Philippine Basin)
Observation Period: June 7, 2009 - February 14, 2011 (UTC)
Sampling Interval: 1 minute
Reported Geomagnetic Components: XYZF
Resolution: 0.01nT
Absolute Precision for the Geomagnetic Total Force: 0.2 nT (Toh and Hamano, 1997)
Absolute Precision for the Geomagnetic Three Components: 1 nT for Z and 5 nT for X and Y
Data Format: IAGA2002
Magnetic Sensors Used: Fluxgate for vector measurements, Overhauser for scalar measurements

Figure 1 shows the site location of WPB. The precise position of WPB at the seafloor with respect to the world-standard geodetic system, WGS84, was determined by connecting the research vessel's GPS position with results of acoustic ranging conducted from the vessel at the time of installation/recovery of the seafloor instrument (SFEMS; Toh et al., 2004, 2006). The seafloor position was also confirmed by the acoustic navigation system of an ROV used for the pin-point delivery of the SFEMS to the desired position. Precision of the acoustic site determination is, therefore, around 10 m. The site code, 'WPB', was given to stand for 'West Philippine Basin'.

The seafloor site, WPB, is geoscientifically unique in the sense that:

(1) It locates around the centre of a local maximum of the geomagnetic secular variation due to the westward drift of the equatorial dipole (Toh et al., 2009).
(2) It locates on an old seafloor aged approximately 49 Ma (Salisbury et al., 2006).
(3) Stagnant slabs are present beneath WPB (Fukao et al., 2009).

The first feature will be useful for research on the Earth's core dynamics and structure of the D"-layer, while the second fact may be of use for study of evolution of the oceanic lithosphere. The last issue enables detection of electrical anomalies in the mantle transition zone using the geomagnetic data from WPB.

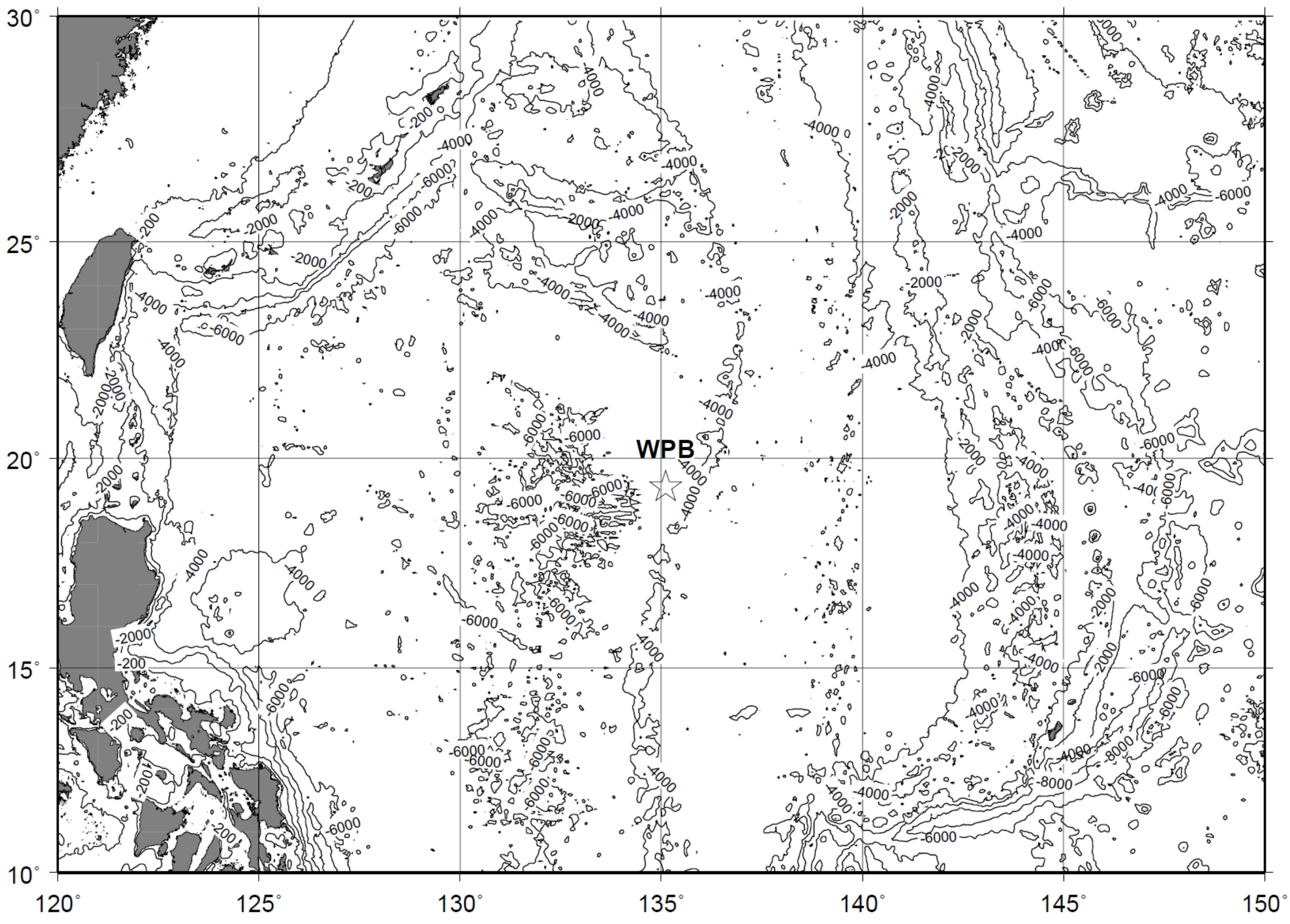
Time precision of the seafloor instrument is approximately 10^{-7} ppm, which has been further corrected using clock calibration data to yield one-minute values in UTC. The clock calibration was conducted before installation as well as after recovery by comparing the instrument's master clock with the research vessel's GPS clock.

The least count of the geomagnetic components is as small as 10 pT. However, the absolute precision of the geomagnetic total force is 0.2 nT (see Toh and Hamano, 1997) while that of the vertical component is 1 nT. As for the horizontal geomagnetic components, their absolute precision is as large as 5 nT. The difference in precision of vector field measurements stems from that of tilt and orientation measurements as described below.

The geomagnetic vector field was corrected for temporal variations of tilt. The instrument, 'SeaFloor ElectroMagnetic Station (SFEMS; Toh et al., 1998; Toh et al., 2006)', installed at WPB is capable of measuring temperature and two horizontal components of tilt and the geoelectric field, in addition to the 3-component geomagnetic field. Precision of temperature, tilt and the geoelectric field is 0.01 degrees, 3 arc seconds and approximately 60 nV/m, respectively. Temperature correction was not conducted, since both the temperature coefficient of the tilt meter used and the actual temperature variations (±0.05 deg within a year) were small. It is well-known that correction for attitude variation of vector magnetometers is essential not only to improve the absolute precision of the observed geomagnetic field but also to detect the geomagnetic secular variation. Because the tilt meter equipped with SFEMS is as precise as 3 arc seconds (Toh et al., 2006), the absolute precision of the corrected vertical geomagnetic component is as good as 1 nT or better in mid-latitudes where WPB is located. However, that of the horizontal geomagnetic components is still as large as 5 nT due to larger errors in the instrument's orientation at the seafloor. A small fibre optical gyro (FOG), originally developed for automated tunnel drillers, was equipped with SFEMS, whose standard error of mean was as large as 10 arc seconds. Furthermore, it turns out that the FOG generates magnetic noise and is power-consuming when activated, which prevents us from monitoring orientation variation continuously. We, therefore, ended up with intermittent orientation measurements at the seafloor once in three months. The final orientation error comes from discrepancy between the FOG's reference frame and the vector magnetometer's frame. This sums up to a total orientation precision of slightly better than 30 arc seconds. The large orientation error and lack in continuous orientation monitoring are the major factors that weaken the meaning of the observed horizontal components. Detailed discussion on the seafloor instrument, the correction method, the error estimation briefly outlined above is given in Toh et al. (1997, 1998 and 2006).

Figure 2 shows temporal variation of the vertical geomagnetic component observed at WPB for as long as 600 days. It is evident from the figure that the vertical geomagnetic component at WPB is presently increasing, which is in good agreement with prediction by global models such as IGRF. Further analysis has revealed that the observed geomagnetic secular variation for the vertical component can be explained by the westward drift of the equatorial dipole terms (g_1^1 and h_1^1) alone. It can be interpreted by a combination of the lack of contribution from the non-dipole geomagnetic field and the presence of a regional maximum of the geomagnetic secular variation due to the equatorial dipole around WPB.

The contents of the seafloor geomagnetic data have been outlined as above. It is finally noted that the gemagnetic data will also be open to public shortly via Japan Agency for Marine-Earth Science and Technology (http://www.jamstec.go.jp/j/database/).



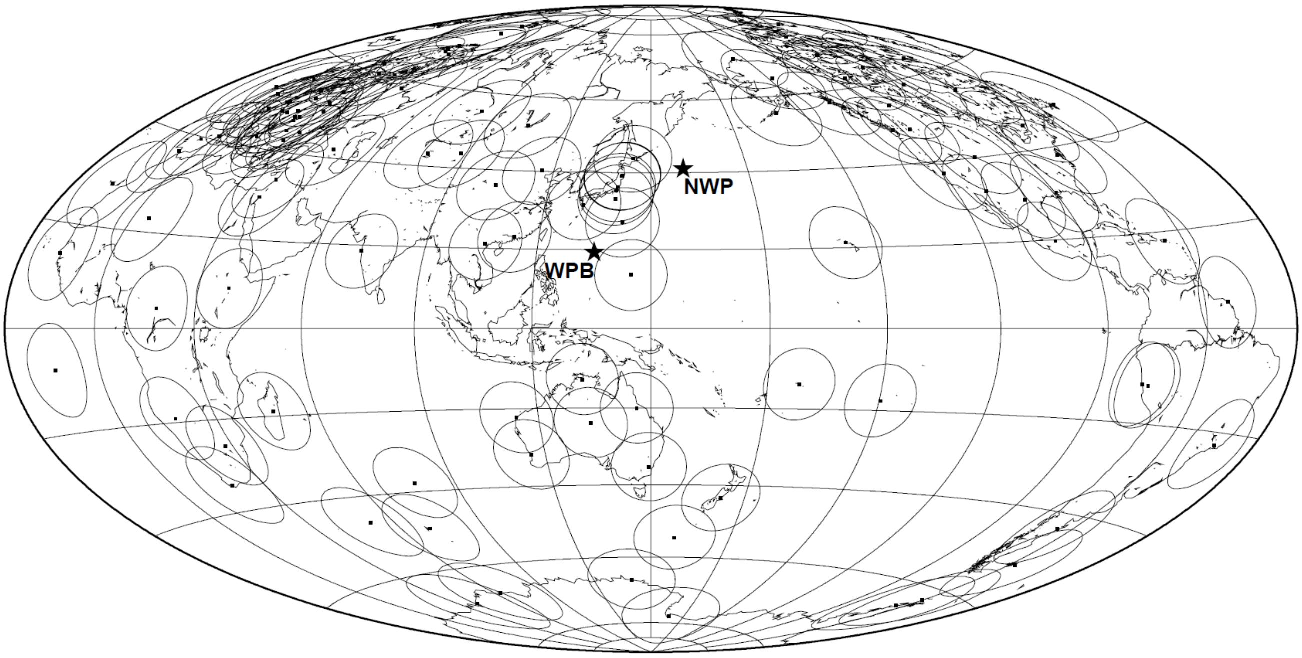


Fig. 1 (Top) Location of the seafloor site, WPB. It is on the West Philippine Basin as deep as 5,700 m and as old as approximately 49 Ma. (Bottom) WPB among the existing geomagnetic observatories on the globe. NWP is another seafloor geomagnetic observation site now being operated in the northwest Pacific.

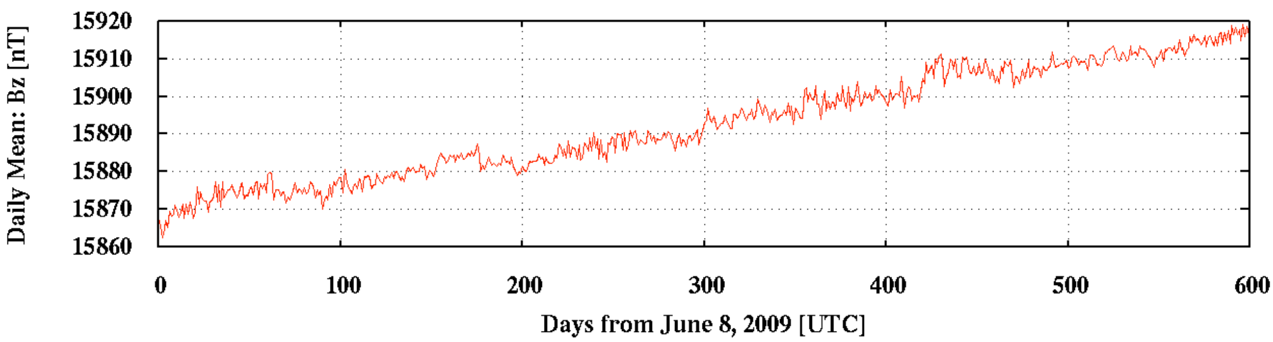


Fig. 2 Observed secular variation revealed in the vertical component of the geomagnetic field at WPB for as long as 600 days. It is evident that the geomagnetic vertical component is presently increasing in the northwest Pacific, and most of the increase can be explained by the westward drift of the equatorial dipole.

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