Advanced Analysis of Changes in the Geomagnetic Total Intensity Caused by The 2000 Eruption of Miyakejima Volcano

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In order to infer temperature changes and rock movements inside the volcano from variations of the geomagnetic total intensity at the surface of the volcano, it is necessary to eliminate nonvolcanic fluctuations such as secular variations and fluctuations of the ionospheric and magnetospheric origin. The simple difference method from the total intensity at a non-volcanic reference site is often used for this purpose. However, it is known that the secular variations are slightly different between the volcanic and reference sites and that the motional induction by surrounding oceanic currents generates geomagnetic variations when the observation site is on an island.

The geomagnetic total intensity has been measured in the Miyakejima island since 1980’s. Just before the 2000 eruption activity started, continuous observations at 7 sites on the island were maintained by Earthquake Research Institute, The University of Tokyo. Several continuous sites were added after the swarm earthquake on June 26, 2000. Sasai et al. (2001) computed the simple differences of the geomagnetic total intensities at Miyakejima island sites from Kakioka or Hachijojima and detected variations caused by the initial caldera collapse following the phreatic eruption on July 8, 2000 and volcanic activities in next two months.

In this study, we aim to precisely extract the volcanomagnetic variations from the total intensities at 7 sites on Miyakejima island for 7 months from January to July, 2000.

As the first step, the Kalman filter procedure (Fujii and Kanda, 2002) was applied to the total intensities at 7 sites to decompose the data into a component correlated with the variations at Kakioka, a periodic component, a trend and a residual. The trend component is used for further analyses. Outliers were removed and data gaps were tentatively filled, too. For comparison, the total intensities at Hachijojima and Kanozan where no volcanic activity was seen were processed with the same way as those at the Miyakejima sites. The trend at Kanozan which is nearest to Kakioka shows almost zero suggesting the removal of the magnetospheric/ionospheric variation and secular variation works. On the other hand, the trends at the 7 Miyakejima sites and Hachijojima show variations for the all time period suggesting existence of variations which are not seen at Kakioka.

As the second step, we compute the secular variation difference between Kakioka and Miyakejima by the main field model CHAOS (Olsen et al., 2009) giving a monotonically increase of the secular variation difference in January to July, 2000. Both the simple difference and the trend at the Miyakejima sites show similar variations suggesting the secular variations are remained after processing.

Finally, the principle component analysis (PCA) is applied to the trend at the Miyaejima sites, Hachijojima and Kanozan. The PCA is conducted to the data set with/ without the summit site at Oyama (OYM) because the site was largely affected by the caldera collapse and the amplitude of its trend is huge. Significant principle components at OYM during and after the initial caldera collapse were estimated by the comparison between the two sets of the PCA results.

The first three principle components are significant: the first one is the variation seen in Miyakejima and the others are in both Miyakejima and Hachijojima. The monotonic increase due to the remaining secular variation is not seen in the three significant components.

Comparison with Quick Bulletins of Ocean Conditions (Japan Coast Guard, 2000) indicates that the two significant principle components over Miyakejima and Hachijojima are related to the location of the current axis of Kuroshio. On the other hand, the first principle component seen only in Miyakejima starts to vary two days before the swarm earthquake and continues to increase/decrease since then. Variations from June 24 at the 7 sites were fitted by a magnetic moment and five magnetic moments were estimated every 7 days by the end of July. All of them locate inside the formed caldera in the summit area and grow with time. If the magnetization is assumed as 8.6 A/m, the estimated volume from the moment for June 24-30 is almost the same as that of the collapsed caldera on July 8.
Thus, we show a possibility to extract the volcanomagnetic variation precisely at a site on a small volcanic island such as Miyakejima which is far from geomagnetic observatories and is surrounded by the oceanic currents.

Keywords: The 2000 eruption of Miyakejima volcano, Geomagnetic Total Intensity , Demagnetization

