Repeat survey of magnetic total intensity on Heisei-Shinzan and cooling of lava dome

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By the eruption of Unzen Volcano from 1990 to 1995, a new lava dome named Heisei-Shinzan was formed. Several years after the eruption terminated, there were only some fumarole activities left near the spine on the summit area, and it is believed that the cooling of erupted magma is going on inside the lava dome. Magnetic observation is a powerful tool we can use to detect temperature changes in volcanic edifice, because rock magnetization is vanished in temperature above Curie point. In order to make the cooling process beneath the lava dome clear, we carried out a series of repeat survey of magnetic total intensity on Heisei-Shinzan.

Our 12 magnetic survey points on Heisei-Shinzan are located on the place with gentle slope near the summit. On each survey point, we measured magnetic total intensity at the height of 2.00m. To reduce the influences of geomagnetic daily variation, irregular disturbance and secular variation, observed intensities are represented in the relative value to the reference point near Nita Path. Such an intensity stands for the amplitude of magnetic anomaly at each survey point. In our survey, magnetic anomaly was up to the range of 1500nT. From this anomaly we can guess the magnetization of the lava dome and its magnetic structure.

Anomaly can be evaluated from topography if the earth is uniformly magnetized. We carried out calculation using Digital Elevation Map of GSI in 50m mesh and its interpolated values for necessary spacing. The topographical data about 4km around Heisei-Shinzan were used, and anomaly 10m above the surface was calculated. Anomaly at 10m high should be the smoothed one of anomaly at 2m, the height of our survey. In West Line, observed anomaly was well agreed with the anomaly calculated with topography, and they were also similar in East Line. However, at points in Center Line, the trends of anomaly are quite different with each other. This line goes through near the spine, and such a result can be made by an irregular magnetization structure beneath it. For an attempt, we assumed a non-magnetized prism in the lava dome. With the prism, the calculated anomaly is consistent with observed value not only in West Line and East Line but also in Center Line. The top of prism was assumed at the height of 1400m above sea level, and it almost reached the surface in the northern slope. This non-magnetic prism was thought to be in temperature above Curie point.

By repeat survey from December 1999 to December 2001, we knew the time variation of the magnetic total intensity at each point. Variations were not bigger than 20nT at many survey points, and there was no definite tendency of the trends depending on the point location. When lava dome becomes cool after eruption, magnetic total intensity is expected to increase in the southern part and to decrease in the northern part. Perhaps we cannot detect systematic variations if they are less than 20nT/year.

We estimated the magnetic change of total intensity on the surface caused by a part of the lava dome that gains the magnetization by cooling. For the case that the body was a cube of 50m (125,000 m3) and located at 1350m above sea level, it means the depth of the body was about 100m from the summit area of Heisei-Shinzan, we expected a variation above +40nT in the southern part, and about -15nT in the northern part. We can detect a variation of this amplitude with the accuracy of our repeat survey. The fact no clear systematic distribution of magnetic change was observed by the repeat survey means that the volume of body magnetized by cooling does not exceed 125,000 m3 for year.