Magnetization structure of Aogashima Island using vector magnetic anomalies obtained by a helicopter-borne magnetometer

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Abstract. On Aogashima Island, a volcanic island located in the southernmost part of the Izu Seven Islands Chain, vector magnetic anomalies were obtained in a helicopter-borne magnetic survey. The purpose of this study was to understand the volcanic structure of Aogashima Island in order to mitigate future disasters.

Commonly, to obtain the magnetic structure of a volcanic island, total intensity anomalies (TIA) have been used, even though they have intrinsic errors that have not been evaluated correctly.

Because the total intensity magnetic anomaly (TIA) is not a physical value, it does not satisfy Maxwell’s Equations, Laplace’s Equation, etc., and so TIA is not suitable for any physical analyses. In addition, it has been conventionally assumed that TIA is the same as the projected total intensity anomaly vector (PTA) for analyses of TIA. However, the effect of the intrinsic error (e₉ = TIA – PTA) on the analysis results has not been taken into account. To avoid such an effect, vector magnetic anomalies were measured so that a reliable analysis of Aogashima Island magnetization could be carried out.

In this study, we evaluated the error in TIA and used vector anomalies to avoid this erroneous effect, in the process obtaining reliable analysis results for 3D, vector magnetization distributions. An area of less than 1 A/m magnetization was found in the south-west part of Aogashima Island at the depth of 1–2 km. Taking the location of fumarolic activity into consideration, the lower-magnetization area was expected to be the source of that fumarolic activity of Aogashima Island.

Key words: Aogashima Island, helicopter-borne vector magnetometer, vector magnetic anomalies, vector magnetization.

Introduction

Magnetic surveys to obtain the geological structure of volcanoes have been widely carried out (e.g. Okuma et al., 1994; Makino et al., 1988). So far, 2D analyses have generally been carried out to understand the magnetic structure of a volcano. For a more detailed interpretation of the volcanic structure, a 3D analysis must be carried out.

Moreover, to detect the temperature distribution, a magnetization analysis is thought to be useful because magnetization intensity reflects temperature distribution well. However, there have been few case studies carried out so far in which detection of subsurface high temperature volumes using magnetic anomalies is reported (Uceda et al., 2008).

The best and only way to avoid the problem with the total intensity magnetic anomaly (TIA) due to the error, e₉ (discussed in the later Theoretical Background section), is to use the vector magnetic field instead of TIA. Vector magnetic surveys have been carried out since shipboard three-component magnetometers and deep-tow three-component magnetometers (DTCM) were developed (e.g. Yamamoto et al., 2005). Vector magnetic anomalies can provide information on many aspects of magnetization, for instance, the depth to top and dip angle of a 2D magnetization source (Nabighian, 1972), and the direction of magnetic anomaly lineations from only one profile (Isezaki, 1986). Kato et al. (2007) used these methods to study the vector anomaly lineations in the Japan Sea.

In this study, the following study targets are adopted:

(1) To estimate the intrinsic errors caused by analysis based on total magnetic anomalies.

(2) To perform a vector magnetic survey using a helicopter-borne magnetometer using the DTCM system.

(3) To perform an inversion analysis for a multilayered vector magnetization distribution.

As mentioned before, the vector field must be used instead of TIA, but it can also be said that the magnetic potential should be used instead of the vector field, to unify treatment of component fields. Moreover, Baranov (1957) proposed a new potential that he called the ‘pseudo-gravity’ potential, which is derived from the magnetic potential, and pointed out the advantages of using a potential field instead of a vector field for analysis of magnetization structure.

In this paper, we will show the magnetization structure obtained from vector magnetic anomaly fields observed in 3D space, which in turn will show important information found by overcoming the deficiency of TIA analysis.

Topography and geology of Aogashima

Aogashima Island is an active volcano at the southern edge of the Izu Islands Chain. It is located 360 km south of Tokyo. The island is in the shape of an ellipse with an area of 5.23 km², and the total length of the coastline is ~9 km. The most recent volcanic eruption occurred from 1780 to 1785, in the Edo period. Villagers had to be evacuated from Aogashima Island to neighbouring Hachijo Island for 50 years, because of the lack of space on Aogashima Island to shelter from the disaster. Even now, if a volcanic eruption should occur, the residents of Aogashima Island would have to be evacuated. Therefore, it is important
to have information that could predict a volcanic eruption, so that villagers could escape from the island.

**Topography**

Figure 1 shows the land and seabed topography around Aogashima Island. The base of the island is considered to be at 900–1200 m below sea level (bsl). Its major axis is in the north-west-south-east direction. The length of the major axis is ~20 km and the length of the minor axis (perpendicular to the major axis) is ~10 km. Aogashima Island is only exposed tip of the whole submarine mountain area. The highest point on the island is 423 m above sea level (asl) in the 1780s. The diameter of the Ikenosawa Caldera is ~1.5 km. Many previous studies of subsurface magnetization distribution have been conducted. In every case, the data used for analyses were $TIA$, defined as the difference between the intensity of the observed geomagnetic total field ($TF$) (boldface symbols represent vector quantities) and the intensity of the geomagnetic main field ($MF$):

$$TIA = |TF| - |MF|,$$

where $TF$ is the total-field vector, and $MF$ is the geomagnetic reference field vector. $MF$ is usually defined from an international geomagnetic main field model. Because $TIA$ is a scalar, without information on its direction, $TIA$ is not a harmonic potential field and does not satisfy Laplace’s Equation.

The geomagnetic anomaly vector $TA$ is defined by

$$TA = TF - MF,$$

It is clear that $TIA \neq |TA|$ except in the case that $TF$ is parallel to $MF$.

We can also define $PTA$ as the anomaly vector $TA$ projected on to $MF$. The magnitude of $PTA$ is defined by equation 3

$$PTA = |PTA| = TA \cdot t,$$

where $t$ is a unit vector in the direction of $MF$.

The error $\varepsilon_T$, the difference between $TIA$ and $PTA$ is,

$$\varepsilon_T = TIA - PTA$$

$$= 2 MF \sin^2(\beta/2) \quad \text{for} \quad TF > MF,$$

$$= 2 TF \sin^2(\beta/2) \quad \text{for} \quad TF > MF,$$
Fig. 2. A typical geological section of Aogashima Island (Tokyo Disaster Prevention Council, 1990). 1–6 are the time sequence numbers described in the text.

where the angle between TF and MF is \( \beta \) (see Figure 3). If \( \beta \) is sufficiently small, then \( \epsilon_T \) is also small (see equation 4) and TF is considered to be parallel to MF. Then TIA is almost the same as PTA. Under this condition, TIA can be regarded as the component of the magnetic anomaly field in the direction of MF. TIA has been treated in almost all analyses (upward continuation, reduction to the pole, etc.) as harmonic without any attention to the limiting condition (e.g. Hughes and Pandrom, 1947; Lourenco and Morrison, 1973).

Because PTA is one component of the geomagnetic potential field, PTA is harmonic and satisfies Laplace’s Equation while TIA does not. PTA can be defined using the scalar magnetic potential \( \nu \), thus:

\[
\mathbf{PTA} = \frac{\partial \nu}{\partial t}
\]

\[
\nabla^2 \mathbf{PTA} = \nabla^2 \left( \frac{\partial \nu}{\partial t} \right) = -\frac{\partial}{\partial t} \left( \nabla^2 \nu \right) = 0. \tag{5}
\]

As seen in Figures 3 and 4, \( \beta \) and \( \epsilon_T \) reach a maximum when TA is almost perpendicular to MF, where \( |\mathbf{TF}| \approx |\mathbf{MF}| \) (that is, \( |TIA| \approx 0 \)). In practice, there is no information about the geomagnetic anomaly vector TA in a total intensity field survey, so TA must be assumed for estimation of \( \epsilon_T \). If the magnitudes of MF and TA are assumed to be \( |\mathbf{MF}| = 50,000 \text{ nT} \) and \( |\mathbf{TA}| = 1000 \text{ nT} \), \( \epsilon_T \) is obtained from equation 4 at any \( \beta \). Figure 4 shows the relative error, defined by \( \epsilon_T/TIA \), for TIA from 1000 nT to –1000 nT. \( \epsilon_T \) changes from 0 at TIA = 1000 nT to the maximum (\( \approx TIA/|\mathbf{MF}| = 0.02 \)), where TA is almost perpendicular to MF and TIA = 0 nT. TF is produced by adding vector TA to vector MF as \( \beta \) changes from 0 (radian) to the maximum (\( \approx 0.02 \) radians). MF, TF, and TA are assumed to be always in the same plane, so that this model corresponds to a 2D case.

In the example in Figure 4, the relative error \( \epsilon_T/TIA \) is greater than 0.02 (2%) for \( |TIA| > 400 \text{ nT} \), which may mean that the result of magnetization analysis in which the magnetic anomaly fields are related linearly to magnetization will be affected by at most

Fig. 3. Geometrical expression for \( \epsilon_T \). MF, TF and TA are the vectors of the main geomagnetic field, the total geomagnetic field, and the geomagnetic anomaly field respectively. MF, TF and TA are in this plane. MF = AB, TF = AC, TA = BC. PTA = BD, PTA = BD TIA = BE, and \( \epsilon_T = \frac{BE}{AC} \). TA will rotate around the point B.

Fig. 4. Relation between TIA and \( \epsilon_T/TIA \) as TA rotates around the point B in Figure 3. While \( \alpha \) increases from 0° to around 90°, \( \beta \) changes from 0 to 0.02 radians, with TIA decreasing from 1000 to 0 nT. When TA rotates more (90° > \( \alpha \) > 180°) in the same plane, \( \beta \) changes from 0.02 to 0 radians as TIA decreases from 0 to –1000 nT. The two arrows indicate that \( \epsilon_T/TIA = \pm 0.02 \) corresponds to TIA = ±400 nT.
2% by using $|TIA| < 400 \text{nT}$ (5% for $|TIA| < 200 \text{nT}$). Though it is very difficult to know how the relative error $\varepsilon_T / |TIA|$ influences the analysis result, it is useful to see the inversion result for magnetization analysis for a 3D block model in Figure 5, which shows that $TIA$ does not provide a good inversion solution, whereas $PTA$ together with three-component anomalies can provide an almost-exact inversion solution. It is very clear from Figure 5 that it is difficult to estimate how much accuracy (or error) the solution obtained from an actual observed $TIA$ might have.

Moreover it is worth comparing the measurement error $\varepsilon$ for $TF$ and $TA$, due to the accuracy of the magnetometer system. It is especially significant if $\varepsilon_T$ greater than $\varepsilon$. To ensure that $\varepsilon_T = 1 \text{nT}$, $|TA|$ should be less than $\sim 300 \text{nT}$; from equation 4, for $|MF| = 50,000 \text{nT}$, $|TA| = 300 \text{nT}$, $b = 300 / 50,000$, and $\varepsilon_T = 1 \text{nT}$. If $TIA$ is generally larger than $300 \text{nT}$ in the target region.

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**Fig. 5.** Inversion results for three components of magnetization, using $PTA$, $TIA$ and three-component anomalies, for a simple block model. (a) Model; (b) Inversion result using $PTA$ as the observed data; (c) Inversion result using $TIA$ as the observed data; (d) Inversion result using three-component (3 C) anomalies as the observed data. The magnetization model was a flat plate made up of an aggregation by blocks. The thickness of the plate was $2000 \text{m}$; the length and width of each block was $500 \text{m}$. The total number of prismatic blocks was $162$ (18 north × 9 east), and as each block had three components of magnetization, then there were $486$ unknowns. Magnetic anomaly data on planes $200$, $350$, $450$, $500$, and $550 \text{m}$ above the surface of the plate were used. The total number of observed (calculated) data was $6377$. To calculate $TIA$ and $PTA$, the following parameters were assumed. 1) $MF = 48,000 \text{nT}$; 2) The declination was $0^\circ$; 3) The inclination was $45^\circ$.  

<table>
<thead>
<tr>
<th>Model</th>
<th>Magnetization</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>$Mx$</td>
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<tr>
<td>Gray</td>
<td>7A/m</td>
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<tr>
<td>Black</td>
<td>5A/m</td>
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<td></td>
<td>1.0A/m</td>
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<table>
<thead>
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<tr>
<td>$Mx$</td>
</tr>
<tr>
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</tr>
<tr>
<td>3.9</td>
</tr>
<tr>
<td>3.7</td>
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<tr>
<td>3.5</td>
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<tr>
<td>3.3</td>
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<tr>
<td>3.1</td>
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<tr>
<td>2.9</td>
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<td>2.7</td>
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<td>2.5</td>
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<tr>
<td>2.3</td>
</tr>
<tr>
<td>2.1</td>
</tr>
<tr>
<td>1.9</td>
</tr>
</tbody>
</table>

$MF$ = 48,000 nT

$Inclination$ = 45 degrees

$Declination$ = 0 degrees
survey area, we are obliged to allow \( e_T > 1 \text{nT} \) despite the measurement error \( e = 1 \text{nT} \). In a survey area where the magnetic anomaly field varies over 1000 \text{nT} (with \( e = 1 \text{nT} \)), \( e_T \) can reach intrinsically 10 \text{nT}; from equation 4, for \( |\mathbf{M}| = 50 000 \text{nT}, |\mathbf{T}| = 1000 \text{nT}, \beta = 1000/50 000, \) and \( e_T = 10 \text{nT} \). In this case the effort made to make measurements with a system error of \( e = 1 \text{nT} \) is in vain.

### Analysis of helicopter-borne vector magnetic anomalies

#### Data acquisition

A helicopter-borne vector aeromagnetic survey was carried out over Aogashima Island on December 6, 2006. The survey was flown with Global Positioning System (GPS) control, at mean altitudes of ~100, 300, and 600 m along north–south flight lines spaced 300 m apart.

The magnetic sensor was a Bartington Instruments Ltd type KEI-9320S three-component fluxgate, with a sampling rate of 5 Hz and a resolution of 0.1 nT. The magnetometer’s attitude was measured by a Japan Aviation Electronics Industry Ltd JIMS-200R-C1 Ring Laser Gyrocompass (RLG), which measured roll, pitch, and yaw with a resolution of 0.001 degrees. The latitude, longitude, and altitude were measured by the GPS in p-code mode, with 1–2 m accuracy. The flightline data are shown in Table 1 and the measurement lines are shown in Figure 6.

The three observed components of the geomagnetic field were converted to northward (X), eastward (Y), and vertical downward (Z) components using the roll, pitch and yaw angles measured by RLG. These components of the measured field were reduced to magnetic anomalies by subtracting DGRF2000 (International Association of Geomagnetism and Aeronomy, 2005). The noise caused by the helicopter’s body was removed by Isezaki’s method (Isezaki, 1986).

To analyse the observed magnetic fields, the data were gridded, at a 50 m interval, according to the following procedure. First, the values at grid points with nearby observations were calculated by the Inverse Distance Weighted Interpolation method (Pelto et al., 1986). After this step, there were many grid points with no values. For these, values were generated by solving Laplace’s Equation as a boundary value problem, using the relaxation method. After these operations, the gridded data at an altitude of 550 m are shown in Figure 7.

#### The magnetization model

##### Block model

The magnetization model was constructed as an aggregation of blocks, in four layers, each 9.2 km \( \times 4.2 \text{km} \) in extent. The thicknesses of the top, second, third, and bottom layers are 300, 700, 1000, and 1000 m, respectively. The length and width of each block were 200 m. The origin coordinates were 139.74°E, 32.375°N.

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**Table 1. Data acquisition flight line information.**

<table>
<thead>
<tr>
<th>Line name</th>
<th>Measurement of line length</th>
<th>Spacing</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 1</td>
<td>15 lines (North–south)</td>
<td>300 m</td>
<td>10 km</td>
</tr>
<tr>
<td>Line 2</td>
<td>13 lines (North–south)</td>
<td>300 m</td>
<td>10 km</td>
</tr>
<tr>
<td>Line 3</td>
<td>13 lines (North–south)</td>
<td>300 m</td>
<td>10 km</td>
</tr>
</tbody>
</table>

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**Fig. 6.** Flight lines at Aogashima Island.

**Fig. 7.** Observed magnetic fields at Aogashima Island (altitude 550 m).
longitude and 32.39°N latitude. The number of blocks in each layer was 1426, therefore, our model was composed of 5704 (46 north × 31 east × 4 layers) blocks. Because each block has three components of magnetization to be determined, the total number of unknown parameters was 17112 (46 × 31 × 4 × 3).

To calculate these parameters, 20,766 three-component magnetic anomaly data observations were used.

The relationship between the magnetic field and the magnetization is:

$$X = \sum_i (A_i \cdot M_{xi} + B_i \cdot M_{yi} + C_i \cdot M_{zi}),$$  \hspace{1cm} (6)

where $X$ is an observed north-component anomaly value, $i$ is number of blocks, $A_i$, $B_i$, $C_i$ are shape factors for the north component, depending on the relative positions of the observation point and the $i$-th block, and $M_{xi}$, $M_{yi}$, and $M_{zi}$ are the north, east, and downward components of magnetization for $i$-th block (Bhattacharyya, 1964). $Y$ (eastward) and $Z$ (downward) component anomalies are computed by similar expressions. Then, we applied the Jacobi iteration method to solve the problem for the unknown values of $Mx$, $My$, and $Mz$.

**Analysis result**

As mentioned before, Aogashima Island is mainly composed of volcanic deposits such as lavas, avalanche debris, or volcanic ash. High values of magnetization intensity were therefore expected.

<table>
<thead>
<tr>
<th>Thickness (m)</th>
<th>Mx</th>
<th>My</th>
<th>Mz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st layer</td>
<td>300</td>
<td>10.0</td>
<td>-0.5</td>
</tr>
<tr>
<td>2nd layer</td>
<td>700</td>
<td>4.0</td>
<td>-0.5</td>
</tr>
<tr>
<td>3rd layer</td>
<td>1000</td>
<td>3.0</td>
<td>-0.5</td>
</tr>
<tr>
<td>4th layer</td>
<td>1000</td>
<td>3.0</td>
<td>-0.5</td>
</tr>
</tbody>
</table>

**Fig. 8.** The convergence of the calculated model with the observations (standard deviation as a function of iteration).

**Fig. 9.** Example of profile and cross-section views of 3D analysis. Top 2 sets of three profiles; black, observed magnetic anomalies ($X$, $Y$, $Z$ components); red, calculated anomalies ($X$, $Y$, $Z$ components). Bottom 2 sets of three cross-sections: $Mx$, northward component of magnetization; $My$, eastward component of magnetization; $Mz$, downward component of magnetization.
A maximum magnetization intensity of 15.0 A/m and an average magnetization intensity of 7.0 A/m were reported for Ohshima Island, located 250 km north from Aogashima (Okuma et al., 1989). Similar initial model values were chosen, as shown in Table 2.

We allowed the inversion to run for 70 iterations. The residual standard deviation between observed data and calculated data reduced as the number of iterations increased, but we found that the standard deviation did not decrease after the 20th iteration. The relationship between standard deviation and iteration number is shown in Figure 8.

We used the term ‘goodness-of-fit ratio’ \( (r) \) (Blakely, 1995, p224) to judge how well synthetic anomalies \( (G) \) fit the observed anomalies \( (F) \): the larger the ratio, the better the fit. The goodness-of-fit ratio \( (r) \) is defined as

\[
\hat{r} = \frac{\sum_{i=1}^{n} |F_i|}{\sum_{i=1}^{n} |F_i - G_i|}.
\]

In this analysis, \( r \) is 2.51 for \( X \), 3.45 for \( Y \), and 2.93 for \( Z \).

Examples of the analysis results are shown in Figure 9. In this figure, the top three profiles are \( X \), \( Y \), and \( Z \) profiles from north to south, on two lines. The black coloured profiles indicate observed data, and the red coloured ones the calculated anomalies. In this

Fig. 10. Distribution of magnetization intensity and magnetization direction. This figure shows a sample of plan views of the third model layer. The colour indicates the magnitude of the total magnetization vectors. The arrows are projections of the magnetization vectors into the plane of the view. AVI, Aogashima Island.
study, we obtained data at different altitudes at the same
cordinates; however, the different values of the observed and
culated data have been plotted at the same distance (northward
distance) from the origin on the profiles.
The bottom panels show the north, east, and downward
components of magnetization along each of the profiles. These
profiles are north-south cross sections at 2.2 km and 3.4 km east of
the origin point. The 2.2 km section is in the west part of Aogashima
Island, and the 3.4 km profile is in the east part of the island.

Figure 10 shows plan views of two layers, and additional
cross-section views, including magnetization direction. In this
figure, the colours show the intensity of magnetization, and the
arrows show magnetization directions.

These figures present the following features.

(1) In the top layer, high magnetization intensity area is detected
in the outer rim of the Ikenosawa caldera (the Ms formation).
High magnetization intensities were also found in the south of
the island.

(2) The magnetization direction in the top layer trends in the
north direction. However, at the outer rim of Ikenosawa
caldera, the directions are oriented in the direction of the
centre of the island.

(3) An area of low magnetization was found in the third and
fourth layers, in the south-west, off Aogashima Island. The
low magnetization area was located at ~3–4 km bsl, and at
2–4 km east, 4–6 km north from the origin point.

Discussion

The volume of high magnetization intensity in the top layer
 corresponds to the areas of thick lava areas. In addition, the
magnetization directions at the outer rim of Ikenosawa caldera
were oriented in the direction of the Aogashima Island centre
which might be interpreted as contraction of the outer rim of
Ikenosawa caldera to the inside of the caldera when the Ms
formation sagged, during caldera formation ~3000 years ago.
Such contraction and expansion would be related to the
movement of the Ms formation.

The volume with low magnetization intensity is possibly
at high temperature. On the west side of the Ikenosawa
caldera, we find fumarolic steam due to magma activity
beneath. The high temperature area would be located near
this area to provide heat for the fumarolic steam. Taking the
locations of surface temperature anomalies and the locations of
low magnetization intensity into consideration, this low
magnetization intensity area may be strongly influenced by
magma activity (see Figure 11).

Therefore, we have installed GPS monitoring systems at
two locations in the Ikenosawa caldera. One has been located
in an area active with fumarolic steam, and the other is
installed 400 m away. There is also a Geographical Survey
Institute GPS monitoring station, and all three locations are
plotted in Figure 1. GPS monitoring was initiated on 6th
December 2005.
Conclusion
The TIA has an intrinsic error that cannot be avoided, even by a high-resolution magnetometer. Moreover, examination of model analyses shows that an inversion result using TIA may be very different from the true model, while the vector anomaly does provide an inversion result almost identical to the true one.

A volume of low magnetization intensity was imaged from vector magnetic anomalies, south-west of Aogashima Island at a depth of 1–2 km below the seabed. We conclude that high temperatures, due to magmatic activity, are present in the low magnetization volume. We have installed GPS stations at two locations in Ikenosawa caldera, and the GSI has installed a further station. We have been monitoring ground movement from October 2006, to detect changes associated with magma activity and its movement.

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空中磁気探査による地磁気三成分異常を用いた青ヶ島の磁化構造

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要旨：青ヶ島火山は伊豆七島の最南端にある島である。本研究ではその火山島で、将来起こる火山災害の低減を目指して、火山内部磁化構造を把握するために、空中三成分磁気探査を実施した。通常このような火山内部の磁化構造把握のためには、その妥当性を評価できない全磁力異常（TIA）が適用されてきた。言い換えれば、磁力異常は物理的な意味をもたないスカラー量、すなわち、マックスウェルの方程式やラプラスの方程式などを満たさない量であるので、物理的な解析には適さない。そのために、磁力異常を投影地磁気異常（PTA）とみなして計算してきた。しかしながら、全磁力異常に投影地磁気異常の差（eT=TIA-PTA）が解析に及ばす影響については、言及されていないままに使われてきた。このような状況下、筆者らは、青ヶ島火山体内部磁化分布の把握のために、全磁力異常と投影地磁気異常の差（eT=TIA-PTA）を考える必要のない、空中三成分磁気探査を採択した。本論文では、まず、全磁力異常に投影磁力と同等とみなしたときの解析への影響を評価して、解析結果の信頼性を保つには三成分増塗を測定する必要性があることを示した。次に、観測された三成分磁場より、青ヶ島火山内部の三次元・三成分磁化構造を解析した。その結果、青ヶ島の南西部の深度1.2 kmにおいて、1 A/m 以下の低磁化領域が把握された。現在の噴気が活発な領域との位置関係を考えると、その低磁化領域は現在の青ヶ島火山活動の熱帯であると考えた。

キーワード：三成分磁場異常、三次元・三成分磁化構造、青ヶ島火山、空中三成分磁気探査

항공 벡터 자기이상 자료를 이용한 아오가시마섬(청도)의 자화구조 연구

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요약：항후 발생할 수 있는 자연재해의 기초 자료 확보를 위해 아오가시마섬 지역의 화산 구조를 연구하였다. 아오가시마 섬은 임금성의 섬이 분포하는 이즈영도의 최남단에 위치하고 있는 화산섬으로 복잡한 탐사를 위하여 멀리 있는 항공 벡터 자기이상 자료를 수행하였다. 일반적으로 화산섬의 자기구조를 연구하기 위해서는 총 자기이상을 이용하게 되는데 이는 본질적인 자료 내포하고 있다. 총 자기이상은 물리적 특성을 정확히 반영하지 못하기 때문에 맥스웰방정식이나 라플라스 방정식을 만족하지 못하며, 물리적으로 정확한 해석을 수행하기 어려운 단점을 가지고 있다. 또한, 해석을 위하여 한 방향으로 두영한 총 자기이상을 사용하기도 하여 이 과정에서 발생하는 오차 때문에 해석상의 오류가 발생할 수 있다. 이러한 문제점을 보완하기 위하여 이번 연구에서는 벡터 자기이상을 직접 측정 하였으며, 이를 이용하여 보다 신뢰성 높은 아오가시마섬의 3차원 자기이상 특성을 연구하였다. 이번 연구의 해석결과를 간단히 정리하면, 1A/m 이하의 자화강도를 보이는 지역은 아오가시마섬 남서쪽에 분포하고 있으며, 그 심도는 1-2 km로 해석되었다. 이러한 낮은 자화강도를 보이는 지역은 화산분기 작용의 특성을 고려할 때, 화산분기 작용이 발생했던 지역으로 생각된다.

주요어：벡터 자기이상，벡터 자화，아오가시마섬，항공 벡터 자력계

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