Summary: Two independent signals detected by ocean bottom electromagnetometers during a non-eruptive volcanic event: Ogasawara Island arc volcano, Nishinoshima

馬場聖至（東大・地震研）、多田訓子（JAMSTEC）、市原寛（名古屋大）、浜野洋三（神戸大）、杉岡裕子（神戸大）、小山崇夫（東大・地震研）、高木朗充 （気象庁）、武尾実（東大・地震研）

Kiyoshi Baba (ERI, UTokyo), Noriko Tada (JAMSTEC), Hiroshi Ichihara (Nagoya Univ.) Yozo Hamano (Kobe Univ.), Hiroko Sugioka (Kobe Univ.), Takao Koyama (ERI, UTokyo), Akimichi Takagi (JMA), and Minoru Takeo (ERI, UTokyo)

Abstract

We introduce a paper, Baba et al. (2020), published in Earth, Planets and Space, which reports distinct time variations of total magnetic force and slope around Nishinoshima volcanic island observed during a non-eruptive period by using ocean bottom electromagnetometers.

小笠原諸島西之島で、2016 年 11 月の噴火休止期間中に顕著な全磁力と傾斜の異常変化が起こった。これを報告した EPS 論文（Baba et al., 2020）について紹介する。

Reference

Baba, K., Tada, N., Ichihara, H., Hamano, Y., Sugioka, H., Koyama, T., Takagi, A., Takeo, M. (2020) Two independent signals detected by ocean bottom electromagnetometers during a non-eruptive volcanic event: Ogasawara Island arc volcano, Nishinoshima. Earth Planets Space 72:112. https://doi.org/10.1186/s40623-020-01240-z.

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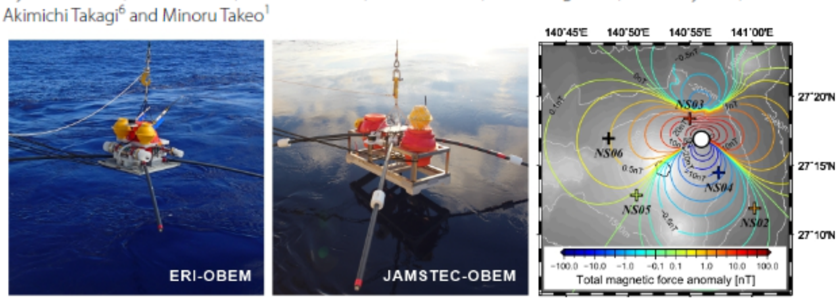
Two independent signals detected by ocean bottom electromagnetometers during a non-eruptive volcanic event: Ogasawara Island arc volcano, Nishinoshima

Kiyoshi Baba[1*], Noriko Tada[1,2], Hiroshi Ichihara[3], Yozo Hamano[4], Hiroko Sugioka[2,5], Takao Koyama[1], Akimichi Takagi[6] and Minoru Takeo[1]



Graphical abstract

Two independent signals:

- 全磁力変動
- 傾斜変動

OBEM1台で2つの独立情報が1度に観測できる → 火山島の活動モニタリングにも有用

将来性

Non-eruptive volcanic event:

2015年11月～2017年4月の間、西之島の噴火活動は確認されていなかったが、2016年11月中旬に顕著な全磁力変動と傾斜変動を複数のOBEMで観測

火山研究分野へのインパクト

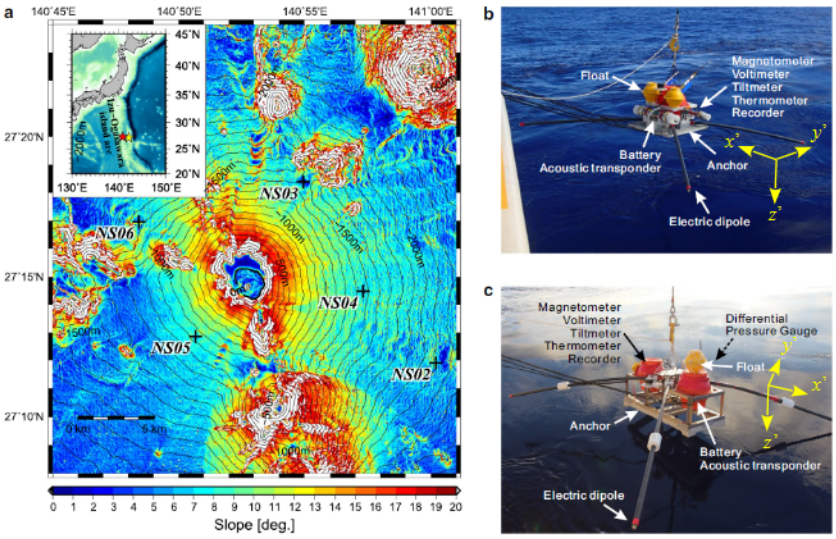


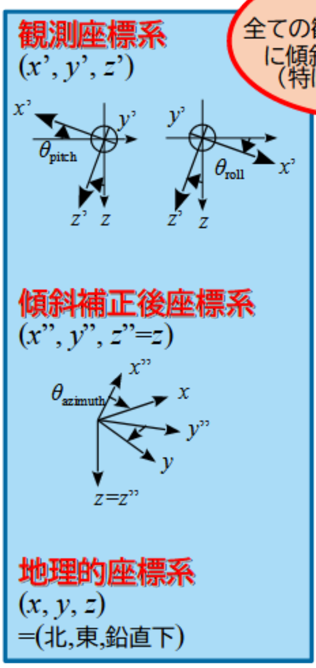
Fig. 1 **a** Observation array on a bathymetric map around Nishinoshima. The contour lines and colors indicate the bathymetry and the slope, respectively. Crosses with labels denote the site location. Inset is a large-scale map showing the location of Nishinoshima (red star) and Chichijima (yellow star). **b** Photograph of ERI-OBEM. **c** Photograph of JAMSTEC-OBEM (taken by M. Shinohara)

観測アレイ・データ取得期間

- 西之島を取り囲む5点
  水深約1000~2100 m
- 2016/10/21~2016/11/28
  詳細はTable S1参照

OBEM

- 3成分電磁場変動
  全磁力は3成分より合成
- 2成分傾斜変動
  2成分電場変動
- FGセンサ付近の温度変化
- sampling間隔: 8Hz (60s)
  60s平均値を解析
- 自由落下による設置
  装置の向き・海底とのcouplingを制御できない



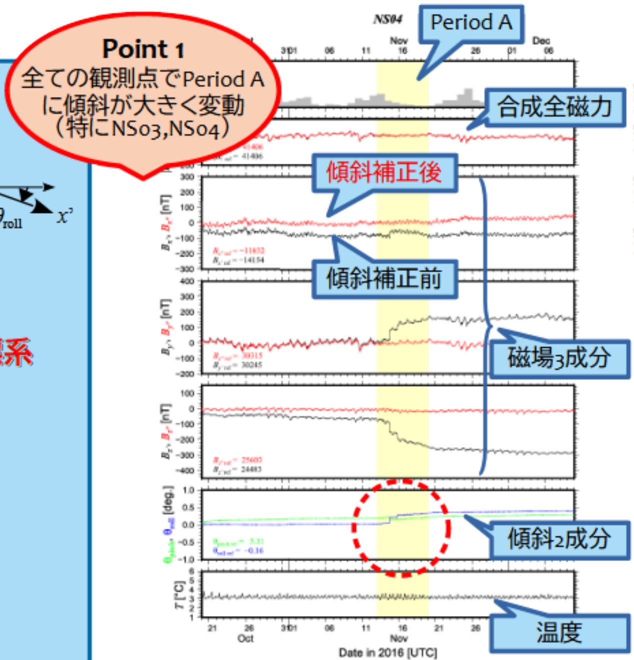
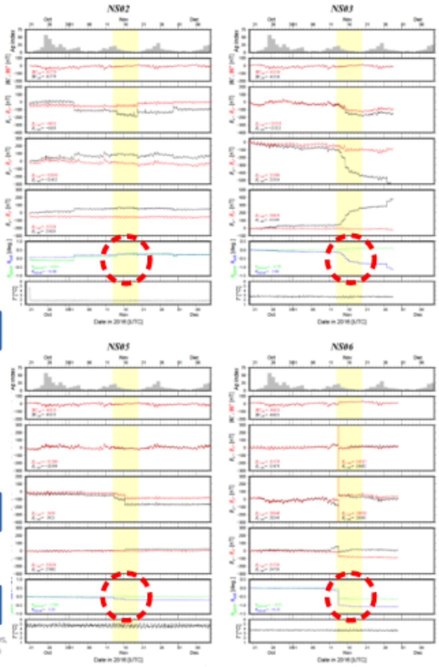


Fig. 2 Time series of Ap index (top) and the data observed by the OBEM deployed at NS04. For the magnetic field data in the second to fifth rows, the black and red lines are the data before and after tilt correction, respectively. These magnetic field data and two components of the tilt data in the sixth row were shifted by a reference value indicated in each panel. The reference values are those at 00:00:00 on October 20th, 2016 (UTC). The bottom row shows the temperature measured near the fluxgate sensor. Yellow shades indicate Period A (November 13–19th, 2016). See also Additional file 1: Figs. S1–S4 for details on the other sites



Figs. S1-S4 (Additional file 1)

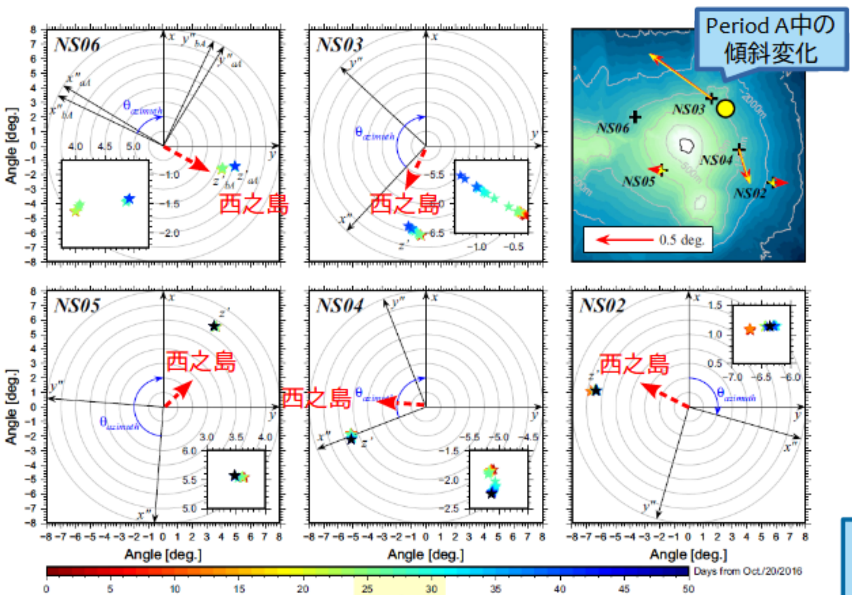


Fig. 3 Tilt variation for each site in the observation period. z' axis is projected in the horizontal plane and plotted by stars colored with the days from October 20th, 2016. Days shaded in the color scale correspond to Period A (November 13–19th, 2016). Insets are magnifications of z'. The horizontal axes x'' and y'' after the tilt correction are plotted by arrows. The angle between x'' and x is $\theta_{azimuth}$ as shown by a blue arc with an arrow. For NS06, x'', y'', and z' are obtained for before and after Period A (denoted with subscripts "bA" and "aA", respectively). In the top right panel, the tilt variation between November 13th and 19th for each site (except for NS06) is plotted as a red vector on the bathymetry map (Black line indicates the island coast.). Yellow vectors are the tilt variations predicted by a spherical pressure source model and the yellow circle indicates the horizontal location of the pressure (deflation) source with the radius of 1.2 km

$$\theta_{\mathrm{azimuth}} = \tan^{-1}\left\{\frac{\mathrm{median}\left(B_{y''}^{\mathrm{quiet}}\right)}{\mathrm{median}\left(B_{x''}^{\mathrm{quiet}}\right)}\right\} + D_{\mathrm{IGRF}}, \quad (1)$$

Table 1 Estimation of the horizontal rotation angle, $\theta_{azimuth}$, to convert the coordinate system into a geographical one

Site	Rotation angle (arc-degrees)		
	Before Period A	After Period A	Entire observation period
NS02	− 105.85	− 105.76	− 105.79
NS03	137.18	137.39	137.21
NS04	111.33	111.27	111.31
NS05	175.59	175.71	175.70
NS06	64.40	58.81	64.36

NS06を除く観測点のOBEMは移動した形跡なし

観測された傾斜変動の全てが山体の変形を反映しているかは疑がわしい(海底面に対するOBEMの姿勢変化+海底面の傾斜変化)ものの、全て地面の変形と仮定して球状圧力源を求めると、NS03の南西海底下5.1 kmに決まる(体積-7.9 km³ →収縮)

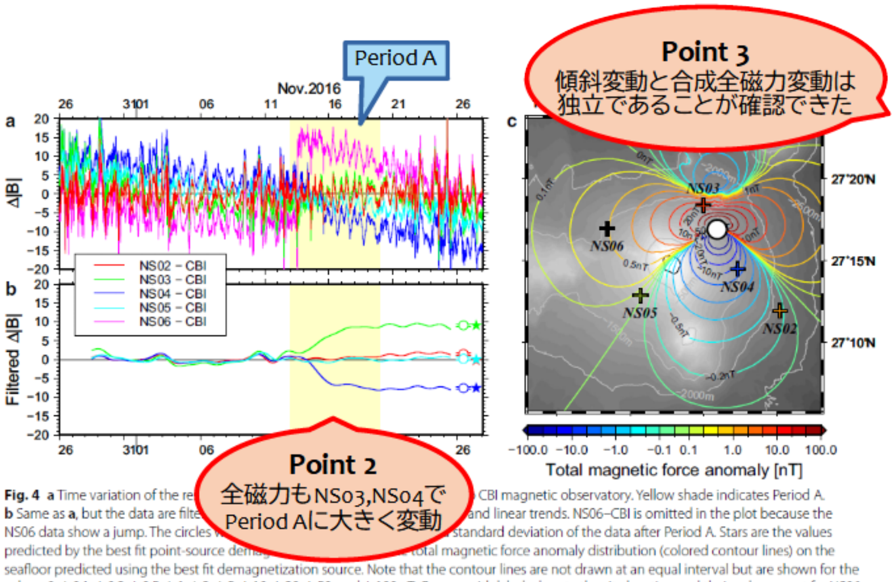


Fig. 4 **a** Time variation of the re… CBI magnetic observatory. Yellow shade indicates Period A. **b** Same as **a**, but the data are filte… and linear trends. NS06–CBI is omitted in the plot because the NS06 data show a jump. The circles … standard deviation of the data after Period A. Stars are the values predicted by the best fit point-source dem… total magnetic force anomaly distribution (colored contour lines) on the seafloor predicted using the best fit demagnetization source. Note that the contour lines are not drawn at an equal interval but are shown for the values, 0, ±0.1, ±0.2, ±0.5, ±1, ±2, ±5, ±10, ±20, ±50, and ±100 nT. Crosses with labels denote the site location and their color except for NS06 indicates the observed total magnetic force change. The white circle denotes the horizontal location of the best fit dipole moment, whose radius corresponds to that of the equivalent demagnetization sphere (1.1 km). The background gray shade is the bathymetry map. The black line indicates the island coast

合成全磁力変化の妥当性

- 3軸直交性
  - 製造時直交性検定あり
  - 傾斜補正前後の合成全磁力はよく一致（RMS < 0.1 nT）→座標系に依らない
- 温度変化
  - ~1.5℃ @ NS05
  - FGセンサーの温度ドリフト：0.2 nT/℃

点磁化源の推定

- NS03の南西海底下1.2 km
- 磁気モーメントの大きさ -9.1×10⁹ Am²（消磁）

より複雑な磁化・傾斜変化モデルによる議論が必要

戦略的多点・長期間観測によって、火山活動研究分野におけるOBEMの有用性を高められるだろう