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A SEAFLOOR GEOMAGNETIC OBSERVATION IN BREID BAY, PRINCESS RAGNHILD COAST, ANTARCTICA

Hiroaki TOH[1], Natsuo SATO[2] and Jiro SEGAWA[1]

[1]*Ocean Research Institute, University of Tokyo,*
15–1, Minamidai 1-chome, Nakano-ku, Tokyo 164
[2]*National Institute of Polar Research,*
9–10, Kaga 1-chome, Itabashi-ku, Tokyo 173

Abstract: An ocean bottom magnetometer was installed in Breid Bay and was successfully retrieved during the 29th Japanese Antarctic Research Expedition (JARE-29). The seafloor geomagnetic observation provided a time series of the three-component geomagnetic field once every minute and this time series continues as long as 36 days. The data obtained were analyzed by spectral analysis methods and compared with the simultaneous data obtained at Syowa Station. The obtained data proved almost satisfactory except for some instrumental limitations such as a lack of a geographical compass equipped with the magnetometer. The result reveals the effectiveness of an ocean bottom magnetometer as a temporal geomagnetic station even in such a logistically difficult region as Antarctica.

1. Introduction

Ocean bottom magnetometers were developed first in the U.S.A. (COX *et al.*, 1971) and then in Canada (LAW and GREENHOUSE, 1981) and Japan (SEGAWA *et al.*, 1982) in order to study conductivity anomalies beneath the seafloor through, for example, the geomagnetic deep sounding method. It has been pointed out in recent years that no satisfactory conductivity models can be extracted from only the limited land observations (UTADA, 1987). This observation, therefore, is primarily aimed at the extension of the research on 'conductivity anomaly' to the Antarctic region. There is, however, another possibility of contribution of the seafloor geomagnetic observation to the upper atmospheric physics in such a region of high local source field activities as the Antarctic auroral zone because of the effectiveness of an ocean bottom magnetometer as a temporary geomagnetic station, *i.e.*, a small drift rate, its instrumental compactness and its self-consistent measuring-recording system. In addition to these characteristics, the stable temperature environment of the sea floor makes the sea observatories superior to the land observatories especially in cold regions such as Antarctica.

The geomagnetic observations in the Antarctic region started from permanent observations on land and they were extended to air-borne surveys and the utilization of satellite data. The marine geomagnetic observations, however, were rarely made in the Antarctic Ocean even by the ship-towed proton magnetometers. The present paper is the first report on the marine geomagnetic observation using an ocean bottom magnetometer in the Antarctic region.

2. Instruments

The ocean bottom magnetometer used in this observation is a three-component fluxgate-type magnetometer with a resolution of 0.1 nT. The size of the magnetometer is relatively small, that is, it weighs approximately 80 kg in air and is 1 m high. The sampling interval can be chosen between 1 minute and 8 minutes by 1 minute step. We chose 1 minute for the measuring interval in this case which ensured the life time of the magnetometer as long as 45 days. In order to avoid the waste of power, the magnetometer is equipped with a delay switch which enables 8.5, 17 or 34 hours delay before start. The power for the instrument is supplied from the self-contained lithium batteries whose capacity amounts to 30 Ah. The data obtained are recorded in five pieces of erasable programmable ROM board with the capacity as much as 64 KB each. Before deployment, the magnetometer is housed in a 17″ glass sphere which withstands the outer pressure up to 6700 m sea depth.

The installation of the instrument is carried out by free fall from the sea surface. The recovery is conducted by an on board acoustic release system. When a release command is sent through the acoustic release controller on board, the acoustic transponder equipped with the magnetometer generates 13 V between the weight suspension made of stainless steel and the cathodes of the release device. The suspension is cut through electrolysis, which enables the magnetometer to float up. The magnetometer, therefore, is equipped with a pressure-tight float made of syntactic foam, a lead weight, a release device, a pair of acoustic transponder and hydrophone and a HF beacon for the sake of finding the magnetometer on the sea surface.

One instrumental improvement was made for this observation. The life time of the acoustic transponder is extended as long as a whole year in case when it should have been impossible to retrieve the magnetometer within the term of the 29th Japanese Antarctic Research Expedition.

As for the details of the ocean bottom magnetometer used here, refer to SEGAWA *et al.* (1986).

3. Problems in the Actual Operation

Two intrinsic problems exist actually in the observation in the logistically difficult region such as Antarctica. One is the difficulty in forecasting the ice condition when the magnetometer is to be retrieved, and the other is that this kind of observation is likely to impose a limitation on the operation of the icebreaker. But detailed inspections of the ice condition at the end of December and the beginning of February for the past three years which were made by using the NOAA satellite data and the radar scanner data of the icebreaker revealed that an open sea was likely to be formed in the eastern area of Breid Bay in these parts of a year. Therefore, we selected the period from the end of December 1987 to the beginning of February 1988 as an observation term. In addition, the extension of life time of the acoustic transponder made the recovery of the magnetometer possible in February 1988, December 1988 or February 1989, which reduced the imposed limitation on the operation of the icebreaker.

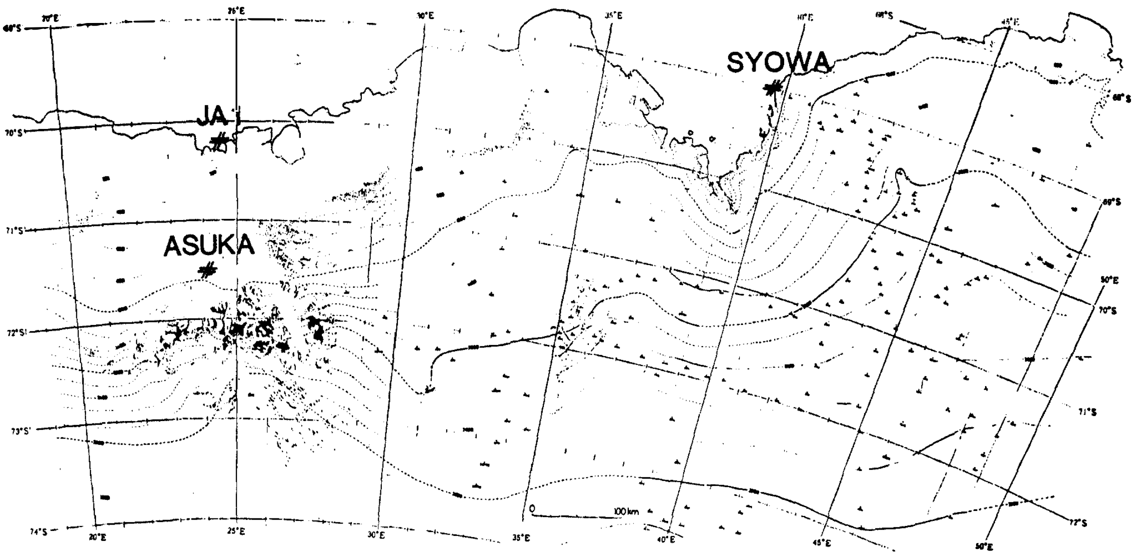

Fig. 1. The location of observation points, Breid Bay (JA1), Syowa Station and Asuka Station.

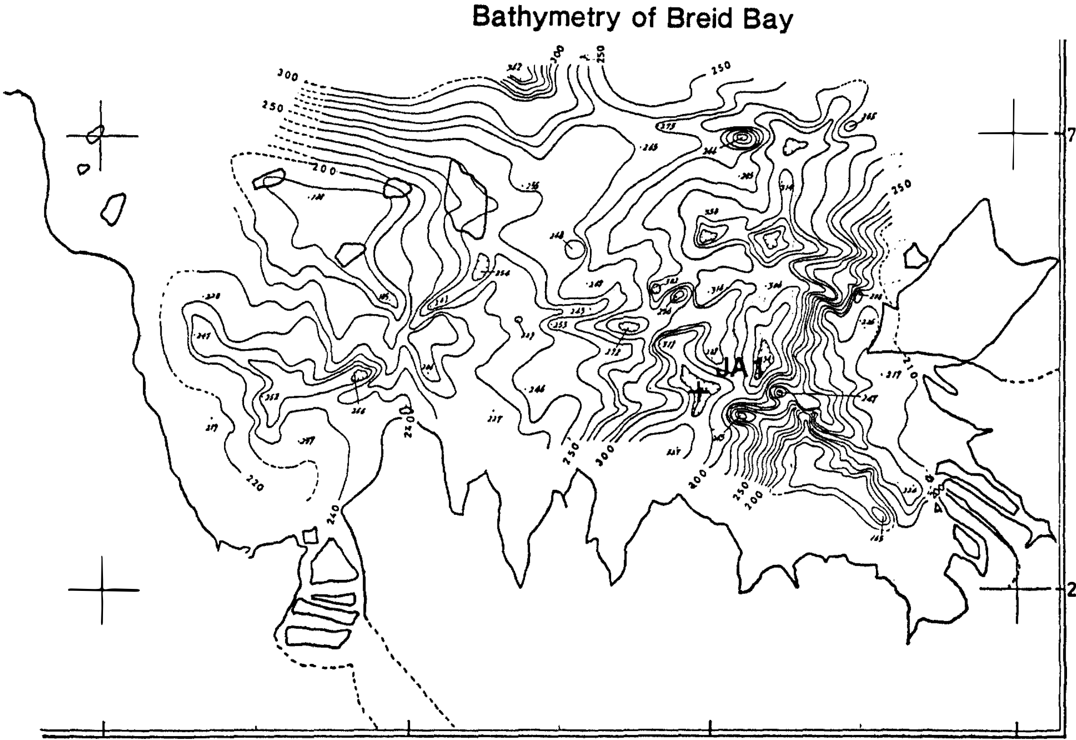
Bathymetry of Breid Bay

Fig. 2. The installation point (JA1) of the ocean bottom magnetometer in Breid Bay.

Thanks to the calm weather, both the installation and the recovery of the magnetometer resulted in success on December 30, 1987 and on February 7, 1988, respectively. Figure 1 shows the location of the observation point along with the location of Syowa Station and Asuka Station. Figure 2 shows the detailed installation position of the magnetometer on a bathymetric map of Breid Bay, and Table 1 gives the

Table 1. A list of geomagnetic observation stations during JARE-29.

Instrument	Stn.	Position NNSS	Geomagnetic Coordinate	Depth (m)	Code	Beacon (MHz)	Start time	Sampling rate
OBMS4	JA1	70°16.3′S 24°18.3′E	67°51.8′S 63°25.3′E	327	1C	OAR 27.045	31st/ DEC. 2200 LT	1 min
	SYO	69° 0.0′S 39°35.0′E	69°39.2′S 77°40.6′E					
	ASK	71°31.6′S 24° 8.3′E	68°52.8′S 61°28.1′E					

data of the installation point together with those of Syowa Station and Asuka Station.

4. Data

The present seafloor geomagnetic observation has provided a time series of the three-component geomagnetic variations of every minute in Breid Bay, starting from December 31, 1987, 0000 UT to February 5, 1988, 2359 UT. The total duration of the time series obtained amounts to 36 days.

Figure 3 shows an example of the data obtained. Here we adopted the (H, D, Z) coordinate system, *i.e.*, geomagnetic north, geomagnetic east and downward, respectively. This is because an ordinary ocean bottom magnetometer is not equipped with a geographical compass for the sake of its instrumental compactness. In the observations at mid-latitudes, it causes no problem because the (H, D, Z) coordinate system only slightly differs from the (X, Y, Z) coordinate system, *i.e.*, geographical north, geographical east and downward, respectively. This approximation, however, does not hold good any more at high latitudes. It is at least required to unify the measuring coordinate systems. Although two geomagnetic data sets obtained at different observatories are usually compared in the (X, Y, Z) coordinate system, a conversion of the coordinate system from (X, Y, Z) to (H, D, Z) was made in this case for the data at Syowa Station utilizing the absolute geomagnetic measurement on a geomagnetic quiet day there. The absolute geomagnetic measurement was carried out on January 28, 1988 and the declination was 46°59.3′W at that time.

In Fig. 3, a remarkable difference is found between Breid Bay and Syowa Station in short-period geomagnetic variations from, say, 0000 UT to 0900 UT. The H- and D-components at short-periods vary almost anti-parallel in Breid Bay during those hours of a day, whereas there are no such short-period variations in the Z-component in Breid Bay or in any component at Syowa Station then.

In order to confirm this phenomenon clearly, we will make a spectral analysis of the seafloor geomagnetic variations in Breid Bay and the simultaneous geomagnetic data obtained at Syowa Station by the 28th Japanese Antarctic Research Expedition and offered to us on a compiled magnetic tape (YAMAGISHI *et al.*, 1987), and will give a speculation with respect to that phenomenon in the following section.

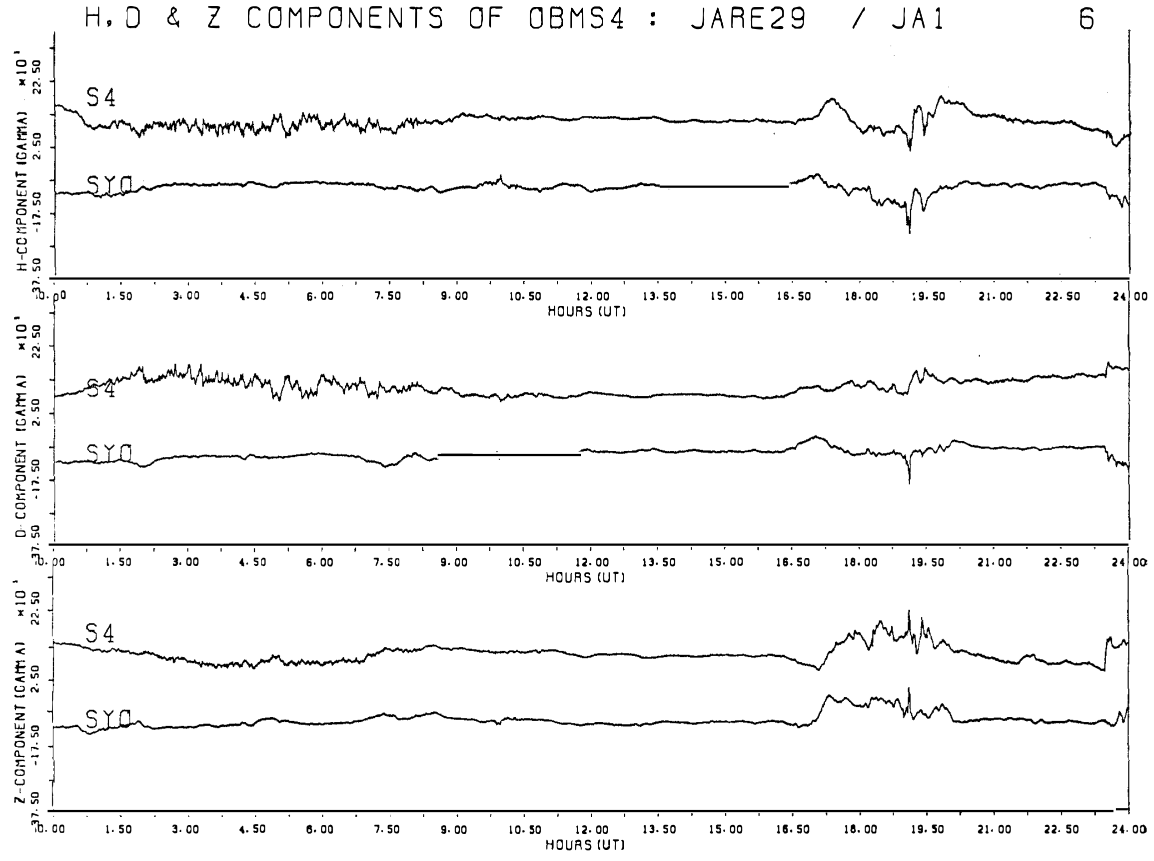

Fig. 3. A magnetogram of Breid Bay (S4) and at Syowa Station (SYO) on January 6, 1988. One division of the vertical axis corresponds to 100 nT.

5. Spectral Analysis

A Fast Fourier Transform method has been applied to the geomagnetic time series obtained in Breid Bay and at Syowa Station. The two time series used here have the duration of one month from January 1, 1988 to January 31, 1988 in universal time. Figures 4 and 5 show the coherences between the geomagnetic components in Breid Bay and at Syowa Station, respectively.

The difference between Breid Bay and Syowa Station in short-period geomagnetic variations which is found in time domain (Fig. 3) is also confirmed through the spectral analysis. The coherence between *H*-component and *D*-component in Breid Bay clearly increases with frequency compared with that of Syowa Station. And no such tendency is found both in the coherence between *Z*-component and each horizontal component in Breid Bay and in every coherence at Syowa Station.

One possible explanation of this phenomenon is that it is caused by the auroral electrojet current. This, however, contradicts the fact that no obvious correlation between horizontal components is observed at Syowa Station in the same period. Syowa Station is located at approximately 570 km east of Breid Bay. If the phenomenon is due to some ionospheric origin such as the auroral electrojet, the wave length of the source field should be larger than or comparable to the distance between the two observation points.

Another explanation could be given with a conductivity anomaly around Breid Bay. WHITHAM and ANDERSEN (1962) reported a similar correlation between horizontal components ($\Delta X = -\Delta Y$, in this case) through the geomagnetic observation at Alert in high latitude district of Canada. They related it to the conductivity anomaly caused by an embedded two-dimensional cylindrical conductor whose strike lies in the northeast to southwest direction. This explanation also might be denied this time, however, because the correlation between X-component and Y-component is always observed at Alert, not limited to any special hours of a day. In addition, Alert is located in the polar cap region, not in the auroral zone, and its geomagnetic latitude is higher than that of Breid Bay approximately by 20 degrees.

It is still unknown why the correlation between the horizontal components is so high in Breid Bay. We, however, make a speculation of attributing it to the effect of the ocean tide in Breid Bay whose depth is rather shallow (around 300 m). It is likely that the diurnal variation of the velocity field of seawater dominates during some specific hours of a day in Breid Bay.

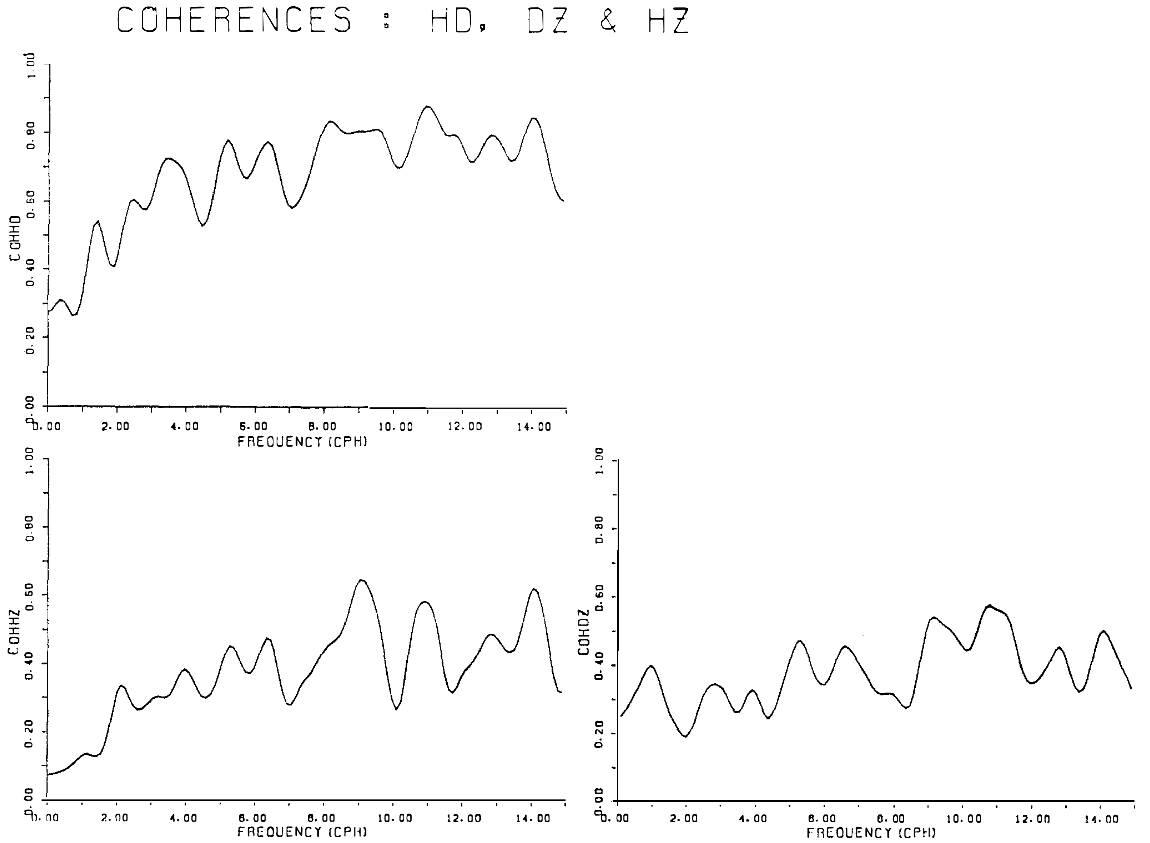

Fig. 4. Coherences between the geomagnetic components observed in Breid Bay. The horizontal axis represents frequency in cycle per hour (CPH).

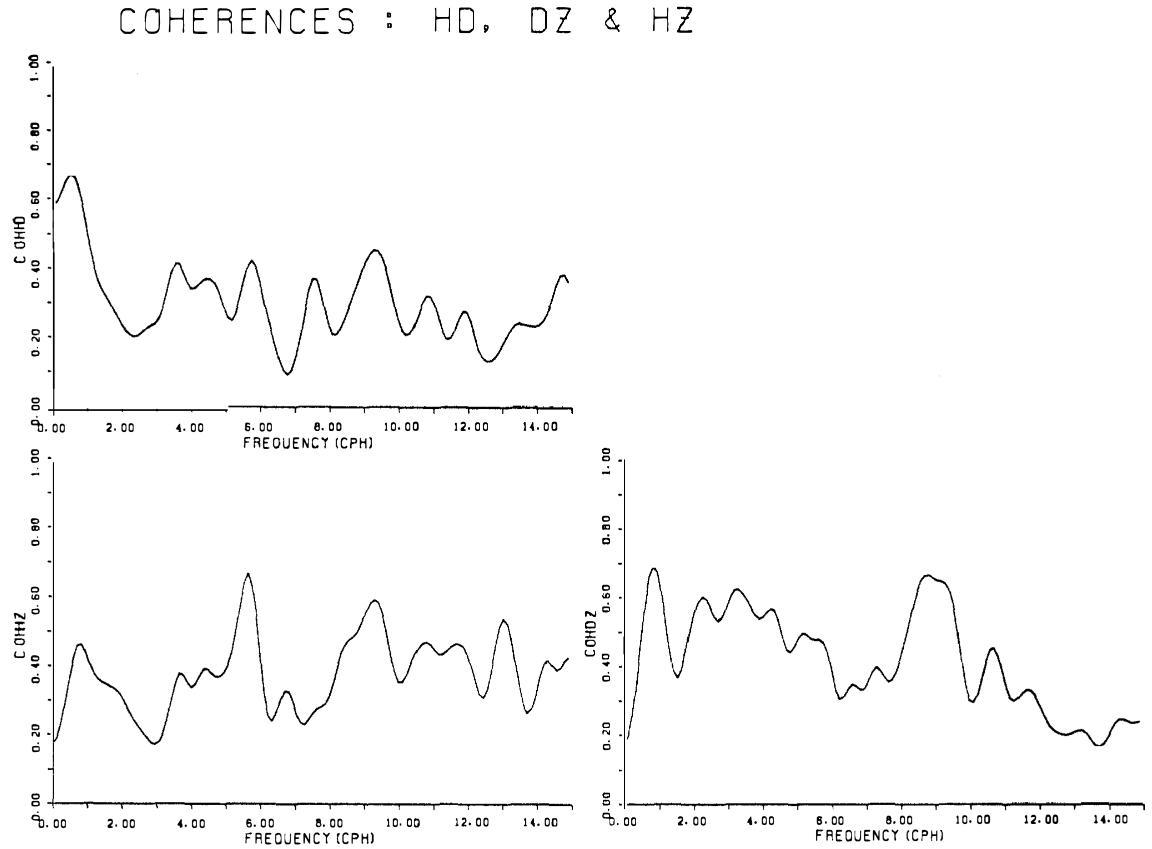

Fig. 5. Coherences at Syowa Station.

6. Summary

In spite of the logistic difficulties, a seafloor geomagnetic observation was carried out and the data obtained proved almost satisfactory except for some particular hours of a day as discussed in the previous sections. This paper has provided only a preliminary result of the observation, and a general feature of the seafloor geomagnetic variations in Breid Bay is investigated in the frequency domain using simultaneous geomagnetic data obtained at Syowa Station. Another approach will be made, however, when the simultaneous geomagnetic data at Asuka Station are available because the station is the nearest geomagnetic observatory at a distance of 140 km south of Breid Bay.

Acknowledgments

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