Preliminary Report of Geomagnetic Survey during JARE the Second.

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要　　旨

今回の観測の結果，プリンス・ハラルド海岸附近からその北方海域のかなり広い範囲にわたつて，VESTINE その他の磁気図による全磁力分布との喰い違いを見出した．この領域が永年変化の大きい領域と殆んど一致していることは，興味ある事実である．尚，途中の航路上に若干の局地異常を認めたが，その主なものは，アフリカ大陸棚の東縁，マダガスカル島の南側及び伊豆大島の北方で，その異常は全磁力でそれぞれ $+700\gamma$，$+460\gamma$，$+470\gamma$ に達している．その他全磁力の日変化振巾が磁気赤道附近において急激に増大する事実が確認され，加えてこの領域における4月19日の日食の影響が見出されている．

1 Introduction

During the Japanese Antarctic Research Expedition (JARE) the Second, two kinds of geomagnetic survey were carried out, *i. e.*,

1) Measurement of three components of geomagnetic field near Lützow-Holm Bay, by a three component magnetometer on the ice-floes, from Dec. 23, 1957 to Jan. 27, 1958.

2) Observation of geomagnetic total intensity during the voyage of the expedition ship from Nov. 19, 1957 to Apr. 27, 1958, through East and South China Sea, Indian Ocean and Antarctic Sea, by using a sea-borne proton magnetometer.

2 Instruments

The three component magnetometer used during this expedition is the same as that used during the first expedition. The accuracy is within 1′ in declination and inclination, and 10γ in total intensity.

The sea-borne magnetometer used during this voyage is of proton-precession

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type which is specially designed and constructed to be towed behind the ship. The adaptation for ship operation of proton megnetometer is simple in principle, requiring only a suitable streamlined, non-magnetic water proof case for detector coil with a bottle of pure water, and suitable towing cable. The case, made of a kind of synthetic resin mixed with glass fibre, is towed by a nylon rope of 8 mm in diameter, about 130 m behind the ship from her center. A teflon covered coaxial cable, 14 mm in diameter, taped to the nylon rope at intervals, is used as an electric cable, and it was proved to be satisfactory in strength and electrical insulation, at speeds from 9 to 11 knots.

The detector coil which picks up the electro-motive force caused by damped precession of proton in pure water, after the cut off of direct current in the coil, sends this signal to an amplifier aboard. The signal wave is amplified and mixed with the standard frequency wave which is controled by a quartz crystal of 100 kc/s,

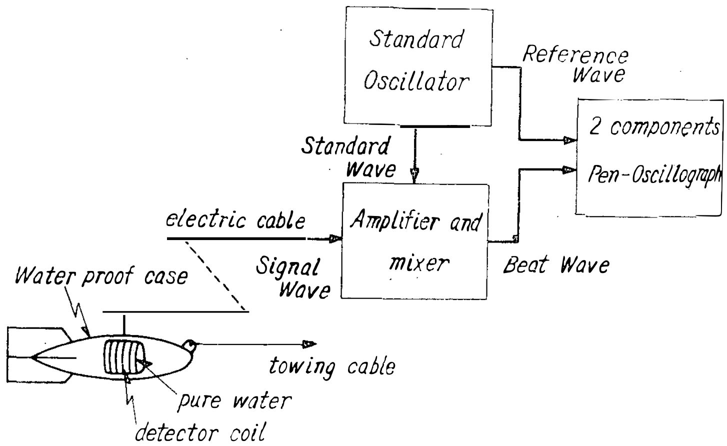


Fig. 1 Block diagram of proton-magnetometer.

and the beat of the signal and the standard wave, is recorded on a pen-oscillograph, as is shown in the block diagram in Fig. 1. Thus the accuracy of the proton-magnetometer itself is subject to accuracy of the standard oscillator, and it is within 2γ. The practical accuracy, however, depends on the rotational disturbances of detector coil in wake and on the effect of magnetization of the ship, amounting to 7×10^8 e.m.u. in dipole moment. The practical accuracy is, estimated within 15γ in average, taking into consideration the relative angle between the direction of geomagnetic field and that due to magnetization of the ship, though it amounts to 30γ in the worst condition.

3 Results and discussion

1) Geomagnetic field around Lützow-Holm Bay When the ship was beset with thick ices, a geomagnetic survey was carried out on the ice-floes around Lützow-Holm Bay. By comparing the present data with the values in VESTINE's world geomagnetic chart[1)] and another data for 1930 in its vicinity, some information on secular variation of geomagnetic field in the area is obtained, which will be discussed later. In Fig. 2 (a), (b), (c) and (d), the geomagnetic field around Lützow-Holm Bay observed during the first and second expeditions is illustrated, where the secular variations from 1957 to 1958 is not taken into account.

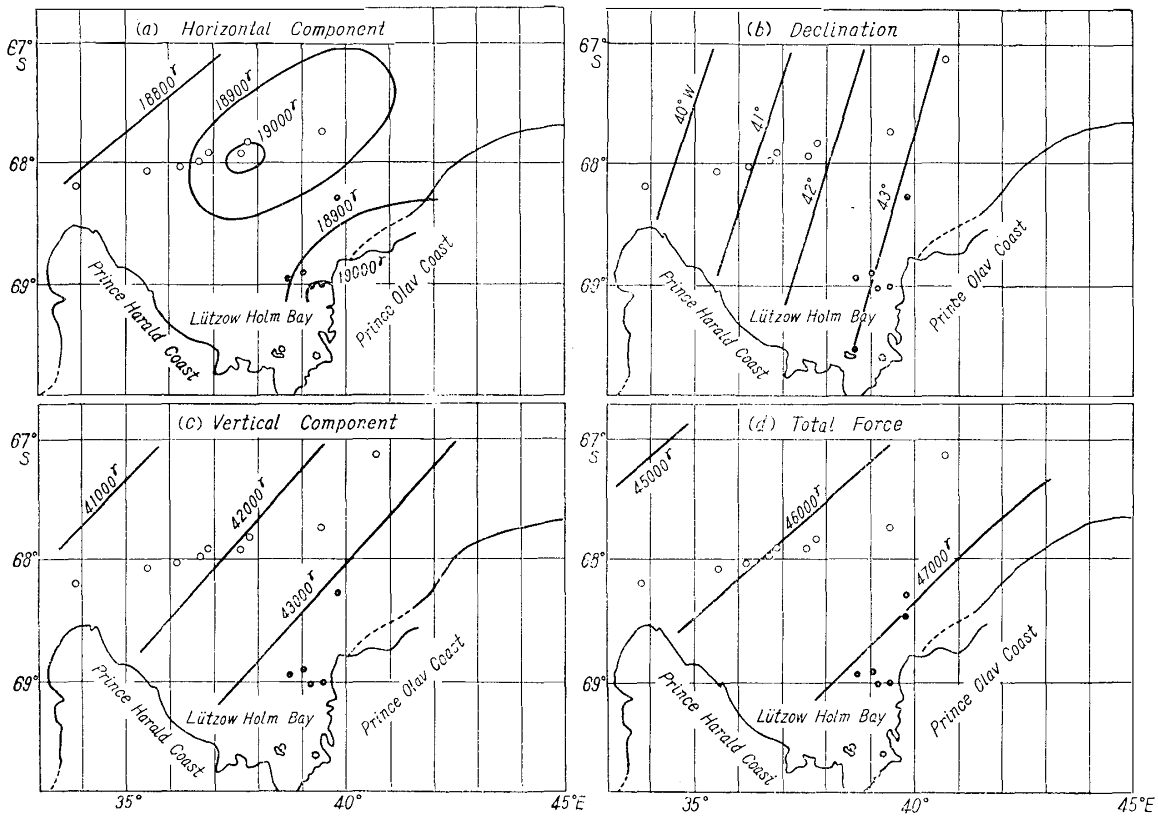


Fig. 2 Geomagnetic features around Lützow-Holm Bay, Antarctica, for 1957–58. The full circles show the points where the observation was carried out during JARE the First, and the hollow circles, the Second.

2) Geomagnetic total intensity along the course of m/s "SOYA" A marine geomagnetic survey was especially planned for one of the important research items of this expedition, because it was found, at the last expedition, that the geomagnetic total force in the neighbourhood of Japanese Antarctic Base ($\varphi=69°00'$S, $\lambda=39°35'$E), is definitely small compared with values described in the charts hitherto published.

Every 3∼5 hour measurement of the geomagnetic total intensity were carried out on the course of the ship on her way to and from the Antarctic during the voyage from Nov. 19, 1957 to Apr. 27, 1958. Successful observation have been made on whole course shown in Fig. 3, devided into five trucks as follows:

1. Indian Ocean—Cape Town Nov. 19—Dec. 1, 1957.
2. Cape Town—Offshore of Enderby Land, Antarctica. Dec. 11—Dec. 20, 1957.
3. Offshore of Cook Penn., Antarctica—Cape Town Feb. 24—Mar. 7, 1958.
4. Cape Town—Singapore Mar. 13—Apr. 7, 1958.
5. Singapore—Tokyo Apr. 15—Apr. 27, 1958.

Trucks 1 and 4 gave trans-Indian Ocean profiles across the continental margin of South Africa, Crozet Swell and Mid-Indian Ocean Ridge. Trucks 2 and 3 are for profiles across the southernmost part of Crozet Swell and of Mid-Atlantic Ridge, and truck 5 covers the course from Singapore to Tokyo through South and East China Sea and southern inshore of the Japan Islands.

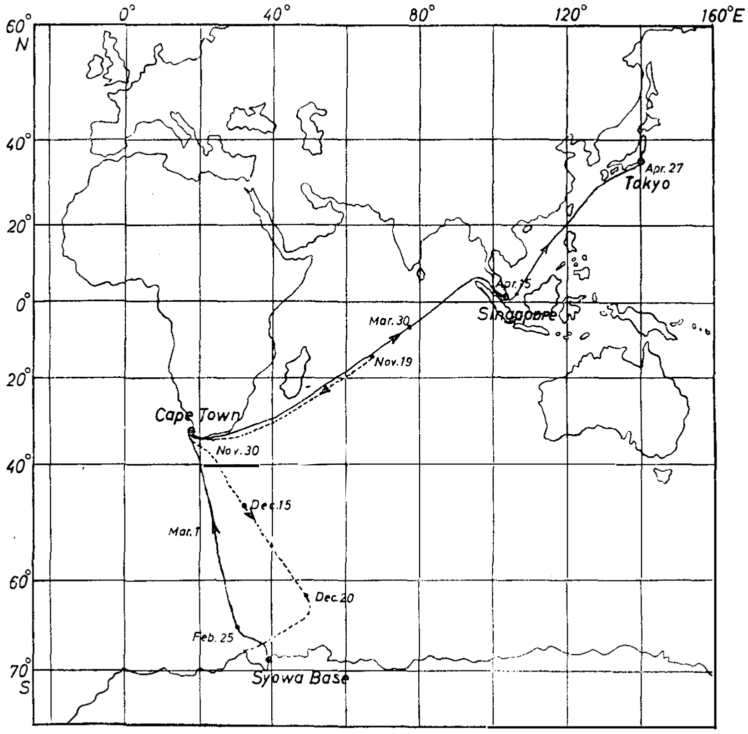


Fig. 3 Along the courses illustrated here, absolute measurement of geomagnetic total intensity was carried out, from Nov. 19, 1957 to Apr. 27, 1958. Dotted line shows the outward course and full line shows the homeward course.

In order to estimate the effect of magnetic disturbances on the data obtained, the magnetograph record of three components at Hermanus, South Africa, Muntinlupa, Phillippines and Kakioka, Japan were consulted. In any detailed mathematical analysis of this data, the effect of magnetic disturbances should be taken into account quantitatively. For the purpose of this paper, however, the data may be discussed as it appeares only with a rough correction for daily variation.

i) GEOMAGNETIC TOTAL FORCE BETWEEN SOUTH AFRICA AND THE ANTARCTIC CONTINENT.

The distributions of geomagnetic total intensity for 1958 and 1945 between 35°S and 69°S is illustrated in Fig. 4. It is clearly seen in the figure that, over a fairly large area including Syowa Base, there is marked discrepancy in geomagnetic total intensity, as was suggested in the report of the last expedition[2]. For instance, there is a large discrepancy between the actually observed value at the point $\varphi = 65°21'S$, $\lambda = 53°40'E$ in 1930 and that observed in 1958 at a point very near to the above reference point. This discrepancy may show that the secular variation in geomagnetic total force during 28 years from 1930 to 1958 in this locality amounts to about 0.064Γ, in other words, the annual mean rate of change in intensity being about -220γ per year. The average rate of decrease in the equatorial intensity of the earth's centred magnetic dipole is only 10γ per year, and the annual rate of

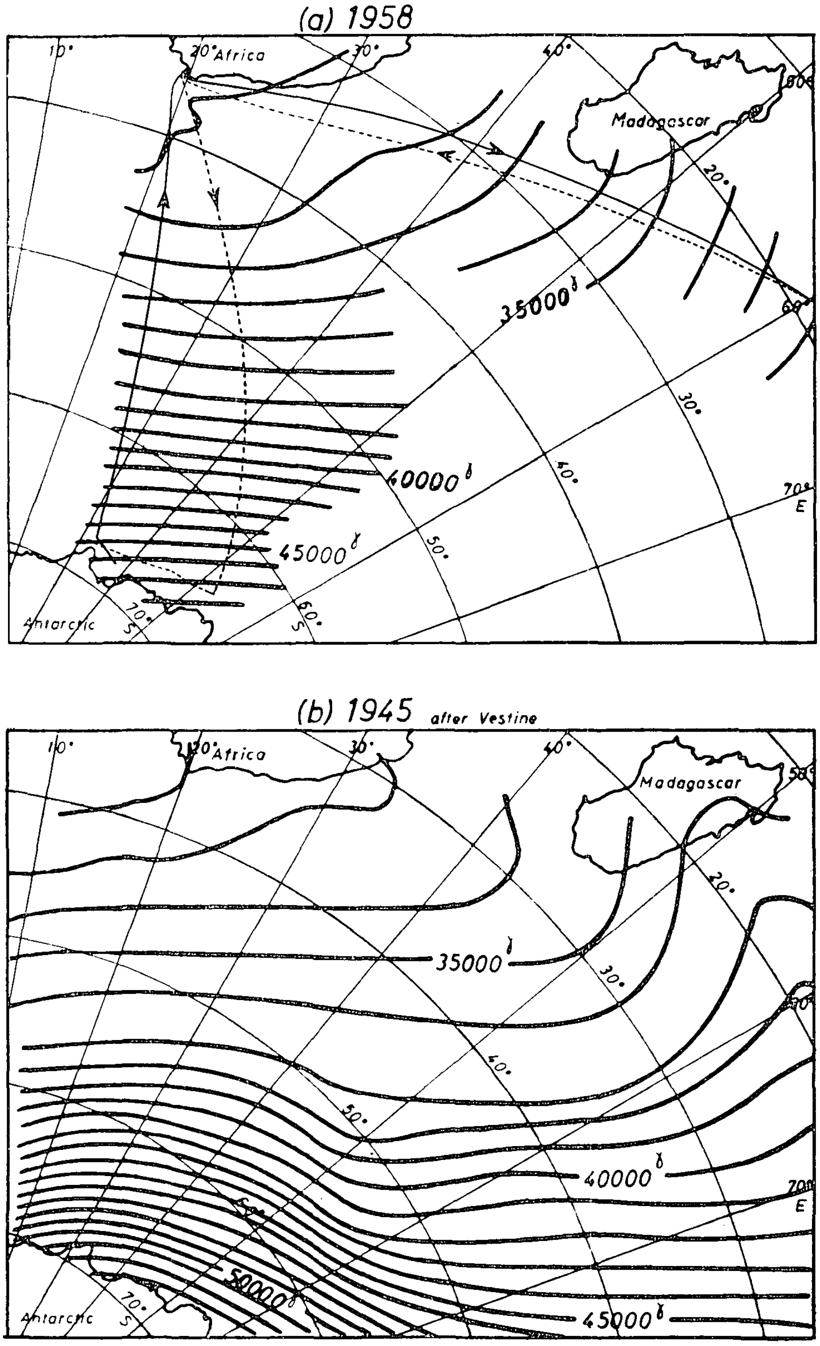


Fig. 4 Distribution of geomagnetic total intensity between South Africa and the Antarctic Continent.

change at the locality is about 19γ per year. The secular change in total intensity concerned here is much larger than that due to the decrease of the intensity of the centred magnetic dipole. This result is not affected by taking into consideration

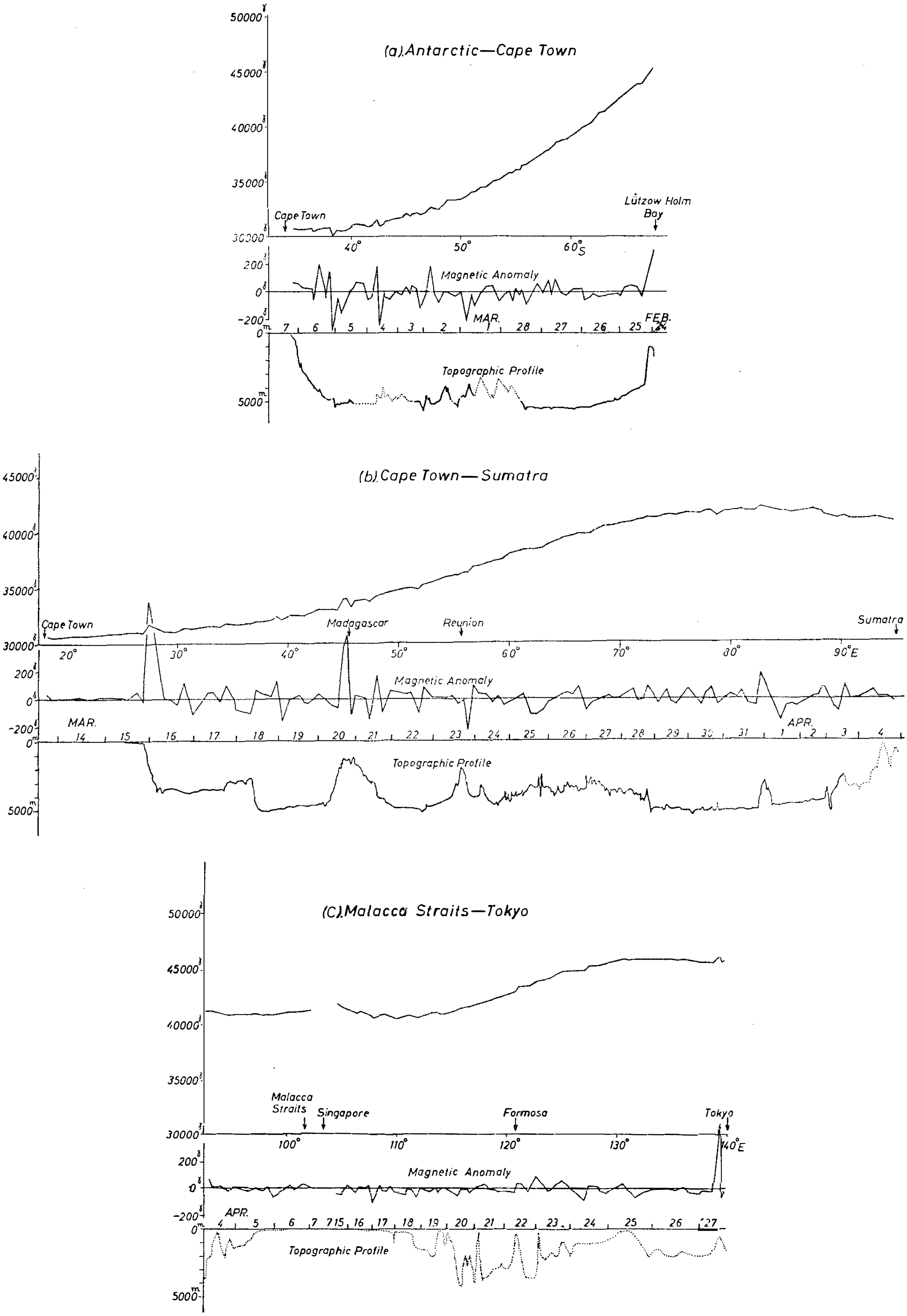


Fig. 5 Magnetic profiles along the course of the expedition ship "Soya" during JARE the Second. In the course where the echo sounding was not in operation the charted values were used in the topographic profiles which are shown as the dotted lines.

eccentric dipole. The behaviour of secular change in geomagnetic total intensity mentioned here, is worth noticing, and this problem is to be studied in detail.

ii) MAGNETIC PROFILES AND SEA BED TOPOGRAPHY.

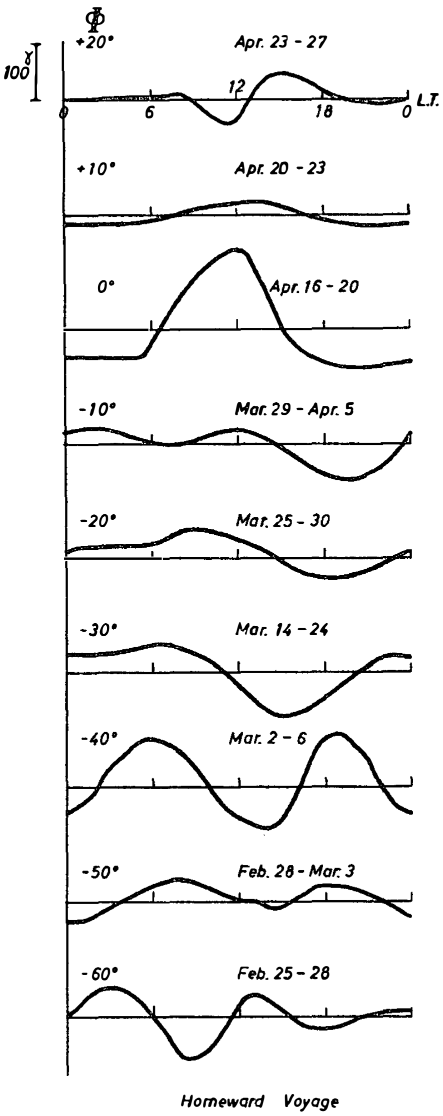
Three examples of the magnetic profiles for the five trucks are shown in Fig. 5 (a), (b) and (c) with the profiles of magnetic anomaly and the sea bed topography observed by an echo sounder. The daily variation in total intensity is roughly removed from the anomaly profiles. It can be seen in these figures that there are some regions where the regional anomaly in total intensity is markedly large. The most striking ones are the south-eastern margin of African continental shelf, southern bank of Madagascar and the area a few kilometers north-west of Izu-Osima, Japan, where the anomalies amount to $+700\gamma$, $+460\gamma$, and $+470\gamma$ respectively. The regional anomaly near Izu-Osima may be attributed to the remanent magnetization of igneous rock in the area, since a fairly large anomaly is observed around Mt. Mihara, a volcono on the island.

Although no definite geological evidence is known at present around the other two area, such a large regional anomaly should correspond to some special geological structure, owing to some tectonic activity in the basement not limited to process in unconsolidated sediments[3].

Other remarkable area, where the regional anomaly is quite large is the offshore south of Africa, from 35°S to 55°S, where an oceanic ridge which may be continued from the Atlantic Ocean and one or two ridges continued from Madagascar, join together and make a complicated topography of the sea floor. Other minor anomalies are found on the Mid-Indian Ocean Ridge and around Mauritius and Reunion Islands. The former may be due to a tectonic activity as the same as that at Mid-Atlantic Ridge, and the latter may be attributed to the remanent magnetization of volcanic rocks.

iii) LATITUDE DEFENDENCY OF THE DAILY VARIATION OF GEOMAGNETIC TOTAL INTENSITY.

The voyage of the ship during the expedition, ranges so widely from 26°N to 69°S in geomagnetic latitudes, that the latitude dependency of daily variation in total intensity, along the course can be roughly estimated. The daily variation at a certain geomagnetic latitude is derived by overlapping the data for several days when the ship was around the latitude. The result is shown in Fig. 6. The most remarkable fact is the augmentation of the amplitude and the phase shift of daily variation near the geomagnetic dip equator. The range of the daily variation in total intensity, which is approximately the same as that of horizontal component, amounts to 200γ. It is shown that the width of the zone of large amplitude of daily variation is about 10° centering the geomagnetic dip equator. The large range of daily variation is considered to be caused by the equatorial electric jet current flowing in a layer of high electrical conductivity in the lower part of the ionosphere, around the geomagnetic dip equator.



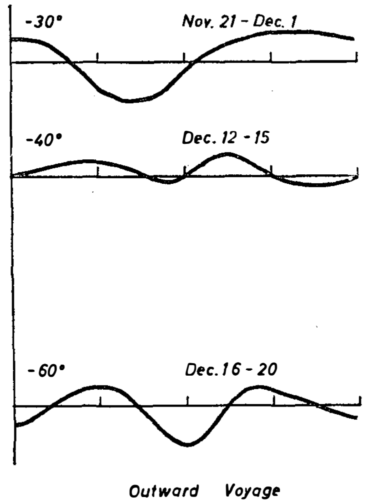


Fig. 6 Latitude dependency of the daily variation in geomagnetic total intensity.

iiii) AN EFFECT OF THE SOLAR ECLIPSE ON APR. 19, 1958 ON THE DAILY VARIATION IN GEOMAGNETIC TOTAL INTENSITY NEAR THE GEOMAGNETIC DIP EQUATOR.

The large amplitude of daily variation near the geomagnetic dip equator, was observed from Apr. 16 to 20. The solar eclipse effect on Apr. 19 on the daily variation was, therefore, observed in the zone around the dip equator. The result is shown in Fig. 7 in comparison with the screening curve of the solar disk. The normal curve of daily variation on Apr. 19, which is expected to be the daily variation without the effect of the solar eclipse,

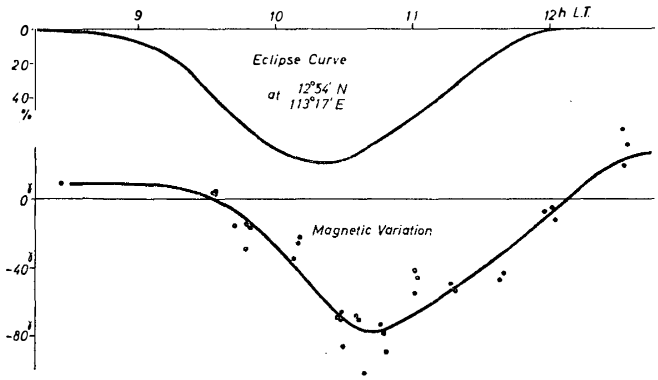


Fig. 7 The effect of the solar eclipse on Apr. 19, 1958, on the daily variation in geomagnetic total intensity, near the geomagnetic dip equator.

is assumed to be the mean daily changes from Apr. 16 to 20. As is seen in this figure, the maximum deviation in total intensity from the normal curve is about 80γ, and it amounts to about 60% of the normal deviation from the daily mean value. This amount seems to be too much larger compared with the values obtained in middle and low latitudes, even at the time of total solar eclipse. It is, however, expected that the anisotropic conductivity may take an essential role around the geomagnetic dip equator to depress the lateral current during the solar eclipse. This problem is to be studied in detail.

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