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PSEUDO MAGNETIC ANOMALIES IN THE ANTARCTIC SEA

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Abstract: Pseudo magnetic anomaly in the Antarctic Sea has been calculated using the gravity data derived from altimetric geoid. Comparison of the pseudo magnetic anomaly thus calculated with the theoretical magnetic anomaly predicted from topography has been made with respect to the large fracture zones composed of short-wavelength ridges and troughs in the Southeastern Pacific, which shows that these two anomalies coincide well with each other. Gravity anomaly calculated from topography only also coincides well with that observed with respect to the fracture zones.

1. Introduction

Pseudo magnetic anomaly can be calculated from gravity anomaly provided that both gravity and magnetic anomalies are caused by the common source materials. The distribution of pseudo magnetic anomaly should be compared with the observed magnetic anomaly in order to detect the parameters characterizing the magnetic data, such as geomagnetic field strength and susceptibility of the ocean bottom materials.

In the Antarctic Sea, few surface-ship gravity surveys have been conducted so far, and the existence of gravity data was quite sparse compared with other oceanic areas of the world. However, recently the gravity maps derived from SEASAT and GEOS-3 altimetry have been published (SEGAWA *et al.*, 1984; SEGAWA and MATSUMOTO, 1987), and they present precise gravity anomaly even in the Antarctic Sea, which enables us to conduct a quantitative analysis of gravity field together with magnetic anomaly data to detect the sub-bottom structure.

In this paper, the authors will introduce the process of the calculation of pseudo magnetic anomaly from $10' \times 10'$ altimetric gravity anomaly, and then discuss one of the results with respect to the large fracture zones in the Southeastern Pacific near Antarctica.

2. Methods of Calculation

A theoretical relationship between gravity and magnetic fields was discussed by BARANOV (1957), ROBINSON (1971), HAGIWARA (1980) and others. If a certain material causes both gravity and magnetic anomalies, then gravity anomaly can be theoretically calculated by the use of magnetic anomaly and *vice versa*, using Poisson's relationship between gravity and magnetic potentials. The theoretically derived anomaly is named pseudo magnetic anomaly or pseudo gravity anomaly. For the calculation of pseudo magnetic anomaly from gravity anomaly, one must assume that the crustal materials have uniform density and susceptibility and are normally magnetized. If the observed magnetic anomaly is well correlated to the pseudo magnetic anomaly thus calculated, it is regarded as evidence that these assumptions are adequate. If not, then other assumptions must be taken into account.

Let the geophysical values be expressed by local cartesian coordinates such as x (positive northwards), y (positive eastwards) and z (positive downwards). Then, using the gravity anomaly $g(x, y, 0)$ which is given on the sea surface ($z=0$) at a position (x, y), the pseudo magnetic total-force anomaly ΔF at the height of $z=-H$ can be expressed as

$$\Delta F(x, y, -H)=\frac{J}{2\pi G\Delta\rho}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\psi(x-x', y-y', -H)\Delta g(x', y', 0)\mathrm{d}x'\mathrm{d}y',$$

where J is magnitude of magnetization vector, G is gravitational constant, $\Delta\rho$ is density contrast causing the gravity effect. ψ is the kernel function expressed as

$$\psi(x, y, -H)=\frac{1}{(x^2+y^2+H^2)^{3/2}}\left\{\frac{3(\alpha x+\beta y+\gamma H)}{x^2+y^2+H^2}-1\right\},$$

where α, β, γ are the direction consines of magnetization vector, being expressed as

$$\alpha=\cos I\cos D,$$
$$\beta=\cos I\sin D,$$
$$\gamma=\sin I,$$

using the inclination I and declination D of the present geomagnetic field.

Further detailed discussions for calculation of three components of the pseudo magnetic anomaly, expressions in wave number domain and the accuracy of these calculations are given by HAGIWARA (1980).

3. Summary of the Results of Calculation

The authors applied this method of calculation to the altimetric gravity data in the Southeastern Pacific near Antarctica. The calculation area includes Eltanin and Udintzev fracture zones which strike from east-southeast to west-northwest. The topographic map of the area is shown in Fig. 1.

In the present calculation, the main geomagnetic field is based on the reference of IGRF 1980, and all the sea bottom materials causing magnetic anomalies are assumed to be normally magnetized. Magnitude of magnetization J is assumed to be 0.01 emu/cc, and the density contrast $\Delta\rho$ is 1.64 g/cm^3, *i.e.* the difference between the mean density of the crust (2.67 g/cm^3) and that of the sea water (1.03 g/cm^3).

Figure 2 shows the result. The figure presents the lineations of peak and moat along the large fracture zones. These fracture zones have large-scale escarpments, and the maximum relative height of the escarpment at about 55°S, 126°W is 4500–5000 m from the result of SEABEAM bathymetric survey (LONSDALE, 1986).

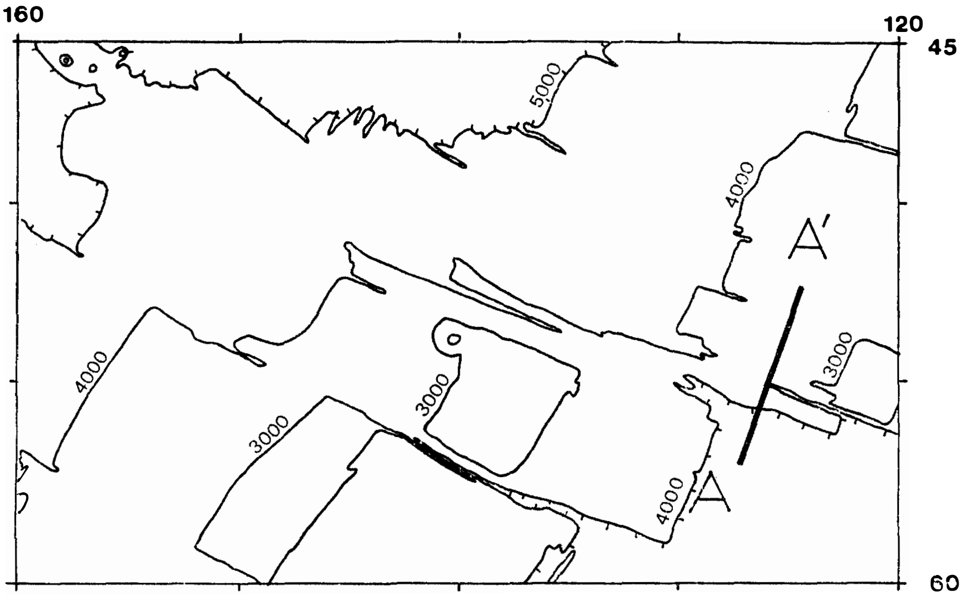

Fig. 1. Topographic map of the Southeastern Pacific near Antarctica. Cross section for model calculation of theoretical gravity and magnetic anomalies in Fig. 3 is expressed as A-A′.

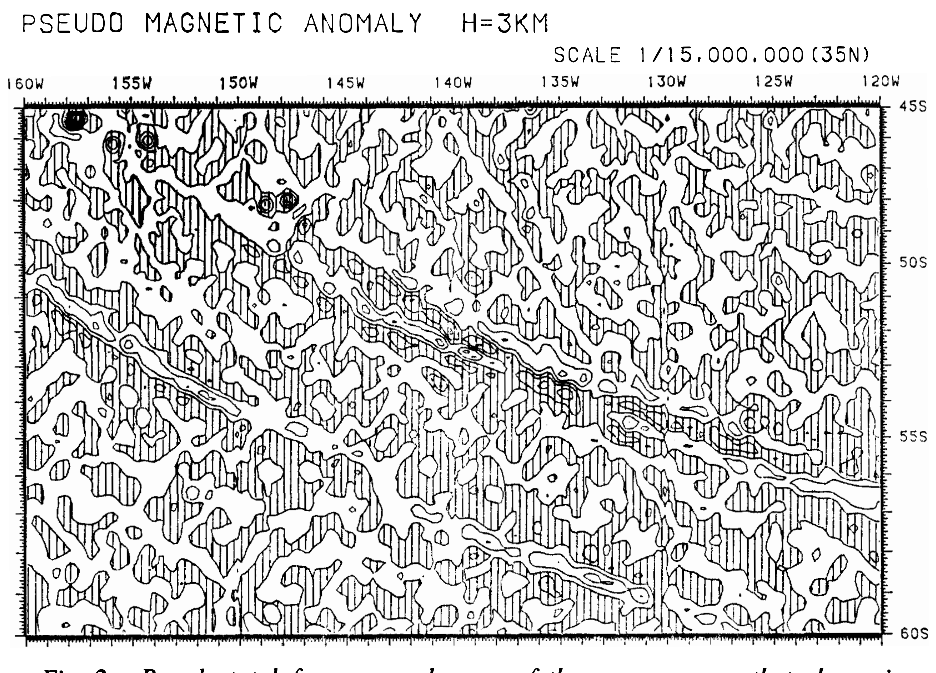

Fig. 2. Pseudo total force anomaly map of the same area as that shown in Fig. 1. Contour interval is 50 nT. Hatched area indicates positive.

Figure 3 shows the cross sections of gravity and magnetic anomalies derived from the topographic model expressed in the uppermost part. The inclination of geomagnetic field around the above fracture zones is about −70 degrees. This figure shows the same pattern as that shown in the cross sectional line in the pseudo magnetic anomaly map (Fig. 2). Then it should be concluded that the magnetic field is determined mainly

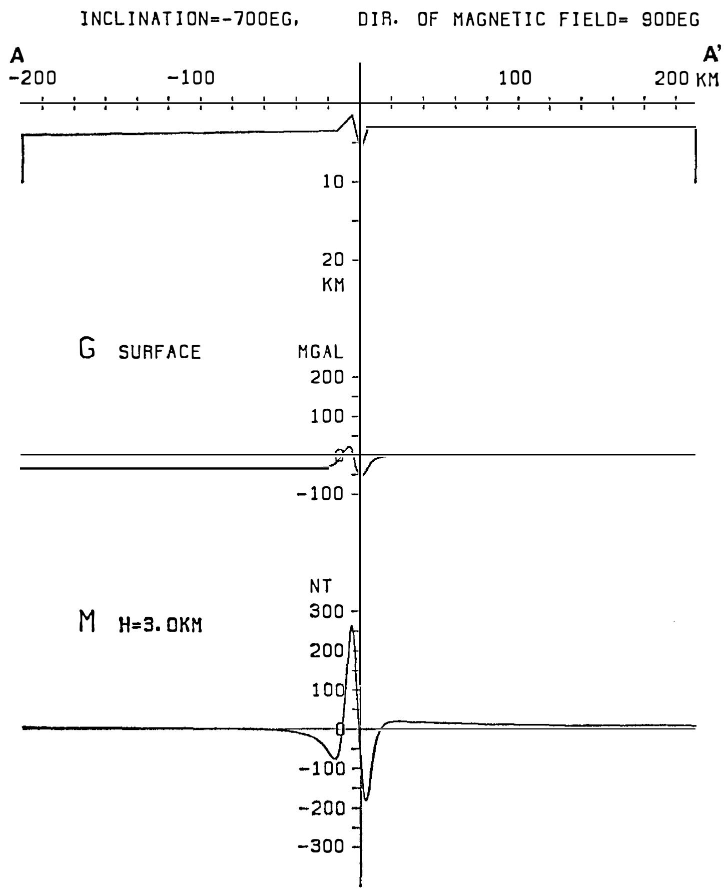

Fig. 3. Cross sections of theoretical gravity and magnetic anomalies calculated from topography across the large fracture zones in the Southeastern Pacific.

by the topographic feature along the fracture zone. Theoretical gravity anomaly also coincides well with the observed values. Since the distribution of gravity and magnetic anomalies does not express the effect of the sub-bottom structure to compensate the topographic load, it is expected that the topographic load at such a fracture zone is not isostatically compensated and is supported by elasticity of the materials of crust and upper mantle as discussed by WATTS (1978) and other authors.

References

BARANOV, V. (1957): A new method for interpretation of aeromagnetic maps; Pseudogravimetric anomalies. Geophysics, **22**, 359–383.

HAGIWARA, Y. (1980): Pseudomagnetic anomaly derived from gravity observations in Central Japan. Bull. Earthq. Res. Inst., **55**, 27–41.

LONSDALE, P. (1986): Tectonic and magmatic ridges in the Eltanin fault system, South Pacific. Mar. Geophys. Res., **8**, 203–242.

ROBINSON, E. S. (1971): The use of Poisson's relation for the extraction of pseudototal magnetic field intensity from gravity observations. Geophysics, **36**, 605–608.

SEGAWA, J. and MATSUMOTO, T. (1987): Free air gravity anomaly of the world ocean as derived from satellite altimetry data. Bull. Ocean Res. Inst. Univ. Tokyo, **25**, 1–122.

SEGAWA, J., MATSUMOTO, T. and KAMINUMA, K. (1984): Free air gravity anomaly of Antarctic region. Spec. Map Ser. Natl Inst. Polar Res., No. 3.

WATTS, A. B. (1978): An analysis of isostasy in the world's oceans. 1. Hawaiian-Emperor seamount chain. J. Geophys. Res., **83**, 5989–6004.

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