Geological Survey of Japan Cruise Report No. 22, p. 19-28, 1992

II. MAGNETIC AND GRAVITY ANOMALIES IN THE NOVA-CANTON TROUGH REGION, CENTRAL EQUATORIAL PACIFIC (GH82-4 AREA)

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Introduction

Measurements of magnetic and gravity anomalies were carried out in the Nova-Canton Trough region, central equatorial Pacific, during the GH82-4 cruise of the R/V Hakurei-maru as a part of the research program, "Geological Study of Deep-sea Mineral Resources." The purpose of the measurements is to present basic data for understanding better the geological history of this area and its relation to the formation of manganese nodules. Only geophysical data in this area available previously was the reconnaissance survey of Rosendahl *et al.* (1974), although the geological structure is not simple and has not been understood well. This report presents the new magnetic and gravity data and discusses the origin of the Nova-Canton Trough.

Geological setting

The Nova-Canton Trough lies in the northern part of the survey area (Figs. II-1 and II-2). The depth of the ENE-trending trough reaches 8000 m in maximum (Fig. II-2). Ridges occur on both sides of the trough. The origin of the trough and ridge system has not yet been made clear, although several models have been presented. They are an abandoned spreading ridge (Winterer, 1976), a deep slot associated with a change in spreading direction (Winterer *et al.*, 1974; Rosendahl *et al.*, 1975), and a transform fault as an extension of the Clipperton Fracture Zone (Menard, 1967) or created by the jump of a triple junction (Larson and Chase, 1972). In the south of the Nova-Canton Trough, many deep-sea hills and small seamounts occur, and gentle slopes or small basins of 5200 to 5800 m in depth occupy among them (Fig. II-2). The depth of the eastern half of the study area is slightly shallower than that of the western half. The basins and hills have a tendency of elongation in the direction normal to the strike of the Nova-Canton Trough.

The Manihiki Plateau, one of midplate swells in the Pacific, occurs to the south of this area (Fig. II-1). The Manihiki Plateau is considered to have been created at about 110 Ma at or near the triple junction among the Pacific, Antarctic, and Farallon plates (Winterer *et al.*, 1974; Jackson and Schlanger, 1976).

Mesozoic magnetic lineations known as the Phoenix lineations occur to the northwest of the study area (Fig. II-1) (Larson *et al.*, 1972). These lineations indicate that the age of the seafloor becomes younger southward. The southernmost lineation iden-

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Keywords: magnetic anomaly, gravity anomaly, Cretaceous, spreading center, transform fault, Central Pacific Basin Hakurei-Maru, Nova-Canton Trough

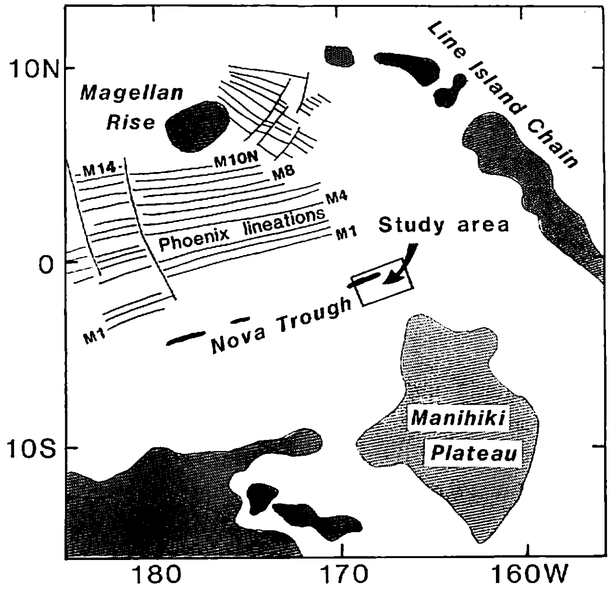

Fig. II-1 Location of study area and magnetic lineations.

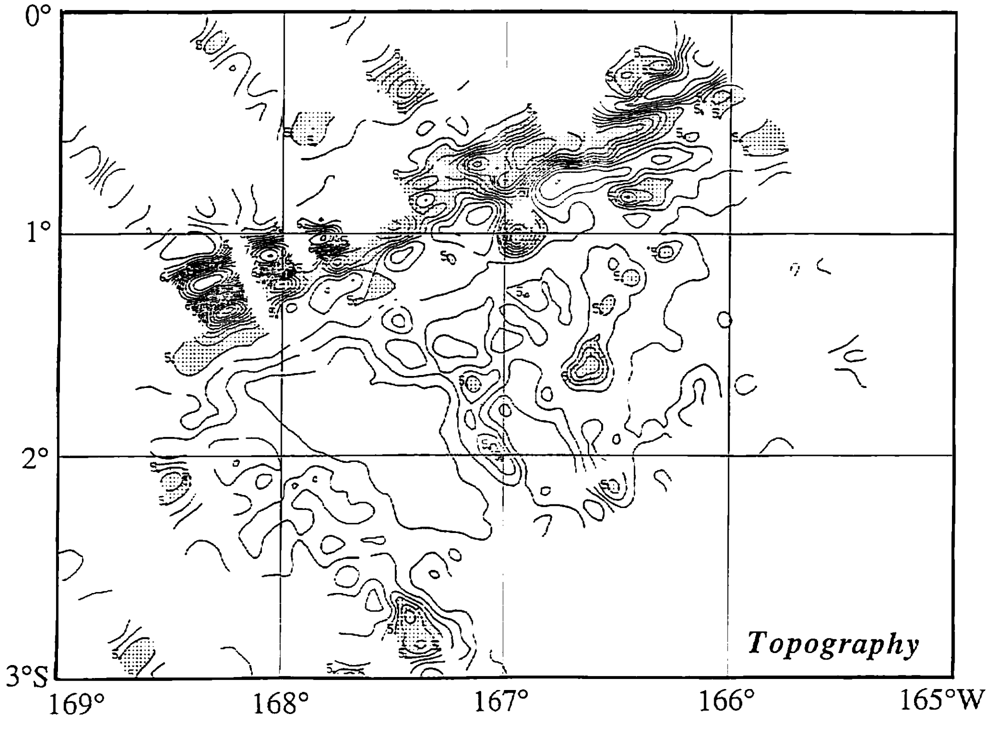

Fig. II-2 Topography of study area. Contour interval is 200 m, water depth in 1000 m. Highs shallower than 5000 m are dotted.

tified corresponds to Chron M1R (127.5 Ma, Harland *et al.*, 1990). The seafloor of the study area is thus considered to be younger than Chron M1 and older than the age of the Manihiki Plateau, that is, between 110 to 127 Ma, although magnetic lineation correlative to Chron M0 (C34R) has not been found yet.

Measurements

Magnetic total force was measured using a proton precession magnetometer (GeoMetrics G801) towed about 250 m behind the R/V Hakurei-maru. Ship's tracks of the magnetic measurement were shown in Fig. II-3. Lines of a preliminary survey during a previous GSJ cruise GH81-4 (Nakao *et al.*, 1986) are included. Residual total magnetic intensity field, that is, magnetic anomaly, was obtained by subtracting the 1985 version of the IGRF (International Geomagnetic Reference Field) (IAGA Division I Working Group 1, 1985) from the observed data. Diurnal correction was not applied.

Gravity measurements were carried out by a LaCoste-Romberg air-sea gravimeter model S-63. The gravity sensor is on a gyrostabilized platform. The gravimeter has an analog computer to calculate cross-coupling corrections. In order to suppress noise

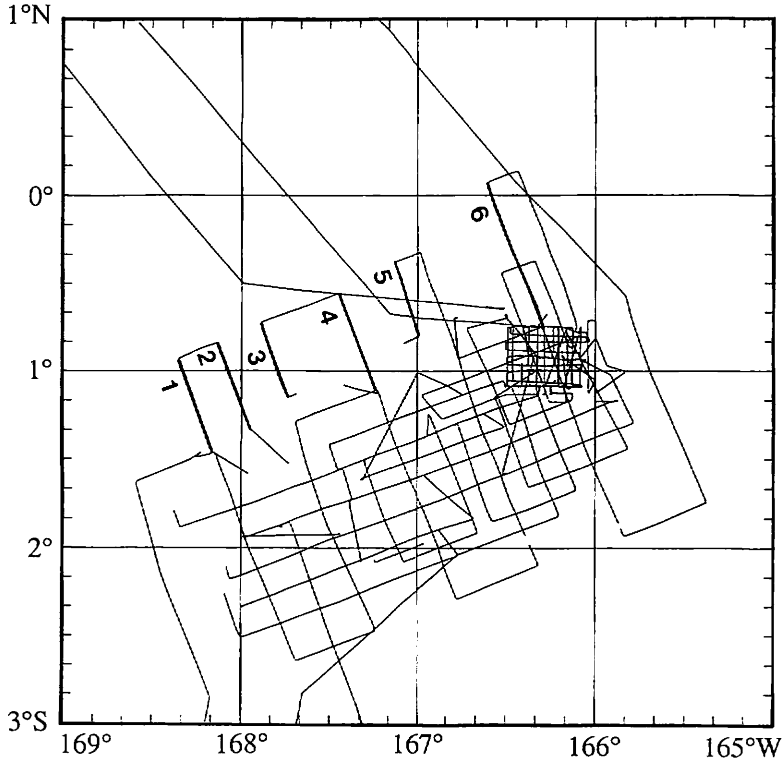

Fig. II-3 Survey lines of magnetic measurements during GH82-4 cruise. Lines of previous survey of the GH81-4 cruise are included. Bold lines with numbers indicate the location of the profiles shown in Fig. II-5.

due to ship's vertical movement an analog low-pass filter was applied to raw outputs of the sensor. The junction to the IGSN 71 system was made at Funabashi Port on the Tokyo Bay. The IAG 1967 gravity formula was used for the latitude correction. A linear drift of the gravimeter was assumed between ports.

Data were logged on magnetic tapes every 30 seconds, and finally edited as a series of records on every five minutes, which contains ship's position, speed, magnetics, gravity, and water depth. Only NNSS-satellite fixes were available for navigation in this area in 1982. The Eötvös correction for gravity anomaly, which is a function of ship's heading and velocity, is thus expected to have an accuracy of about 5 mgal.

Results and interpretation

Magnetic anomalies

Magnetic anomaly profiles along ship's tracks are presented in Figure II-4. Lineated magnetic anomalies associated with the trough and ridge system are conspicuous. The peak-to-trough amplitude of these anomalies is about 800 nT in maximum. Typical anomaly profiles across the trough are shown in Fig. II-5 with topography and free-air gravity anomalies. Positive peaks of magnetic anomalies occur south of topographic lows, and negative peaks lie south of topographic highs. In the south of the trough, negative anomalies are dominant except for the southwestern corner of the study area. Relatively short wave-length variations of the negative anomalies, the amplitude of which is about 300 nT, are observed, but no magnetic lineations can be recognized.

We have evaluated the effect of the large relief of the trough and ridge system on the magnetic anomalies by a forward modeling (Fig. II-6). The line 1 shown in Fig. II-5 was chosen for this purpose because the topographic relief is the largest there. We assumed that the thickness of the magnetized layer is 2 km, and the top of the layer coincides with acoustic basement. The relief was approximated by an assemblage of two-dimensional rectangular blocks. It was assumed that they have uniform magnetization of normal polarity and intensity of 10 A/m. The skewness parameter of $-130°$ was used, which is the same as that of the Phoenix lineations (Larson and Chase, 1972; Larson, 1976). The calculated anomalies fairly well fit the observed data. It is thus concluded that the lineated magnetic anomalies accompanied by the trough and ridge system can be explained by the effect of topography, but are not caused by a sequence of magnetic polarity reversals.

Another problem is why magnetic lineations of seafloor-spreading origin do not occur in the Nova-Canton Trough region. The age of this area is between 110 to 127 Ma based on the ages of the Phoenix lineations and the Manihiki Plateau. It is hence reasonable to consider that this area would be within the earliest part of the Cretaceous Magnetic Quiet Zone. A question why the magnetic lineation correlative to Chron M0, which should occur between the anomaly M1 of the Phoenix lineations and the Cretaceous Magnetic Quiet Zone, have not been recognized yet. We point out a possibility that original magnetic lineations may be disturbed by later volcanic and tectonic activities. Seismic reflection (Tanahashi, chapter IV of this volume) and heat flow studies (Yamazaki, chapter V of this volume) suggest such activities.

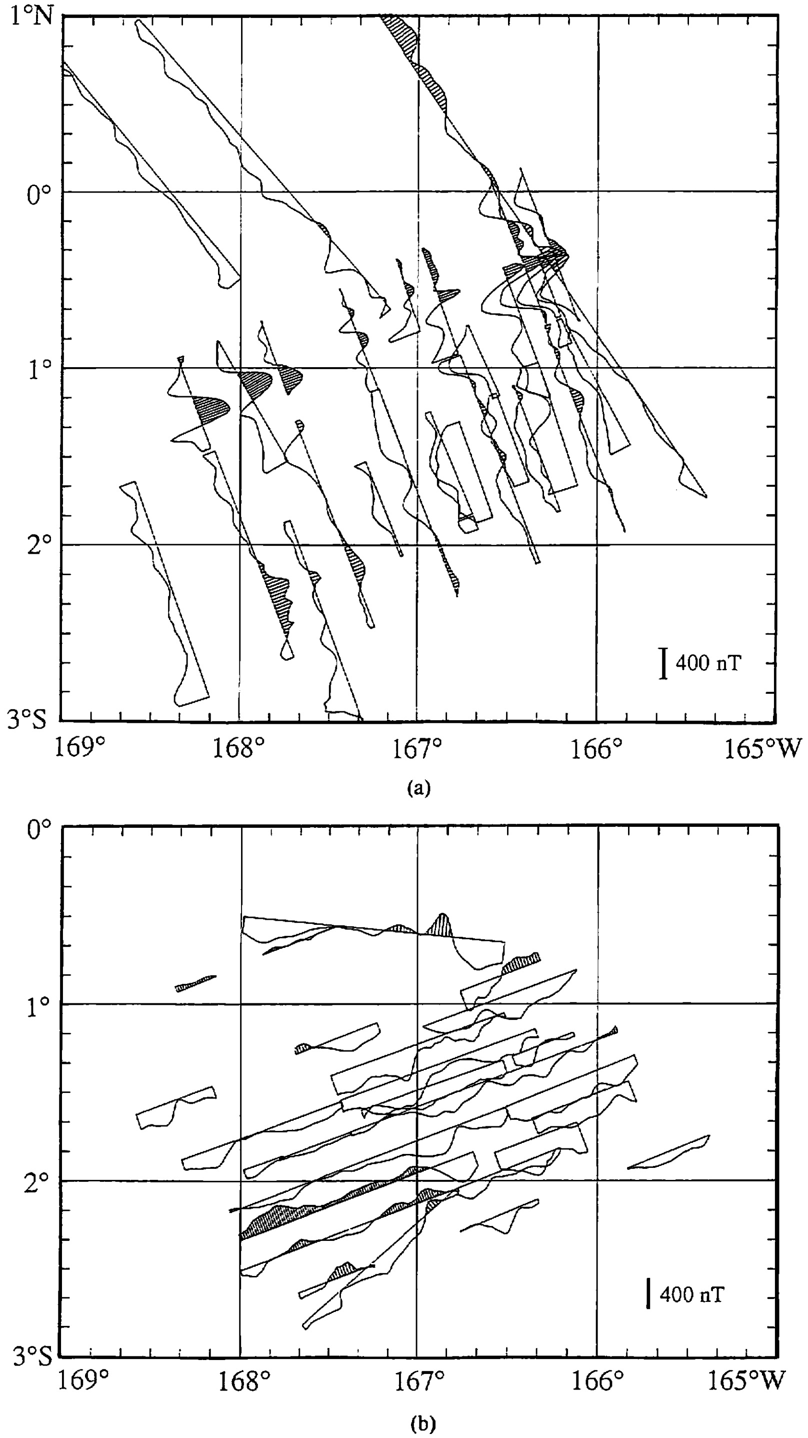

Fig. II-4 Magnetic anomaly profiles along the lines (a) normal to the strike of the Nova-Canton Trough, and (b) parallel to it. Positive anomalies are shaded.

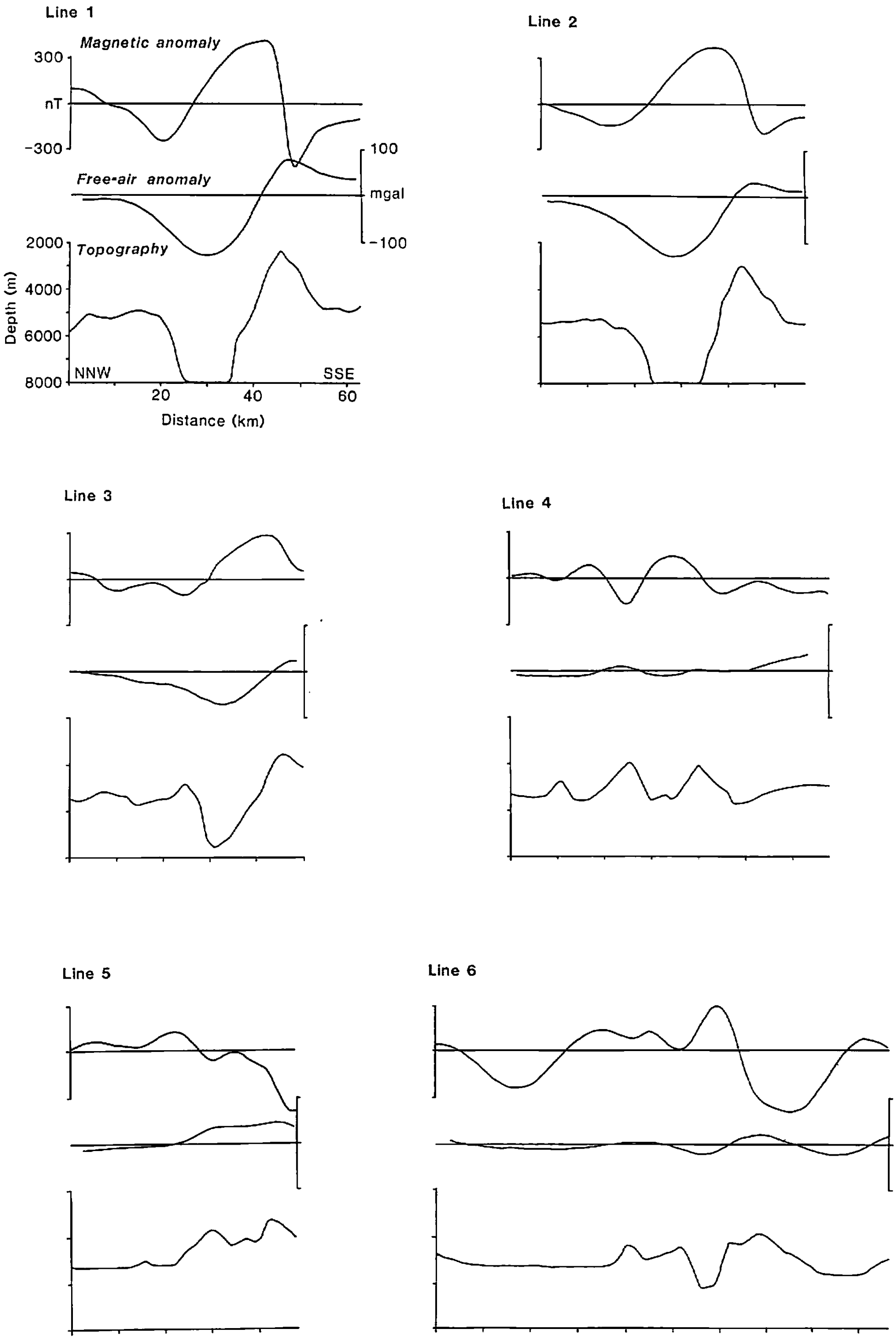

Fig. II-5 Profiles of magnetic anomaly, free-air gravity anomaly and topography along tracks across the Nova-Canton Trough. The location of these lines are indicated in Fig. II-3.

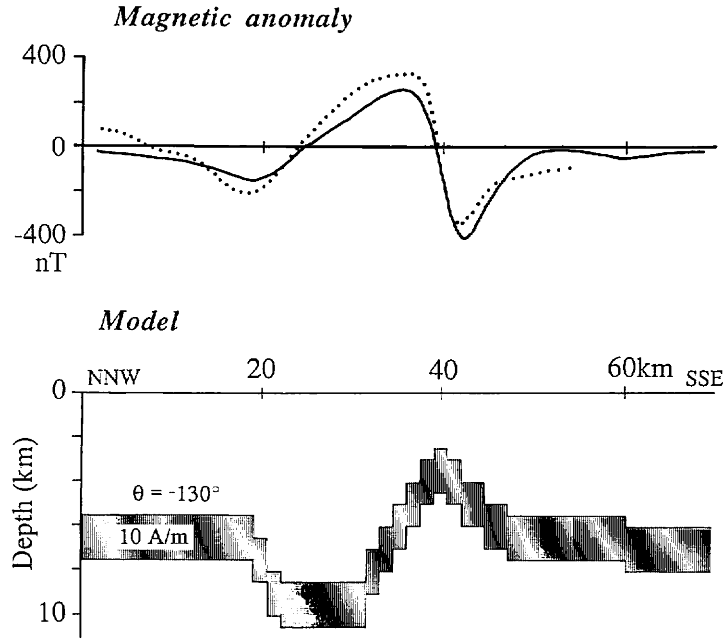

Fig. II-6 Magnetic anomalies produced by the topographic relief of the Nova-Canton Trough (Line 1 in Fig. II-5). It was assumed that a magnetized layer of 2 km thick has the intensity of 10 A/m. The skewness parameter of − 130° was adopted. A solid curve is calculated anomalies, and a dotted curve is observed anomalies.

Gravity anomalies

A contour map of free-air gravity anomalies is shown in Figure II-7. In addition to the ship's tracks presented in Figure II-3, data were collected during transit between sampling sites. Lines of two GSJ cruises, GH80-1 (Joshima and Okuda, 1982) and GH83-3 (unpublished), are also included. The trough and ridges accompany large negative and positive anomalies, respectively. On the westernmost survey line where the topographic relief is largest, the trough of 8000 m depth has an anomaly of − 120 mgal and the ridge of 2500 m has a value of 80 mgal (Fig. II-5). In the south of the Nova-Canton Trough, positive anomalies up to 20 mgal are distributed dominantly in the eastern part, and negative anomalies up to − 20 mgal are accompanied by the basins in the western part. This anomaly pattern corresponds to the slight difference in the average depth of the seafloor.

Contribution of the relief of the seafloor and crust-mantle boundary (Moho) to the free-air gravity anomalies over the Nova-Canton Trough was calculated using the two-dimensional method of Talwani *et al.* (1959). Figure II-8 shows a model which fits well the observed free-air anomalies along the line 1 in Figure II-5. The density of the crust was assumed to be 2.67 g/cm^3, and that of the mantle 3.3 g/cm^3. In this model the thickness of crust is assumed to be 5 km. This result confirms the existence of a crustal root beneath the Nova-Canton Trough, which was first proposed by Rosendahl *et al.* (1975).

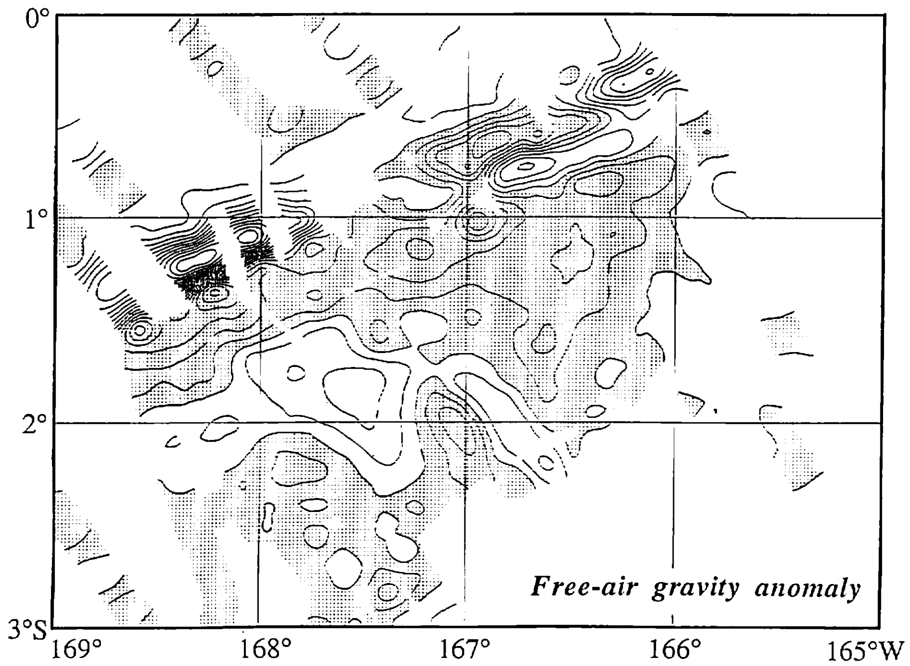

Fig. II-7 A contour map of free-air gravity anomalies. Contour interval 10 mgal. Positive anomalies are dotted. Data collected during transit between sampling sites, GH80-1 cruise (Joshima and Okuda, 1982) and GH83-3 cruises (unpublished) are included.

Discussion: origin of the Nova-Canton Trough

Magnetic and gravity anomalies can give a constraint on the origin of the Nova-Canton Trough. As mentioned before, there are two major ideas for their origin, that is, an abandoned spreading-center model and a transform-fault model. Gravity anomalies show that the thickness of the crust does not decrease beneath the Nova-Canton Trough. This result prefers the spreading-center model because occurrence of an anomalously thin crust is frequently documented at oceanic fracture zones (e.g. Prince and Forsyth, 1988). The interpretation of magnetic anomalies do not contradict to the spreading-center model. The lineated anomalies associated with the Nova-Canton Trough can be explained by the same value of the skewness parameter as the Phoenix lineations. This implies that the magnetization directions are the same between these two areas, suggesting the same rotational movement since the creation of the crusts.

A discontinuity of the axis of the Nova-Canton Trough is observed at about 1°S, 167°30′W in the middle of the study area. This locality corresponds to a structural boundary which strikes normal to the Nova-Canton Trough. This boundary can be recognized on the topography and gravity anomalies. To the west of the boundary, seafloor is deeper and free-air anomalies are dominantly negative. A steep slope of the eastern side of a NNW-trending topographic high on the boundary (centered at 2°S, 167°W) is probably of fault origin (Tanahashi, chapter IV of this volume). This bound-

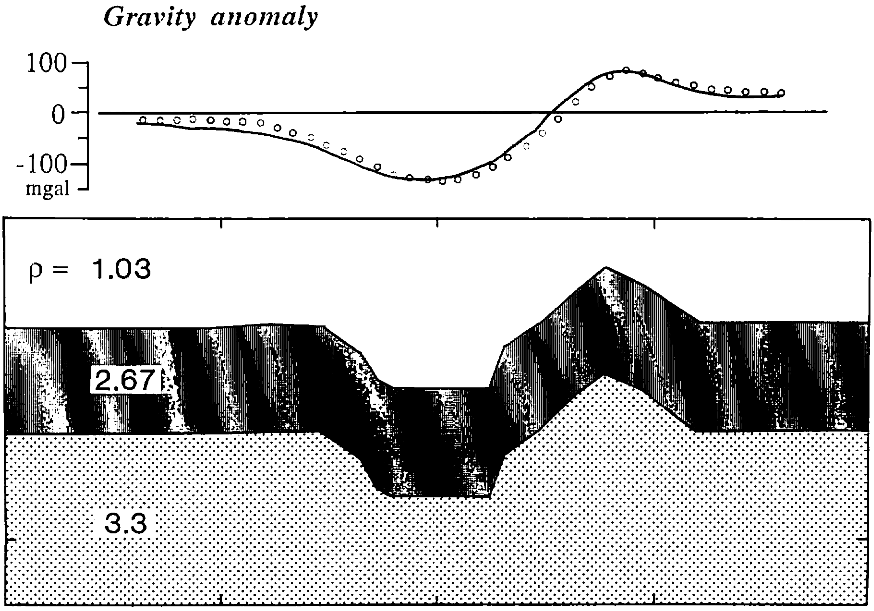

Fig. II-8 Free-air gravity anomalies and deduced lithospheric structure beneath the Nova-Canton Trough (Line 1 in Fig. II-5). A model having a constant crustal thickness of 5 km fit the observed data well. A solid curve is calculated anomalies, and open circles are observed anomalies. Densities of sea-water, crust and mantle are assumed 1.03, 2.67 and 3.3 g/cm^3, respectively.

ary may be a transform fault.

Conclusions

We interpret observed magnetic and gravity measurements on and in the south of the Nova-Canton Trough, central equatorial Pacific as follows:

1) No seafloor-spreading magnetic lineations are observed. The trough with ridges on both sides is accompanied by lineated magnetic anomalies, but they can be explained by the topographic relief. The study area would be within the earliest part of the Cretaceous Magnetic Quiet Zone.

2) Gravity anomalies over the Nova-Canton Trough show that the crustal thickness would not decrease beneath the trough. Our result prefers the abandoned spreading-center model to the transform-fault model for the origin of the Nova-Canton Trough.

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