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MEASUREMENTS AND INTERPRETATION OF GRAVITY ANOMALY IN AND AROUND ROSS ISLAND, ANTARCTICA

Satoshi MIURA[1] and Katsutada KAMINUMA[2]

[1]*Faculty of Science, Tohoku University, 14–46, Shogun-no Minami 1-chome, Akita 011*
[2]*National Institute of Polar Research, 9–10, Kaga 1-chome, Itabashi-ku, Tokyo 173*

Abstract: Gravity surveys were carried out at 11 sites in Ross Island, Dailey Islands and the Dry Valleys during the 1986–1987 field season. Bouguer anomalies in Ross Island and Dailey Islands are nearly zero, within a few tens of mgals, whereas those in the Dry Valleys show large negative values down to −170 mgal. Therefore, the anomalies change steeply from west to east. A simple model for the crust and upper mantle around the region is proposed to explain the Bouguer anomalies. According to the model calculation, a possible interpretation of the steep variation of Bouguer anomaly up to 170 mgal is attributed to the difference in depth of the Moho discontinuity. This suggests that the depth of Moho at the Transantarctic Mountains is deeper than that beneath the McMurdo Sound by about 20 km.

1. Introduction

Gravity surveys have been carried out in and around Ross Island every field season since 1982–1983 in order to investigate the subsurface structure of the most active volcano in Antarctica, Mount Erebus, in combination with the seismological observation operated by an international cooperative project named IMESS (International Mount Erebus Seismic Study) promoted by Japan, the United States and New Zealand (KAMINUMA *et al.*, 1987).

According to the recent studies (KAMINUMA *et al.*, 1984; MIURA *et al.*, 1987), the distribution of the Bouguer anomaly is relatively high around the Mount Erebus. MIURA *et al.* (1987) suggested that the volcano might be classified as a type similar to the Kilauea Volcano of Hawaii Island or the Osima Volcano of Japan. The regional tectonics around the volcano is also informative to investigate its origin and the mechanism of its activity. During the 1986–1987 field season, gravity surveys were carried out at 11 sites in Ross Island and the Dry Valleys. In this study, the distribution of gravity anomaly across the Victoria Land and the McMurdo Sound is discussed and interpreted using a simple model of the crust and the upper mantle.

2. Gravity Measurements

Gravity surveys were carried out on December 29, 1986 and January 5, 1987. Figure 1 and Table 1 show locations of gravity stations surveyed in the season. At Scott Base, Lake Brownworth, Vanda Station, Lake Bonney and Lake Fryxell, gravity was measured on bench marks whose locations and altitudes had been determined already. Locations of other stations were read from a topographical map and altitudes, estimated using barometric altimeters. With calibrations by taking difference between readings at gravity stations and those at sea or lake level, the accuracy of altitudes at each site is estimated within 5 m.

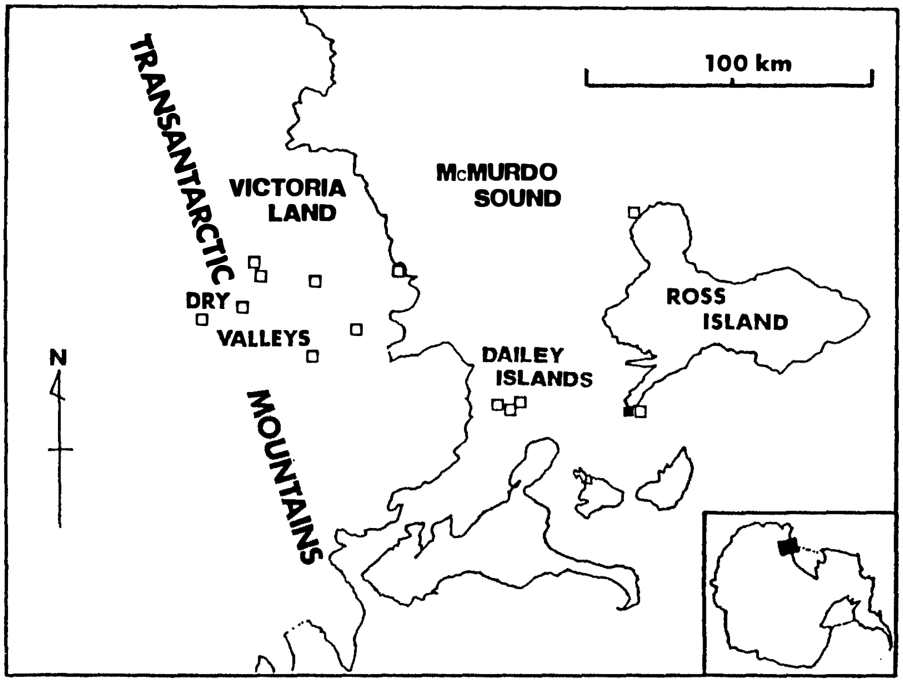

Fig. 1. Locations of gravity stations in Ross Island and Dry Valleys (open squares). A solid square indicates a location of the absolute gravity station 59676C at McMurdo Station. Surveys were carried out on December 29, 1986 and January 5, 1987 using a LaCoste gravimeter, G-682.

Table 1. Results of gravity measurements in Ross Island, McMurdo Sound and Victoria Land.

Station name	Gravity value (mgal)	Free-air anomaly (mgal)	Simple Bouguer anomaly (mgal)	Latitude (deg min)	Longitude (deg min)	Height (m)
Scott Base	982972.319	−3.534	−7.249	77 50.9 S	166 45.0 E	33.20
Lake Brownworth	982807.460	−73.285	−105.816	77 26.2	162 41.3	290.79
Vanda Station	982809.336	−135.292	−145.866	77 31.4	161 40.4	94.52
Don Juan Pond	982780.375	−155.211	−169.642	77 33.9	161 11.3	129.00
Lake Bonney	982833.825	−127.281	−134.388	77 42.3	162 30.4	63.53
Lake Fryxell	982877.870	−93.631	−95.753	77 37.0	163 4.6	18.97
Cape Bird	982969.923	8.129	7.950	77 13.6	166 24.4	1.60
Lake Vida #1	982772.873	−87.333	−126.611	77 23.2	161 50.5	351.10
Lake Vida #2	982774.627	−85.957	−125.426	77 24.6	161 57.3	382.80
Marble Point	982936.517	−24.642	−27.663	77 24.7	163 40.2	27.00
Dailey Is. #1	982981.232	−5.491	−5.693	77 52.8	164 53.4	1.80
Dailey Is. #2	982979.815	−6.785	−7.054	77 52.9	165 1.3	2.40
Dailey Is. #3	982975.877	−9.821	−10.101	77 51.5	165 13.8	2.50

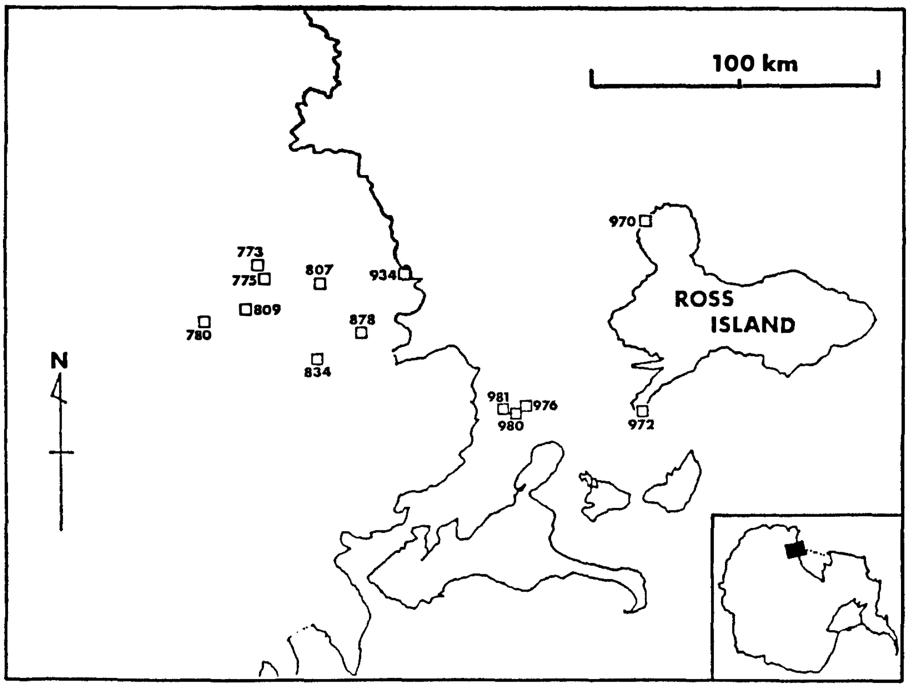

Fig. 2. Gravity values at each station. Values subtracted 982000 mgal are denoted in mgal units. The absolute gravity value, 982969.771 mgal at the gravity station 59676C in McMurdo Station was taken as a standard value. All the gravity values were determined by relative measurements to this station.

Every survey started from the bench mark set at the seismological observatory of WWSSN (World Wide Standardized Seismograph Network) near Scott Base (SBA) and ended at the same place to detect the instrumental drift of the gravimeter. Closing error in each survey was within 1 mgal. The gravity value on each bench mark was determined with reference to the absolute gravity station 59676C at Earth Science Laboratory of McMurdo Station, whose gravity value of the IGSN71 (International Gravity Standardization Net 1971) is 982969.771 mgal. Locations, observed gravity values and calculated anomalies are tabulated in Table 1. Figure 2 shows gravity values at each station.

3. Distribution of Gravity Anomaly

Figure 3 shows the distribution of Bouguer anomaly at each station without terrain correction. In Ross Island and Dailey Islands, the anomalies are less than ± 10 mgal, whereas large negative anomalies appear in the Dry Valleys, and the tendency that the anomalies decrease in proportional to the distance from the coast line is clearly recognized. This pattern of anomaly has already been pointed out by SMITHSON (1972).

Gravity anomalies are projected in the east-west profile in Fig. 4. Gravity data in the eastern part of Ross Island derived from the previous work (MIURA *et al.*, 1987) are also included in the same figure. The Bouguer anomaly varies with a large gradient from large low values in the Dry Valleys to relatively high values around zero over the McMurdo Sound. According to the gravity anomaly map published by Geophysics

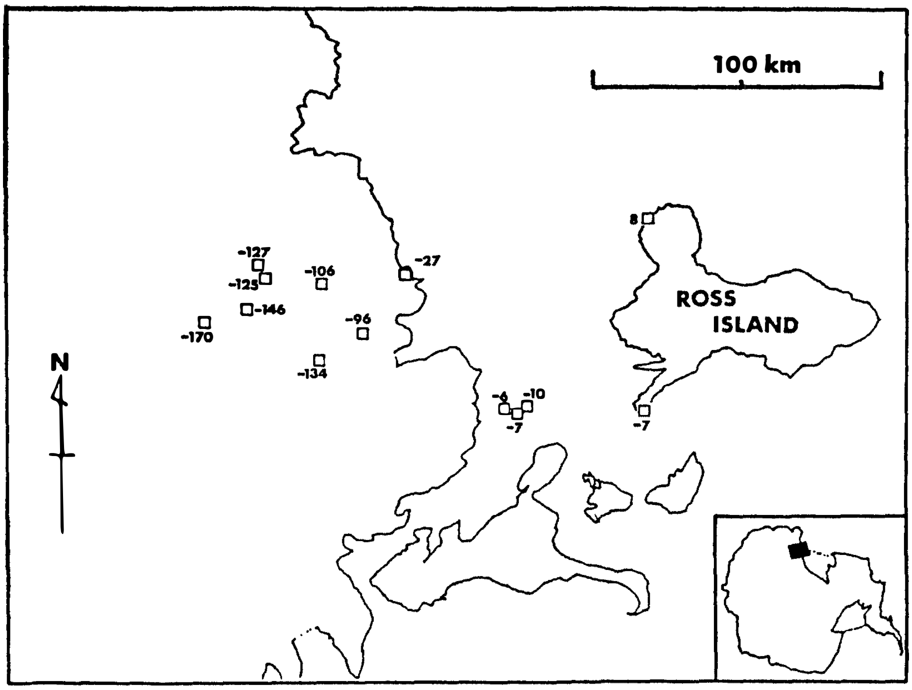

Fig. 3. Simple Bouguer anomaly distribution in Ross Island and Dry Valleys. Unit is in mgal.

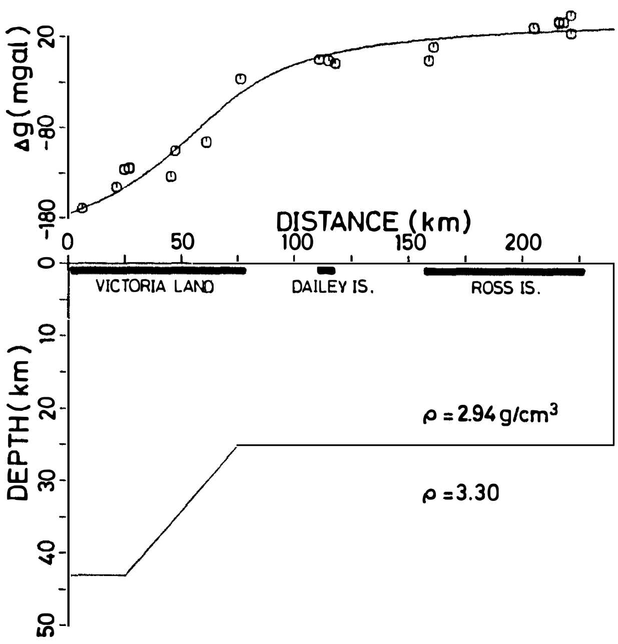

Fig. 4. Profile of the simple Bouguer anomaly along the east-west direction (open circles) and that of a computed gravity anomaly (a solid curve) using a simple crustal model shown in the lower part. Gravity data in the eastern part of Ross Island from the recent work carried out by MIURA *et al. (1987) are also included.*

Division, DSIR (Department of Scientific and Industrial Research), New Zealand (1987), the anomaly on the ice shelf around the McMurdo Sound is consistent with this pattern, showing that regional contours of the Bouguer anomaly are parallel to the coast line and the anomaly decreases steeply from west to east. This suggests that the depth of the Moho generally deepens from west to east across Ross Island and the Transantarctic Mountains. In the next section, a possible interpretation is presented by the use of a rather simple crustal model.

4. Interpretation

Figure 4 shows a calculated gravity profile by a solid curve together with the observed gravity anomalies (upper figure) and a model of the crust and the upper mantle used in the two-dimensional computation (lower figure).

In this study, since we do not have many data so as to discuss short wavelength anomalies, we modeled only the Moho depth. MCGINNIS *et al.* (1983) reported the Moho depth of 25 km beneath the McMurdo Sound from their seismic refraction experiments. For the computation, we assume the same Moho depth beneath the McMurdo Sound and also assume the same densities of 2.94 and 3.3 g/cm^3 for the crust and the upper mantle, respectively. We determine the Moho depth underneath the Victoria Land to fit the calculated anomaly to the observed anomaly pattern, assuming that the Moho continues farther east and west with the same depths. Eventually the appropriate Moho depth in the western part is determined as 43 km. In spite of the simplicity of the model, the fitness of the calculated data to observe anomaly is excellent as shown in Fig. 4.

5. Conclusion

A crustal model across the Victoria Land and the McMurdo Sound is proposed by the analysis of gravity data obtained from surveys carried out in the 1986–1987 field season. Using the results of seismic refraction experiments (MCGINNIS *et al.*, 1983), the crustal thickness beneath the Victoria Land is estimated as 43 km. The difference of the Moho depth should be closely related to the regional tectonics, such as the origin of the Transantarctic Mountains and the Ross Sea, the existence of active volcanoes around the Victoria Land, and so on.

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