A PRELIMINARY REPORT OF THE GRAVITY SURVEY IN ROSS ISLAND, ANTARCTICA

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Abstract: Gravity surveys were carried out on Ross Island during the austral summer of 1982–1983. Twenty-one gravity stations were established in the summit area of Mount Erebus and eleven stations in the other area of Ross Island. The Bouguer gravity anomaly distribution shows a possibility of the maximum positive anomaly in the northeast side of the Erebus main crater, though the gravity stations are sparse there. This might be due to the fact that the structure of Mount Erebus is not a caldera type but nearly of the same type as the Kilauea Volcano of Hawaii Island and the O Sima Volcano of Japan.

1. Introduction

Ross Island with four major volcanoes is one of the volcanic islands in the McMurdo Sound area, Antarctica, on the southwest edge of the Ross Sea. Mount Erebus (3794 m) is at present the only active volcano not only in Ross Island but also throughout Antarctica. A radio-telemetered seismic network has been established on Ross Island for monitoring the seismic activity of Mount Erebus and in the surrounding area. The continuous seismic observation was started in December 1980 as an international cooperative program (IMESS: International Mount Erebus Seismological Study) of Japan, the United States and New Zealand.

One of the purposes of IMESS is to identify the structure of Mount Erebus. Gravity surveys for revealing the structure were carried out in Ross Island during the austral summer of 1982–1983. Twenty-one gravity stations were established in the summit area and eleven stations including McMurdo in the other area of Ross Island. All measurements were started from the absolute gravity base station 59676C, the bench mark at Earth Sciences Laboratory of McMurdo Station, and ended by calibrating the values there. The location of 59676C is 77°51.0'S, 166°40.4'E and 43.18

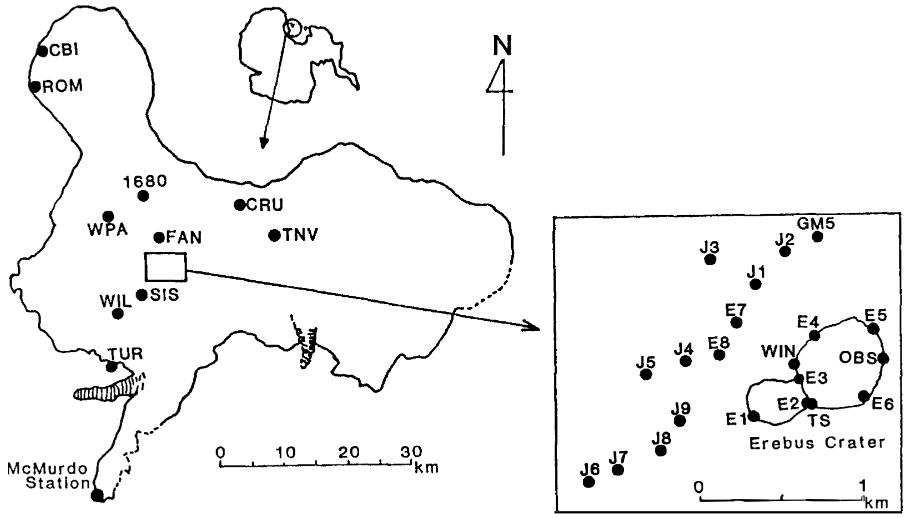

Fig. 1. Locations of gravity stations in Ross Island, Antarctica.

m in elevation above mean sea level, and its gravity value of the IGSN71 (International Gravity Standardization Net 1971) is 982969.771 mgal. The location of gravity stations is given in Fig. 1.

2. Survey

The gravity surveys in the summit area were carried out on 23–25 December, 1982. The locations of the measurement points are given in the square of Fig. 1. The location and elevation of the measurement points were determined on the 1: 5000 topographic map of "Mt. Erebus, Antarctica" which was published by Department of Lands and Survey, New Zealand. This map has a contour interval of 5 m. The elevation at a triangulation point is given with the order of 1 cm and of 10 cm at a noticeable outcrop on the map. The measurement points were selected at the triangulation points or the noticeable outcrops. Then accuracy of elevation at the gravity station in the summit area was estimated to be better than 1 m.

The gravity stations in the other area were mostly at the same points of the temporary seismic stations, of which location and elevation were determined on the 1: 250000 topographic map of Ross Island (UEKI *et al.*, 1984). This map was published by the U.S. Geological Survey and had a contour interval of 200 m. The location of the gravity stations on Ross Island except the summit area is given in the left part of Fig. 1. Elevation of the gravity stations was measured by a barometric altimeter. The measurements of gravity and elevation at five stations out of eleven, however, were carried out twice. The elevations of the two different measurements at the same stations corresponded to each other within about 10 m, except one station named Williams' Cliff, a southwestern flank of Mount Erebus. The elevation corrections for the air pressure change during the survey were made using the barogram at Scott Base. So, the accuracy of elevation at each station was estimated to be better than 10 m and that at Williams' Cliff was 30 m. The gravity values at each station with their locations are given in Table 1.

Table 1. List of gravity stations.

Station	Gravity (mgal)	Free air anomaly	Simple Bouguer anomaly	Bouguer anomaly	Latitude (S)	Longitude (E)	Height (m)	Normal gravity
McMurdo (MCM)	982969.771	−3.065	−7.896	16.307	77°51.0′	166°40.4′	43.18	982987.027
Turkshead (TUR)	982947.169	18.388	0.085	20.996	77 40.0	166 46.1	163.60	982980.122
Abbottwest (WPA)	982684.102	175.416	7.685	70.031	77 27.4	166 47.3	1499.30	982972.095
Romanesbeach (ROM)	982967.664	22.795	15.770	31.197	77 16.6	166 21.2	62.80	982965.113
Capebird 1 (CBI)	982966.337	20.304	14.386	24.964	77 13.7	166 25.0	52.90	982963.223
1680 Point (1680)	982641.750	201.462	9.231	68.047	77 26.1	167 0.7	1718.30	982971.259
Wilicliff (WIL)	982731.327	122.023	−11.005	39.828	77 35.1	166 46.6	1189.10	982977.016
Crashsite (CRU)	982810.494	108.716	11.286	−11.101	77 26.2	167 8.6	870.90	982971.324
Fangridge (FAN)	982448.734	303.728	3.673	103.285	77 29.3	167 5.7	2682.10	982973.313
Sisters (SIS)	982586.623	192.678	−18.169	42.653	77 33.9	166 57.9	1884.70	982976.252
Terranova (TNV)	982767.287	157.501	26.106	59.150	77 28.8	167 51.9	1174.50	982972.993
E7	982160.700	301.556	−102.440	76.360	77 30.5	167 8.4	3611.20	982974.082
E8	982156.980	300.141	−104.784	71.034	77 30.9	167 8.3	3619.50	982974.338
E1	982124.900	296.269	−119.093	66.288	77 31.8	167 8.4	3712.80	982974.913
E2	982103.770	297.138	−126.178	66.401	77 31.7	167 8.6	3783.90	982974.848
E6	982103.304	297.785	−125.912	66.525	77 31.6	167 8.8	3787.30	982974.785
Obspoint (OBS)	982117.333	301.338	−118.421	71.067	77 31.0	167 8.8	3752.10	982974.401
E5	982111.484	301.544	−120.318	74.785	77 30.6	167 8.8	3770.90	982974.146
E4	982110.844	300.657	−121.115	74.016	77 30.6	167 8.6	3770.10	982974.146
Transsite (TS)	982093.660	287.028	−136.288	56.291	77 31.7	167 8.6	3783.90	982974.848
E3	982111.770	300.488	−121.049	69.157	77 31.3	167 8.6	3768.00	982974.593
Winchsite (WIN)	982122.199	300.988	−116.903	70.326	77 31.1	167 8.6	3735.40	982974.465
J1	982165.350	303.752	−99.214	87.640	77 29.9	167 8.4	3602.00	982973.697
J2	982158.995	302.898	−101.970	94.127	77 29.5	167 8.5	3619.00	982973.441
GM5	982175.375	307.315	−93.146	104.776	77 29.2	167 8.6	3579.60	982973.249
J3	982184.116	302.876	−92.875	94.307	77 29.5	167 8.3	3537.50	982973.441
J4	982173.022	299.923	−99.128	70.263	77 31.0	167 8.2	3567.00	982974.401
J5	982184.119	297.009	−97.007	66.565	77 31.2	167 8.1	3522.00	982974.529
J8	982167.901	293.722	−105.262	70.976	77 32.4	167 8.1	3566.40	982975.296
J7	982175.906	290.306	−104.605	73.284	77 32.7	167 8.0	3530.00	982975.487
J6	982180.264	290.900	−102.646	73.992	77 32.7	167 7.9	3517.80	982975.487
J9	982176.413	295.520	−100.914	66.603	77 31.9	167 8.2	3543.60	982974.976

3. Gravity Anomalies in the Summit Area

The elevation of the stations in the summit area ranges from 3500 to 3700 m. The stations are located around the crater rim and on the western and the north-western slopes of the crater. Free air anomaly, simple Bouguer anomaly and Bouguer anomaly with terrain corrections in the summit area are given in Table 1 and Bouguer anomaly is shown in Fig. 2. Terrain corrections here were of nearly the same method as the one that MATSUMOTO applied to the submarine gravity measurements (TALWANI and EWING, 1960; MATSUMOTO, personal communication). This terrain correction excludes the effects of both the mountain body and the island itself, not only from the observation point up to the summit and/or the highest point of the island but also from the observation point down to the sea level. The corrections assumed a basement density of 2.40 Mg/m^3 which seems reasonable one in the volcanic area.

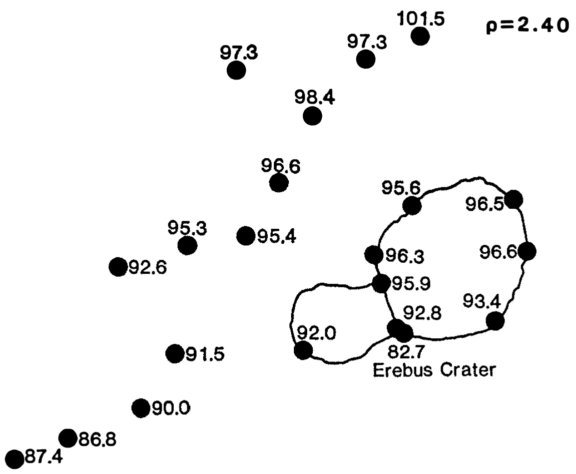

Fig. 2. Bouguer anomaly in the summit area. Basement density $\rho=2.40$ Mg/m^3.

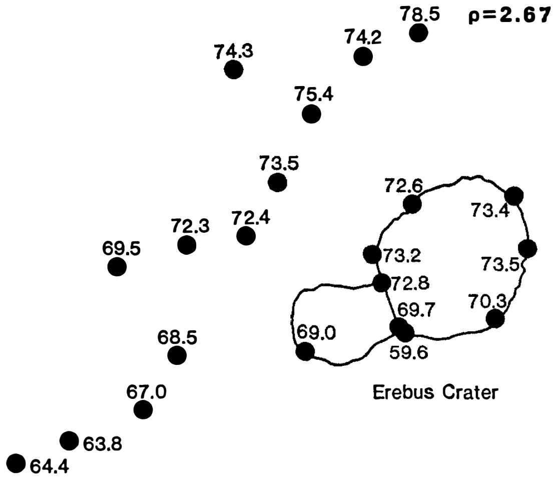

Fig. 3. Bouguer anomaly in the summit area. Basement density $\rho=2.67$ Mg/m^3.

Free air anomalies in Table 1 range from 287.0 to 307.3 mgal and simple Bouguer anomalies from −92.9 to −136.3 mgal. Bouguer anomalies with terrain correction in Fig. 2 range from 82.7 to 101.5 mgal. If the corrections assumed a basement density of 2.67 Mg/m^3, the Bouguer anomalies would range from 59.6 to 78.5 mgal as shown in Fig. 3. As the basement density of Mount Erebus is still unknown, the absolute values of the Bouguer anomalies may be changed in the future study.

4. Gravity Anomalies in Ross Island

The locations of the ten gravity stations in Ross Island are shown in Fig. 1. Free air anomalies in Ross Island range from −3.0 up to 303.7 mgal as given in Table 1.

Bouguer anomalies with terrain correction are shown in Fig. 4. The corrections assumed the basement density of 2.67 Mg/m^3. In Fig. 5, Bouguer anomalies with terrain correction assuming the density of 2.40 Mg/m^3 are also given.

The maximum positive anomaly in Figs. 4 and 5 was 103.3 and 123.6 mgal at

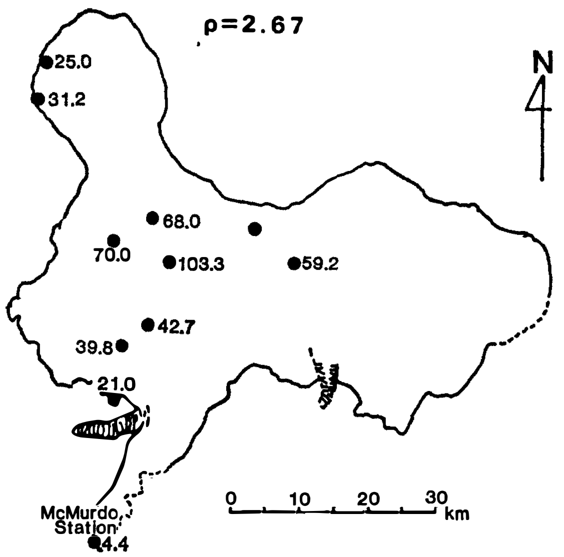

Fig. 4. Bouguer anomaly in Ross Island. Basement density ρ=2.67 Mg/m³.

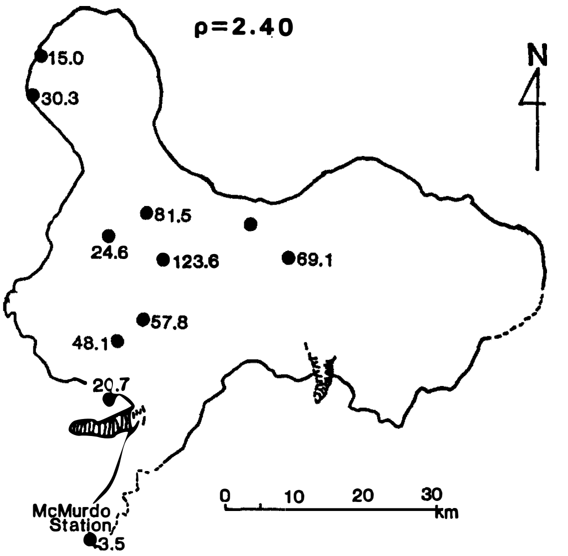

Fig. 5. Bouguer anomaly in Ross Island. Basement density ρ=2.40 Mg/m³.

Fang station which is located 5 km north of the summit crater. Considering the Bouguer anomalies in the summit area in Figs. 2 and 3, the maximum positive anomaly area is estimated to be located in the northeastern flank of Mount Erebus. This tendency of Bouguer anomaly distribution in Figs. 2–5 shows that the structure of Mount Erebus is not a caldera type but is nearly of the same type as the Kilauea Volcano of Hawaii Island (KINOSHITA *et al.*, 1974) and the O Sima Volcano of Japan (YOKOYAMA, 1969), because the Bouguer anomalies in Figs. 2 and 3 show the possibility of the maximum positive anomaly in the northeast side of the main crater. The scale of the positive anomaly however, is not clear at present because of the lack of data on the east side of the crater. A detailed analysis is one of the future problems.

5. Conclusion

The gravity anomalies of Mount Erebus and Ross Island were calculated in this study. Only the anomaly values are given in the present paper. This gravity survey of Mount Erebus and Ross Island has shown at least that the structure of Mount Erebus is not a caldera type because of the existence of a positive Bouguer anomaly area in a relatively high part of the northern flank of Mount Erebus. However, the number of gravity stations in the mountain area is less than 30 and no gravity stations are located in the eastern flank and the southern flank of the mountain. There would be many difficulties in establishing gravity stations in the mountain area, but more gravity stations are required for the detailed structure analysis.

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