DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Principal Facts for 64 Gravity Measurements in the vicinity of Beardmore Glacier, McMurdo Station, and CASERTZ Field Camp, Antarctica

by

R.W. Saltus[1], G. Perasso[1], K. Covert[1], M. Hower[1], and R.P. Kucks[1]

Open-File Report 92-322

[1] *Denver, Colorado*
1992

Abstract

This report describes data for 64 gravity measurements made during three field seasons in Antarctica. In 1985-1986, 19 measurements were made in McMurdo and in the vicinity of the Beardmore field camp. In 1986-1987, 34 measurements were made in McMurdo and in the vicinity of the Dry Valleys. In 1991-1992, 11 measurements were made in McMurdo and in the vicinity of the CASERTZ field camp. The measurements were made by U.S. Geological Survey personnel with Lacoste and Romberg gravity meters G-17, G191, and G192. Elevation control is from Doppler, vertical angle, and GPS satellite positioning. Tables in this report list principal facts and reduced free-air and simple Bouguer (no ice correction applied) anomalies on the IGSN 71 datum. Page-sized plots show the measurement site locations and locations of previous gravity measurements in the same regions.

Gravity Data Collection

The gravity measurements in this report were made in three field seasons, 1985–86, 1986–87, and 1991–92 (Fig. 1). In the first two seasons, gravity data were collected in conjunction with U.S. Geological Survey geodetic control surveys. During the 1991–92 season, gravity measurements were made to provide base ties for the CASERTZ (Corridor Aerogeophysics of the Southeast Ross Transect Zone) airborne geophysical survey.

1985–86 field season

In the 1985–86 season, Gary Perasso and Marguerite Hower (both with U.S. Geological Survey, National Mapping Division) made measurements with Lacoste and Romberg meters G-17 and G-192 in the vicinity of the Beardmore glacier camp and at selected horizontal traverse stations to the north, terminating in an area on the Nimrod glacier (Fig. 2). Previous gravity measurement locations and free air anomalies in the same vicinity (from the Defense Mapping Agency (DMA) data set on the National Geophysical Data Center CD-ROM (Hittelman, et al., 1992)) are shown on Figure 3. The main base station for this work was the benchmark "SEISMIC" in the back of the Thiel Earth Sciences Laboratory. The field base was the station "BEARD" on the Bowden Neve at the Beardmore South Field Camp. The Beardmore base station was a wooden platform inside a Hex tent set in the snow. The field base station was tied to the McMurdo base with four one-way ties, one with each meter at the beginning and end of the field season. The gravity measurements were taken at USGS triangulation stations reached by helicopter from Beardmore camp. The sites are on rock in mountainous regions and are monumented with USGS benchmarks (complete benchmark names are given in the Appendix). Elevations are from processed geodetic control data based on Doppler and vertical angle traverses (James E. Stoner, USGS National Mapping Division, personnal communication, March 1988).

1986–87 field season

In the 1986–87 season, Kathy Covert (U.S. Geological Survey, National Mapping Division) made measurements with Lacoste and Romberg meter G-17 in the vicinity of McMurdo station and the Dry Valleys (Fig. 4). Previous gravity measurement locations and free air anomalies in the same vicinity (from the DMA gravity data base, Hittelman et al., 1992) are plotted on Figure 5. The main base station for this work was the benchmark "SEISMIC" in the back of the Thiel Earth Sciences Laboratory. The gravity measurements were taken at USGS triangulation stations reached by helicopter from McMurdo Station. The sites are on rock in mountainous regions and are monumented with USGS benchmarks (complete benchmark names given in the Appendix). Elevations are from processed geodetic control data based on Doppler and vertical angle traverses. (James E. Stoner, USGS National Mapping Division, personnal communication, March 1988).

1991–92 field season

In the 1991–92 season, Richard Saltus and Robert Kucks (U.S. Geological Survey, Geologic Division, Branch of Geophysics) made measurements with Lacoste and Romberg meter G-191 at several sites surrounding the CASERTZ base camp (Fig 6). Previous gravity measurement locations and free air anomalies in the same vicinity (from the DMA gravity data base, Hittleman et al., 1992) are plotted in Figure 7. The main base station for this work was the concrete slab in the gravity base station hut at McMurdo (Building 57 - sometimes called "Hugo's hut"). The field base station was the site "CTZ" on a wooden pier embedded in the snow. This base was tied to the McMurdo base with two one-way ties, one at the beginning and one at the end of the field season. The "CTZUP" site was at the initial height of the base pier before it was cut off at floor level in the "Science Jamesway" hut at CASERTZ camp. The "CTZ" site was several feet higher than the base station site for the 1990–91 CASERTZ camp (because of snow accumulation between the two seasons). The "NVR" sites were at the locations of remote navigation beacons set up for the 1991–92 aerogeophysical survey. These beacons were removed at the end of the field season. The sites were reached with ski-equipped aircraft (DeHaviland Twin Otter). Elevation and position control is from a Global Positioning System (GPS) survey by the Naval Research Laboratory (James Jarvis, Naval Research Laboratory, personnal communication, 1991).

Gravity Data Reduction

Observed gravity values were obtained from the gravity meter readings using the calibration tables provided by Lacoste and Romberg for each gravity meter. Secondary calibration factors, as determined by USGS calibration, of 1.00252 for G-17 and 1.000412 for G-192 were used in addition to the factory calibration tables. Gravity meter drift was modeled by a splined curve through the base station readings for each entire season for each meter. Typical daily drift rates observed were about 0.01 mGal/hour and base stations were visited about once a day during surveys, so average errors of about 0.1 mGal are expected in the observed gravities reported here.

Bouguer gravity anomalies were calculated using the 1967 Geodetic Reference System formula (International Association of Geodesy, 1971) using Branch of Geophysics software (methods as described in Cordell et al., 1982) modified for use in Antarctica. The measurements are tied to International Gravity Standardization Network of 1971 (IGSN 71, Morelli, 1974) values for base stations "SEISMIC" (at Thiel Laboratory) and "BLD57" (at Building 57) at McMurdo Station. The assumed values for these base stations are given in table 1 (values from Charles Bentley, University of Wisconsin, personnal communication). A Bouguer reduction density of 2.67 g/cm^3 was used to calculate the simple Bouguer anomalies. An Earth curvature correction is included in the simple Bouguer anomaly. No attempt has been made to make terrain corrections or ice thickness corrections to these data. Terrain corrections are likely to exceed 10 mGal in some of the mountainous sites.

Table 1: IGSN 71 Base Station Values at McMurdo Station

Station	*Location*	*Latitude*		*Longitude*		*Elevation*	*Obs. Gravity*
		deg	*min*	*deg*	*min*	*meters*	*mGal*
SEISM	Benchmark behind Thiel Lab	-77	53.11	166	45.30	47	982,969.85
BLD57	Building 57 - "Hugo's Hut"	-77	50.86	166	40.47	35	982,972.72

The lack of ice thickness corrections is particularly important for the 1991–92 data set in the CASERTZ vicinity. Previous gravity data from over-snow traverses typically contain an ice correction to the simple Bouguer anomaly, so the Bouguer values given here will be much lower than the older data. When ice thickness estimates have been computed from the airborne radar collected during the CASERTZ 1991–92

season, these corrections will be made. Data from the 1985–86 and 1986–87 seasons were collected on rock sites, so the lack of ice correction is justified for those data.

Gravity Data Table

The gravity data table contains the principal facts and reduced gravity anomalies for the three surveys. The station name is a five-letter abbreviation, complete station names for USGS triangulation sites are given in the Appendix. Latitudes and longitudes are reported in degrees and minutes to the nearest hundredth of a minute. Elevations are given in both feet and meters. Gravity anomalies are reported in mGals (1 mGal = 10^{-5} m/s^2) to the nearest hundredth. *OG* is observed gravity, *FAA* is free air anomaly, and *SBA* is simple Bouguer anomaly. The last column of the table, *n*, is the number of readings averaged in the reported value; a '*' in that column indicates a base station.

Table 2: Gravity Measurements in the Vicinity of McMurdo Station, Beardmore Glacier, and CASERTZ field camp

Station	*Latitude*		*Longitude*		*Elev.*		*OG*	*FAA*	*SBA*	*n*
	deg	*min*	*deg*	*min*	*ft*	*m*	*gravity in mGal*			
McMurdo area sites (1985–86)										
CAMPA	-77	50.88	166	40.23	167	50.9	982969.51	-1.75	-7.52	2
CRATE	-77	50.32	166	43.45	986	300.5	982908.48	14.54	-19.50	1
HUTPT	-77	50.82	166	37.94	40	12.2	982976.25	-6.90	-8.29	1
RM2	-77	49.48	166	40.60	929	283.2	982911.80	13.03	-19.05	1
SEISM	-77	53.11	166	45.30	153	46.6	982969.85	-4.11	-9.40	*
Beardmore area sites (1985–86)										
BEARD	-84	0.23	164	24.71	5850	1783.1	982594.31	-17.01	-218.03†	*
CHA	-83	58.65	160	10.45	8572	2612.7	982451.28	96.00	-197.78	4
DEMPS	-84	22.15	164	55.15	12556	3827.1	982167.50	178.89	-249.78	3
DENIS	-84	11.80	160	57.39	8819	2688.0	982438.14	101.97	-200.20	3
DORA	-83	43.29	164	8.59	5970	1819.7	982613.14	18.53	-186.58	2
JESSI	-83	12.49	158	6.49	7568	2306.7	982485.86	51.86	-207.76	4
KRIST	-84	8.21	163	14.77	7486	2281.7	982527.60	67.39	-189.44	4
MAUDE	-83	27.28	166	51.92	8868	2703.0	982422.03	104.87	-198.96	1
NIMRO	-82	33.47	159	46.36	4268	1300.9	982720.17	-9.18	-156.05	1
NORTO	-83	54.17	158	56.62	8697	2650.8	982444.16	102.05	-195.97	4
POP	-82	52.35	157	27.70	6606	2013.5	982538.89	21.90	-204.93	3
SWINF	-84	26.63	167	22.07	9544	2909.0	982387.53	114.97	-211.81	1
UKE	-83	50.32	162	30.39	7335	2235.7	982531.10	62.37	-189.31	4
VANES	-83	30.68	160	47.18	8559	2608.8	982455.62	108.31	-185.03	2
McMurdo area sites (1986–87)										
ABBOT	-77	27.42	166	54.55	5880	1792.2	982602.86	183.16	-18.88	1
ASTRO	-77	31.62	161	40.79	309	94.2	982807.97	-137.79	-148.46	2
BIRDA	-77	16.09	166	21.70	93	28.3	982968.69	12.65	9.43	1
BOOTS	-77	30.78	169	19.96	1213	369.7	982891.80	31.53	-10.33	1

†= ice correction needed.

Table 2 - continued

Station	*Latitude*		*Longitude*		*Elev.*		*OG*	*FAA*	*SBA*	*n*
	deg	*min*	*deg*	*min*	*ft*	*m*	*gravity in mGal*			
McMurdo area sites (1986-87) - continued										
BRATI	-78	0.35	165	33.10	105	32.0	982960.31	-22.65	-26.27	1
BROWN	-77	30.06	169	3.01	4471	1362.8	982688.74	135.02	-18.80	1
CAMPA	-77	50.88	166	40.23	167	50.9	982969.10	-2.17	-7.94	1
CRASH	-77	26.68	167	33.53	2833	863.5	982809.58	104.16	6.53	1
DEB	-77	16.29	166	44.74	5901	1798.6	982588.86	178.33	-24.43	1
HENDE	-78	17.58	166	19.42	1116	340.2	982935.85	37.40	-1.12	1
HERB	-77	43.56	163	52.68	3603	1098.2	982689.57	45.75	-78.32	2
HOGBA	-77	29.10	163	36.57	2407	733.7	982772.86	25.86	-57.12	1
HUTPT	-77	50.82	166	37.94	40	12.2	982976.17	-6.98	-8.36	1
JOEBM	-77	50.54	166	43.79	729	222.2	982978.66	60.43	35.25	1
KELLI	-77	22.58	168	5.79	166	50.6	982986.96	33.57	27.84	1
KELME	-76	58.40	166	54.42	8	2.4	982977.10	24.70	24.42	1
KEVIN	-78	11.12	167	29.80	1674	510.2	982899.87	57.77	0.03	1
MARY	-78	17.20	163	31.23	575	175.3	982966.46	17.41	-2.45	1
MELAN	-78	8.05	166	7.87	698	212.8	982971.03	39.08	14.98	1
MILLS	-77	56.20	164	4.83	4056	1236.3	982689.81	80.65	-58.96	4
MWISE	-78	7.84	165	22.99	2684	818.1	982813.11	67.91	-24.59	1
NSFCH	-77	50.89	166	40.16	94	28.7	982973.60	-4.53	-7.78	1
PAT	-78	0.99	167	24.99	139	42.4	983004.15	24.00	19.20	1
PKING	-78	33.08	164	21.53	4253	1296.3	982702.89	89.95	-56.41	1
REPEA	-77	30.35	162	37.09	5903	1799.2	982484.10	64.67	-138.15	1
SBAST	-77	50.99	166	45.76	52	15.8	982976.62	-5.52	-7.32	2
SBUSA	-77	50.95	166	45.39	112	34.1	982973.21	-3.25	-7.12	1
SCALL	-78	12.05	166	44.42	633	192.9	982977.96	37.47	15.61	1
SEISM	-77	53.11	166	45.30	153	46.6	982969.85	-4.11	-9.40	*
SPOLE	-90	0.00	180	0.00	9270	2825.5	982312.96	-34.15	-351.64†	2
STONR	-77	26.38	168	19.48	4529	1380.4	982704.25	158.34	2.53	2
TANKR	-77	50.91	166	41.54	206	62.8	982967.17	-.44	-7.56	1
TERRA	-77	30.43	167	55.10	6369	1941.3	982584.83	209.12	-9.62	1
VINCE	-77	26.75	166	25.96	57	17.4	982963.61	-2.71	-4.68	1
McMurdo area sites (1991-92)										
BLD57	-77	50.86	166	40.47	115	35.1	982972.72	-3.41	-7.38	*
HUTPT	-77	50.82	166	37.94	40	12.2	982976.14	-7.01	-8.40	1
THIEL	-77	51.04	166	40.06	151	46.0	982970.28	-2.58	-7.80	3
CASERTZ area sites (1991-92)										
CALIB	-82	21.75	-118	9.57	3327	1014.1	982788.97	-24.15	-138.75†	1
CTZ	-82	21.57	-118	7.84	3445	1050.0	982780.72	-21.24	-139.88†	*
CTZUP	-82	21.57	-118	7.84	3448	1051.0	982780.52	-21.17	-139.91†	2
NVR1	-81	22.86	-112	17.71	5650	1722.1	982582.99	13.03	-181.15†	1
NVR2	-82	18.65	-109	25.19	5797	1766.9	982551.40	-28.49	-227.69†	1
NVR3	-83	22.03	-109	56.16	5489	1673.0	982653.17	20.30	-168.07†	1
NVR4	-84	6.62	-115	21.53	4505	1373.1	982765.11	25.48	-129.52†	2
NVR6	-82	10.36	-116	39.26	3852	1174.1	982727.46	-31.76	-164.37†	1

†= ice correction needed.

References

Cordell, Lindrith, Keller, G.R., and Hildenbrand, T.G., 1982, Bouguer gravity map of the Rio Grande Rift, Colorado, New Mexico, and Texas: *U.S. Geological Survey Geophysical Investigations Map GP-949*,

Hittelman, A.M., Haberman, R.E., Dater, D.T., and Di, Liping, 1992, Gravity Earth System Data CD-ROM, Alpha Release, National Geophysical Data Center, 325 Broadway, Boulder, CO 80303-3328.

International Association of Geodesy, 1971, Geodetic Reference System 1967: *International Association of Geodesy Special Publication*, 116 p.

Morelli, C., 1974, The international gravity standardization net 1971: International Association of Geodesy Special Publication 4, 194 p.

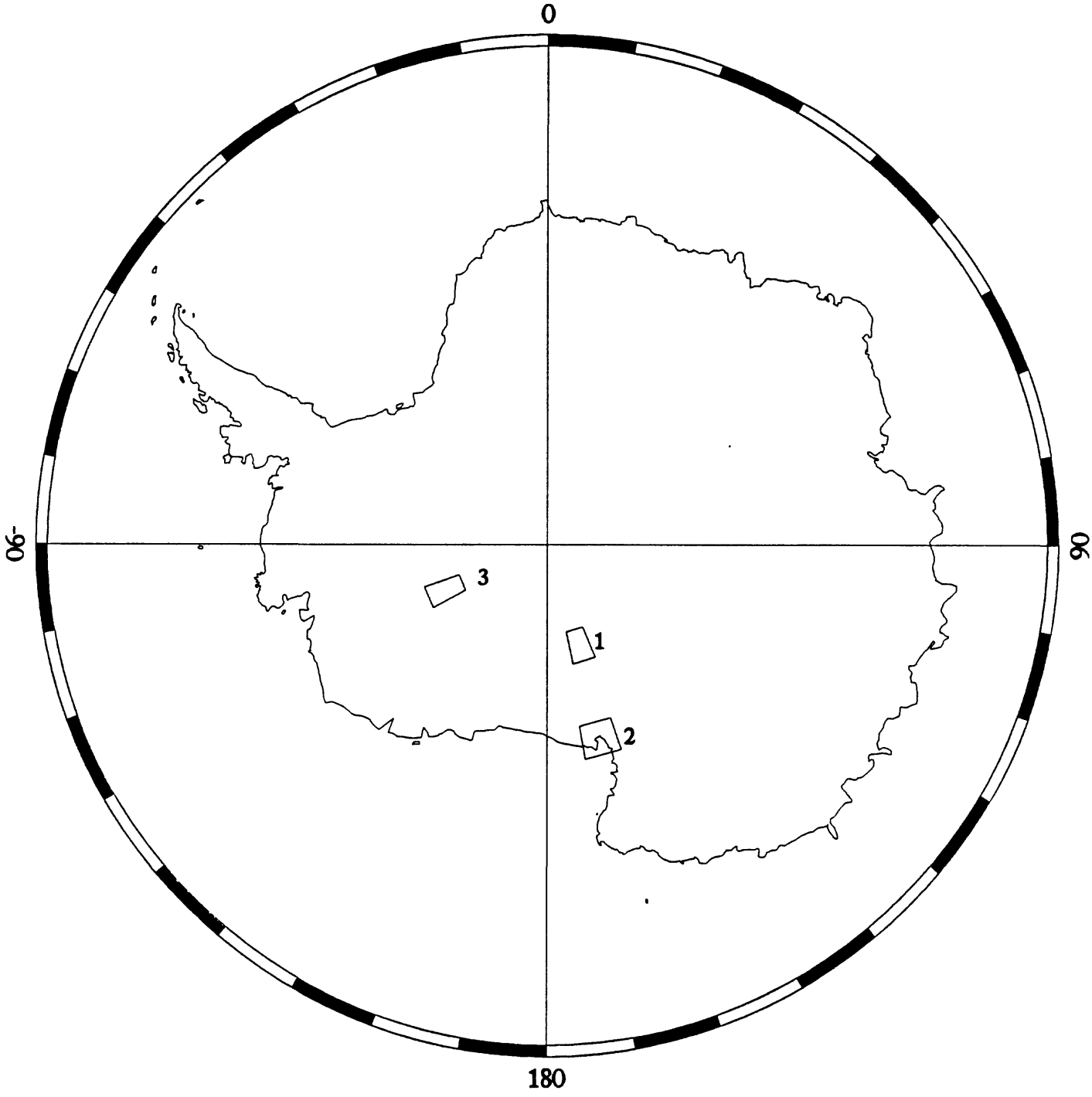

Figure 1: Location of gravity surveys in Antarctica. **1** = Beardmore vicinity survey (1985–86), **2** = McMurdo vicinity survey (1986–87), **3** = CASERTZ survey (1991–92).

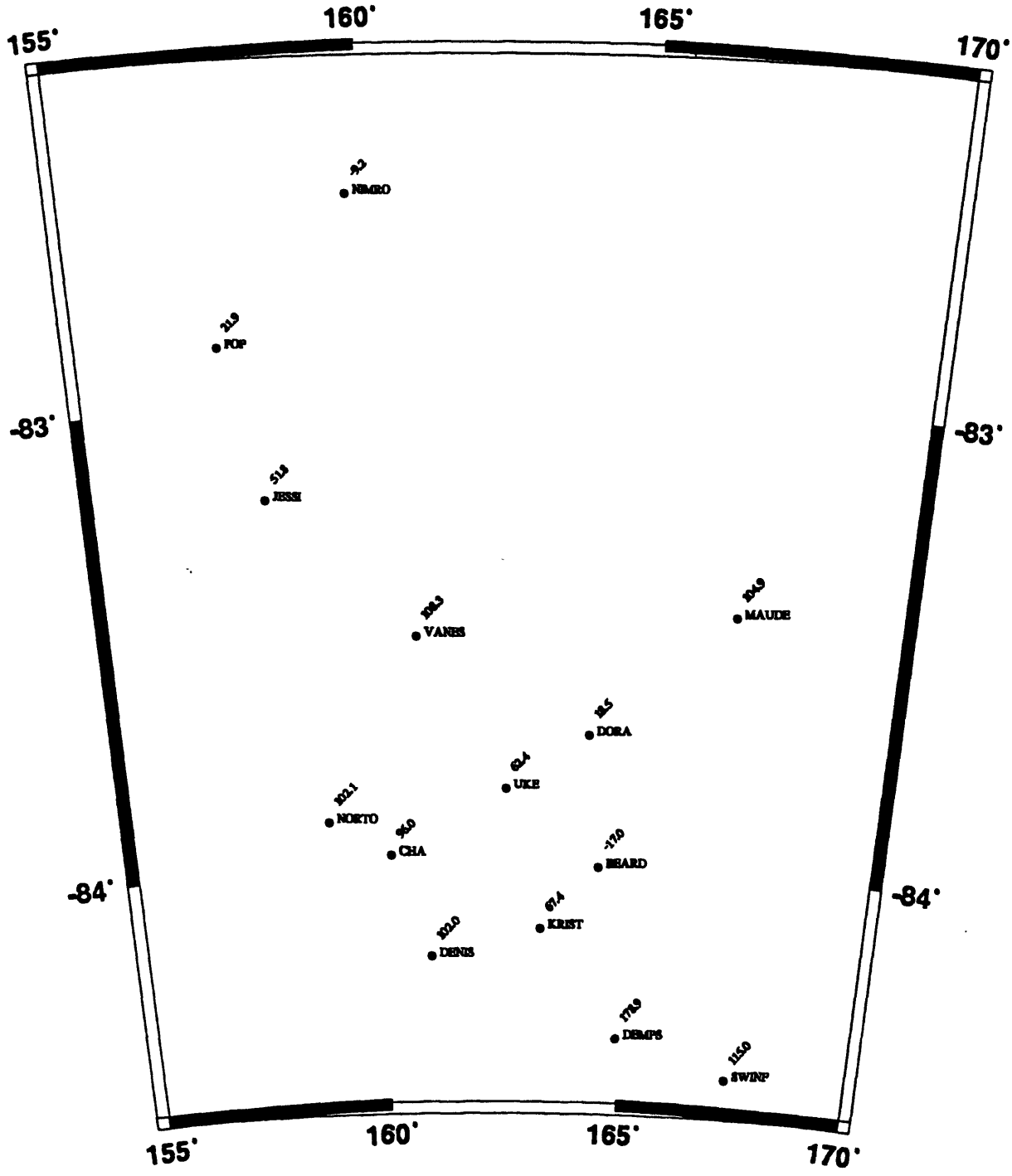

Figure 2: Gravity measurement sites in the Beardmore vicinity. Values are free air anomalies in mGal.

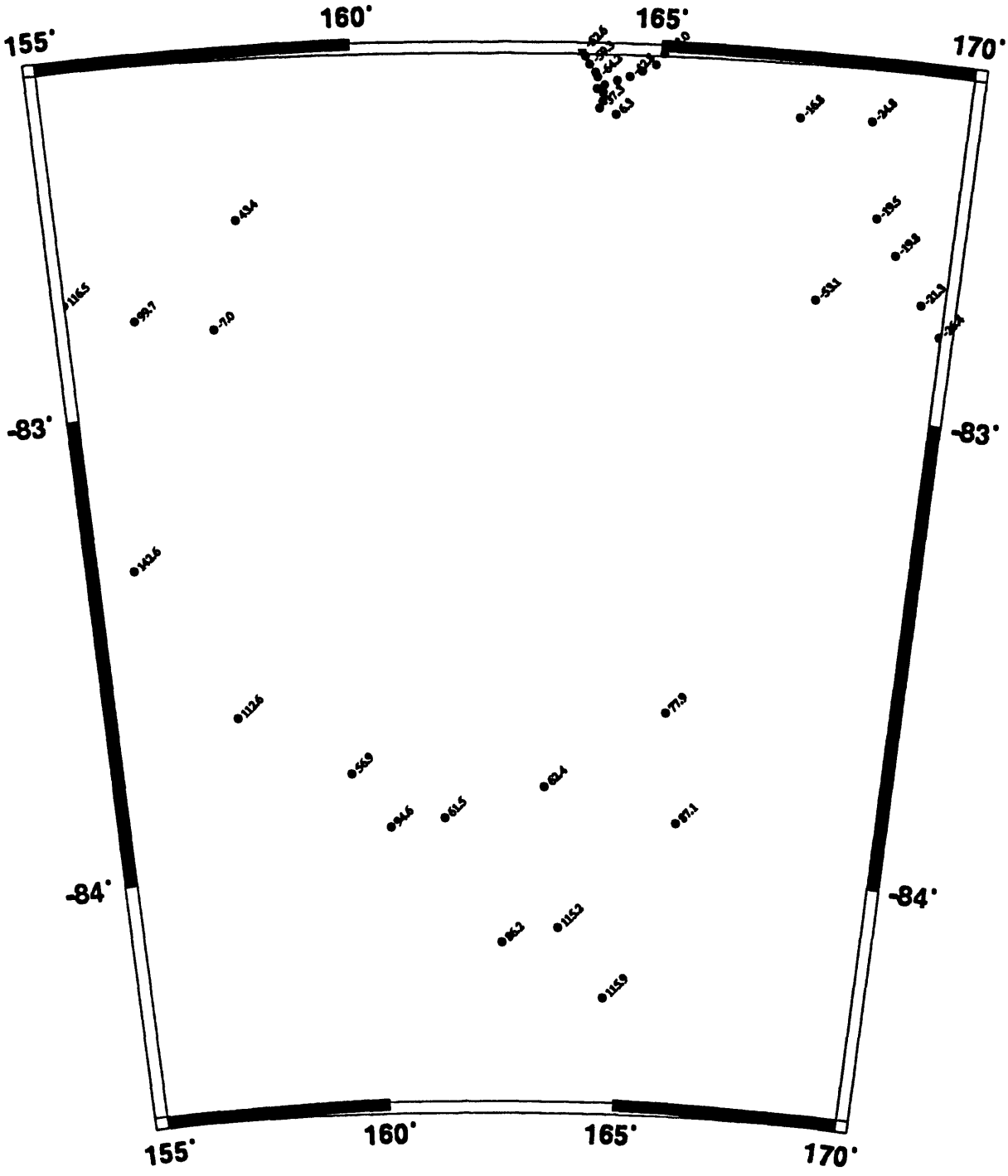

Figure 3: Previous gravity measurements in the Beardmore vicinity from the DMA gravity data base. Values plotted are free air anomalies in mGal.

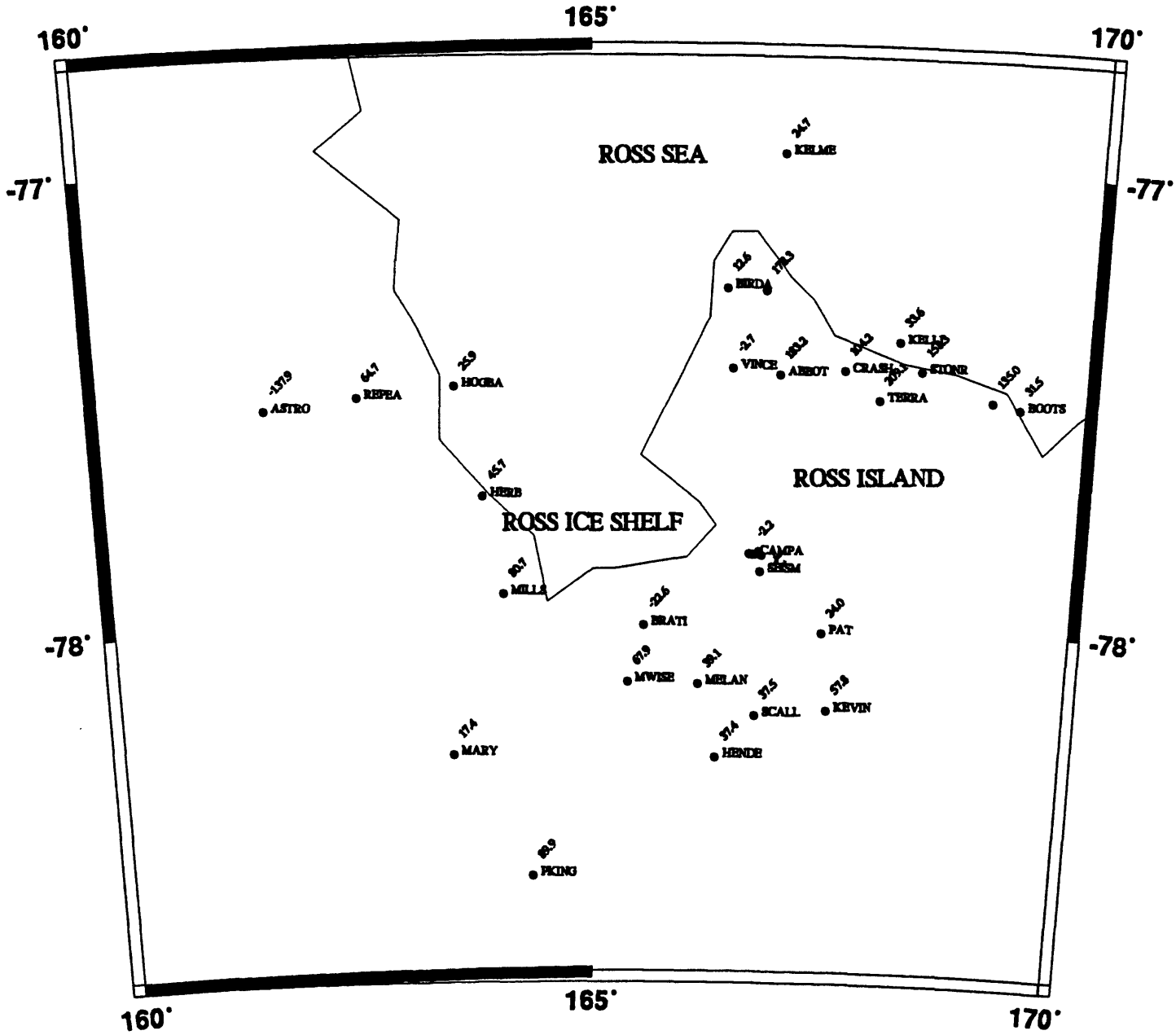

Figure 4: Gravity measurement sites in the McMurdo vicinity. Values are free air anomalies in mGal.

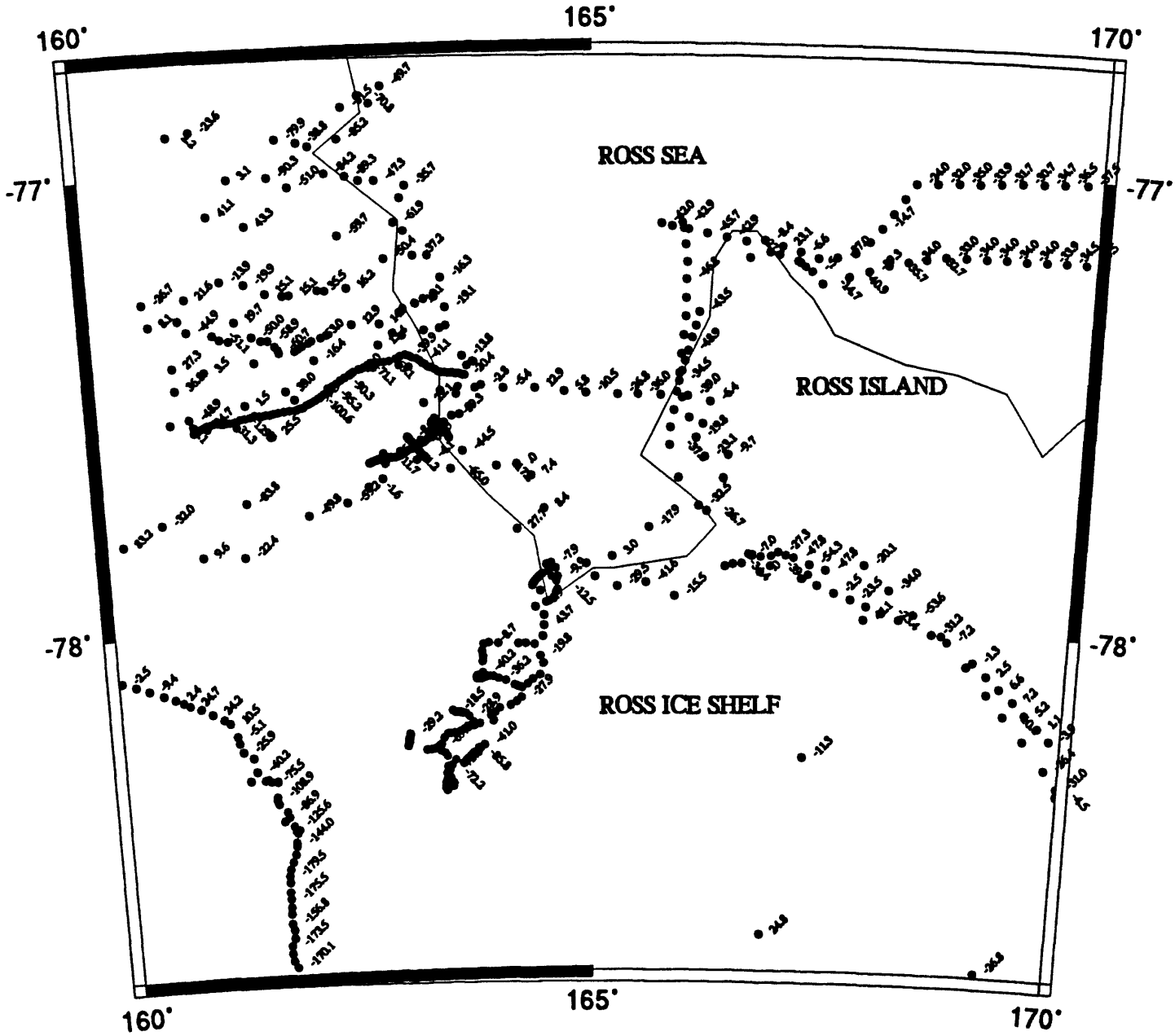

Figure 5: Previous gravity measurements in the McMurdo vicinity from the DMA gravity data base. Values plotted are free air anomalies in mGal.

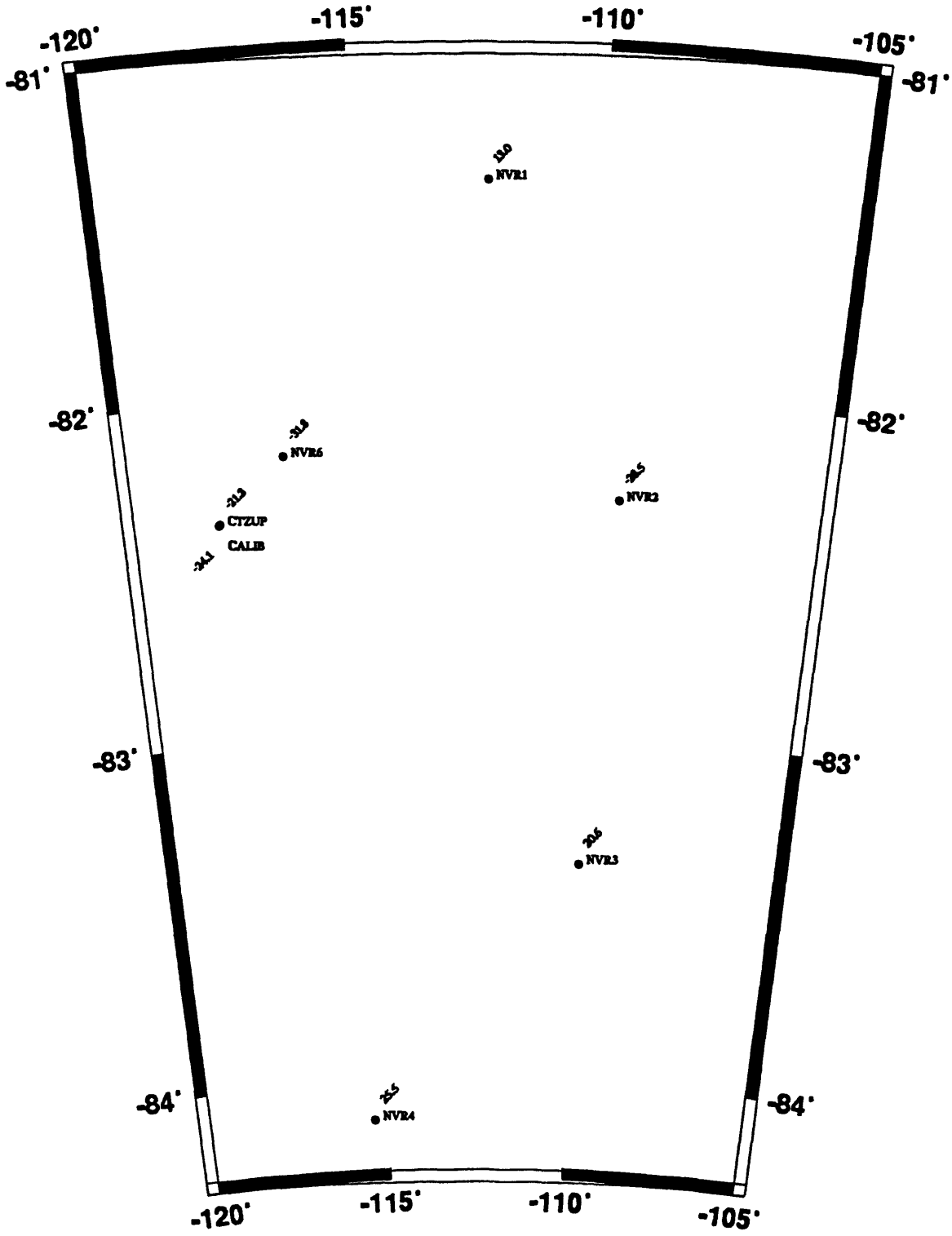

Figure 6: Gravity measurement sites in the CASERTZ vicinity. Values are free air anomalies in mGal.

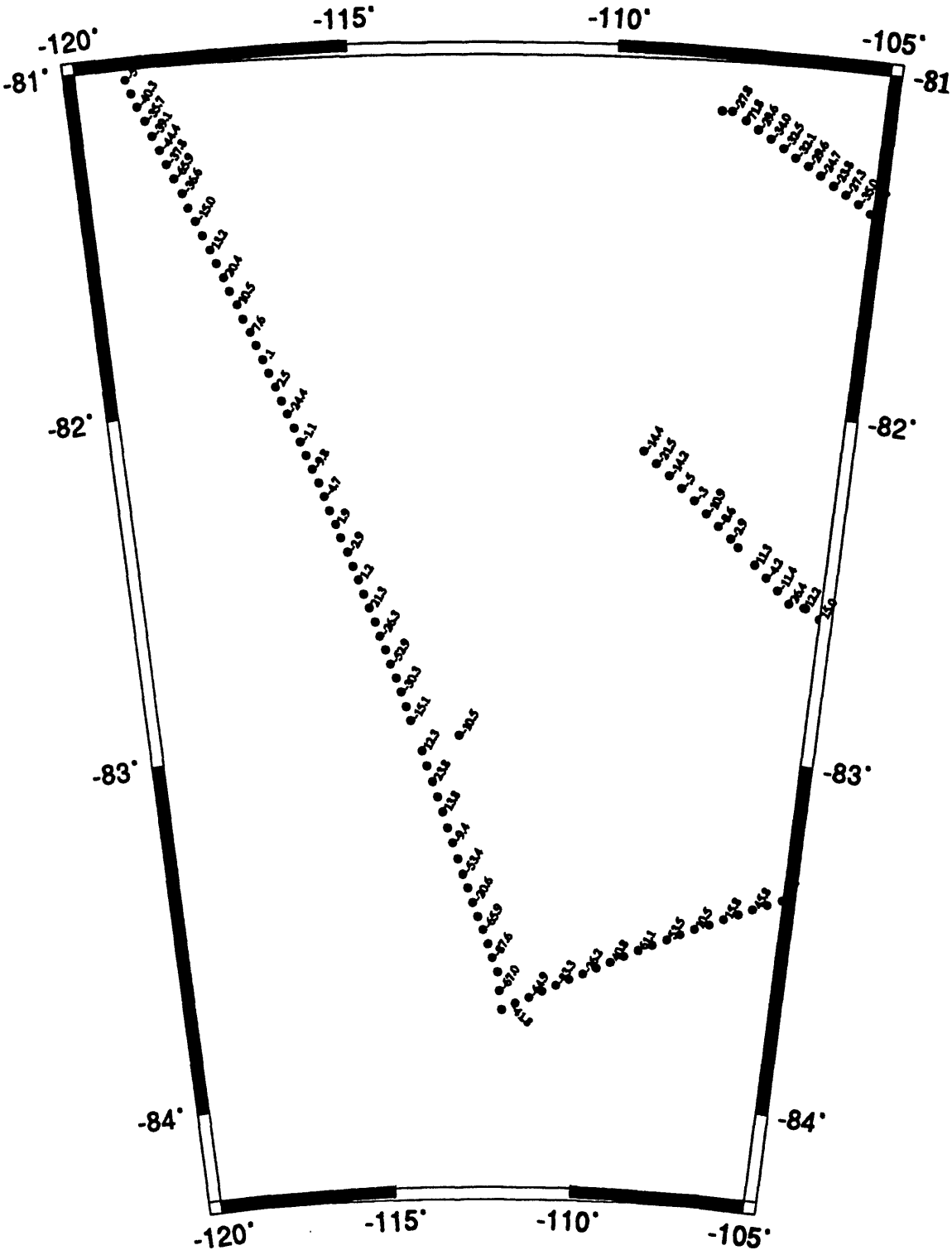

Figure 7: Previous gravity measurements in the CASERTZ vicinity from the DMA gravity data base. Values plotted are free air anomalies in mGal.

Appendix - USGS Triangulation Station Names

The gravity data table contains five-letter abbreviations of the complete station names. The following table contains the complete designation as stamped on the USGS triangulation station benchmark.

Complete USGS Triangulation Station Names

Site name	*Complete triangulation station name*
ABBOT	ABBOTT ECC 1986–87
ASTRO	VANDA ASTRO "A" NZARP
BIRDA	CAPE BIRD "A" ECC-NZARP
BOOTS	BOOTS 1964–65
BRATI	BRATINA 1986–87
BROWN	BROWN 1986–87
CAMPA	CAMP AREA 1961–62
CHA	CHA 1985–86
CRASH	CRASH 1986–87
CRATE	CRATER HILL - JAN 1956
DEB	DEB–MT BIRD 1964-65
DEMPS	DEMPSEY 1985–86
DENIS	DENISE 1985–86
DORA	DORA 1985–86
HENDE	HENDERSON 1986–87
HERB	HERB ECC 1986–87
HOGBA	HOGBACK TOPO NORTH #2
HUTPT	HUT RESET 1964–65
JESSI	JESSICA 1985–1986
JOEBM	JOES TIDAL BM 1986–87
KELLI	KELLI 1986–87
KELME	KELMELIS 1986–87
KEVIN	KEVIN 1986–87
KRIST	KRISTIN 1985–86
MARY	MARY 1986–87
MAUDE	MAUDE (on Mt. Allen Young, not Mt. Maude)
MELAN	MELANIA 1986–87
MILLS	MILLS ECC 1986–87
MWISE	MT WISE NO 2 ECC (NZARP)
NIMRO	NIMROD (on Kon-tiki Nunataks)
NORTO	NORTON 1985–1986
NSFCH	NSF CHALET 1986–87
PAT	PAT 1986–87
PKING	PEAK–ING 1983–84
POP	POP 1985–1986
REPEA	REPEATER ECC 1986–87
RM2	SECOND CRATER RM #2
SBAST	SCOTT BASE ASTRO–NZARP
SBUSA	SCOTT BASE USAF GRAVITY
SCALL	SCALLOP 1986–87
SEISM	MCMURDO GRAVITY DISC # 59676C
SPOLE	SOUTH POLE (actual site unknown)
STONR	STONER 1986–87
SWINF	SWINFORD
TANKR	TANK RESET 1974–75
TERRA	TERRA NOVA 1986–87
UKE	UKE 1985–86
VANES	VANESSA 1985–1986
VINCE	VINCE 1986–87