

NEW DOPPLER SATELLITE CONTROLLED GRAVITY STATIONS IN ANTARCTICA

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ABSTRACT. Eleven gravity stations were established between 1977 and 1979 at Doppler satellite controlled localities. Station positions and gravity values are given.

The first field season of a joint USARP (United States Antarctic Research Program)–BAS Doppler satellite positioning programme was completed during the austral summer of 1975–76. This was primarily concerned with the determination of three-dimensional coordinates for selected points critical to topographic survey control. However, it also provided an opportunity to establish relocatable, photo-identifiable and precisely positioned gravity stations. Twenty-six on-rock gravity stations were occupied (Renner, 1982).

The joint programme continued with two additional field seasons between 1977 and 1979. For each, the United States Geological Survey (USGS) provided two surveyors and a JMR-1 Doppler satellite receiver while BAS provided the logistic support including a De Havilland Twin Otter aircraft, aircrew and a field assistant/geophysicist. One of the authors (LJS) accompanied the 1977–78 survey as geophysicist and the other (RGBR) participated the following year. Airborne field operations centred on Siple Station (lat. $75^{\circ}56'24''$ S, long. $84^{\circ}14'54''$ W), while stations to the north of Rothera Station (lat. $67^{\circ}34'09''$ S, long. $68^{\circ}07'30''$ W) were dependent on ship support.

THE GRAVITY SURVEY

Gravity measurements were taken at all Doppler localities but a number were on snow and ice of unknown thickness. Since future reoccupations of the ice stations would be liable to error, only on-rock stations (Fig. 1) have been considered here. Whenever possible, intermediate stations were occupied in order to monitor instrumental drift and to establish a succession of tighter closed loops around which closure errors could be distributed. Intermediate stations were occupied at Fossil Bluff, Sweeney Mountains, Wilson Nunataks, Siple Station and Belgrano Station. Several established gravity stations on the west coast of Graham Land were re-occupied during the ship-based leg from Rothera to South Georgia.

Two gravity meters were used during the surveys, a Worden Master model (No. 886) in 1977–78 and, in 1978–79, a Lacoste and Romberg model G (No. 456) kindly loaned by the Institute of Geological Sciences (IGS), London, England. The following drift rates were measured (see Appendix).

A. Worden Master meter

- (i) Airborne operations – The overall drift Rothera–Rothera over a period of 54 days averaged $+0.24$ gu/day. This does not include the severe drift measured on three overnight stops which was attributed to the effect of unexpectedly large temperature reversals on the non-thermostatically controlled meter.

Table I. Gravity Stations occupied during the 1977-78 and 1978-79 USGS-BAS Doppler Satellite Programme.

Locality	USGS Station Ref.	Photo Identification No.	International Spheroid			WGS 72 Spheroid			Surveyed height above sea level (m)	Absolute value of gravity ($m s^{-2}$)
			Latitude °S	Longitude °W	Height relative to spheroid (m)	Latitude °S	Longitude °W	Height relative to spheroid (m)		
King Edward Point, South Georgia	22212	RN Endurance 4/76 No 106 Jan 1976	54° 17' 03.06''	36° 29' 37.38''	- 165	54° 17' 00.25''	36° 29' 37.38''	27	2.7	9.815241
Signy Island, South Orkney Islands	22211	RN BAT Signy 5 Feb 1968	60° 42' 30.78''	45° 35' 34.76''	- 130	60° 42' 28.25''	45° 35' 34.76''	53	25.0	9.821354
King George Island, South Shetland Is.	22209	26 FID 39 149 Dec 1956	62° 05' 11.06''	58° 23' 37.09''	- 140	62° 05' 08.61''	58° 23' 37.09''	42	18.3	9.821907
Welchness Peninsula, Dundee Island	22210	26 FID 42 017 Dec 1956	63° 28' 50.45''	56° 13' 19.50''	- 88	63° 28' 48.08''	56° 13' 19.50''	92	64.8	9.822189
Tottan Hills, Dronning Maud Land	22204	TMA 2116 F33 069	74° 36' 50.83''	14° 40' 13.49''	958	74° 36' 49.32''	14° 40' 13.49''	1126	1143.1	9.825831
Lyon Nunatak	22258	TMA 1850 F32 70	74° 50' 02.34''	73° 54' 23.07''	1077	74° 50' 00.85''	73° 54' 23.07''	1245	Not known	9.826219
Haag Nunataks, Ronne Ice Shelf	22201	TMA 1885 F33 206	77° 02' 17.33''	78° 14' 54.61''	1037	77° 02' 16.04''	78° 14' 54.61''	1203	Not known	9.827168
Littlewood Nunatak, Luitpold Coast	22205	TMA 2063 F32 283	77° 52' 57.45''	34° 18' 59.15''	117	77° 52' 56.23''	34° 18' 59.15''	283	Not known	9.829045
Theron Mountains	22207	TMA 1839 F32 096	78° 56' 15.56''	27° 36' 02.26''	476	78° 56' 14.45''	27° 36' 02.26''	642	665.1	9.828375
Lewis Chain, Shackleton Range	22219	TMA 2050 F-32-N, 219	80° 24' 01.39''	26° 51' 07.65''	942	80° 24' 00.41''	26° 51' 07.65''	1105	1112	9.828320
Patuxent Range, Pensacola Mountains	22220	TMA 1498, F31 BIA 3.2 Exp 202	84° 59' 38.30''	66° 14' 30.58''	1402	84° 59' 37.79''	66° 14' 30.58''	1564	Not known	9.828034

Table II. Descriptions of Gravity Stations.

<i>Locality</i>	<i>Description</i>
King Edward Point	BAS station on King Edward Point. At base of concrete pillar (astro point) 1.3 m high. West side of customs house.
Signy Island	On ridge behind BAS station complex. At base of cairn 4 m south of old balloon shed. Marked by metal spike.
King George Island	Keller Peninsula. Site of old BAS Station, Admiralty Bay. Marked by brass cartridge set in concrete plinth 15 × 15 cm, directly beneath anemometer tower.
Dundee Island	Highest point on moraine ridge behind Argentine Petrel station. Marked by iron post surmounted by drum. Reading at base of post outside supporting pillar.
Tottan Hills	Summit of small nunatak (DOS site 'SB'). Marked by USGS tablet stamped 'Jerry 1977-78'. Surmounted by small cairn.
Lyon Nunatak	Summit of small rock ridge running east from main peak of Lyon Nunatak. Marked by USGS tablet stamped 'Lewis 1977-78'. Surmounted by small cairn.
Haag Nunataks	On summit of most westerly of three nunataks. Marked by USGS tablet stamped 'Judy 1977-78'. Surmounted by small cairn.
Littlewood Nunatak	Summit of highest and most southerly of Littlewood group, 9 m west of small Argentine refuge. Marked by USGS tablet stamped 'Leslie 1977-78'. Surmounted by small cairn.
Theron Mountains	Summit of first major nunatak to south west of Goldsmith Glacier. Marked by USGS tablet stamped 'Robin 1977-78'. Surmounted by small cairn.
Shackleton Range	Summit of most southern nunatak of Lewis Chain. Station marked by brass tablet and surmounted by 1-m cairn.
Pensacola Mountains	Summit of small nunatak in Patuxent Range at southern end of Pensacola Mountains. Marked by standard USGS brass tablet. Surmounted by 1-m cairn.

Table III. Gravity values at 1977-78 and 1978-79 Doppler satellite stations.

<i>Locality</i>	<i>Absolute value of gravity m s⁻²</i>	<i>Theoretical value of gravity m s⁻²</i>	<i>Absolute gravity anomaly g.u.</i>	<i>Elevation correction g.u.</i>	<i>Bouguer anomaly g.u.</i>
		<i>International Gravity Formula 1930</i>			
King Edward Point	9.815241	9.814535	+ 706	5	+ 711.3
Signy Island	9.821354	9.819791	+ 1563	49	+ 1612.2
King George Island	9.821907	9.820838	+ 1069	36	+ 1105.0
Dundee Island	9.822189	9.821865	+ 324	127	+ 451.4
Tottan Hills	9.825831	9.828556	- 2725	2247	- 477.7
Lyon Nunatak	9.826219	9.828658	- 2439	—	—
Haag Nunatak	9.827168	9.829600	- 2432	—	—
Littlewood Nunatak	9.829045	9.829925	- 880	—	—
Theron Mountains	9.828375	9.830301	- 1926	1307	- 618.4
Shackleton Range	9.828320	9.830768	- 2448	2186	- 261.8
Pensacola Mountains	9.828034	9.831818	- 3784	—	—

- (ii) Shipborne operations – The overall drift Rothera–South Georgia over a period of 29 days averaged +2.2 gu/day.

B. LaCoste and Romberg meter – thermostatically controlled at 53°C

- (i) Overall drift Rothera–Rothera over a period of 25 days was 0.75 gu/day.
 (ii) Travelling drift in Twin Otter aircraft and motor toboggan was +0.80 gu/day.
 (iii) Non-travelling drift averaged +0.35 gu/day.

Gravity meter calibration constants were verified along the established calibration line between Prees and Hatton Heath in Cheshire (Masson Smith and others, 1974) both before and after the Antarctic field seasons.

Values of absolute gravity and station descriptions are presented in Tables I and II with corresponding Bouguer anomalies in Table III. Two on-rock stations (Shackleton Range and Pensacola Mountains) were occupied during the 1978–79 season, the remainder being established in 1977–78. Earth tidal gravity effects have not been applied as they were calculated to be less than 0.20 gu. All gravity measurements were made relative to the absolute value of gravity at Rothera Station of 9.824817 ms^{-2} (Renner, 1981). A density value of 2.67 Mg m^{-3} was used in the elevation corrections.

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APPENDIX

Whilst acceptable drift rates were measured with the LaCoste and Romberg gravity meter during the Doppler survey there were less desirable drifts/‘tares’ encountered during the remainder of the 1978–79 season. The drift values appeared dependent on the mode of transport and have been attributed to vibration.

(a) Hercules LC-130 aircraft and tracked vehicle

During a gravity tie between Siple Station and McMurdo Station (Renner, 1981) a travel drift of +3.1 gu/day was measured. The meter was carefully stowed and cushioned in the aircraft and hand held during the oversnow journey between Williams Field airstrip and McMurdo Station.

(b) Ship and launch

On three occasions ‘tares’ approaching 30 gu were measured during routine ship-to-shore surveys intended to strengthen the existing Antarctic Peninsula gravity network. Although it is difficult to isolate the cause, each ‘tare’ occurred on the only occasions when the meter lay in direct contact with the launch superstructure and therefore with engine vibrations.

(c) *Motor toboggan*

A 'tare' approaching 30 gu was measured after a one hour skidoo journey over rough snow surfaces, although the vehicle was driven sympathetically and the meter was constantly cradled by the passenger.

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