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Record 1975/103

AUSTRALIAN CALIBRATION LINE GRAVITY SURVEY 1971

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CONTENTS

SUMMARY

Fourteen stations of the Australian Calibration Line (ACL) spanning about 2775 mGal were re-occupied in April 1971 with four La Coste & Romberg gravity meters. Of these meters G20 behaved well and appeared to have regained approximately the scale correction factor (SCF) derived for it in 1969 relative to the mean Australian milligal; the value is now about 1.000170 compared with 0.999880 found on the ACL traverse in 1970. G101 behaved erratically again as it did on the two earlier calibration line surveys, preventing any estimation of its SCF. G132 behaved very well and exhibited the same SCF (0.999905) as it had shown on the 1969 and 1970 surveys. G252, a new meter, which had not previously been used on a calibration line, behaved fairly well, but occasional tares prevented the derived SCF of 0.999935 being regarded as firmly established.

During this survey, an accurate tie was made between the BMR pendulum station in Sydney (5099.9905) and the reference point for the CSIRO absolute determination of gravity at Sydney.

1. INTRODUCTION

In April 1971, a party of two observers (R.J.S. Cooke, D.A. Coutts) took the four BMR La Coste & Romberg geodetic gravity meters G20, G101, G132, G252 over an abbreviated version of the Australian Calibration Line (ACL) which was established in 1970 (Cooke, 1970). Fourteen of the original twenty-five ACL stations were occupied (Plate 1) using the ladder sequence of measurement (ABC.....N..... CBA). Commercial air transport was used for all ties; the gravity meters were always carried in the pressurized aircraft cabin and were handled only by the observers. The section Canberra-Mt Hagen was measured between 18 and 24 April 1971, and the Canberra-Hobart section on 29 and 30 April.

The objectives of this work were:

(a) to determine the scale correction factor (SCF) (relative to the Australian gravity standard) for the new gravity meter G252, delivered in February 1971;

(b) to determine the SCF for meter G101, which had performed erratically during 1969 and 1970 calibration line surveys (Cooke, 1970);

(c) to investigate further the SCF stability of meters G20 and G132, which had been used on the 1969 and 1970 surveys. The SCF for G20 had changed significantly between these two determinations, while that for G132 had remained the same.

The survey was carried out as planned, except in one respect; the outward flight booked for Melbourne-Hobart, which was scheduled to land at Launceston, did not do so. Consequently, the intervals involving Launceston were measured on the return journey only. To obtain some comparative gravity observations within the large (490 mGal) interval Melbourne-Hobart a tie was made from Hobart to a station at the summit of Mt Wellington.

While the party was in Sydney the opportunity was taken to tie the reference point for the CSIRO absolute determination of gravity (Gibbings et al., 1971; Bell et al., 1973) to the nearby BMR pendulum station (5099.9905).

The gravity observations reported in this Record have been independently analysed by Wellman et al. (1974a, b).

2. CALIBRATION LINE GRAVITY RESULTS - DISCUSSION AND RECOMMENDATIONS

The measured gravity intervals, calculated with the manufacturer's calibration factors for each meter, are listed in Table 1. All original meter readings were corrected for earth tide effects using the tables published by the European Association of Exploration Geophysicists (Goguel, 1954), and the intervals were calculated from the corrected readings, i.e. assuming no meter drift.

The intervals measured on the outward and return journeys are both tabulated. As in the computations for the Western Pacific Calibration Line (WPCL) survey of 1969 (Cooke, 1970), and in agreement with the procedure of Woollard (1964), one of these intervals is assumed to be wrong if the two differ by more than about 0.06 mGal. A tare or a faulty reading is assumed in this case. However, observational errors in recording, beam-setting, or levelling should not have occurred as checks of these operations were made by the second operator. In practice it is rarely possible to decide which of the two values if faulty unless the discrepancy is very much greater than 0.06 mGal. Thus there is a range of discrepancy for which the two values must be averaged even though one is believed to be faulty.

Examination of the discrepancies (Table 1) shows that all of the G132 intervals are acceptable. Only one of the G20 intervals is uncertain (by 0.09 mGal); the probable faulty value of this pair has been rejected (285.290 R). Otherwise intervals for G20 and G132 are obtained by averaging the two measurements and rounding off. For these two meters, values of observed gravity at the stations occupied are derived from cumulative addition of these intervals to a base value at Sydney airport. These station values are compared with those determined by the same meters in 1970 (Table 2 and Plate 2d), after adjustment at Melbourne and Launceston, where different excentres were used.

Least squares analysis shows that for G132 the 1969, 1970, 1971 SCF's are not significantly different and have a value of 0.999905.

The 1971 G20 values differ systematically from those of 1970 (Plate 2a); they yield a probable SCF of 1.000170 for 1971, to be compared with 1.000110 for 1969 and 0.999880 for 1970. It is possible that the closeness of the present SCF to the 1969 figure is significant; however, further calibration line surveys would be needed to show

whether this is merely coincidence. Changes of SCF ("adjustment") for large meter G1 are discussed by Woollard (1964). He attributes these changes to the temporary presence of a magnetic effect which was subsequently removed by "degaussing". The effect amounted to 0.26 mGal/Gal, and was apparent in a variation of meter reading by up to 0.1 mGal with meter orientation. A meter orientation test was carried out on G20 on 2 April 1971; no observable change in reading was associated with different orientations.

As in 1969 and 1970, G101 on this survey performed very erratically. Examination of G101 measurements in Table 1 shows that very few intervals are acceptable by the standards described above. The high incidence of serious discrepancies suggests that on some of the ties neither value is correct, so that rejection of only one value for each poor interval might still lead to misleading results. For most ties measured on the ACL in 1970 the G101 results were so bad that a comparison with the present results is pointless. The only interval which appears consistent on each of the 1970 and 1971 surveys is Cairns-Port Moresby, for which the 1970 value was 288.13 mGal and the 1971 value is 288.005 mGal. No attempt has been made here to derive a SCF, on the grounds that its uncertainty would be too great for it to be of practical use. Table 1 shows that G101 intervals tend to be larger than those of the other meters south of Canberra, and tend to agree with the others north of Canberra.

After the poor results had been obtained with G101 on earlier calibration line surveys, the instrument's thermostat had been replaced, as it seemed likely the poor performance had been caused by minor temperature fluctuation. The meter performed excellently during several weeks of ground survey immediately before the present work, so it seems possible that the poor performance has been caused in some way by the air transport involved in the three calibration line surveys.

The G252 results show three ties with uncertain intervals, and a fourth tie for which only one interval value could be obtained, owing to a temperature drop in the instrument. Consequently, determination of a SCF depends on rejections of one or other value in uncertain ties; the rejected values are shown by 'R' in Table 1. A least-squares analysis of the accepted gravity intervals gives a SCF of 0.999935 for G252. However, the SCF cannot be regarded as firmly established.

In view of the possible variation of SCF in the LaCoste & Romberg geodetic gravity meter, proven for G20 and suggested for G101, it is obvious that precision ties over

large intervals should not be attempted in future without some control on the meter SCF provided by at least a partial measurement on the ACL. For example a sequence such as Canberra, Sydney, Brisbane, Rockhampton, Townsville, Cairns should be measured before or after the precision ties, or both, the actual stations used depending on the direction of the survey area. For work of this type whose importance is not sufficient to warrant the expense of such additional measurements, it is recommended that G132 be used, although there is no guarantee that its SCF is stable.

The 1971 G20 and G252 results are compared with the mean of 1970 and 1971 results for G132 in Table 3.

3. TIE TO ABSOLUTE GRAVITY MEASUREMENT SITE AT SYDNEY

On 18 April 1971, a tie was made between a reference point for the absolute gravity measurement equipment (room B37, National Standards Laboratory, CSIRO, Sydney) and the BMR pendulum gravity station No. 5099.9905 in the same room. The gravity station at the absolute reference point was a rigidly mounted steel plate, just large enough to hold a gravity meter, fixed to the front of the absolute gravity apparatus about 1.2 m above floor level. All four meters were used to make two ties between the stations. The results are tabulated in Table 4. The adopted interval shows the gravity value at the absolute site to be 0.34 mGal lower than the pendulum station value.

4. ACKNOWLEDGEMENTS

Mr D.A. Coutts carried out one half the gravity measurements reported. Mr G.A. Bell of CSIRO Division of Applied Physics (National Standards Laboratory), Sydney provided transport and access to the site of the absolute gravity measurement.

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Original material for this survey is filed as survey 7190 in Regional Gravity Group, BMR.

TABLE 1

GRAVITY INTERVALS ACL 1971 CALCULATED USING MAKER'S TABLES (MILLIGALS)

STATION	G20	G101	G132	G252
Mt Wellington 7090.1138				
	- 274.670	- 274.97	- 274.870	- 274.82
	- 274.650	- 275.10	- 274.870	- 274.87
Hobart 6091-0160				
	- 4.695	- 4.63	- 4.645	- 4.65
	- 4.645 -	- 4.66	- 4.630	- 4.66
Hobart 6491.0160				
	173.595	173.81	173.605	173.66
Launceston 6850.0271	487.875	488.47	488.095	488.10
	314.250	314.61	314.465	314.42
Melbourne 6491.0101				
	195.545	195.39	195.560	195.60
	195.560	195.66	195.620	195.53
Albury 6793.1136				
	144.985	145.26	145.020	145.03
	144.980	145.32	144.960	145.05
Canberra 6893.0104				
	- 78.175	- 78.22	- 78.140	- 78.24
	- 78.180	- 78.25	- 78.140	- 78.23
Sydney 6891.0105				
	539.075	539.66	539.130	539.29 R
	539.100	540.07	539.160	539.15
Brisbane 6491.0147				
	285.300	285.40	285.410	-
	285.390 R	285.18	285.410	285.46
Rockhampton 6499.0149				
	140.040	140.05	140.105	140.08
	140.010	140.02	140.130	140.10
Mackay 6491.0161				
	110.075	110.11	110.110	110.19
	110.085	110.00	110.100	110.18

STATION	G20	G101	G132	G252
Townsville 7090.0151				
	123.425	123.48	123.455	123.40
	123.440	123.39	123.435	123.42
Cairns 5099.9952				
	287.880	288.01	288.085	287.92
	287.915	288.00	288.040	288.12 R
Port Moresby 6791.0476				
	201.800	201.81	201.825	201.85
	201.800	201.72	201.835	201.90
Lae 6791.0177				
	332.860	332.63	332.770	332.82
	332.910	332.80	332.780	333.08 R
Mt Hagen 6791.0178				

R = reject

TABLE 2

COMPARISON OF UNADJUSTED ACL GRAVITY VALUES 1970 AND 1971, G20 AND G132 (mGal)

STATION	G20			G132		
	1970	1971	Difference	1970	1971	Difference
Mt Wellington	980 169.840[1]	169.695	- 0.145	980 169.870	169.820	- 0.050
Hobart	980 449.140[1]	449.025	- 0.115	980 449.335	449.330	- 0.005
Launceston	980 275.785[1]	275.705[2]	- 0.080	980 275.955	276.000[2]	0.045
Melbourne	979 961.180	961.145[3]	- 0.035	979 961.195	961.230[3]	0.035
Albury	979 765.650	765.615	- 0.035	979 765.620	765.660	0.040
Canberra	979 620.665	620.630	- 0.035	979 620.655	620.670	0.015
Sydney (base)	979 698.810	698.810	0.000	979 698.810	698.810	0.000
Brisbane	979 159.555	159.720	0.165	979 159.640	159.665	0.025
Rockhampton	978 874.140	874.420	0.280	978 874.200	874.255	0.055
Mackay	978 734.085	734.395	0.310	978 734.105	734.135	0.030
Townsville	978 623.940	624.315	0.375	978 624.030	624.030	0.000
Cairns	978 500.510	500.885	0.375	978 500.570	500.585	0.015
Port Moresby	978 212.500	212.985	0.485	978 212.520	212.525	0.005
Lae	978 010.710	011.185	0.475	978 010.700	010.695	- 0.005
Mt Hagen	977 677.760	678.300	0.540	977 677.890	677.920	0.030

Notes:
1. Based on an assumed value at Moorabbin
2. Adjusted by 0.28 mGal to 1970 excentre 6491.0171
3. Adjusted by 0.02 mGal to 1970 excentre 7090.0101

TABLE 3

GRAVITY VALUES AND DIFFERENCES ACL, G20, G132 AND G252 (mGal)

STATION	G132 MEAN OF 1970, 1971	G20[1] 1971	G132-G20[1] MEAN 1971	G252[1]	G132-G252[1] MEAN
Mt Wellington	980 169.845	169.695	0.150	169.770	0.075
Hobart	980 449.330	449.025	0.305	449.270	0.060
Launceston	980 275.975[2]	275.705[2]	0.270	275.885[2]	0.090
Melbourne	979 961.210[2]	961.145[2]	0.065	961.160[2]	0.050
Albury	979 765.640	765.615	0.025	765.615	0.025
Canberra	979 620.660	620.630	0.030	620.575	0.085
Sydney (base)	979 698.810	698.810	0.000	698.810	0.000
Brisbane	979 159.650	159.720	- 0.070	159.660	- 0.010
Rockhampton	978 874.225	874.420	- 0.195	874.200	0.025
Mackay	978 734.120	734.395	- 0.275	734.110	0.010
Townsville	978 624.030	624.315	- 0.285	623.925	0.105
Cairns	978 500.575	500.885	- 0.310	500.515	0.060
Port Moresby	978 212.520	212.985	- 0.465	212.595	- 0.075
Lae	978 010.695	011.185	- 0.490	010.720	- 0.025
Mt Hagen	977 677.905	678.300	- 0.395	677.900	0.005

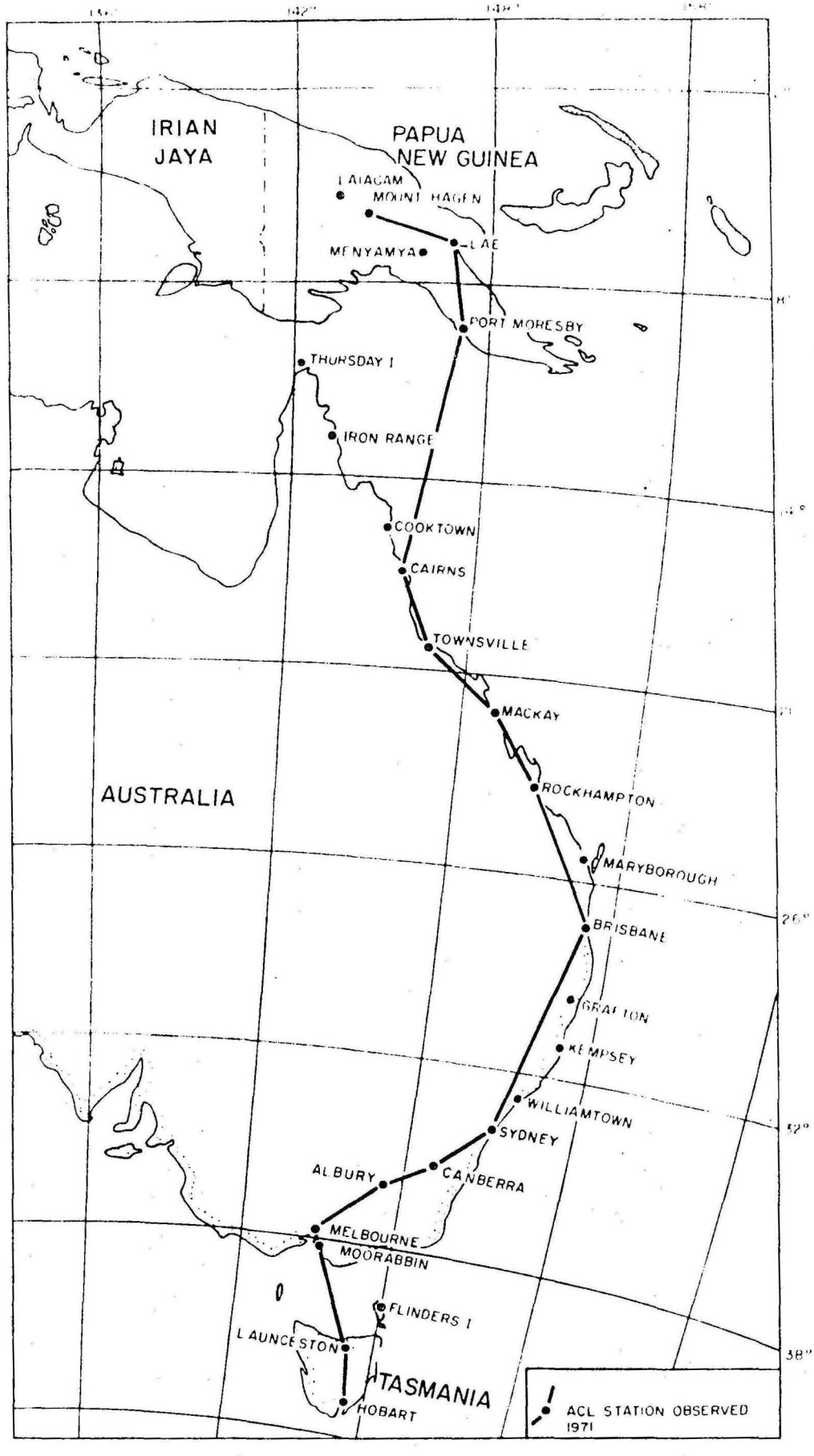
NOTES:
1. Preferred values shown
2. 1971 values adjusted to 1970 excentre

TABLE 4

EXCENTRE TIES ACL 1971 AT SYDNEY (mGal)

Station Interval	G20	G101	G132	G252
5099.9905-Absolute Site	0.350	0.335	0.335	0.325
6891.0105-5099.9905	13.000	13.060	12.960	13.005

PLATE I



ROUTE OF 1971 AUSTRALIAN CALIBRATION LINE SURVEY

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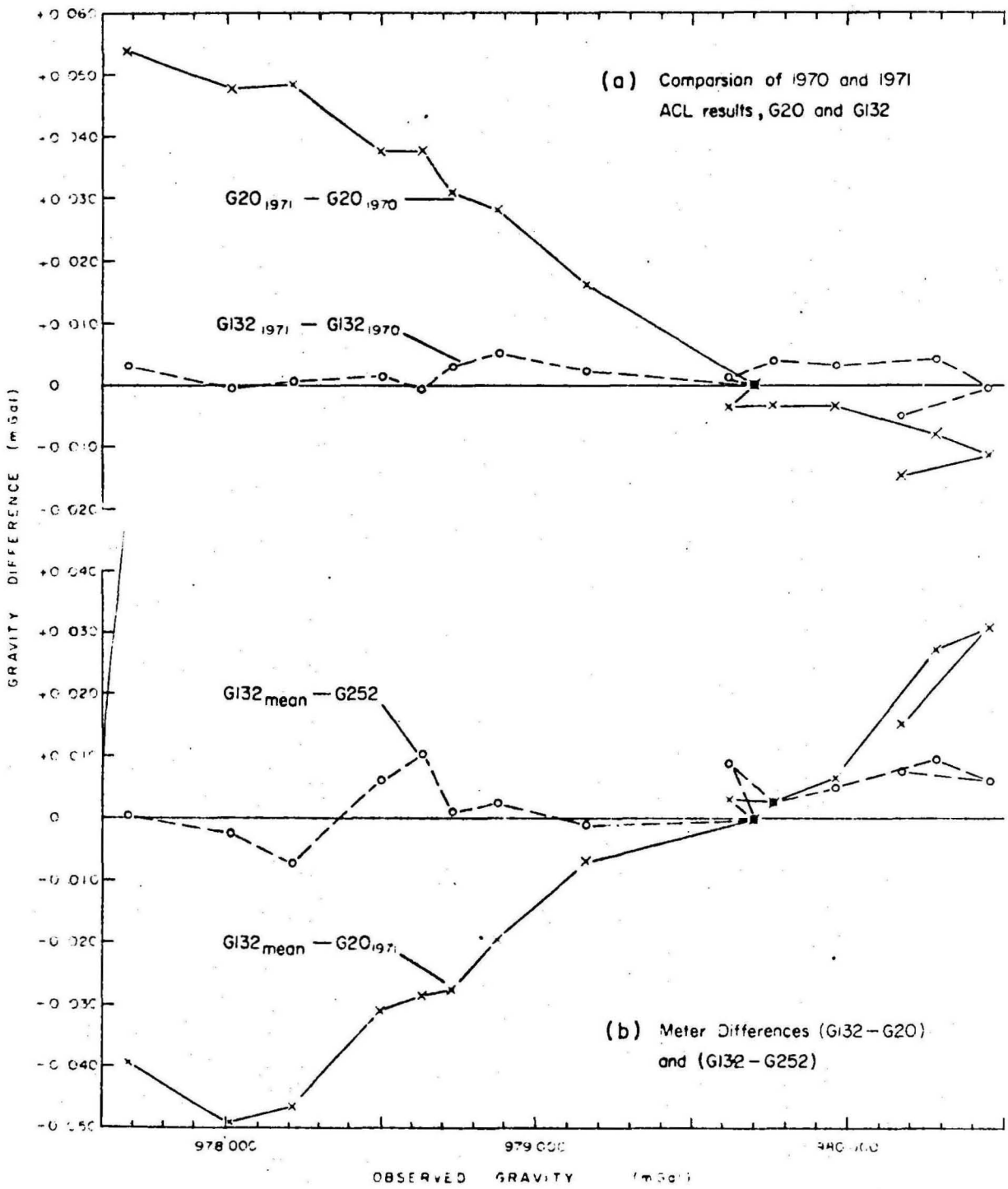
PLATE 2


(a) Comparsion of 1970 and 1971 ACL results, G20 and G132
G20 1971 — G20 1970
G132 1971 — G132 1970
(b) Meter Differences (G132 – G20) and (G132 – G252)
G132 mean — G252
G132 mean — G20 1971
GRAVITY DIFFERENCE (mGal)
OBSERVED GRAVITY (mGal)
978 000
979 000