1974/121

OPEN FILE.
~~Restricted until after publication.~~
Manuscript submitted for publication
to: 7th Meeting of International
Gravimetric Commission
Sept 1974.

DEPARTMENT OF MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD 1974/121

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ABSTRACT

LaCoste & Romberg gravity meter measurements suggest that the IGSN71 scale on the Western Pacific Calibration Line is about 3 ± 1 parts in 10^5 smaller than the GAG-2 gravity meter scale along the Australian Calibration Line. On the Australian Calibration Line differences between measurements in 1965, 1970-71, and 1973 suggest that secular variation may be occurring at rates of up to 6 μGal per year.

An accurate gravity scale has been established for the Western Pacific Calibration Line (WPCL) in the IGSN71 adjustment (Morelli et al., 1974), and an independent scale accurate to 2.5 parts in 10^5 has been established for the Australian Calibration Line (ACL) by co-operative Soviet-Australian measurements using GAG-2 gravity meters (Boulanger et al., 1973; Wellman et al., 1974). It is possible to accurately compare these scales using the results of those LaCoste & Romberg gravity meter surveys that included both the WPCL and at least part of the ACL. If secular variation of gravity at base stations on a calibration line is a function of distance along the line, then effects of different types will result, depending on the wavelength of this function. Short-wavelength effects should only decrease the accuracy of scale comparisons, whereas long-wavelength effects will cause an apparent change in scale. The transition wavelength if about half the length of the observed part of the line. Gravity measurements on the ACL and WPCL have been made over a period of many years, so secular variation effects may be significant.

LaCoste meters were used for gravity measurements along the WPCL, and along the central part of the ACL by the U.S. Air Force in 1965 (Whalen, 1966), by the Dominion Observatory of Canada in 1966 (Dept. Mines, Energy and Resources, pers. comm.), and by the Australian Bureau of Mineral Resources, Geology and Geophysics (BMR) in 1969-1970. Measurements restricted to the ACL were made by BMR in 1971, 1972, and 1973 (Wellman et al., 1974). Results from these measurements have been reduced to a common scale and datum as follows. Observations were reduced to equivalent readings in milligals using manufacturer's tables, and then corrected for earth tides. Gravity intervals were calculated, intervals with obvious tares were rejected, observations with full drift control were corrected for drift, and then intervals were meaned and summed along the calibration line. Observations along the WPCL (between Alaska and Darwin) were fitted by least squares to IGSN71 values (Morelli et al., 1974). Observations along the ACL were fitted by least squares to ISOGAL74 values which are on GAG-2 ACL scale (Wellman et al., 1974) and have the IGSN71 value at Sydney as datum. Results of meter G7 in 1966, and of G101 in 1969, 1970, and 1971, could not be used because they contained too many tares.

The ratio IGSN71 WPCL scale/ISOGAL74 scale was calculated for each of the remaining gravity meters (Table 1). G132, G20, and G104 give a wide spread in ratio values, probably because of changes in meter calibration factors between WPCL and ACL surveys which were separated by 7 months to three years. Calibration factor changes of the required magnitude and rate have been detected in repeat surveys along the ACL (Wellman et al., 1974, table 5). Results from these three meters are therefore unsuitable for accurate scale comparison. The 1965 and 1966 measurements on the WPCL and ACL were each completed within a few months, and over this time calibration factors are unlikely to have changed. If secular variation effects on the WPCL and ACL scales are insignificant, the 1965 and 1966 results show that the IGSN71 scale on the WPCL is only slightly smaller than the ISOGAL74 scale on the ACL, the best estimate of the difference being 3 ± 1 parts in 10^5 (Table 1). Boulanger et al. (1973) have shown that the IGSN71 scale on the ACL is considerably smaller than the GAG-2 scale on the ACL, the best estimate of the difference being 15 parts in 10^5. The poorly-defined IGSN71 scale on the ACL must therefore differ by about 12 parts in 10^5 from the IGSN71 scale on the WPCL.

On the ACL, secular variation effects of short wavelength (i.e. much less than the length of the line) has been evaluated as follows. The differences have been determined between the ISOGAL74 values and the values calculated from LaCoste results on the same scale and datum. From these differences, mean differences have been calculated for the 1965 survey, the 1970 and 1971 surveys combined, and the 1973 survey (Table 2). Apparent gravity changes are shown in Figure 1. The changes based on the 1965 and 1973 mean differences range from +51 ± 15 (standard deviation) μGal at Townsville, to -49 ± 24 μGal at Brisbane; the corresponding rates of secular variation range from +6±2 μGal/year to -6 ± 3 μGal/year. It is to be expected that, at most places, secular variation of gravity will be in one direction and approximately constant over a period of eight years. Figure 2 shows that the amounts of apparent gravity change for the two periods (1970.9-1965.2 and 1973.4-1970.9) have the expected ratio of +2.3 to within experimental error, with the possible exception of one station. Short-wavelength secular variation effects are not proven from these results, but secular variation seems to be the best explanation for the apparent gravity changes between 1965 and 1973.

A scale change of 3 parts in 10^5 would result from a change of 40 μGal in the 1.5 Gal interval of the central part of the ACL observed in 1965-1966. Secular variation effects of long wavelength (i.e. greater than half the length of the observed part of the line) could cause such a change. The secular variations suggested above have large enough magnitude, but could not cause a significant scale change because the maximum wavelength (Fig.2) is too small by a factor of two. Longer-wavelength secular variation effects may actually exist and may have been removed as an apparent change in the calibration factors of the gravity meters. Accurate absolute determinations of gravity repeated after an interval of several years are required to measure such effects.

ACKNOWLEDGEMENTS

The authors express their gratitude to Professor Yu. D. Boulanger of the Soviet Geophysical Committee, Academy of Sciences of USSR, for establishing an accurate scale along the Australian Calibration Line using GAG-2 gravity meters. We thank the Director of BMR for permission to present this paper.

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TABLE 1 COMPARISON OF IGSN71 WPCL SCALE AND GAG-2 ACL SCALE

Meter number	Year	$\frac{\text{LaCoste scale}}{\text{IGSN71 WPCL scale}} - 1$ $\times 10^4$ *	ERMS μGal	$\frac{\text{LaCoste scale}}{\text{ISOGAL74 scale}} - 1$ $\times 10^4$ *	ERMS μGal	$\frac{\text{IGSN71 WPCL scale}}{\text{ISOGAL74 scale}} - 1$ $\times 10^4$ *	Weight used ($1/s.d.^2$)
G43	1965	$-3.517 \pm .220$	96	$-2.508 \pm .284$	45	$-1.009 \pm .359$	7.7
G44	1965	$-1.280 \pm .060$	27	$-1.182 \pm .254$	40	$-0.098 \pm .261$	14.4
G47	1965	$+0.465 \pm .099$	43	$+0.473 \pm .218$	34	$-0.008 \pm .239$	17.5
G48	1965	$-0.164 \pm .047$	21	$+0.164 \pm .113$	18	$-0.328 \pm .122$	67.2
G9	1966	$-1.521 \pm .131$	53	$-1.049 \pm .555$	81	$-0.472 \pm .570$	3.1
G132	1969/1970	$-3.725 \pm .026$	13	$-4.202 \pm .008$	27	$+0.477 \pm .029$	100.0
G20	1969/1970	$-5.477 \pm .138$	60	$-3.849 \pm .150$	44	$-1.629 \pm .204$	24.0
G104	1969/1972	$-2.549 \pm .066$	34	$-3.141 \pm .105$	30	$+0.592 \pm .124$	65.0
		1965-1966 results		weighted mean		$-0.298 \pm .116$ **	
				unweighted mean		$-0.383 \pm .177$	
		1965-1972 results		weighted mean		$+0.047 \pm .273$	
				unweighted mean		$-0.309 \pm .261$	

* = standard deviation (s.d.); ** = standard devistion of mean; ERMS = root mean square error

Table 2 Values of B.C.B. g Observed (ISOGAL74 Scale) – g ISOGAL74 in microgals

Gravity meter Year	G43 1965	G44 1965	G47 1965	G48 1965	G9* 1966	G20 1970	G132 1970	G20 1971	G132 1971	G252 1971	G104* 1972	G20A 1973	G101 1973	G132 1973	G252 1973	Mean±sdm 1965	Mean±sdm 1970–71	Mean±sdm 1973
Place																		
Laiagam						−78	−77	–	–	–	–	+19	−11	−32	−16		(−77 1)	−10 11
Mount Hagen						−33	+41	−96	+28	–	−41	+25	− 3	− 5	+ 2		−15 31	+ 5 7
Lae						+96	+21	+43	−26	–	−18	−12	−33	−21	+ 3		+33 25	−16 8
Port Moresby						+64	+18	+71	−19	–	−36	−13	+ 7	−10	−17		+33 21	− 8 5
Iron Range						− 5	−11	–	–	–	–	+ 2	+ 8	+25	+ 6		(− 8 3)	+10 5
Cooktown						+41	− 4	–	–	–	–	−14	− 6	+39	−17		(+18 22)	+ 0 13
Cairns	−30	−25	+55	+ 3	−12	−18	−15	−26	−23	–	+27	–	–	–	–	+ 1 20	−20 2	–
Townsville	−40	−37	−57	−15	− 2	−18	+35	+19	+ 8	−54	+16	− 9	+ 4	+47	+15	−37 9	− 2 15	+14 12
Mackay	− 6	+ 7	−36	−11	+75	+ 9	− 4	+10	− 1	+ 5	+45	−12	+39	+ 3	+ 7	−11 9	+ 4 3	+ 9 11
Rockhampton	+40	+54	+23	+13	−142	−34	+ 7	−17	+26	+ 2	+22	− 5	+40	+ 8	+10	+32 9	− 3 10	+13 10
Brisbane	+70	+47	+18	+36	+79	−32	+28	−14	+27	+47	+33	0	− 6	−19	+ 2	+43 11	+11 15	− 6 5
Kempsey	−11	−50	− 8	−21	–	+26	+12	–	–	–	–	− 5	−24	− 7	+20	−22 10	(+19 7)	− 4 10
Sydney	−42	−32	+25	−14	−12	−21	−16	+19	+25	+42	+ 3	+ 3	−13	− 6	− 2	−16 15	0 13	− 4 3
Canberra	+51	+32	+ 2	− 0	+66	+24	+ 5	+ 3	+ 9	−13	+ 3	+ 3	+ 6	−23	+20	+21 12	+ 6 6	+ 1 9
Albury	+16	+27	−19	0	–	+ 5	−27	+15	− 5	+18	+ 2	–	–	–	–	+ 6 10	+ 1 8	–
Melbourne	−49	−24	− 5	+ 8	−52	−25	−15	+39	− 1	−11	− 9	+ 6	− 5	–	+ 9	−17 12	− 3 11	+ 3 4
Flinders Island						–	− 9	–	–	–	–	− 6	+13	–	− 8		− 9 –	0 7
Hobart							+10	−66	+ 2	−35	−47	+18	−16	–	−34		−22 17	−11 15

sdm = standard deviation of mean

* Data not used in assessment of secular variation

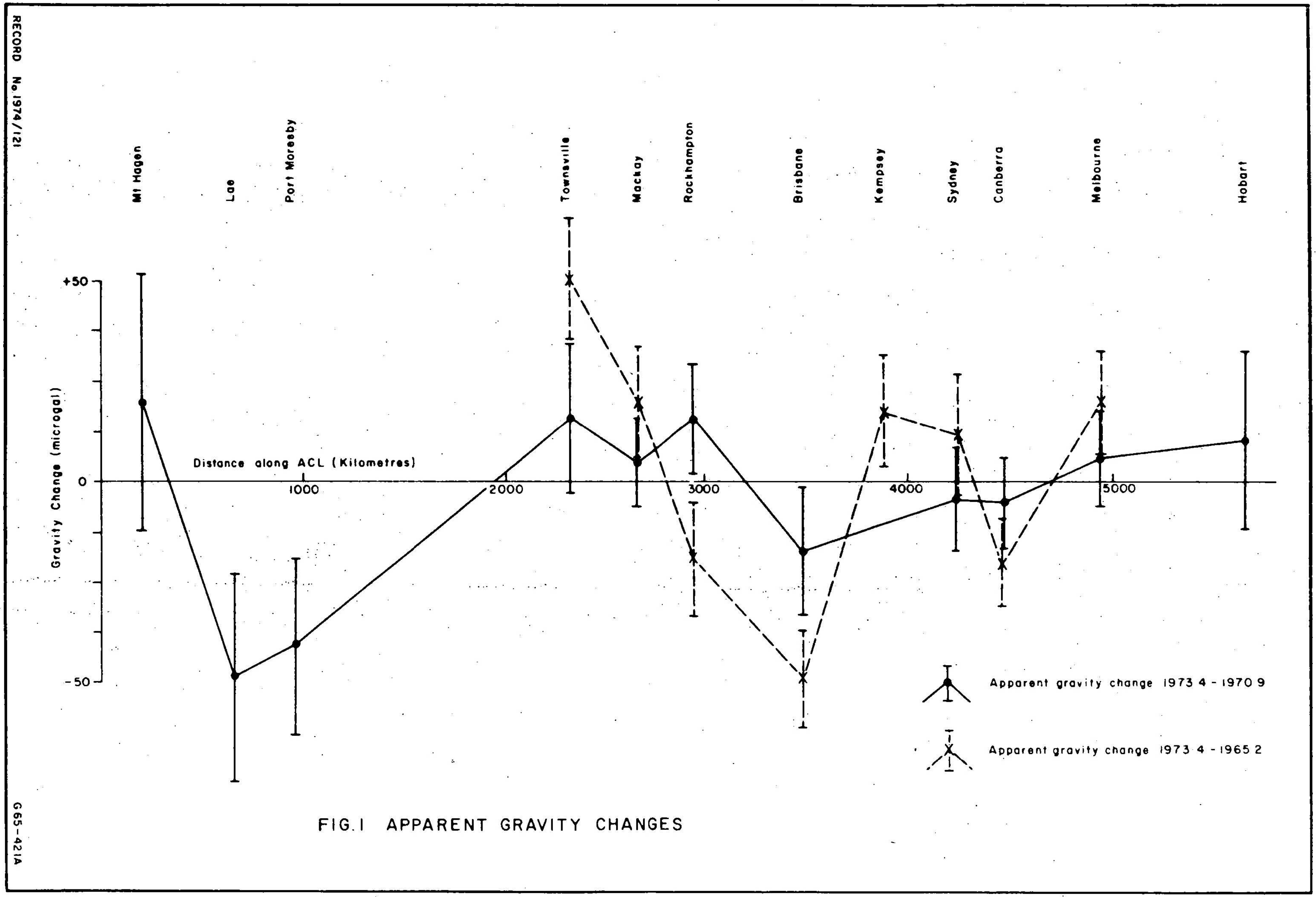

FIG.1 APPARENT GRAVITY CHANGES

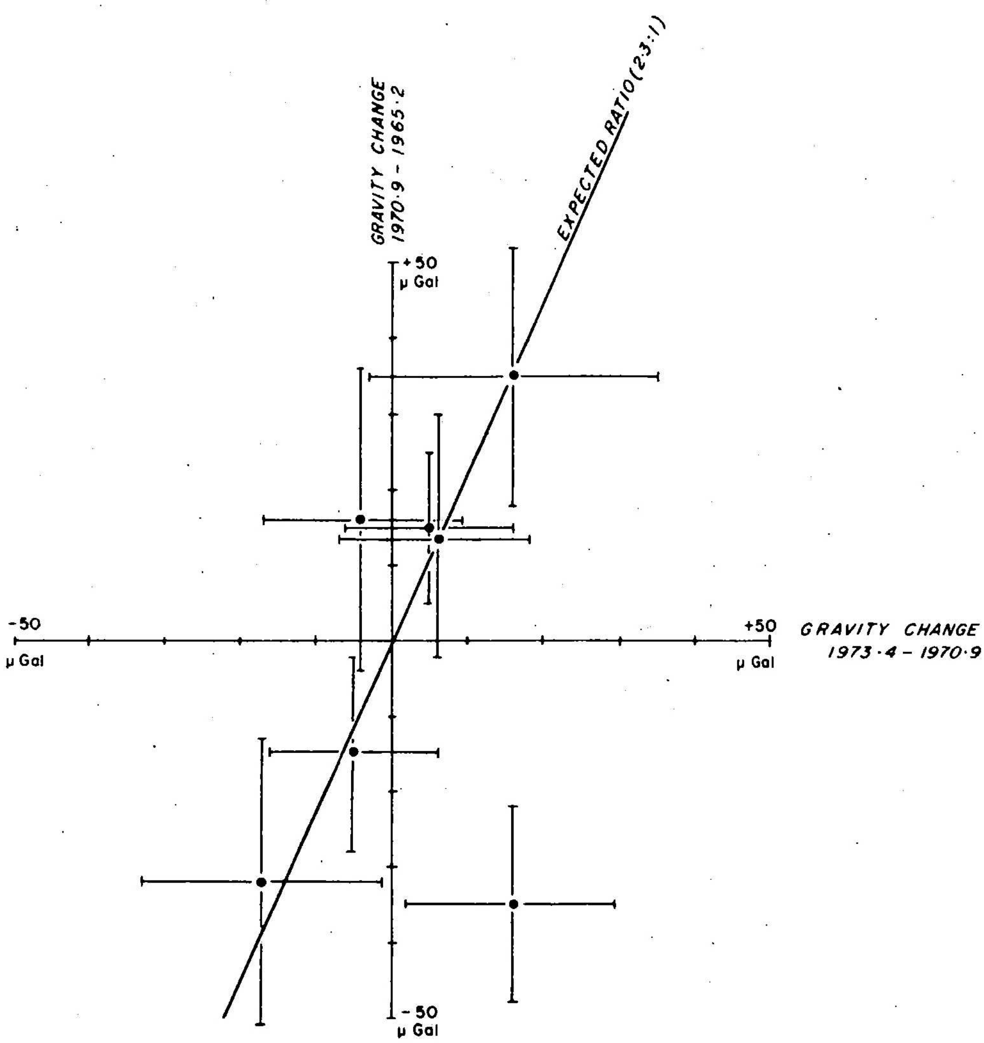

FIG. 2 COMPARISON FOR SEVEN TOWNS OF THE OBSERVED AND EXPECTED RATIO OF THE GRAVITY CHANGES 1970·9-1965·2/1973·4-1970·9