Early Australian gravity observations

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Since the publication of 'Gravimetry in Australia 1819-1976' (Dooley & Barlow, 1976), our attention has been drawn to the paper by Day (1966) on early Australian geophysical history. We apologise for our ignorance of this interesting paper, which refers to many of the nineteenth-century gravity measurements listed in our Table I, and gives further details of the observers and the background to the measurements.

In Table 1, we had compared the results of the older measurements with currently accepted values of gravity. For completeness, we analyse below a notable series of measurements at Parramatta between 1821 and 1828, which we omitted from our history. The initiative was taken by Sir Thomas Brisbane, Governor of New South Wales from 1821-25, who set up an astronomical and geophysical observatory at his own expense. Pendulum observations were made in London by Kater, Brisbane, and Rumker before departure in April 1821, and at Parramatta by Brisbane and Dunlop in August-September 1821 (Kater, 1823). The units used were far removed from the uniform SI system we know today, the results being recorded in 'vibrations in 24 hours', and then converted to 'length of the pendulum vibrating seconds' in inches.

The results were as follows, corrected to 60°F and in a vacuum:

London, first series (Kater)	86 090.17 vibrations in 24 hr
London, second series (Brisbane & Rumker)	86 090.17 vibrations in 24 hr
Parramatta, first series (Brisbane)	86 021.59
Parramatta, second series (Dunlop)	86 022.21
Length of second pendulum at London	39.13929 in.
Length of second pendulum at Parramatta (1)	39.07696
Length of second pendulum at Parramatta (2)	39.07751

These figures, with other observations, were used to estimate the Earth's polar flattening, giving values ranging from 1/291.83 to 1/303.95—compared with the currently accepted value of 1/298.247 (IAG, 1971).

Using the formula for gravitational acceleration $g = 4\pi^2 L/T^2$ (L = length of pendulum, T = period), with T = 2s and the SI factor .0254 for converting inches to metres, we get for

$$\left.\begin{array}{l}\text{London,} \quad g = 981.175 \\ \text{Parramatta,} \quad g = 979.619\end{array}\right\} \Delta g = 1.556 \text{ Gal}$$

The London station was at the house of a Mr Browne in Portland Place, at a height of 83 ft above low water; latitude 51°31′08.4″N (longitude not stated). The Parramatta station was in the grounds of Government House, height 77 ft above high water, latitude 33°48′43″S and longitude 151°00′15″E. Estimates of Bouguer anomaly from modern maps are −10 mGal for London (density 2.67 t/m³) and +12mGal for Parramatta (density 2.2 t/m³). By working back from the Bouguer anomalies, the modern 'observed' values should be approximately (Potsdam system):

$$\left.\begin{array}{l}\text{London} \quad 981.198 \\ \text{Parramatta} \quad 979.652\end{array}\right\} \Delta g = 1.546 \text{ Gal}$$

Thus the difference was measured with an error of only about 10 mGal.

We were incorrect in stating (Dooley & Barlow, 1976, p. 266) that 'The first and, to date, only absolute determination of the acceleration due to gravity in Australia was made by Bell & others (1973) at the National Standards Laboratory (NSL) Sydney'. Day (1966) records that, following Brisbane's return to England, Rumker swung a Fortin pendulum in an attempt to measure absolute gravity at Parramatta (Rumker, 1828). This result for 'the length of the pendulum vibrating seconds of mean solar time *in vacuo* on the level of the sea at Parramatta' is 992.412801 mm; this figure includes a correction of 0.007313 mm to sea level. Thus the figure at Parramatta is 992.405488 mm, corresponding to observed gravity of 979.464 Gal—0.188 Gal too low.

Rumker discusses various comparisons of the metric and English standards for comparison of the 'absolute' result with the previous pendulum determination; in a footnote, Baily points out that the correct factor, taking into account different standard temperatures, is 1 m = 39.37079 English inches (cf. modern value of 39.370 0787 in). However, Rumker later had his Lenoir brass metre standard compared with a British scale giving 1 m = 39.387988 English inches (Rumker, 1829). If we use this conversion factor and assume that the Lenoir metre was incorrect, we get 979.910 Gal, or 0.258 Gal too high.

Thus, either way his determination is in error by about 200 mGal. In view of the difficulties and undetected systematic errors which occurred in absolute gravity determinations for about 100 years after Rumker's observations, this is hardly surprising.

References

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