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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1963/13

ONSLOW/DERBY, REGIONAL GRAVITY TRAVERSE, WA 1953

by

J.C. Dooley

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SUMMARY

Gravity-meter and barometer readings were taken at stations along the road from Onslow to Derby, WA. The results are presented in tabular form and Bouguer anomalies are shown on a map. A postulated granite batholith between Roebourne and Marble Bar may be responsible for negative anomalies in that area.

1. INTRODUCTION

During May and June 1953, the author travelled by road with a Bureau of Mineral Resources gravity party that had been working in the Carnarvon Basin, and was transferring to Derby to begin a survey in the Fitzroy Basin. The opportunity was taken of obtaining gravity readings at intervals of about 20 miles along the road from Onslow to Derby. This could be accomplished without seriously affecting the rate of travel. The purpose of these observations was firstly to obtain some gravity readings in an area that was at that time unsurveyed, and secondly to make some assessment of the accuracy of unrepeated gravity readings.

The observations were made by I.B. Everingham and the author.

The De Grey River was in flood at the time of the survey; hence it was necessary to deviate inland from Port Hedland to cross the river at Yarrie Crossing. The coast road was rejoined near Wallal Station.

2. OPERATIONS

Worden gravity meter No. 61 was used. Single readings only were taken at each station, except where a stop was made overnight or for a similar length of time. Readings were made at the pendulum stations established by the Bureau at Onslow, Port Hedland, Anna Plains, and Derby (Dooley, McCarthy, Keating, Williams, and Maddern, 1961); these readings were used to reduce the gravity data to the national network.

Elevations were obtained by reading an Askania microbarometer at the same time as the gravity meter. Wherever possible, readings were made at sea-level or at points of known elevation, to provide control data.

3. REDUCTION OF RESULTS

The calibration factors used for Worden gravity meter No. 61 were 36.0 mgal/division for the large dial, and 0.0758 mgal/division for the small dial. These factors were applied to the readings to give gravity values in milligals on an arbitrary datum.

Curves for diurnal drift were drawn up from the drifts observed during the field surveys made immediately before and after the traverse from Onslow to Derby. These drifts showed a considerable variation from day to day. A mean diurnal-drift curve was drawn from these, and was used to apply a correction to the gravity values during intervals when no repeat readings were made. No attempt was made to calculate tidal corrections for the individual readings, as the errors due to neglecting these would be small compared with other errors present.

The corrected values were then compared with the values at the pendulum stations at Onslow, Port Hedland, Anna Plains, and Derby. A base-station correction was determined at each of these points. This was assumed to be composed of a constant datum correction, and a varying correction due to a steady drift in the gravity-meter reading additional to the diurnal-drift correction already applied. The varying correction was distributed between pendulum stations in proportion to the time elapsed in traversing.

The major work involved in reducing the results was in calculating the elevations of the stations from the barometer readings. These readings were first converted to equivalent heights on the standard atmosphere, and an instrumental temperature correction was applied.

No base barometer readings were made. The diurnal variations in pressure were obtained from the nearest stations operated by the Bureau of Meteorology. These included aerodrome stations at Onslow, Port Hedland, and Broome, and additional stations at Roebourne, Marble Bar, La Grange, and Derby (Plate 1). At the aerodrome stations, the staff made barometer readings at three-hourly intervals throughout the day and night (except at 1800 hours at Onslow). The readings at the other stations were less accurate and less reliable, and were generally available only at 0600, 0900, 1200, and 1500 hours. At Marble Bar readings were taken at three-hourly intervals except at midnight.

These barometer readings were converted to altitude in the standard atmosphere, and were plotted as a function of time. It was found that the general level of the readings at some stations differed considerably from that at others, presumably owing to an erroneously-assumed elevation used in reducing the stations to sea-level, or to a zero error in the barometer reading. In order to bring these stations into line, corrections were applied as follows: Roebourne, add 66 ft; Marble Bar, add 77 ft; Derby, add 100 ft.

As can be seen from Plate 1, the gravity stations lie fairly close to straight lines joining the meteorological stations. As a first approximation to the equivalent sea-level pressure at each gravity station, the positions of two meteorological stations were projected onto a line joining the stations and the 'altitude' was interpolated between these stations. This was done using aerodrome stations only, and also using the two nearest stations, whether aerodromes or not. A pressure gradient perpendicular to the traverse was determined from the isobaric weather-chart for the day, and a further correction was applied to allow for the offset distance of the station from the line joining the meteorological stations.

The results obtained using the readings at aerodromes only agreed generally within about 4 ft with those obtained using the readings at all meteorological stations, but several differences of over 10 ft were found. An average of the two values was adopted as the equivalent sea-level 'altitude' at the station. This was subtracted from the altitude determined by the microbarometer.

In the absence of any other information the instrument temperature was taken to represent the atmospheric temperature. The relative humidity was assumed to be 40 percent throughout the survey, and a correction was applied for atmospheric temperature and humidity. Variations in humidity would not seriously affect the results.

The corrected elevations were then compared with the true elevations where known, and adjustments were determined at these points. The adjustments were distributed according to the time of reading at intermediate stations, allowance being made for stations repeated at overnight stops, etc. to ensure that the repeated values were the same. The adjustments used are plotted against time on Plate 2. Variations of about 20 ft are common, sometimes in short time intervals. This suggests that errors of this order may be present in the intermediate elevations.

Station locations were determined by identifying features such as road intersections, homesteads, fences, etc., on the Western Australian Lands Department maps (10 mile to 1 in.), or on the military maps (4 mile to 1 in.) Speedometer readings were taken at all stations to assist identification. The maps are not very accurate in some areas, and the co-ordinates of some stations may be in error by one or two miles. Locations of Stations 13, 15, 16, 22, and 24 in particular are doubtful, as there appeared to be discrepancies between the positions of the roads indicated by the maps and the existing roads.

Corrections were made for normal gravity variation with latitude, and for elevation, to give free-air anomalies. Bouguer corrections were applied using an assumed density of 2.67 g/cm^3 for the material between the station and sea-level. No terrain corrections were applied. As the terrain was generally nearly flat, the corrections would be negligible at most (if not all) stations occupied in this survey.

4. ACCURACY OF RESULTS

Plate 3 shows the total drift corrections applied to the gravity readings to bring them into agreement with the pendulum values. The standard deviation of the departures from a straight line representing uniform gravity-meter drift of 1.44 mgal per day is 0.7 mgal. The estimated standard errors of the pendulum stations (Dooley et al.,1961) are as follows:

Onslow	0.5 mgal
Port Hedland	0.6 mgal
Anna Plains	0.8 mgal
Derby	1.2 mgal

Thus the observed deviations are of the order that could be expected on the basis of errors in the pendulum observations alone. This does not enable any reliable estimate of the accuracy of the gravity-meter readings, except that they are presumably no less accurate than the pendulum observations.

Departures of repeated readings from the assumed diurnal drift curve are about 0.1 to 0.2 mgal during a day's traversing. Overnight changes in readings at repeated stations range from 0 to 1.5 mgal, with a mean of 0.5 mgal.

None of the above considerations enables a reliable estimate of the accuracy of the gravity measurements. It is considered that they are probably accurate within about 0.5 mgal.

The errors in elevation determinations are estimated as about 10 to 20 ft. Hence corresponding errors in the free-air and Bouguer anomalies may be about 1 mgal or more. Errors of this magnitude may also occur because of errors in the latitudes of the stations.

Thus the overall errors are probably of the order of 2 mgal. Errors in the gravity-meter observations are probably not important compared with the surveying errors.

5. DISCUSSION OF RESULTS

Details of the stations are listed in Table 1 which gives free-air and Bouguer anomalies. The Bouguer anomalies are plotted on Plate 1, together with the regional geology taken from the BMR Tectonic Map of Australia, 1960.

The gravity observations are too far apart to make any reliable geological interpretation. However, a few features of general interest can be noted:

From about Stations 6 to 21 the traverse lies on, or close to, outcropping Precambrian rocks. The Bouguer anomalies are all negative in this zone, ranging from about -15 to -37 mgal. There does not seem to be any particular correlation with the various geological formations shown on the map. Generally speaking, granite is lighter than Precambrian sedimentary and metamorphic rocks. The negative anomalies suggest that the traverse crosses a large granite batholith, and that the other Precambrian features are relatively shallow pockets. However, this conclusion could be modified if densities of the various rock-types were known.

The decrease of 14 mgal between Stations 17 and 18, only two miles apart, is interesting, and could be due to a fault, or to a dyke or other intrusive body. This suggests the possibility that similar local variations may occur over the Precambrian rocks more generally than might appear from most of the observations.

There is a large increase in gravity south-west from Station 5 to 4, and this is probably due to a change in basement from granite to a denser rock. One would expect the Cretaceous and Quaternary sediments to have a lower density than granite; hence the positive anomalies between here and Onslow suggest that there is no great thickness of these younger sediments present.

On the north-east of the Precambrian rocks, the traverse enters the Canning Basin, where there are outcrops of Jurassic rocks, which are also marked by a change to positive anomalies. The anomalies become slightly negative between Anna Plains and Broome, and this may represent a deepening of the Basin in that area.

From Port Hedland north-eastwards, the areas crossed by the traverse have been covered subsequently by more comprehensive gravity work. Interpretation of this work will be discussed in other reports.

6. CONCLUSIONS

Gravity surveys, using single readings only, with a Worden gravity meter and an Askania microbarometer can be used to give rapid coverage of unsurveyed areas, with an accuracy of about 2 mgal in the Bouguer anomalies.

The Precambrian complex in the Roebourne/Port Hedland/Marble Bar region gives predominantly negative Bouguer anomalies, and this suggests granite as the chief rock type. Positive anomalies over the sediments flanking this region suggest that no great thickness of sediments exist near the margins of the complex. These conclusions are tentative in the absence of definite information on rock densities in the area.

7. REFERENCE

DOOLEY, J.C.	1962	Australian gravity network adjustment, 1962. Bur. Min. Resour. Aust. Rec. 1962/141 (unpubl.)
DOOLEY, J.C., McCARTHY, E., KEATING, W.D., WILLIAMS, L.W. and MADDERN, C.A.	1961	Pendulum measurements of gravity in Australia, 1950-1951, Bur. Min. Resour. Aust. Bull. 46

APPENDIX

BASE VALUES FOR GRAVITY DATA

Since the reduction of the results in this survey, gravity values at Australian base stations have been readjusted (Dooley, 1962). The new values at the base stations used for this survey are given below, followed by their standard deviation and the adjustment to the previous values in milligals:

P.S. No. 25	Onslow	978,773.1 ± 0.2	+ 0.6
26	Port Hedland	978,646.0 ± 0.3	+ 0.8
27	Anna Plains	978,624.9 ± 0.4	+ 1.7
28	Derby	978,520.3 ± 0.9	+ 0.9

As the result of this readjustment, it was concluded that the calibration factor of the gravity meter should be 1.6 parts per thousand higher than the value used in this survey; i.e. all gravity intervals should be increased by a factor of 1.0016. From the residuals of the observations of this and similar surveys, the standard error of the observed gravity values appears to be about 1 mgal.

The effect of the above adjustments will not be large compared with the errors inherent in the survey, and will not affect the discussion of the results of this survey, as no detailed interpretation was considered.

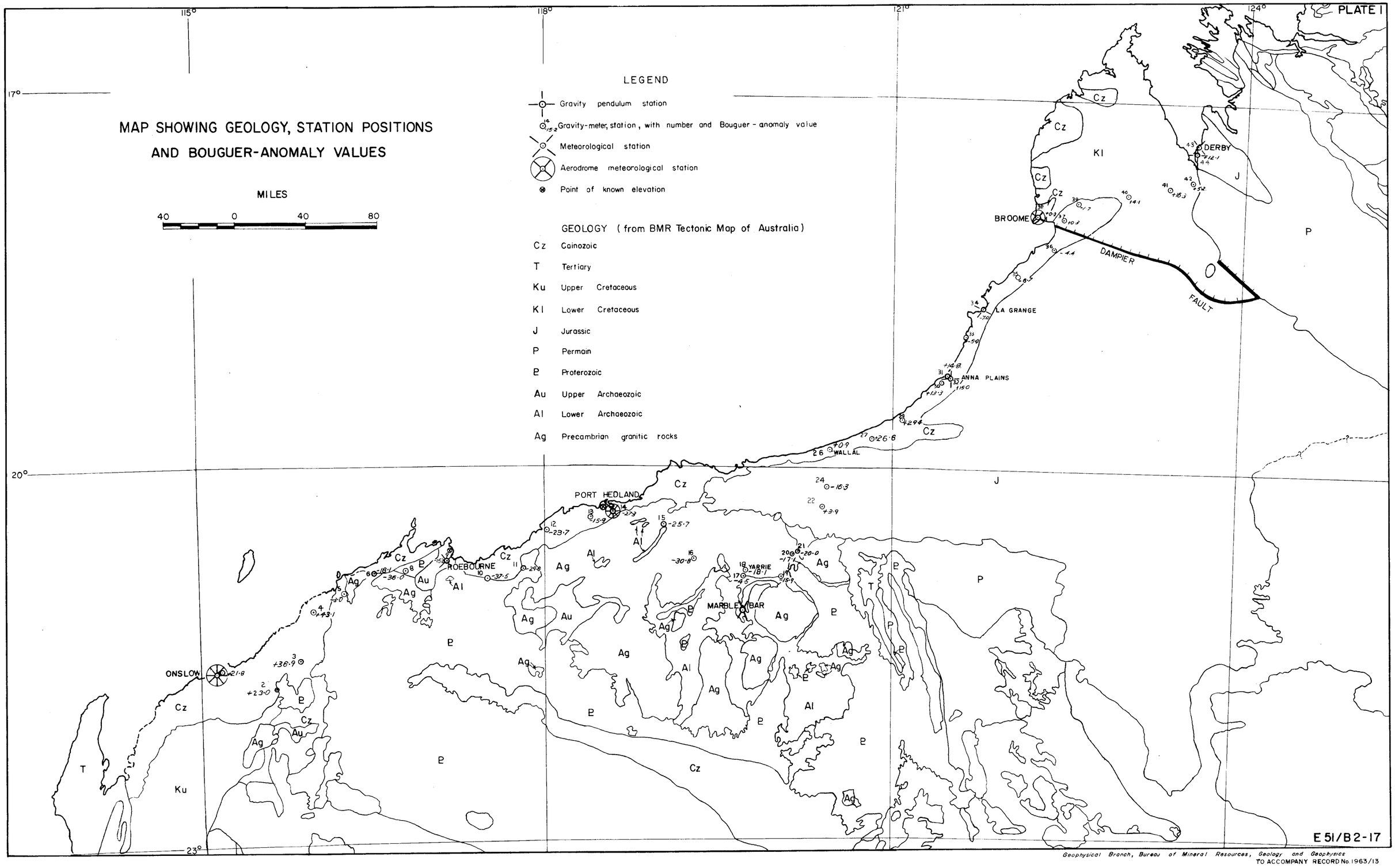
The data for this survey are stored in BMR gravity file No. 53-045.

TABLE 1

DETAILS OF GRAVITY STATIONS

ONSLOW/DERBY TRAVERSES

Station	Latitude		Longitude		Elevation	Observed gravity	Normal gravity	Free air correction	Free air anomaly	Bouguer correction	Bouguer anomaly
	°	'	°	'	ft	978,000+	978,000+				
1(PS25)	21	40.2	115	06.2	14	772.5	751.5	1.3	+22.3	-0.5	+21.8
2		50.0		37.7	255	769.4	761.7	24.0	+31.7	-8.7	+23.0
3		36.6		51.2	232	770.9	747.9	21.8	+44.8	-7.9	+36.9
4		11.3	115	58.3	87	760.0	722.1	8.2	+46.1	-3.0	+43.1
5	21	2.9	116	15.0	185	699.5	713.6	17.4	+ 3.3	-6.3	- 3.0
6	20	52.2		30.0	51	681.7	702.9	4.8	-16.4	-1.7	-18.1
8		50.8	116	48.2	138	657.2	701.5	13.0	-31.3	-4.7	-36.0
9		46.0	117	09.0	37	679.3	696.7	3.5	-13.9	-1.3	-15.2
10		55.5		32.0	85	663.6	706.2	8.0	-34.6	-2.9	-37.5
11		50.6	117	50.7	141	663.2	701.3	13.3	-24.8	-4.8	-29.6
12		31.2	118	02.8	15	657.5	682.1	1.4	-23.2	-0.5	-23.7
13		25.0		26.1	55	656.8	676.0	5.2	-14.0	-1.9	-15.9
14(PS26)		23.0	118	37.9	26	645.2	674.0	2.4	-26.4	-0.9	-27.3
15		28.2	119	03.7	195	641.8	679.1	18.3	-19.0	-6.7	-25.7
16		45.5		19.6	254	650.2	696.2	23.9	-22.1	-8.7	-30.8
17		52.1		45.4	375	675.8	702.8	35.3	+ 8.3	-12.8	- 4.5
18		51.0	119	46.7	328	663.9	701.7	30.9	- 6.9	-11.2	-18.1
19		52.6	120	04.9	473	659.1	703.3	44.5	+ 0.3	-16.2	-15.9
20		41.4		12.9	322	655.8	692.2	30.3	- 6.1	-11.0	-17.1
21		40.5		13.6	333	651.4	691.3	31.3	- 8.6	-11.4	-20.0
22		18.8		26.5	520	642.7	669.9	48.9	+21.7	-17.8	+ 3.9
24	20	09.2		28.5	374	621.9	660.6	35.2	- 3.5	-12.8	-16.3
26	19	50.2		29.8	29	641.5	642.3	2.7	+ 1.9	- 1.0	+ 0.9
27		44.1	120	51.2	40	660.6	636.4	3.8	+28.0	- 1.4	+26.6
29		36.2	121	06.8	39	655.9	628.9	3.7	+30.7	- 1.3	+29.4
30		17.8		26.5	41	622.4	611.6	3.9	+14.7	- 1.4	+13.3
31		14.5		29.8	25	621.8	608.5	2.4	+15.7	- 0.9	+14.8
32(PS27)	19	15.5		29.3	20	623.2	609.4	1.9	+15.7	- 0.7	+15.0
33	18	55.5		38.3	25	584.4	590.9	2.4	- 4.1	- 0.9	- 5.0
34		41.3	121	46.6	27	569.3	577.9	2.5	- 6.1	- 0.9	- 7.0
35		24.8	122	04.1	86	551.1	563.0	8.1	- 3.8	- 2.9	- 6.7
36	18	10.8		22.0	34	544.1	550.5	3.2	- 3.2	- 1.2	- 4.4
37	17	56.4		27.5	26	536.6	537.8	2.4	+ 1.2	- 0.9	+ 0.3
38		58.3		15.0	20	538.4	539.4	1.9	+ 0.9	- 0.7	+ 0.2
39		48.5		34.6	84	524.1	530.8	7.9	+ 1.2	- 2.9	- 1.7
40		43.9	122	59.3	266	515.0	526.8	25.6	+13.2	- 9.1	+ 4.1
41		40.0	123	20.5	50	536.8	523.5	4.7	+18.0	- 1.7	+16.3
42		36.6		32.0	28	524.1	520.5	2.6	+ 6.2	- 1.0	+ 5.2
43		18.6		31.7	?	517.8					
44(PS28)	17	22.7	123	39.2	22	519.4	508.6	2.1	+12.9	- 0.8	+12.1



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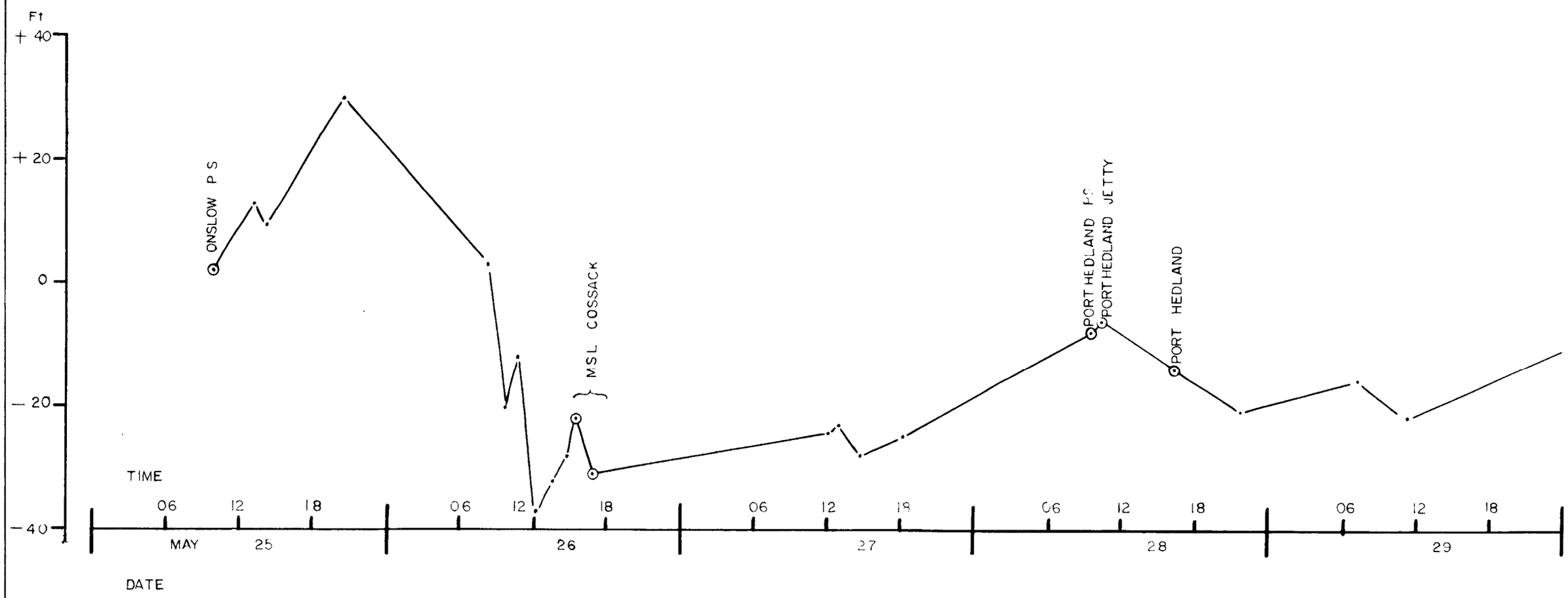

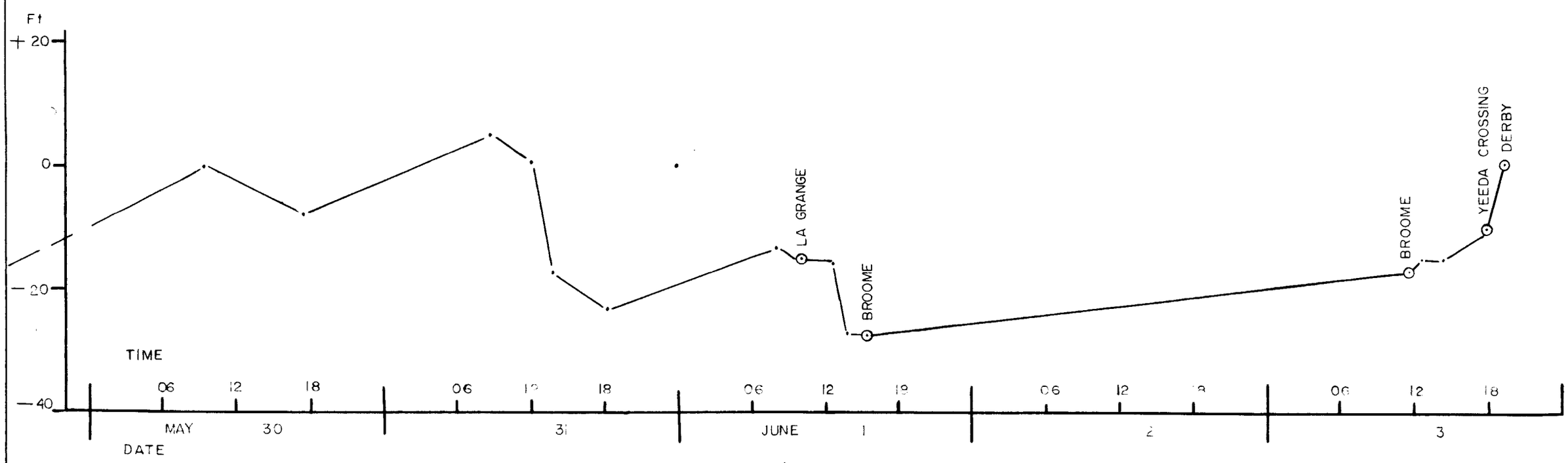

ONSLOW/DERBY REGIONAL GRAVITY TRAVERSE W A 1953

BAROMETRIC ELEVATION ADJUSTMENTS

⊙ Point of known elevation

P S Pendulum station

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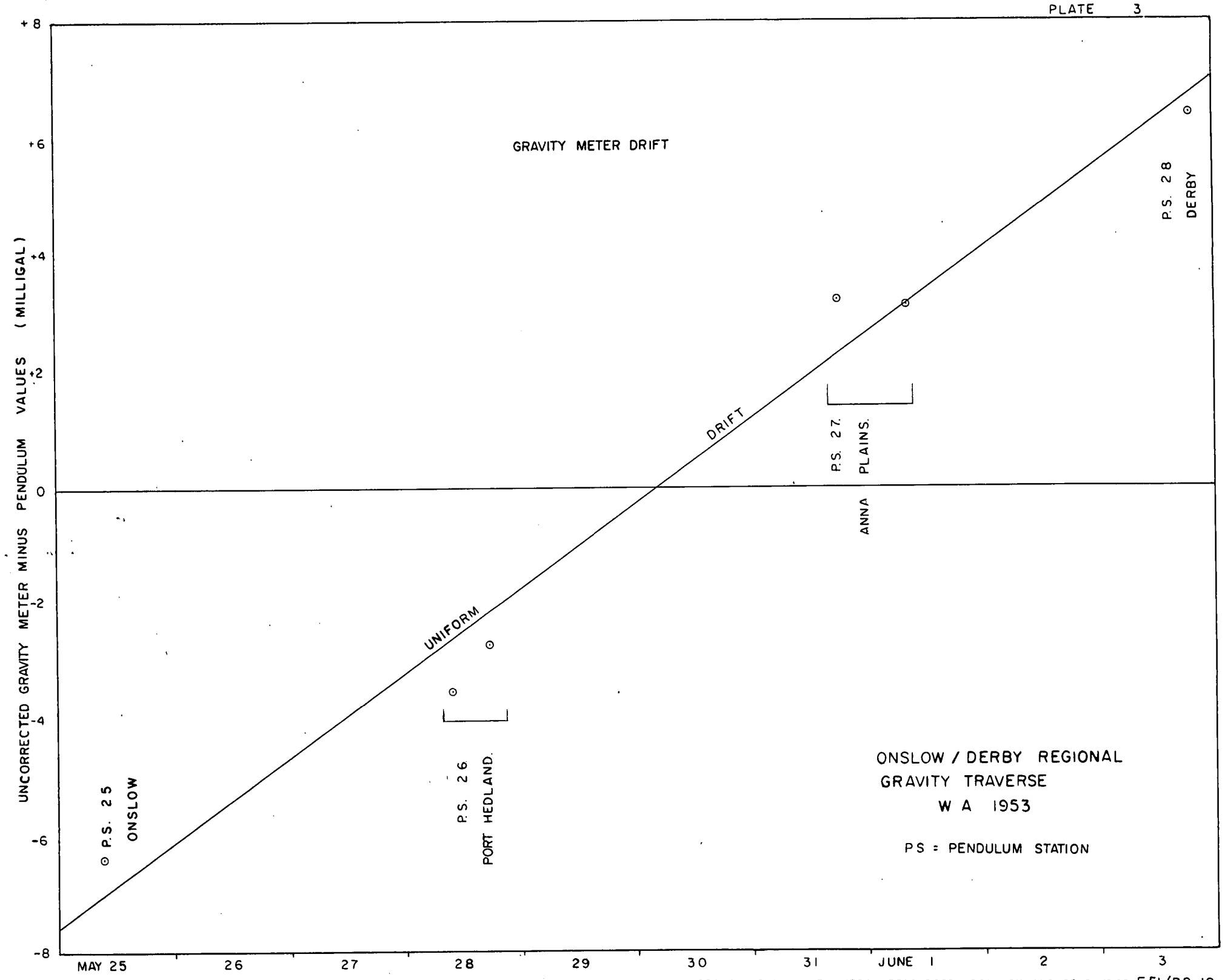

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