DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

RECORD 1975/48

OPERATIONAL REPORT ON THE SOVIET GRAVITY TIE MOSCOW - PORT MORESBY - HOBART, 1974

by

Peter Wellman

RECORD 1975/48

OPERATIONAL REPORT ON THE SOVIET GRAVITY TIE MOSCOW - PORT MORESBY - HOBART, 1974

by

Peter Wellman

CONTENTS

SUMMARY

Soviet OVM pendulums were used to make a pendulum tie Moscow - Port Moresby - Hobart in October to November 1974. The tie was a cooperative project between the Academy of Sciences of the USSR, the University of Tasmania, and BMR. This report lists the OVM pendulum equipment and details of the logistics of the project together with details of the observation sites and ties from these sites to airport gravity stations. Preliminary pendulum results confirm the 1973 GAG-2 gravity scale on the Australian Calibration Line, and give further support to the suggestion that the IGSN71 values in Australia are not correct in scale.

1. INTRODUCTION

A limiting factor in making accurate measurements of the acceleration due to gravity is the determination of datum and scale.

The gravity datum for Australia and Papua New Guinea up to 1973 was based on measurements of the gravity intervals between Australia and overseas absolute measurements using gravity meters and Cambridge pendulums. Since 1971 accurate datum determinations have been made by an absolute measurement of gravity in Sydney (Bell et al., 1973), by an OVM pendulum tie between Moscow and Sydney (Gusev, 1972), and by a world-wide adjustment of the absolute, pendulum,and gravity meter measurements available to 1969 (IGSN71 adjustment; Morelli et al., 1971). These datum determinations agree to within experimental error, and a new datum for Australia and Papua New Guinea was selected by Boulanger et al. 1973).

Until 1973 gravity scale was based on Cambridge pendulum measurements in Australia. Since 1973 two accurate gravity scales have become available, the scale given by the station values of the IGSN71 adjustment (Morelli et al., 1971) and the scale given by GAG-2 gravity meter measurements in Australia and Papua New Guinea (Wellman et al.,1974a). However, these two new scales do not agree to within experimental error, and Wellman et al. (1974b) suggests that the IGSN71 scale is incorrect in Australia. The 1973 GAG-2 gravity meter scale was adopted for Australia and Papua New Guinea by Boulanger et al. (1973).

An OVM pendulum tie Moscow-Port Moresby-Hobart was undertaken to confirm the scale of the GAG-2 gravity meter measurements in Australia and Papua New Guinea, and to strengthen the gravity tie between Papua New Guinea and the world gravity base station at Potsdam. The tie was a cooperative project between the Academy of Sciences of the USSR, BMR, and the University of Tasmania, the equipment being owned and operated by the Central Scientific Research Institute of Geodesy, Aerial Survey and Cartography (TSNIIGAIK) which is based in Moscow.

2. OPERATIONAL DETAILS

The TSNIIGAIK pendulum party, led by Dr. N. Gusev, consisted of two scientists and four engineers (Appendix 1). They brought to Australia a set of five OVM pendulums having a total weight of about one tonne (Appendix 2a, 2b) (Slivin, 1973; Wellman et al., 1973). Between Moscow and Hobart they were accompanied by Professor Yu. D. Boulanger, Vice-President of the Soviet Geophysical Committee, while in Moscow and Singapore by Mr. D.A. Coutts of BMR, and while in Australia and Papua New Guinea, by the author. Observations were made in the sequence Moscow - Port Moresby - Hobart - Port Moresby - Moscow (Appendix 3). Commercial air transport was used for the legs Moscow - Singapore (Aeroflot), Singapore - Port Moresby (Qantas), and Port Moresby - Sydney (TAA); a chartered jet-prop aircraft (King Air A90) was used to move the delicate equipment (approximately 587kg) between Sydney and Hobart, most of the personnel and excess baggage travelling by TAA commercial flights.

At each site the pendulum observations took about five days. The pendulum swinging chambers were placed in position on small holes drilled in the flat concrete floor, and were levelled. The control panels that operate the pendulums were checked and faulty components were replaced. These control panels are valve electronics carried as excess baggage; they were sometimes damaged by aircraft porters (particularly at Singapore) and extensive repairs were needed for some units. The control panels were then used to check the pendulums, and monitor the evacuation of gas that had leaked into the swinging chambers. The quartz crystal clocks, and the generators (oscillators) for the photoelectric recorders were then checked, the frequency dividers on the clocks needing some maintenance. The relative periods of the quartz crystal clocks was measured. The mean temperature and vertical temperature gradient of the observing sites were approximately equalized by using heaters, fans, and air-conditioning units. All this preliminary work took about one day.

Over the next three to four days, 6 to 10 periods were determined for each pendulum. Observations were made on each of the five pendulums in sequence, observations on each pendulum being at different times of the day so as to average the effects of diurnal and irregular variations in temperature, pressure, and vibration. Finally the relative periods of the quartz crystal clocks were redetermined. Packing the equipment takes approximately two hours. The five 60 AH batteries are charged the night before the next flight stage; they keep the pendulums on the heat for about 14 hours. The batteries have a life of about 7 years. The pendulums themselves are kept on heat and under vacuum at all times during the survey.

The most satisfactory truck for surface movement is a two-ton walk-through van with an experienced driver. A medium-sized utility can be used but two trips are necessary to move the pendulums. The pendulums and clocks are carried with foam rubber (Parolon amortisators) below and around them; the are packed tight to prevent them falling on their side, but are not tied. A pendulum party member travels in the back of the truck with the equipment.

Loading the pendulums and clocks into an aircraft cabin takes 30 to 90 minutes. Three pairs of first-class seats are either moved back as far as possible, or they are removed and placed in the hold. Foam rubber is placed on the floor and along the walls, the pendulums and clocks are directly placed on this, and are then firmly tied down with straps to tie-down points placed in the floor seat-tracks. Regulations limit the amount of seat movement, the mass that can be tied down, and call for the equipment to be accompanied by a passenger in the same cabin.

At aircraft departure and arrival points prior arrangements had to be made with the following personnel - airport security, the top airline representative at the airport, Customs, and Immigration. Care was needed not to hold up the flight. Customs entry into Papua New Guinea was effected by endorsement on the passengers baggage declaration. Customs entry into

Australia was effected by placing the equipment under bond to Sydney, and by personal assurance (by P. Wellman) to the Sub-Collector of Customs (Sydney) that the equipment would be exported within 12 months (section 162 of the Customs Act). Personnel with Soviet passports passed only slowly through Immigration, causing some difficulty. The main problem at airports was the requirement to have a member of the Soviet group with the equipment at all times, to ensure that the pendulums did not go off heat.

While pendulum measurements were being made at a site a long time was spent booking and confirming the aircraft seats for the next and subsequent flights.

3. PRELIMINARY SCIENTIFIC RESULTS

Pendulum observations were carried out at three sites, all on flat concrete floors. The Moscow pendulum site (Plate 1) is in a laboratory of the Institute of Physics of the Earth, in the village of Ledovo near Moscow (Boulanger et al., 1974). This site has a gravity value 290.603 ± 0.012 mGal greater than Potsdam S2 (Boulanger, 1974). The Port Moresby pendulum site (7090.0576, 34697D, Plate 2) is in the library of the Port Moresby Geophysical Observatory. The Hobart pendulum site (7499.0160, 49027B, Plate 3) is in the 1974 extension to the University of Tasmania seismic vault (TAU) in Hobart.

At the time this report was written only preliminary OVM pendulum results were available because the precise drift of the quartz clock had not been determined. The preliminary results given the gravity interval Hobart B - Port Moresby D = 2215.64 ± 0.06 mGal.

The scale defined by this pendulum result can be compared with earlier scales defined by the Hobart - Port Moresby gravity interval: the mean Australian milligal scale used by the 1970 BMR survey (Cooke, 1970), the International Gravity Standardization Net 1971 (IGSN71) scale (Morelli et al., 1971), and the GAG-2 gravity meter scale (Wellman et al., 1974b). The intervals defined by these surveys together with the relevant excentre ties are given in Plate 4 and Table 1. The sources of the excentre ties are as follows: Port Moresby D-T, T-L, and Hobart P-T from Wellman et al., (1974b), Port Moresby L-J from Boulanger et al., (1973), Hobart B-P was measured during the 1974 pendulum survey (details in Appendix 4A), and Hobart T-K is estimated.

When all the results are reduced to the gravity interval Hobart B - Port Moresby D (Table 2) it can be seen that the 1974 OVM pendulum scale agrees to within experimental error with the 1973 GAG-2 gravity meter scale. Wellman et al. (1974a) have shown earlier that the 1973 GAG-2 scale agrees to within experimental error with the scale of the IGSN71 values on the Western Pacific Calibration Line between Singapore and Alaska. These scales are significantly different from both the mean Australian milligal scale and the scale defined either by the IGSN71 Hobart and Port Moresby gravity values, or by the IGSN71 gravity values of stations between Melbourne and Cairns. These OVM pendulum results support the decision to base the new Australian milligal scale on the GAG-2 gravity meter results, rather than the IGSN71 gravity values on the ACL (Boulanger et al., 1973; Wellman et al., 1974a; Wellman et al., 1974b).

After the OVM pendulum measurements were made in Hobart four LaCoste & Romberg gravity meters were used to redetermine the Hobart Calibration Range interval. The result of this tie is Hobart L (6091.0160) - Hobart M (6091.0260) = 54.648 ± 0.004 mGal (Appendix 4B). This interval for the Hobart Calibration Range is more accurate than earlier work,and it is consistent with the interval inferred from the 1970 quartz meter and LaCoste measurements (54.65 mGal; Wellman et al., 1974b). The interval of 54.71 mGal given by Barlow (1967) is in error; the gravity interval 54.65 mGal should be used for all future calibrations on the Hobart Calibration Range.

4. REFERENCES

BARLOW, B.C., 1967 - Gravity meter calibration ranges in Australia. Bur. Miner. Resour. Aust. Rep. 122.

BELL, G.A., GIBBINGS, D.L.H., & PATTERSON, J.B., 1973 - An absolute determination of the gravitational acceleration at Sydney, Australia. Metrologia, 9, 47-61.

BOULANGER, Yu, D., 1974 - Secular variations of gravity. 7th Mtg. Int. Gravity Commission,1974, Paris.

BOULANGER, Yu. D., SHCHEGLOV, S.N., WELLMAN, P., COUTTS, D.A., & BARLOW, B.C., 1973 - Soviet-Australian gravity survey along the Australian Calibration Line. Bull. Geodesique, 110, 355 - 66.

BOULANGER, Yu. D., GUSEV, N.A., LOKHOV, V.V., SLIVIN, Yu.A., HEIFETZ, M.E., SHCHEGLOV, S.N., 1974 - Determination of gravitational acceleration at Moscow (Ledovo), Murmansk, Odessa and Nakhodka. Bur. Gravimetrique Int. Bull. d'Information, 34(I), 25-30.

COOKE, R.J.S., 1970 - Gravity meter measurements on the Western Pacific, Japanese and Australian Calibration Lines. Bur. Miner. Resour. Aust. Rec. 1970/118. (unpubl.).

GUSEV, N.A., 1973 - Determination of gravity acceleration at Sydney with pendulum apparatus. Central Research Institute of Geodesy, Aerial Survey and Cartography, Moscow, USSR, report 1973. English translation Bur. Miner. Resour. Aust. Rec. 1973/115. (unpubl.).

MORELLI, C., and others, 1971 - The International Gravity Standardization Net 1971 (I.G.S.N. 71). Int. Ass. Geodesy. Spc. Publ. 4. Paris.

SLIVIN, Yu. A., 1973 - Papers on the measurement of gravity with USSR pendulum equipment. Bur. Miner. Resour. Aust. Rec. 1973/119 (unpubl.). Translated by J.C. Dooley from Trans. central scient. Res. Inst. Geodesy. Aerosurvey. Cartog. Vol. 170.

WELLMAN, P., BARLOW, B.C., & COUTTS, D.A., 1974a - Comparison of Western Pacific and Australian Calibration Line gravity scales and an evaluation of secular variation. Paper presented at 7th meeting International Gravity Commission 2-6 September 1974 Paris. Bur. Miner. Resour. Aust. Rec. 1974/121 (unpubl.).

WELLMAN, P., BOULANGER, Yu. D., BARLOW, B.C., SHCHEGLOV, S.N., & COUTTS, D.A., 1974b - Australian and Soviet gravity surveys along the Australian Calibration Line. Bur. Miner. Resour. Aust. Bull. 161.

WELLMAN,P., DOOLEY, J.C., & BARLOW, B.C., 1973 - Soviet gravity tie from Moscow to Sydney 1972. Bur. Miner. Resour. Aust. Rec. 1973/119 (unpubl.).

Table 1   Station Numbers

Place	IGC No.	BMR No.	Other No.
Port Moresby	34697 D	7090.0576	-
	34697 T	7390.0176	-
	34697 L	6791.0476	-
	34697 J	6791.0176	WHOI: WA3069 BMR: 6351.0195 USNOO:0079.01
Hobart	49027 B	7499.0160	-
	49027 P	7390.0160	-
	49027 T	6491.0160	Helfer 255?, Hobart K in BMR Bull.161
	49027 K	7530.0160	-

Table 2. Estimates of the gravity interval Hobart B - Port Moresby D.

	Gravity Interval (m al)	Difference from OVM (m al)
OVM Pendulums 1974 (preliminary value)	2215.64 ± .06	
GAG-2 gravity meters 1973	2215.699 ±.043	+.059 ± .073
Mean Australian milligal scale 1970	2214.473	-1.167
IGSN71 values of Hobart & Port Moresby only	2215.388 ±.109	-.252 ± .124
Using scale given by IGSN71 values of Stations between Cairns and Melbourne and GAG-2 gravity metre intervals *	2215.369 ±.080	-.271 ±.106

* Calculated using scale ratio as given in Wellman et al. (1974b, Table 12).

$$\frac{\text{IGSN71 interval}}{\text{GAG-2 interval}} = 0.999851 \pm .000036$$

APPENDIX 1. PERSONNEL OF EXPEDITION

Professor Yuri D. Boulanger

Address : Moscow, D-242
10 Bol. Gruzinskaya
Institute of Physics of the Earth

Dr. Nikolai A. Gusev	(leader, Chief of Laboratory)
Mr. Valeri Lokhov	(senior scientist)
Mrs. Antonina G. Goidycheva	(engineer)
Mr. Nikolai N. Korolev	(engineer)
Mr. Alexandr P. Metlin	(engineer)
Mr. Vitali Barsdel	(engineer)

Address : Moscow
26 Onezhskaya Street
TSNIIGAIK (Central Scientific Research Institute of Geodesy, Aerial Survey and Cartography)

Dr. Peter Wellman	BMR in Port Moresby and Hobart
Mr. D.A. Coutts	BMR in Moscow and Singapore
Mr. S.J. Lambert	BMR in Sydney

APPENDIX 2a. PENDULUM EQUIPMENT PLACED IN THE CABIN OF THE AIRCRAFT.

Package Number	Instruments	Dimensions (cm)	Kind of Package	Weight of Package (kg)
1	Pendulum apparatus EVP6101, EOMZ, TSNIIGAIK	45 x 45 x 60	box	50
2	Pendulum apparatus EVP6102, EOMZ, TSNIIGAIK	45 x 45 x 60	box	50
3	Pendulum apparatus EVP6301, EOMZ, TSNIIGAIK	45 x 45 x 60	box	50
4	Pendulum apparatus EVP6302, EOMZ, TSNIIGAIK	45 x 45 x 96	box	80
5	Pendulum apparatus EVP6303, EOMZ, TSNIIGAIK	45 x 45 x 60	box	50
6	Instrument testor Z437 No. 88641	21 x 33 x 16	box	5
7	Quartz crystal clock KCC-11 EOMZ, TSNIIGAIK	25 x 32 x 40	in a cover	12
8	Quartz crystal clock KCC-12 EOMZ, TSNIIGAIK	25 x 32 x 40	in a cover	12
9	Quartz crystal clock KCC-13 EOMZ, TSNIIGAIK	25 x 32 x 40	in a cover	12
10	Generators to photoelectrical recorders FR-03 and FR-05	17 x 27 x 40	box	10
11	Vacuum pump BM - 0,1, EOMZ TSNIIGAIK	20 x 20 x 28	metal casing	8
12-17	5 Accumulators 10 KNB-60M	each 22 x 45 x 25	metal box each	32
18	Connecting wires	45 x 45 x 60	suitcase	40
19	Parolon amortisators	each 5 x 40 x130	in covers	10
			Total Weight	587

APPENDIX 2b. PENDULUM EQUIPMENT SENT AS EXCESS BAGGAGE.

Package Number	Instruments	Dimensions	Kind of Package	Weight of Package (kg).
20	Control panel of apparatus 6101 EOMZ, TSNIIGAIK			
	Control panel of apparatus 6102 EOMZ, TSNIIGAIK	45 x 45 x 60	box	45
	Extra materials and parts			
21	Control panel of apparatus 6301 EOMZ, TSNIIGAIK			
	Control panel of apparatus 6302 EOMZ, TSNIIGAIK			
	Oscillograph C1-6 (EMO-2) No.1824.			
	Extra materials and parts	45 x 45 x 60	box	45
22	Photoelectrical recorder FR-03, EOMZ, TSNIIGAIK			
	Extra materials and parts	45 x 45 x 60	box	45
23	Photoelectrical recorder FR-09 EOMZ, TSNIIGAIK			
	Extra materials and parts	45 x 45 x 60	box	45
24	Photoelectrical recorder FR-07, EOMZ, TSNIIGAIK			
	Extra materials and parts	45 x 45 x 60	box	45
25	Autocollimation level EOMZ TSNIIGAIK, Power Supply BCA-6M-K, TSNIIGAIK, OSCILOGRAPH C-I-35 NL01051, spare parts	45 x 45 x 62	box	45
26	Control panel of apparatus No.6303, EOMZ, TSNIIGAIK Autotransformer No.3147 "Electropribon", Tester, Radio set "Ivolga - 66" No. 724548	45 x 45 x 60	box	45
			Total weight	315

APPENDIX 3. ITINERARY

About 30 September	Start measurements at Lodovo
4 October	Finish measurements at Lodovo
6 October	Flight SU551 Moscow to Singapore
8 October	Flight QF720 Singapore to Port Moresby
9 October	Start measurements at Port Moresby
14 October	Finish measurements at Port Moresby
15 October	Flight TN1305 Port Moresby to Sydney
	Chartered flight for pendulums Sydney to Hobart
16 October	Flight TN539/447 for rest of personnel
	Start measurements at Hobart
23 October	Finish measurements at Hobart
24 October	Flight TN448/454 for personnel Hobart to Sydney
	Chartered flight for pendulums
25 October	Flight TN1304 Sydney to Port Moresby
	Start measurements at Port Moresby
1 November	Finish measurements at Port Moresby
2 November	Flight QF717 Port Moresby to Singapore
4 November	Flight SU552 Singapore to Moscow
	Start measurements at Moscow
About 10 November	Finish measurements at Moscow

APPENDIX 4A. HOBART GRAVITY TIE

INTERVAL HOBART B (7499.0160) - HOBART P (7390.0160).

LaCoste gravity meter number	Date	Gravity Intervals (scale divisions)	Correction for nonlinearity and scale *	Gravity Intervals (mGal)	Differences from mean (mGal)
G20A	22-10-74	17.274		18.178	+.041
		17.252	1.05194	18.155	+.018
		17.249	x1.0003782	18.152	+.015
	23-10-74	(17.113)	=1.05234	(18.009)	
		17.248		18.151	+.014
		17.245		18.148	+.011
G101	22-10-74	17.267		18.112	-.025
		17.255	1.04610	18.099	-.038
		17.260	x1.0026897	18.104	-.033
	23-10-74	17.255	=1.04891	18.099	-.038
		17.260		18.104	-.033
		17.275		18.120	-.017
G132	22-10-74	17.120		18.153	+.016
		17.125	1.05985	18.158	+.021
		17.118	x1.0004416	18.151	+.014
	23-10-74	-	=1.06031	-	
		17.123		18.156	+.019
		17.113		18.145	+.008
G252	22-10-74	17.228		18.126	-.011
		17.257	1.05158	18.157	+.020
		17.225	x1.0005338	18.123	-.014
	23-10-74	17.240	=1.05214	18.139	+.002
		17.235		18.134	-.003
		17.250		18.149	+.012

* Using the makers tables and corrections for scale given in Wellman et al (1974a).

Mean interval	18.137
number of intervals	22
standard deviation of intervals	.023
standard deviation of mean.	.005

APPENDIX 4B. HOBART GRAVITY TIE

INTERVAL HOBART L (6091.0160) - HOBART M (6091.0260)

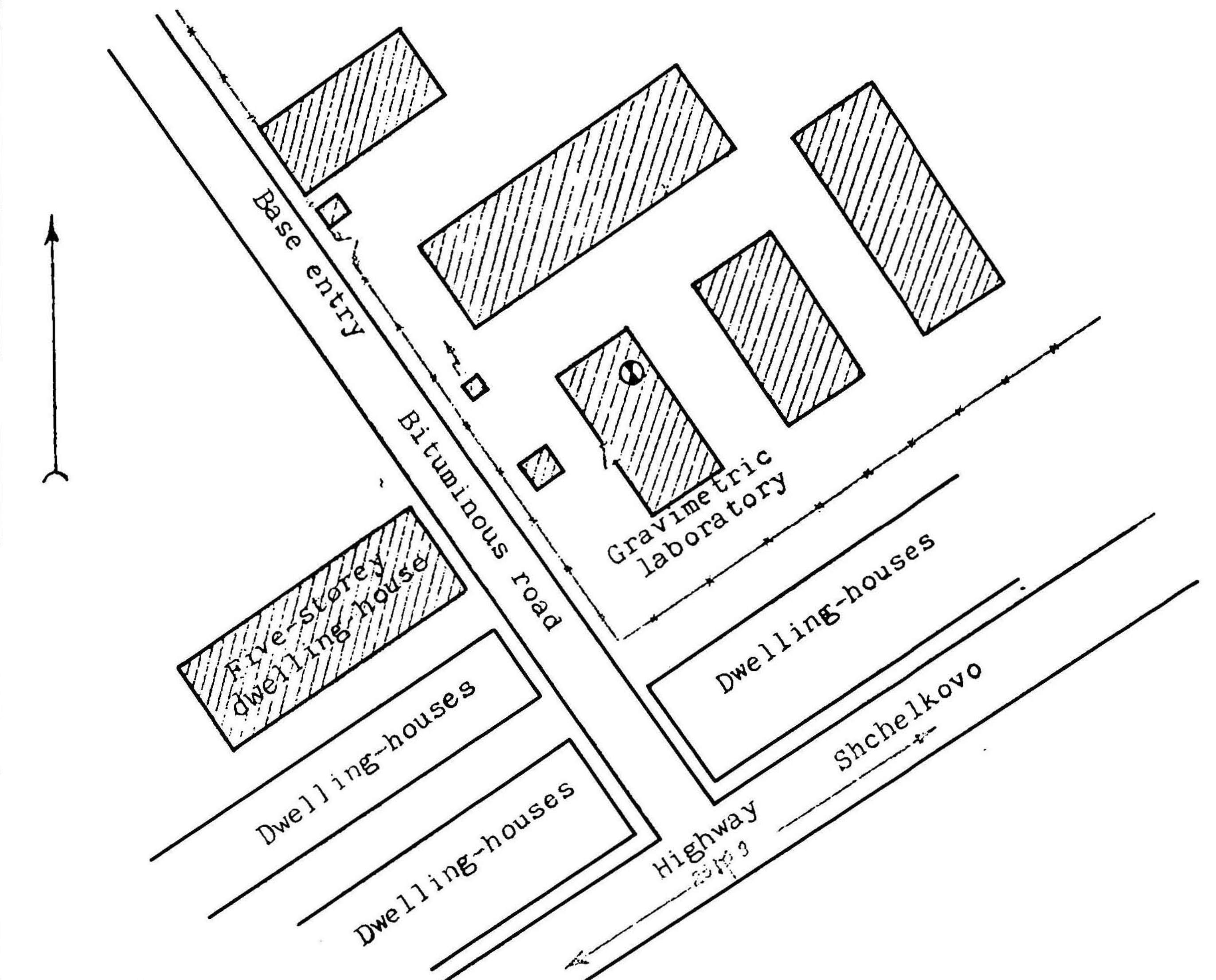
LaCoste gravity meter number	Date	Gravity Intervals (scale divisions)	Correction for nonlinearity and scale *	Gravity Intervals (mGal)	Differences from mean (mGal)
G20A	21-10-74	51.964		54.684	+.036
		51.936		54.654	+.006
		51.971	1.05194	54.691	+.043
	23-10-74	51.945	x1.0003782 =1.05234	54.664	+.016
		51.940		54.658	+.010
		51.925		54.643	-.005
G101	21-10-74	52.095		54.643	-.005
		52.082		54.629	-.019
		52.092	1.04610	54.640	-.008
	23-10-74	52.085	x1.0026897 =1.04891	54.633	-.015
		52.077		54.624	-.024
		52.057		54.603	-.045
G132	21-10-74	51.520		54.626	-.022
		51.530		54.637	-.011
		51.525	1.05982	54.631	-.017
	23-10-74	51.560	x1.0004416 =1.06029	54.668	+.020
		51.543		54.650	+.002
		51.554		54.662	+.014
G252	21-10-74	51.932		54.640	-.008
		51.937		54.645	-.003
		51.935	1.05158	54.643	-.005
	23-10-74	51.949	x1.0005338 =1.05214	54.658	+.010
		51.950		54.659	+.011
		51.951		54.660	+.012

* Using the makers tables and corrections for scale given in Wellman et al. (1974a).

Mean interval	54.648
number of intervals	24
standard deviation of intervals	.020
standard deviation of mean	.004

code IGB : 213 57

Station Ledovo (Moscow)

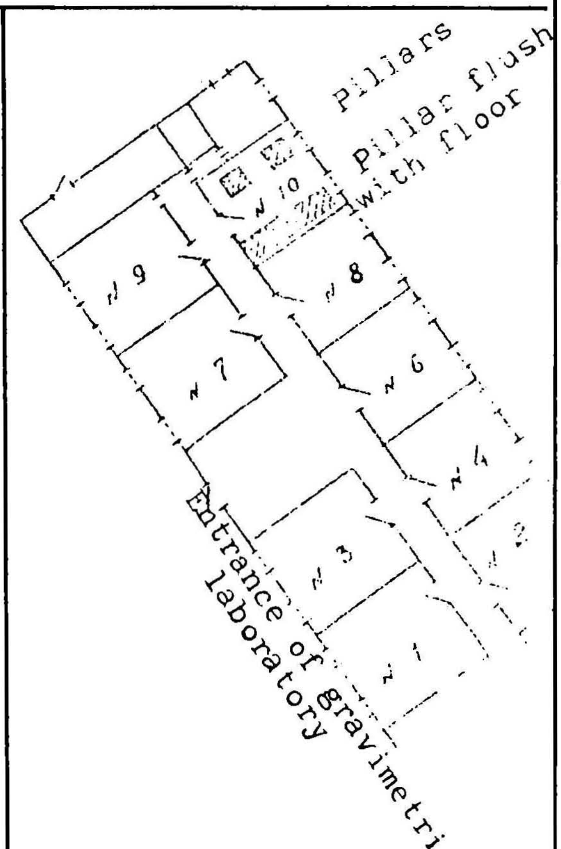


The station is situated at the area of the Ledovo-test base of the Institute of Earth's Physics (IFZ) of the Academy of Sciences of the USSR near Moscow (village Dolgoe-Ledovo, district Shchelkovo, IFZ base Ledovo).

Measurements were made on the concrete pillar in room No.10 of the gravimetric laboratory of the IFZ. The pillar is provided with mark No.5035.

Approximetely :

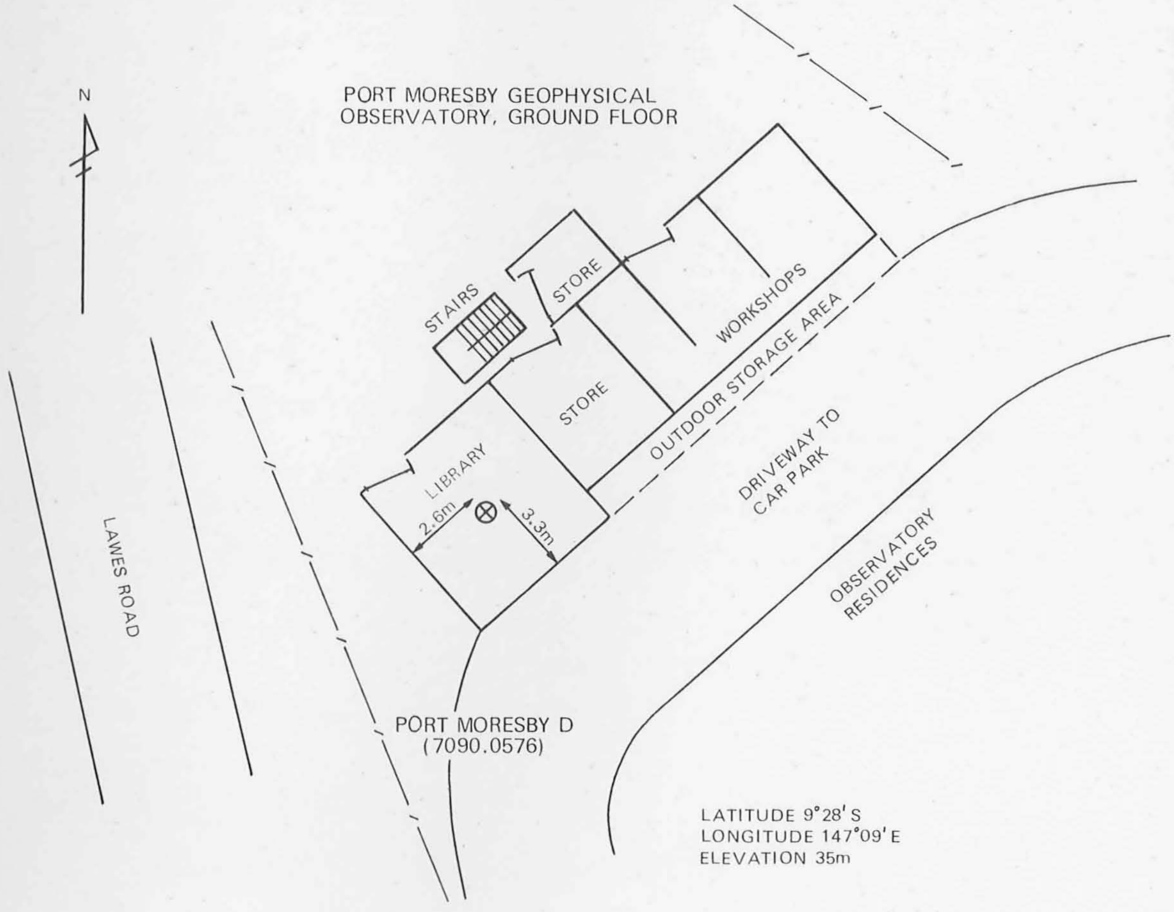
φ = 55°45'N λ = 37°42'E.G.

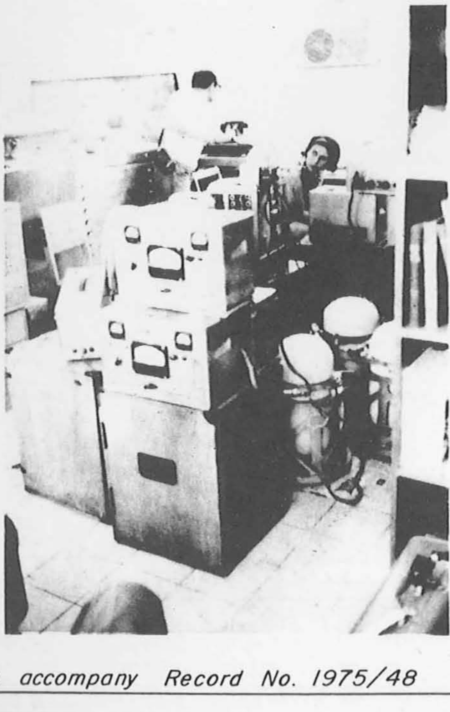


G65-438A

PORT MORESBY D
(PNG)

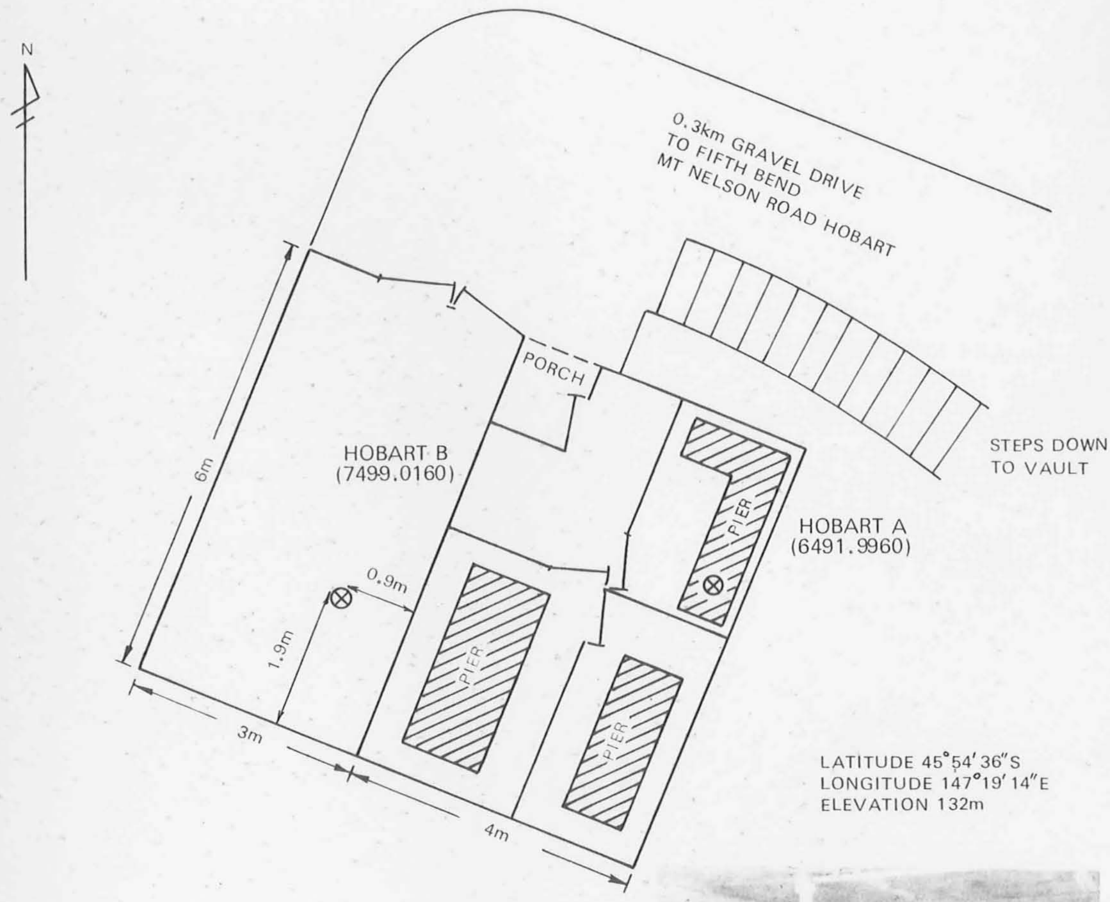
Port Moresby D (7090.0576) is in the library of the Port Moresby Geophysical Observatory, Lawes Road, Port Moresby. The station is on the concrete floor, 2.6m from the SW wall, 3.3m from the SE wall, and it is marked by a brass disc.

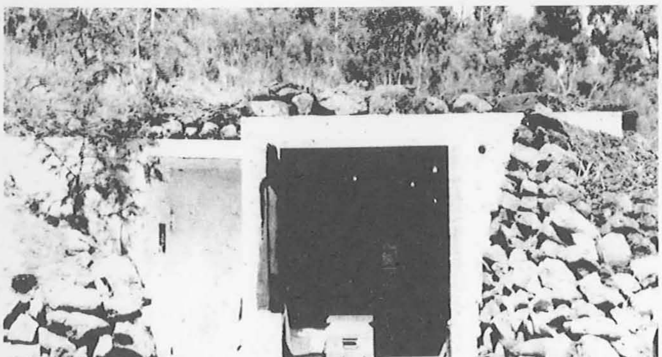


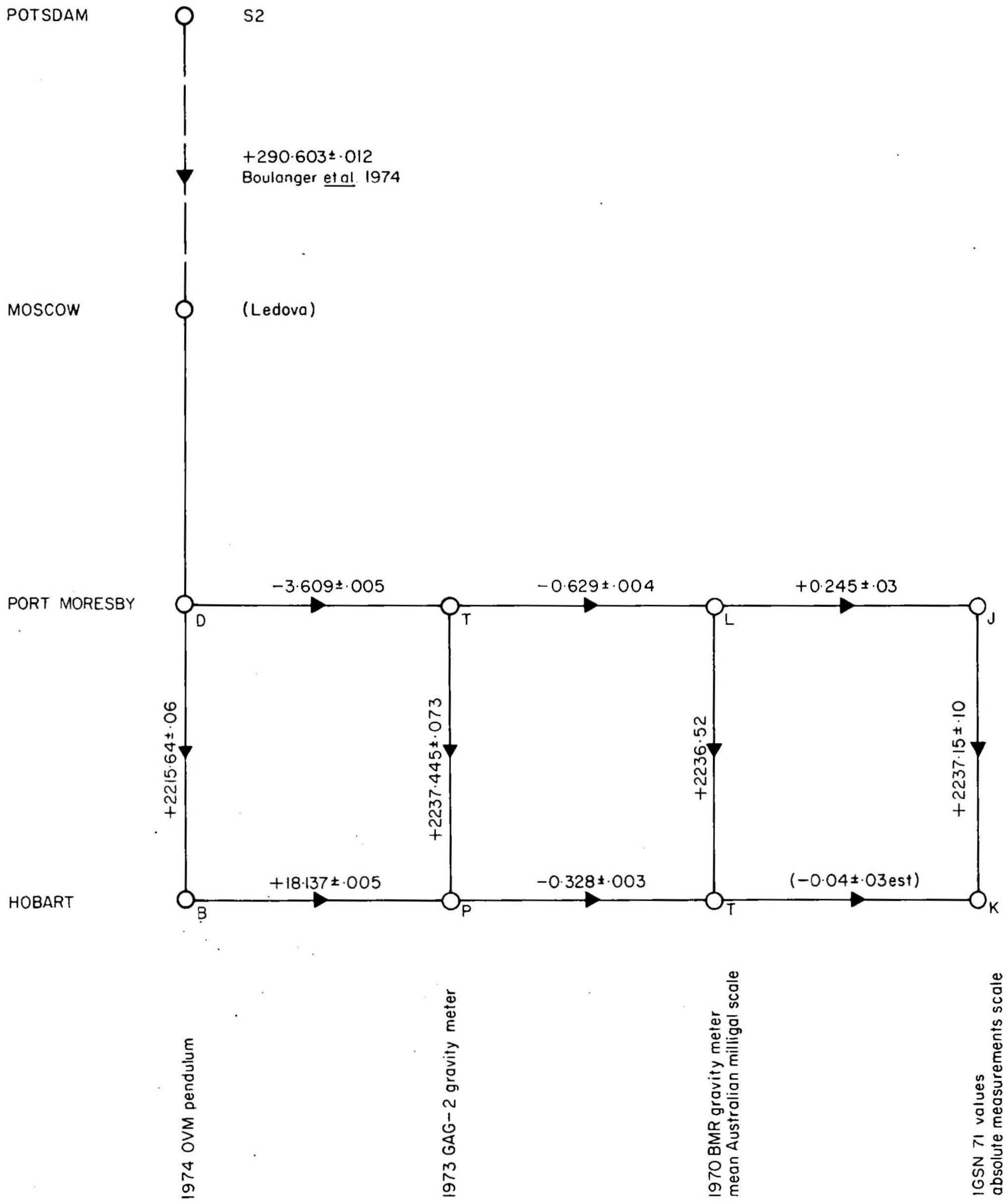


HOBART B
(AUSTRALIA)

Hobart B (7499.0160) is in the 1974 extension to the TAU seismic vault in the grounds of the University of Hobart. The site is 1.9m from the back wall and 0.9m from the vault wall.







SCHEMA OF GRAVITY TIES