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Gravity in Northwestern Canada

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GRAVITY IN NORTHWESTERN CANADA

INTRODUCTION

During the season of 1921 five gravity stations were established in the Mackenzie river basin. Four more, two of which are farther north than any of the stations of 1921, were occupied in 1922; one of these, Arctic Red River, is about 60 miles north of the Arctic circle. A preliminary report* on the work of the previous season has already been published. The present publication contains the results of the two seasons' work.

The determinations were made with a half seconds pendulum apparatus of the Mendenhall type. Three bronze pendulums, each of approximately one half-second period, constitute the pendulum set. In some cases only two pendulums were used but at most of the stations observations were taken with all three. Concrete piers were erected on which to set up the apparatus; the flexure was measured with an interferometer. At all the nine stations, with the exception of Peace River, which is on a telegraph line, the rates of the chronometers were obtained from the Annapolis wireless signals. These were determined by Mr. Henderson of this Observatory, who made the time comparisons in the field. The corrections to the signals were determined at Ottawa by comparison with the standard Observatory clocks.

When the results of the work of 1921 were published the computation of the corrections for topography and compensation had not been made for the various stations occupied during that season. This reduction was postponed on account of the uncertainty that then existed in the elevations, and until better maps could be secured for the purpose. Contour maps or sketch maps of the country in the vicinity of stations where the topography is very uneven have now been obtained. Near most of the remaining stations the country is flat and the need for such maps is not so great. For the topography of the country beyond that immediately surrounding the stations and extending out to a distance of approximately 500 miles the relief map of Canada published in the Department's Atlas of 1915 has been used. As this area is responsible for a large proportion of the correction for each station, the reductions are of course to a considerable extent dependent upon the general accuracy of this map. During the summer of 1922 a line of levels was run down to Mackenzie river by the Topographical Surveys Branch. This practically determines the elevations of stations on the upper part of the river and around Great Slave lake, and has made it possible to estimate with greater confidence the elevation of stations farther down the river.

The isostatic reductions for the nine stations in this part of the country have therefore been made and the results are given in the following pages of this publication. These have not, of course, the finality of results that are based on accurate maps of well-surveyed territory. As new information is obtained from the survey of the country it may be necessary to make certain corrections to these computations but it is not likely that these corrections will in any case be very large.

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*Publications of the Dominion Observatory Vol. V, No. 10. This publication also contains a summary of all gravity work done in this country up to 1921.

The correction for topography and compensation for Ottawa was recomputed, chiefly owing to the fact that from the previous computation no record of the corrections for separate zones was available. A difference of ·008 dynes exists between the value recently obtained and that which was previously given for Ottawa.* However, the writer is satisfied that the present value represents the true correction to be found from the maps that are now available, which should be sufficiently accurate for the purpose of the reduction.

DESCRIPTIONS OF STATIONS

Descriptions of the gravity stations occupied during the season of 1922 are given below. The astronomical stations to which they are referred were established at the same time as the gravity stations. A cement pier for the reception of the pendulum case was erected at each station.

Corresponding information for the stations of 1921 is given in Vol. V, No. 10 of these Publications.

Liard River, B.C.—The gravity station is located on the right bank of Liard river in latitude 59 ° 59′, approximately. It is about 5 miles below the mouth of La Biche river and opposite a small island shown on the west side of the river on R. G. McConnell's map of 1890. A log cabin 8 by 8 feet in which to set up the apparatus was built when occupying the station. The pier, the top of which is flush with the ground, is in the west end of this building. It is 140 feet north and 10 feet east of the astronomical station and was 18 feet above the level of Liard river at this point on July 3.

Good Hope, N.W.T.—The pier was placed in the north side of the powder magazine of the Hudson's Bay Co., the top of the pier being about 9 inches above the floor level. It is 285 feet north and 25 feet east of the astronomical station and was 52 feet above the water level of Mackenzie river in front of the Company's landing on August 11.

Arctic Red River, N.W.T.—A pier, the top of which was about 18 inches above the floor level, was erected in the north end of a log building 18 by 20 feet, owned by the Hudson's Bay Co., and kept for the accommodation of Indians coming to the post during the winter. The pier is approximately 50 feet west of the astronomical station and was about 100 feet above the water level at the mouth of Arctic Red river on August 17.

Chipewyan, Alta.—At this place the top of the pier was about 18 inches above the ground level and was erected in the west end of the Hudson's Bay Co's. blacksmith shop. The base of the pier rests on solid rock. The gravity pier is 20 feet south and 5 feet west of the astronomical station and is 47 feet above the high-water mark of lake Athabaska.

EXPLANATION OF TABLES

In Table I are given the periods of the pendulums obtained from the five standardizations that have been made at Ottawa since the resumption of gravity work in this country in March, 1921. The mean of the first two was used in making the relative determination of g between Ottawa and Washington (see Vol. V, No. 10, Table III). The mean of the second and third was used for the field work of 1921 and that of the fourth and fifth for the field work of 1922.

*Vol. V, No. 10, Table VI.

The periods of the pendulums at the stations occupied during 1922 and the resulting values of the force of gravity in dynes are given in Table II.

The pendulum observations and the reduction of the times of vibration of the pendulums at Ottawa and the four field stations of 1922 are given in Table III.

Information regarding the work of 1921, corresponding to that given in Tables I to III of this report, is given in the publication for that year. (Vol. V, No. 10).

Table IV gives the corrections for topography and compensation for separate zones (depth of compensation 113·7 km.) for each of the stations occupied during 1921 and 1922. The elevations of the various zones were found from the maps for each station and then the corrections were obtained by using the tables in Special Publications Nos. 10 and 40 of the U. S. Coast and Geodetic Survey.

In Table V will be found the corrections for various depths of compensation. These were computed from the quantities in Table IV by making use of the tables given on pages 98 and 99 of Special Publication No. 40.

Table VI gives for various depths of compensation the gravity anomalies deduced from Helmert's formula of 1901, $\gamma_o = 978{\cdot}030\ (1 + {\cdot}005302 \sin^2 \phi - {\cdot}000007 \sin^2 2\phi)$. This is one of the earlier gravity formulae of this form. While the results do not in all likelihood represent the most probable anomalies they are of some interest.

They may be compared with the Helmert anomalies obtained in other countries and by simply subtracting ·008 dyne from each of the quantities in the table the anomalies resulting from Hayford's formula of 1912* are obtained. They may also be used in conjunction with similar data to determine corrections to the constants in Helmert's formula. Dr. Wm. Bowie has used the Helmert anomalies in deriving a number of gravity formulae. In deducing a new formula it is as convenient to start with Helmert's formula as any other, and by so doing at least a certain amount of computation may be saved by taking advantage of some of Dr. Bowie's results.

In 1916 Dr. Bowie derived the following gravity formula from 348 stations in different parts of the world: $\gamma_o = 978{\cdot}039\ (1 + {\cdot}005294 \sin^2 \phi - {\cdot}000007 \sin^2 2\phi)$. Of these stations 216 were in the United States, 73 in India, 42 in Canada and 17 in Europe. As this formula is one of the most recent and probably one of the best gravity formulae we have, it has been thought worth while to compute by this formula the gravity anomalies at the different assumed depths of compensation. These anomalies are given in Table VII.

In Table VIII are given the principal facts for the stations of 1921 and 1922. In accordance with previous custom the gravity anomalies are given for the purposes of comparison by three methods of reduction. These anomalies are given in the last three columns of the tables.

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*In Special Publication No. 40 U. S. C. & G. S. the Hayford anomalies are given for 409 stations in different parts of the world.

FREE AIR, BOUGUER AND ISOSTATIC METHODS OF REDUCTION

By a gravity anomaly at any place is meant the difference between the observed value and the computed value of gravity for that place. If the observed value is less than the computed value the anomaly is negative, indicating a deficiency of gravity, while on the other hand if the anomaly is positive the observed value is greater than the computed value, which indicates an excess of gravity. The observed value of gravity is a certain definite quantity for each station and is determined from the pendulum observations. The computed value may be obtained by several different methods of reduction and the quantity obtained for it depends upon the method that is adopted. It will first of all depend upon the formula that is used to represent g at sea-level. In table VIII Bowie's formula, $\gamma_0 = 978 \cdot 039\ (1 + \cdot 005294 \sin^2 \phi - \cdot 000007 \sin^2 2\phi)$†, has been used for this purpose. In this formula γ_0 represents the value of g in dynes at sea-level and ϕ the latitude. By substituting for ϕ the latitude of the point where gravity is required the computed value at sea-level is at once obtained.

Most gravity stations are not at sea-level but at a certain height above it. In computing a value of gravity for a station it therefore becomes necessary to make some correction to γ_0 to allow for the height of the station above sea-level.

In the *Free Air* method of reduction only one correction to γ_0 is made. It is simply the correction that must be made in accordance with the universal law of gravitation, in any method of reduction, to take account of the increased distance of the station from the centre of attraction of the earth. As far as the computation of the correction is concerned, the station is considered to be standing out in space at its own elevation and as if all the material in the crust of the earth above sea-level were taken away to an infinite distance. The station would then be left standing in the air, which no doubt accounts for the name that is given the method.

A close approximation to the value of the correction may be easily obtained. Imagine the earth to be a sphere. The attraction of the sphere on one gram of matter at a point on or outside the surface, which would be the value of gravity at the point for a spherical earth, would then be $\frac{MG}{r^2}$, where M is the mass of the earth, G the gravitation constant ($= 6 \cdot 66 \times 10^{-8}$ c.g.s. units*) and r the distance of the point from the centre of the earth, which for stations at ordinary elevations is approximately the radius of the earth. The rate of change of g for a point outside the surface will be $\frac{dg}{dr}$. We have then

$$g = \frac{MG}{r^2}$$

$$\frac{dg}{dr} = -\frac{2MG}{r^3} = -\frac{2g}{r}$$

Substituting the value of g at 45° (980·621) and the mean value of r (637×10^4 metres) this becomes

$$\frac{dg}{dr} = -3 \cdot 08 \times 10^{-4} \text{ dynes per metre.}$$

By taking account of the earth's flattening Helmert** obtained the value $3 \cdot 086 \times 10^{-4}$ and this has since been generally used to correct for the elevation of the station. It may be remarked, however, that this is itself an approximation found by Helmert by neglecting very small terms in the complete expression he obtained for the value of the quantity.

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†Tables giving the value of γ_0 obtained from this formula for various latitudes from 0 to 90 are published in the Smithsonian Physical Tables and also in the Smithsonian Meteorological Tables.

*Smithsonian Physical Tables.

**Encyklopädie der Mathematischen Wissenschaften, Band $VI_{1,7}$ S 97.

The computed value by the Free Air method is then γ_o − ·0003086 x height of station in metres.

In the *Bouguer method* the above correction for elevation is first applied and in addition an attempt is made to take account of the attraction of the material in the earth's crust above sea-level. The effect of this is assumed to be represented by the attraction of a slab or disc of infinite radius and of thickness equal to the elevation of the station. The station is supposed to be located at the centre of the upper surface of the disc. The attraction of the disc at this point can easily be shown to be equal to $2\pi\ \delta GH$, where G is again the gravitation constant, δ is the density of the material forming the disc, which may be taken as the mean continental surface density of the earth (=2·67), and H is the thickness of the slab or the elevation of the station.

Approximately the value of gravity at the station is

$g = \frac{MG}{r^2} = \frac{4}{3}\pi\Delta\, r\, G.$

where Δ is the mean density of the earth (5·5247)*;

from which it follows that

$G = \frac{3g}{4\pi\Delta r}$

If this value of G be substituted in the expression $2\pi\ \delta$ GH it is seen that the attraction of the disc is equal to $\frac{2gH}{r} \times \frac{3}{4}\frac{\delta}{\Delta}$

It has already been shown that,

$\frac{dg}{dr} = -\frac{2g}{r}$

This is the elevation correction per unit distance. For an elevation H it will be equal to $-\frac{2gH}{r}$. As the Bouguer correction is the sum of this and the attraction due to the infinite disc, in order to get the computed value of g by the Bouguer method we must add to γ_o the quantity given by $-\frac{2gH}{r} + \frac{2gH}{r}\frac{3}{4}\frac{\delta}{\Delta} = -\frac{2gH}{r}\left(1 - \frac{3}{4}\frac{\delta}{\Delta}\right)$, in which form the correction is frequently expressed. Substituting for δ and Δ the values 2·67 and 5·52, respectively, the correction becomes

$-\frac{2g}{r} \times \cdot 637\, H$

It is thus ·637 times the simple elevation correction.

The Bouguer reduction takes no account of any uneveness in the topography nor does it make any allowance for the curvature of the earth. However, neither of these omissions probably accounts for the fact that it gives values of g that are more in error than those obtained by either of the other two methods. At first sight one would certainly expect the Bouguer method to be more nearly correct than the Free Air method because the former reduction takes account, to a large extent, of the attraction of material above sea-level. Notwithstanding this it will be seen that the Bouguer method gives, for the stations in the table, values of g that are much too large. In fact if we leave the attraction of the material above sea-level out of consideration altogether, as is done in the Free Air method, we obtain quantities that are nearer the observed values. In spite of this we know that any correct method of reduction must take account of all matter in the earth's crust and that there must be an explanation of the fact that the Bouguer values of g are so much in error.

*Smithsonian Physical Tables.

The failure of the method can be accounted for if we suppose that we have material of less than normal density underneath the continent. If at the same time we suppose the water of the oceans, on account of its lower density, is underlain with material of greater than normal density and still greater than that which lies under the continents, we have a state of affairs known as isostasy. The fact that both the Free Air and Bouguer anomalies have been found to be generally positive for stations near the ocean lends support to this view. Moreover, there is a mass of evidence from the study of deflections of the vertical and of geology and gravity observations in favour of isostasy.

In order to obtain a definite idea of the quantities that are involved in gravity reductions by the isostatic method, imagine two columns to be taken in the earth's crust. One of these may be taken in a land area on the continent and the other in the ocean. We shall suppose further that each column extends for the same depth below sea-level and has for its base a cross-section of unit area. The sides of the column will be formed by vertical lines passing through the perimeter of the base, while the top will be a small portion of the surface of the earth of approximately unit area. If the depth of these columns below sea-level be taken equal to the depth of compensation, then the theory of isostasy requires the pressures at the bases of these and all similar columns to be the same. If we attribute the pressures at the bottom to the weights of the columns then, neglecting small variations in gravity, it follows that the masses of the columns are equal. As the depth of compensation is measured from sea-level, the land columns will be longer than the ocean columns. If we consider a land column to be divided into two parts by the sea-level surface, then compared with the mass of a normal column (i.e. a column taken at the sea coast or under land where the elevation is only slightly above sea-level) there must be a deficiency of matter in the lower part of the column exactly equal to the quantity of matter in the part of the column above sea-level. On the other hand in the solid portion of an ocean column there must be an excess of matter to compensate for the lightness of the water. This deficiency or excess of matter is spoken of as the compensation. The extent of it will depend upon the elevation of the land or the depth of the sea and, for any of the columns, may be computed from the average continental density or from the known density of sea water. The elevations or sea depths which are also required in this connection may be obtained from contour or relief maps. The land above sea-level or the water in the ocean is called the topography. The computed value of g obtained by the application of the theory of isostasy is γ_0 − elevation correction ± the correction for topography and compensation.

Tables for the evaluation of the isostatic corrections have been published by Meissner* in Germany and by Hayford and Bowie** in the United States. The latter have been used for gravity stations in this country. In these tables the whole surface of the earth is divided into 33 zones in all. The station whose correction is required becomes the centre of each of these zones. After finding, from the maps, the average elevations or depths of the zones for any given station, the corrections for topography and compensation may at once be obtained from the tables. The corrections are given for various elevations and depths for each zone.

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*Astronomische Nachrichten, Band 206, Nr. 4924-25, Band 214, Nr. 5125.

**Special Publications Nos. 10 & 40, U. S. C. & G. S.

In computing the corrections for the tables the curvature of the earth is taken into account and the compensation is supposed to be uniformly distributed down to the depth of compensation. Each topographic feature, however small, is considered to be completely compensated.

SUMMARY OF RESULTS

TABLE I

Date	Periods of Pendulums in Seconds		
	1	2	3
March 14-17, 1921	[a]·5013476	[a]·5014658	[a]·5014396
April 20-23, 1921	·5013471	·5014646	·5014385
Oct. 27-Nov. 4, 1921	·5013455	·5014628	·5014365
Feb. 25-27, 1922	·5013464	·5014635	·5014373
Nov. 7-18, 1922	·5013442	·5014624	·5014364

TABLE II

Station	Periods of Pendulums in Seconds			Value of g in Dynes			
	1	2	3	1	2	3	Weighted Mean
Ottawa (Feb. 25-27)	[a]·5013464	·5014635	·5014373	....	....	....	980·618
Liard River	·5010460	·5011635	·5011377	981·790	981·790	981·789	981·790
Good Hope	·5009058	·5010234	·5009969	982·340	982·339	982·341	982·340
Arctic Red River	·5008820	·5009990	....	982·433	982·435	....	982·434
Chipewyan	·5010627	·5011810	·5011555	981·724	981·722	981·720	981·723
Ottawa (Nov. 7-18)	·5013442	·5014624	·5014364	....	....	....	980·618

TABLE III

PENDULUM OBSERVATIONS AND REDUCTIONS

STATION: OTTAWA. OBSERVER: A. H. MILLER

Date	Swing number	Pendulum	Position	Knife-edge	Coincidence Interval		Arc		Temperature	Pressure	Period Uncorrected		Corrections (7th Decimal Place)						Period Corrected		
					Chronometer						Chronometer					Rate			Chronometer		
					Dent No. 56182	Dent No. 48419	Initial	Final			Dent No. 56182	Dent No. 48419	Arc	Temp.	Pressure	D 56182	D 48419	Flexure	Dent No. 56182	Dent No. 48419	Mean
1922																					
Feb. 25...........	1	1	D	1	186·42	183·85	7·3	2·0	10·60	60·5	·5013446	·5013631	−17	+ 184	+ 1	− 138	− 331	− 9	·5013467	·5013459	·5013463
" 25...........	2	1	D	1	186·70	184·70	7·5	1·9	10·10	61·5	·5013426	·5013573	−17	+ 205	+ 1	− 143	− 285	− 9	·5013463	·5013468	·5013466
																Mean........		....	·5013465	·5013464	·5013464
Feb. 25-26.........	3	2	D	1	171·44	167·85	7·7	1·8	10·40	65·0	·5014625	·5014939	−17	+ 193	− 3	− 156	− 469	− 9	·5014633	·5014634	·5014634
" 26...........	4	2	D	1	171·44	168·05	8·0	1·9	10·33	61·8	·5014625	·5014921	−18	+ 196	0	− 155	− 457	− 9	·5014639	·5014633	·5014636
																Mean........		....	·5014636	·5014634	·5014635
Feb. 26-27.........	5	3	D	1	174·20	172·53	7·7	1·9	10·74	59·8	·5014393	·5014532	−17	+ 178	+ 2	− 171	− 312	− 9	·5014376	·5014374	·5014375
" 27...........	6	3	D	1	174·38	173·39	7·5	1·8	10·74	61·9	·5014378	·5014460	−17	+ 178	0	− 161	− 238	− 9	·5014369	·5014374	·5014372
																Mean........		....	·5014373	·5014374	·5014373

TABLE III—*Continued*

PENDULUM OBSERVATIONS AND REDUCTIONS

STATION: RIGHT BANK OF LIARD RIVER IN VICINITY OF 60TH PARALLEL OF LATITUDE. OBSERVER: A. H. MILLER

Date	Swing number	Pendulum	Position	Knife-edge	Coincidence Interval		Arc		Temperature	Pressure	Period Uncorrected		Corrections (7th Decimal Place)						Period Corrected		
					Chronometer						Chronometer					Rate			Chronometer		
					Bond No. 627	Dent No. 56182	Initial	Final			Bond No. 627	Dent No. 56182	Arc	Temp.	Pressure	B 627	D 56182	Flexure	Bond No. 627	Dent No. 56182	Mean
June 20	1	1	D	1	251·97	242·32	7·9	1·6	11·17	58·5	·5009941	·5010338	−17	+ 160	+ 4	+ 358	− 23	−11	·5010435	·5010451	
" 20-21	2	1	D	1	249·27	240·55	8·0	1·7	12·62	60·0	·5010049	·5010415	−17	+ 100	+ 3	+ 358	− 23	−11	·5010482	·5010467	
																Mean			·5010459	·5011459	·5010459
June 21	3	1	D	1	248·98	240·56	7·9	1·6	12·71	61·0	·5010061	·5010414	−17	+ 96	+ 2	+ 337	− 16	−11	·5010468	·5010468	
" 21-22	4	1	D	1	249·52	240·98	7·9	1·8	12·53	61·5	·5010039	·5010396	−18	+ 103	+ 1	+ 337	− 16	−11	·5010451	·5010455	
																Mean			·5010460	·5010462	·5010461
June 22	5	1	D	1	249·34	240·22	7·8	1·9	12·62	62·5	·5010046	·5010429	−18	+ 100	+ 1	+ 346	− 38	−11	·5010464	·5010463	·5010464
June 23	6	2	D	1	222·25	215·39	8·1	1·8	13·76	56·2	·5011274	·5011634	−18	+ 52	+ 7	+ 331	− 16	−11	·5011635	·5011648	
" 23-24	7	2	D	1	222·25	215·85	8·4	1·7	13·54	57·0	·5011274	·5011609	−19	+ 61	+ 6	+ 331	− 16	−11	·5011642	·5011630	
																Mean			·5011639	·5011639	·5011639
June 24	8	2	D	1	222·24	216·02	8·1	2·0	13·51	58·0	·5011274	·5011600	−20	+ 62	+ 5	+ 314	− 10	−11	·5011624	·5011626	·5011625
June 26	9	3	D	1	226·38	219·62	8·1	1·5	15·18	57·0	·5011068	·5011409	−17	− 8	+ 6	+ 342	+ 3	−11	·5011380	·5011382	
" 26-27	10	3	D	1	228·59	221·83	8·1	1·8	12·70	57·0	·5010960	·5011295	−19	+ 96	+ 6	+ 342	+ 3	−11	·5011374	·5011370	
																Mean			·5011377	·5011376	·5011377
June 27	11	3	D	1	229·12	222·60	8·1	2·1	10·96	57·0	·5010935	·5011256	−20	+ 169	+ 5	+ 299	− 23	−11	·5011377	·5011376	·5011377

TABLE II—*Continued*

PENDULUM OBSERVATIONS AND REDUCTIONS

STATION: OTTAWA. OBSERVER: A. H. MILLER

STATION: GOOD HOPE, N.W.T. OBSERVER: A. H. MILLER

Date	Swing number	Pendulum	Position	Knife-edge	Coincidence Interval Chronometer Bond No. 627	Coincidence Interval Chronometer Dent No. 56182	Arc Initial	Arc Final	Temperature	Pressure	Period Uncorrected Chronometer Bond No. 627	Period Uncorrected Chronometer Dent No. 56182	Corrections (7th Decimal Place) Arc	Temp.	Pressure	Rate B 627	Rate D 56182	Flexure	Period Corrected Chronometer Bond No. 627	Period Corrected Chronometer Dent No. 56182	Mean
1922																					
July 24...........	1	1	D	1	289·91	282·30	8·0	1·5	12·23	58·2	·5008639	·5008872	−16	+ 116	+ 5	+ 330	+ 96	−10	·5009064	·5009063	
" 24-25.........	2	1	D	1	293·07	285·15	8·0	1·6	10·16	58·0	·5008545	·5008783	−17	+ 203	+ 4	+ 330	+ 96	−10	·5009055	·5009059	
																Mean........			·5009060	·5009061	·5009060
July 25...........	3	1	D	1	291·61	283·57	8·2	1·6	11·50	59·0	·5008588	·5008832	−18	+ 147	+ 3	+ 329	+ 98	−10	·5009039	·5009052	
" 25-26.........	4	1	D	1	287·20	279·86	8·0	1·7	14·13	60·0	·5008720	·5008949	−17	+ 36	+ 3	+ 329	+ 98	−10	·5009061	·5009059	
																Mean........			·5009050	·5009056	·5009053
July 26...........	5	1	D	1	284·86	277·73	8·0	1·6	15·60	61·5	·5008792	·5009018	−17	− 25	+ 1	+ 305	+ 89	−10	·5009046	·5009056	
" 26-27.........	6	1	D	1	285·00	278·96	7·9	1·6	14·60	62·5	·5008787	·5008978	−17	+ 17	+ 1	+ 305	+ 89	−10	·5009083	·5009058	
																Mean........			·5009065	·5009057	·5009061
July 28...........	7	2	D	1	254·53	249·35	7·8	1·3	12·70	55·5	·5009841	·5010046	−15	+ 96	+ 7	+ 302	+ 106	−10	·5010221	·5010230	
" 28-29.........	8	2	D	1	252·74	248·14	8·4	1·5	13·75	57·8	·5009911	·5010096	−18	+ 52	+ 5	+ 302	+ 106	−10	·5010242	·5010231	
																Mean........			·5010232	·5010231	·5010231
July 29...........	9	2	D	1	252·60	......	8·1	1·3	14·87	60·8	·5009917	....	−16	+ 5	+ 2	+ 307	......	−10	·5010205		
" 29-30.........	10	2	D	1	250·24	......	7·7	1·4	15·56	63·0	·5010010	....	−15	− 23	0	+ 307	......	−10	·5010269	....	
																Mean........			·5010237	....	·5010237

						Dent 48419						Dent 48419					Dent 48419			Dent 48419	
July 31...........	11	3	D	1	262·99	252·04	7·8	1·6	11·89	55·0	·5009524	·5009938	−16	+ 130	+ 7	+ 319	− 119	−10	·5009954	·5009930	
" 31-Aug. 1.....	12	3	D	1	262·50	250·51	7·9	1·6	11·75	56·2	·5009542	·5010000	−17	+ 136	+ 6	+ 319	− 119	−10	·5009976	·5009996	
																Mean.	....	....	·5009965	·5009963	·5009964
Aug. 1...........	13	3	D	1	263·62	252·23	8·1	1·7	11·44	57·5	·5009501	·5009931	−18	+ 149	+ 4	+ 338	− 110	−10	·5009964	·5009946	
" 1-2..........	14	3	D	1	263·23	250·79	7·9	1·7	11·44	59·0	·5009516	·5009988	−17	+ 149	+ 3	+ 338	− 110	−10	·5009979	·5010003	
																Mean.	....	....	·5009972	·5009975	·5009973

TABLE III—*Continued*

PENDULUM OBSERVATIONS AND REDUCTIONS—*Continued*

STATION: ARCTIC RED RIVER, N.W.T. OBSERVER: A. H. MILLER

Date	Swing number	Pendulum	Position	Knife-edge	Coincidence Interval: Chronometer Bond No. 627	Coincidence Interval: Chronometer Dent No. 56182	Arc: Initial	Arc: Final	Temperature	Pressure	Period Uncorrected: Chronometer Bond No. 627	Period Uncorrected: Chronometer Dent No. 56182	Corrections (7th Decimal Place): Arc	Temp.	Presure	Rate B 627	Rate D 56182	Flexure	Period Correcte: Chronometer Bond No. 627	Period Correcte: Chronometer Dent No. 56182	Mean
Aug. 21...........	1	1	D	1	298·60	291·81	7·9	1·5	10·90	54·2	·5008386	·5008582	−16	+ 172	+ 8	+ 258	+ 83	−11	·5008797	·5008818	
" 21-22.........	2	1	D	1	296·02	290·72	7·8	1·5	11·42	55·0	·5008459	·5008614	−16	+ 150	+ 7	+ 258	+ 83	−11	·5008847	·5008827	
																Mean...........			·5008822	·5008823	·5008822
Aug. 22...........	3	1	D	1	297·55	291·64	7·7	1·4	11·71	56·0	·5008417	·5008587	−15	+ 138	+ 6	+ 270	+ 110	−11	·5008805	·5008815	
" 22-23.........	4	1	D	1	295·94	290·88	7·8	1·4	12·11	57·0	·5008462	·5008610	−15	+ 121	+ 5	+ 270	+ 110	−11	·5008832	·5008820	
																Mean...........			·5008819	·5008818	·5008818
Aug. 24...........	5	2	D	1	258·02	253·95	7·8	1·2	14·88	53·0	·5009708	·5009864	−14	+ 5	+10	+ 279	+ 129	−11	·5009977	·5009983	
" 24-25.........	6	2	D	1	257·17	253·51	8·2	1·3	14·77	55·0	·5009740	·5009881	−16	+ 10	+ 8	+ 279	+ 129	−11	·5010010	·5010001	
																Mean...........			·5009994	·5009992	·5009993
Aug. 25...........	7	2	D	1	258·55	254·37	8·1	1·2	14·01	56·0	·5009688	·5009847	−15	+ 41	+ 7	+ 284	+ 118	−11	·5009994	·5009987	
" 25-26.........	8	2	D	1	260·71	256·03	8·0	1·2	12·44	57·0	·5009608	·5009784	−14	+ 107	+ 6	+ 284	+ 118	−11	·5009980	·5009990	
																Mean...........			·5009987	·5009989	·5009988

TABLE III—*Continued*

PENDULUM OBSERVATIONS AND REDUCTIONS

STATION: CHIPEWYAN, ALBERTA. OBSERVER: A. H. MILLER

Date	Swing number	Pendulum	Position	Knife-edge	Coincidence Interval		Arc		Temperature	Pressure	Period Uncorrected		Corrections (7th Decimal Place)						Period Corrected		
					Chronometer						Chronometer					Rate			Chronometer		
					Bond No. 627	Dent No. 56182	Initial	Final			Bond No. 627	Dent No. 56182	Arc	Temp.	Pressure	B 627	D 56182	Flexure	Bond No. 627	Dent No. 56182	Mean
Sept. 25-26.........	1	1	D	1	244·48	240·42	7·9	1·4	12·85	49·8	·5010247	·5010420	−15	+ 90	+12	+ 304	+ 132	− 9	·5010629	·5010630	·5010630
Sept. 26............	2	1	D	1	244·15	240·36	7·9	1·8	12·91	50·2	·5010260	·5010423	−18	+ 88	+12	+ 291	+ 126	− 9	·5010624	·5010622	
" 26-27.........	3	1	D	1	244·56	240·67	7·8	1·8	12·31	51·0	·5010243	·5010409	−17	+ 113	+11	+ 291	+ 126	− 9	·5010632	·5010633	
																Mean.........			·5010628	·5010628	·5010628
Sept. 27............	4	1	D	1	245·75	241·93	7·7	1·7	11·84	51·0	·5010194	·5010355	−16	+ 132	+11	+ 298	+ 148	− 9	·5010610	·5010621	
" 27-28.........	5	1	D	1	244·41	241·16	8·0	1·7	12·49	51·0	·5010250	·5010388	−17	+ 105	+11	+ 298	+ 148	− 9	·5010638	·5010626	
																Mean...........			·5010624	·5010624	·5010624
Sept. 28............	6	2	D	1	220·78	217·03	8·0	1·5	10·51	53·5	·5011349	·5011546	−16	+ 188	+ 8	+ 308	+ 98	− 9	·5011828	·5011815	
" 28-29.........	7	2	D	1	225·17	220·53	8·0	2·1	5·95	56·2	·5011128	·5011362	−20	+ 379	+ 5	+ 308	+ 98	− 9	·5011791	·5011815	
																Mean...........			·5011810	·5011815	·5011812
Sept. 29............	8	2	D	1	225·32	220·65	7·9	1·5	6·67	64·8	·5011120	·5011356	−16	+ 349	− 3	+ 361	+ 129	− 9	·5011802	·5011806	
" 29-30.........	9	2	D	1	226·61	222·08	7·9	1·6	5·10	56·2	·5011056	·5011283	−17	+ 415	+ 5	+ 361	+ 129	− 9	·5011811	·5011806	
																Mean..........			·5011807	·5011806	·5011806
Sept. 30............	10	2	D	1	228·40	222·79	7·9	2·1	3·47	56·2	·5010970	·5011247	−20	+ 483	+ 5	+ 385	+ 109	− 9	·5011814	·5011815	·5011815
Oct. 1-2..........	11	3	D	1	238·01	230·74	8·0	1·0	−0·02	67·8	·5010526	·5010858	−13	+ 629	− 8	+ 430	+ 98	− 9	·5011555	·5011555	·5011555

TABLE III—*Concluded*

PENDULUM OBSERVATIONS AND REDUCTIONS

STATION: OTTAWA. OBSERVER: A. H. MILLER

Date	Swing number	Pendulum	Position	Knife-edge	Coincidence Interval: Chronometer Bond No. 627	Coincidence Interval: Chronometer Dent No. 56182	Arc: Initial	Arc: Final	Temperature	Pressure	Period Uncorrected: Chronometer Bond No. 627	Period Uncorrected: Chronometer Dent No. 56182	Corrections (7th Decimal Place): Arc	Temp.	Pressure	Rate B 627	Rate D 56182	Flexure	Period Corrected: Chronometer Bond No. 627	Period Corrected: Chronometer Dent No. 56182	Mean
Nov. 7...........	1	1	D	1	189·92	187·50	8·0	1·9	15·90	55·0	·5013198	·5013369	−18	− 38	+ 8	+ 301	+ 134	− 9	·5013442	·5013446	·5013444
" 7-8..........	2	1	D	1	189·98	187·56	7·9	1·7	15·86	55·0	·5013194	·5013365	−17	− 36	+ 8	+ 305	+ 132	− 9	·5013445	·5013443	·5013444
Nov. 8............	3	1	D	1	190·27	187·59	8·0	1·5	15·85	55·2	·5013174	·5013363	−16	− 36	+ 8	+ 319	+ 130	− 9	·5013440	·5013440	
" 8-9..........	4	1	D	1	190·33	187·56	8·0	1·9	15·76	56·2	·5013170	·5013365	−18	− 32	+ 7	+ 319	+ 130	− 9	·5013437	·5013443	
																Mean...........			·5013439	·5013442	·5013440
Nov. 13-14........	5	2	D	1	174·94	172·66	7·7	1·8	15·02	53·7	·5014332	·5014521	−17	− 1	+ 9	+ 310	+ 123	− 9	·5014624	·5014626	·5014625
Nov. 14...........	6	2	D	1	174·94	172·69	7·7	1·85	14·95	54·5	·5014331	·5014519	−17	+ 2	+ 9	+ 313	+ 122	− 9	·5014629	·5014626	
" 14-15.........	7	2	D	1	174·99	172·65	7·7	1·55	15·15	55·0	·5014328	·5014522	−15	− 6	+ 8	+ 313	+ 122	− 9	·5014619	·5014622	
																Mean...........			·5014624	·5014624	·5014624
Nov. 15...........	8	2	D	1	175·07	172·40	7·8	1·6	15·25	55·1	·5014321	·5014544	−16	− 10	+ 8	+ 330	+ 105	− 9	·5014624	·5014622	·5014623
Nov. 16-17........	9	3	D	1	178·35	175·78	7·6	1·3	14·86	56·0	·5014057	·5014263	−14	+ 6	+ 7	+ 314	+ 108	− 9	·5014361	·5014361	·5014361
" 17...........	10	3	D	1	178·45	176·07	8·0	1·3	14·56	57·0	·5014049	·5014239	−15	+ 18	+ 6	+ 317	+ 126	− 9	·5014366	·5014365	·5014366
" 17-18.........	11	3	D	1	178·82	176·09	8·2	1·8	14·43	57·0	·5014020	·5014238	−19	+ 24	+ 6	+ 343	+ 125	− 9	·5014365	·5014365	·5014365
																Mean...........			·5014364	·5014364	·5014364

TABLE IV

AVERAGE ELEVATIONS AND CORRECTIONS FOR TOPOGRAPHY AND COMPENSATION FOR SEPARATE ZONES

The unit for the corrections in this Table is ·0001 dyne.

Zone	Elevation in Feet	Topography	Compensation	Topography and Compensation	Elevation in Feet	Topography	Compensation	Topography and Compensation
	Ottawa, Ont., No. 1				Peace River, Alta., No. 43			
A	270	+ 2	0	+ 2	1,060	+ 2	0	+ 2
B	275	+ 46	0	+ 46	1,070	+ 63	0	+ 63
C	263	+ 28	0	+ 28	1,074	+106	0	+106
D	248	+ 11	0	+ 11	1,113	+ 87	− 1	+ 86
E	236	+ 6	0	+ 6	1,178	+ 45	− 2	+ 43
F	210	+ 1	− 1	0	1,332	+ 16	− 4	+ 12
G	240	0	− 1	− 1	1,417	+ 7	− 5	+ 2
H	275	0	− 1	− 1	1,524	+ 4	− 7	− 3
I	275	0	− 2	− 2	1,683	+ 3	− 13	− 10
J	288	0	− 3	− 3	1,766	+ 1	− 20	− 19
K	340	0	− 5	− 5	1,860	+ 1	− 30	− 29
L	411	0	− 10	− 10	1,940	0	− 46	− 46
M	506	0	− 28	− 28	1,880	0	−110	−110
N	650	0	− 42	− 42	2,240	0	−115	−115
O	883	0	− 49	− 49	2,415	0	−120	−120
18				− 12				− 29
17				− 12				− 27
16				− 10				− 27
15				− 10				− 31
14				− 10				− 37
13				− 18				− 57
12				− 7				− 31
11				− 5				− 28
10				+ 4				− 10
9				+ 7				− 1
8				+ 11				+ 3
7				+ 7				+ 4
6				+ 3				+ 4
5				+ 8				+ 9
4				+ 5				+ 6
3				+ 4				+ 3
2				+ 3				+ 3
1				+ 1				0
Total				− 79				−384

TABLE IV—*Continued*

Zone	Elevation in Feet	Topography	Compensation	Topography and Compensation	Elevation in Feet*	Topography	Compensation	Topography and Compensation
	Resolution, N.W.T. No. 44				Providence, N.W.T., No. 45			
A	497	+ 2	0	+ 2	510	+ 2	0	+ 2
B	497	+ 56	0	+ 56	510	+ 56	0	+ 56
C	496	+ 60	0	+ 60	508	+ 61	0	+ 61
D	495	+ 30	− 1	+ 29	498	+ 30	− 1	+ 29
E	497	+ 12	− 1	+ 11	494	+ 12	− 1	+ 11
F	498	+ 4	− 1	+ 3	500	+ 4	− 1	+ 3
G	497	+ 2	− 2	0	500	+ 2	− 2	0
H	499	+ 1	− 2	− 1	500	+ 1	− 2	− 1
I	500	+ 1	− 4	− 3	500	+ 1	− 4	− 3
J	501	0	− 5	− 5	750	0	− 8	− 8
K	499	0	− 8	− 8	750	0	− 12	− 12
L	499	0	− 12	− 12	750	0	− 18	− 18
M	571	0	− 32	− 32	798	0	− 45	− 45
N	626	0	− 32	− 32	1,128	0	− 58	− 58
O	798	0	− 45	− 45	1,267	0	− 66	− 66
18				− 10				− 13
17				− 11				− 13
16				− 11				− 14
15				− 13				− 14
14				− 16				− 16
13				− 27				− 31
12				− 18				− 24
11				− 18				− 21
10				− 13				− 11*
9				− 5				− 3*
8				0				+ 1*
7				+ 2				+ 3*
6				+ 4				+ 4*
5				+ 9				+ 9*
4				+ 6				+ 6*
3				+ 4				+ 4*
2				+ 3				+ 3*
1				0				0*
	Total			− 91				−179

*These values have been interpolated from those obtained for neighbouring stations.

TABLE IV—*Continued*

Zone	Elevation in Feet	Topography	Compensation	Topography and Compensation	Elevation in Feet	Topography	Compensation	Topography and Compensation
	Simpson, N.W.T. No. 46				Norman, N.W.T., No. 47			
A	430	+ 2	0	+ 2	280	+ 2	0	+ 2
B	430	+ 56	0	+ 56	276	+ 41	0	+ 41
C	418	+ 51	0	+ 51	265	+ 27	0	+ 27
D	417	+ 21	0	+ 21	265	+ 11	0	+ 11
E	409	+ 9	− 1	+ 8	268	+ 6	− 1	+ 5
F	415	+ 3	− 1	+ 2	271	+ 1	− 1	0
G	440	+ 2	− 2	0	325	+ 1	− 1	0
H	465	+ 1	− 2	− 1	479	0	− 2	− 2
I	490	+ 1	− 4	− 3	631	0	− 5	− 5
J	525	0	− 6	− 6	409	0	− 5	− 5
K	550	0	− 9	− 9	514	0	− 8	− 8
L	615	0	− 15	− 15	702	0	− 17	− 17
M	709	0	− 40	− 40	1,150	0	− 64	− 64
N	1,039	0	− 52	− 52	1,844	0	− 93	− 93
O	1,322	0	− 70	− 70	1,930	0	− 95	− 95
18				− 17				− 18
17				− 20				− 18
16				− 22				− 18
15				− 23				− 21
14				− 23				− 19
13				− 39				− 32
12				− 28				− 22
11				− 20				− 18
10				− 10*				− 10
9				− 2*				− 2
8				+ 2*				+ 2
7				+ 3*				+ 2
6				+ 4*				+ 3
5				+ 8*				+ 7
4				+ 6*				+ 6
3				+ 4*				+ 3
2				+ 3*				+ 3
1				0*				0
	Total			−230				− 355

*These values have been interpolated from those obtained for neighbouring stations.

TABLE IV—*Continued*

Zone	Elevation in Feet	Topography	Compensation	Topography and Compensation	Elevation in Feet	Topography	Compensation	Topography and Compensation
	Liard River, B.C., No. 48				Good Hope, N.W.T., No. 49			
A	525	+ 2	0	+ 2	200	+ 2	0	+ 2
B	518	+ 55	0	+ 55	180	+ 33	0	+ 33
C	513	+ 62	0	+ 62	180	+ 15	0	+ 15
D	513	+ 32	− 1	+ 31	181	+ 5	0	+ 5
E	525	+ 13	− 1	+ 12	188	+ 2	0	+ 2
F	550	+ 5	− 2	+ 3	210	+ 1	− 1	0
G	600	+ 2	− 2	0	230	0	− 1	− 1
H	650	+ 1	− 3	− 2	250	0	− 1	− 1
I	750	+ 1	− 5	− 4	275	0	− 2	− 2
J	1,500	− 1	− 17	− 18	300	0	− 3	− 3
K	1,700	− 1	− 27	− 28	435	0	− 7	− 7
L	2,300	− 3	− 55	− 58	640	0	− 15	− 15
M	2,082	− 2	−121	−123	634	0	− 35	− 35
N	2,336	− 1	−119	−120	1,000	0	− 52	− 52
O	2,899	− 1	−141	−142	1,690	0	− 87	− 87
18				− 36				− 20
17				− 37				− 19
16				− 36				− 18
15				− 37				− 20
14				− 41				− 20
13				− 53				− 32
12				− 30				− 15
11				− 18				− 14
10				− 8				− 9*
9				0				− 1*
8				+ 4				+ 2*
7				+ 4				+ 3*
6				+ 4				+ 4*
5				+ 9				+ 7*
4				+ 6				+ 6*
3				+ 4				+ 3*
2				+ 3				+ 3*
1				0				0*
	Total			−592				−286

*These values have been interpolated from those obtained for neighbouring stations.

TABLE IV—*Concluded*

Zone	Elevation in Feet	Topography	Compensation	Topography and Compensation	Elevation in Feet	Topography	Compensation	Topography and Compensation
	Arctic Red River, N.W.T., No. 50				Chipewyan, Alta. No. 51			
A	135	+ 2	0	+ 2	748	+ 2	0	+ 2
B	129	+ 28	0	+ 28	741	+ 58	0	+ 58
C	122	+ 9	0	+ 9	716	+ 84	0	+ 84
D	108	+ 2	0	+ 2	715	+ 52	− 1	+ 51
E	99	+ 1	0	+ 1	721	+ 22	− 2	+ 20
F	140	0	0	0	719	+ 9	− 2	+ 7
G	190	0	− 1	− 1	713	+ 4	− 3	+ 1
H	230	0	− 1	− 1	720	+ 2	− 3	− 1
I	275	0	− 2	− 2	717	+ 2	− 6	− 4
J	320	0	− 4	− 4	720	+ 1	− 8	− 7
K	360	0	− 6	− 6	725	+ 1	− 12	− 11
L	420	0	− 10	− 10	740	+ 1	− 18	− 17
M	395	0	− 22	− 22	755	0	− 42	− 42
N	828	0	− 49	− 44	1,088	0	− 56	− 56
O	1,625	0	− 82	− 82	1,287	0	− 70	− 70
18				− 16				− 13
17				− 19				− 14
16				− 19				− 15
15				− 20				− 15
14				− 22				− 15
13				− 24				− 28
12				− 14				− 20
11				− 15				− 18
10				− 7				− 14
9				0				− 7
8				+ 3				− 2
7				+ 4				+ 2*
6				+ 5				+ 4*
5				+ 6				+ 9*
4				+ 6				+ 6*
3				+ 4				+ 3*
2				+ 3				+ 3*
1				0				0*
	Total			−255	Total			−119

*These values have been interpolated from those obtained for neighbouring stations.

TABLE V

CORRECTIONS IN DYNES FOR TOPOGRAPHY AND ISOSTATIC COMPENSATION FOR GIVEN DEPTHS OF COMPENSATION

Number and Name of station	Depth 42·6 km.	Depth 56·9 km.	Depth 85·3 km.	Depth 113·7 km.	Depth 127·9 km.	Depth 156·25 km.	Depth 184·6 km.
1. Ottawa....................	−·0061	−·0074	−·0080	−·0079	−·0077	−·0069	−·0060
43. Peace River..............	−·0324	−·0340	−·0370	−·0384	−·0390	−·0396	−·0392
44. Resolution...............	−·0047	−·0055	−·0075	−·0091	−·0098	−·0108	−·0113
45. Providence...............	−·0125	−·0142	−·0161	−·0179	−·0185	−·0191	−·0194
46. Simpson..................	−·0139	−·0162	−·0201	−·0230	−·0240	−·0259	−·0267
47. Norman...................	−·0257	−·0290	−·0335	−·0355	−·0363	−·0372	−·0373
48. Liard River..............	−·0490	−·0522	−·0569	−·0592	−·0599	−·0606	−·0602
49. Good Hope................	−·0190	−·0221	−·0262	−·0286	−·0297	−·0306	−·0313
50. Arctic Red River.........	−·0165	−·0191	−·0229	−·0255	−·0264	·−0277	·−0281
51. Chipewyan................	−·0065	−·0080	−·0104	−·0119	−·0124	−·0133	−·0135

TABLE VI

ANOMALIES COMPUTED FROM HELMERT'S FORMULA FOR VARIOUS DEPTHS OF COMPENSATION

Number and Name of station	Depth 42·6 km.	Depth 56·9 km.	Depth 85·3 km.	Depth 113·7 km.	Depth 127·9 km.	Depth 156·25 km.	Depth 184·6 km.
	$g-g_c$	$g-g_c$	$g-g_c$	$g-g_c$	$g-g_c$	$g-g_c$	$g-g_c$
1. Ottawa....................	−·001	·000	+·001	+·001	+·001	000	−·001
43. Peace River..............	+·006	+·008	+·011	+·012	+·013	+·014	+·013
44. Resolution...............	−·011	−·010	−·008	−·007	−·006	−·005	−·005
45. Providence...............	−·003	−·002	·000	+·002	+·003	+·003	+·003
46. Simpson..................	+·002	+·004	+·008	+·011	+·012	+·014	+·015
47. Norman...................	−·011	−·008	−·003	−·001	−·001	·000	·000
48. Liard River..............	−·024	−·021	−·016	−·014	−·013	−·012	−·013
49. Good Hope................	+·006	+·009	+·013	+·016	+·017	+·018	+·018
50. Arctic Red River.........	+·015	+·017	+·021	+·024	+·024	+·026	+·026
51. Chipewyan................	−·010	−·009	−·007	−·005	−·005	−·004	−·003
Mean with regard to sign.......	−·003	−·001	+·002	+·004	+·005	+·005	+·005
Mean without regard to sign....	·009	·009	·009	·009	·010	·010	·010

TABLE VII

ANOMALIES COMPUTED FROM BOWIE'S WORLD FORMULA OF 1916 FOR VARIOUS DEPTHS OF COMPENSATION

Number and name of station	Depth 42·6 km.	Depth 56·9 km.	Depth 85·3 km.	Depth 113·7 km.	Depth 127·9 km.	Depth 156·25 km.	Depth 184·6 km.
	$g-g_c$	$g-g_c$	$g-g_c$	$g-g_c$	$g-g_c$	$g-g_c$	$g-g_c$
1. Ottawa.................	−·006	−·005	−·004	−·004	−·004	−·005	−·006
43. Peace River..........	+·002	+·004	+·007	+·008	+·009	+·010	+·009
44. Resolution..........	−·014	−·013	−·011	−·010	−·009	−·008	−·008
45. Providence.............	−·006	−·005	−·003	−·001	·000	·000	·000
46. Simpson.............	−·002	·000	+·004	+·007	+·008	+·010	+·011
47. Norman.............	−·014	−·011	−·006	−·004	−·004	−·003	−·003
48. Liard River.............	−·027	−·024	−·019	−·017	−·016	−·015	−·016
49. Good Hope.............	+·003	+·006	+·010	+·013	+·014	+·015	+·015
50. Arctic Red River........	+·012	+·014	+·018	+·021	+·021	+·023	+·023
51. Chipewyan.............	−·014	−·013	−·011	−·009	−·009	−·008	−·007
Mean with regard to sign......	−·007	−·005	−·002	·000	+·001	+·002	+·002
Mean without regard to sign...	·010	·010	·009	·009	·009	·010	·010

TABLE VIII

PRINCIPAL FACTS FOR GRAVITY STATIONS ESTABLISHED DURING 1921 AND 1922

Station	Longitude	Latitude	Altitude	Computed g at sea-level	Corrections: Altitude	Corrections: Topography and Isostatic Compensation	Computed Gravity	Observed Gravity	Hayford and Bowie anomaly O-C	Bouguer anomaly O-C	Free Air anomaly O-C
	h m s	° ′ ″	metres	dynes	dynes	dynes	dynes	dynes	dynes	dynes	dynes
1. Ottawa.........	5 02 52	45 23 38	83	980·656	·026	−·008	980·622	980·618	−·004	−·021	−·012
43. Peace River....	7 49 09	56 14 04	324	981·612	−·100	−·038	981·474	981·482	+·008	−·066	−·030
44. Resolution......	7 34 42	61 10 05	152	982·008	−·047	−·009	981·952	981·942	−·010	−·036	−·019
45. Providence.....	7 50 37	61 21 14	156	982·022	−·048	−·018	981·956	981·955	−·001	−·036	−·019
46. Simpson	8 05 23	61 51 39	132	982·061	−·041	−·023	981·997	982·004	+·007	−·031	−·016
47. Norman........	8 22 17	64 53 59	87	982·281	−·027	−·036	982·218	982·214	−·004	−·050	−·040
48. Liard River....	8 15 10	59 58 43	160	981·915	−·049	−·059	981·807	981·790	−·017	−·094	−·076
49. Good Hope.....	8 34 33	66 15 18	59	982·374	−·018	−·029	982·327	982·340	+·013	−·023	−·016
50. Arctic Red River........	8 54 57	67 26 37	41	982·452	−·013	−·026	982·413	982·434	+·021	−·010	−·005
51. Chipewyan.....	7 24 35	58 42 44	229	981·815	−·071	−·012	981·732	981·723	−·009	−·047	−·021
Mean anomaly with regard to sign..................									·000	−·041	−·025
Mean anomaly without regard to sign..................									·009	·041	·025

DEPTH OF COMPENSATION FOR THE NINE FIELD STATIONS*

From the results of a large number of gravity stations, suitably distributed over the earth's surface, it is possible by the method of least squares to obtain a formula for γ_o and at the same time the most probable depth of compensation. From the gravity formula a value of the earth's flattening or ellipticity is easily deduced. A number of such solutions have already been made by Bowie* for stations in the United States and in other parts of the world.

With only ten stations in a comparatively limited area it is not possible to obtain a complete solution that is of any value. If, however, we have a formula that is known to represent the variations in gravity sufficiently well the depth of compensation can be determined even though the stations are not distributed over such a wide area. The depth so determined will give some idea of the depth of compensation in the area under consideration.

For the stations included in this report two solutions have been made for the depth of compensation using (1) Helmert's formula of 1901 and (2) Bowie's world formula of 1916.

It should be remarked that these are in principle special cases of the more general solutions that have been made by Bowie. If γ_o be the value of gravity at sea-level computed from one of the formulae, g the observed value for any particular station, Z the combined correction due to elevation, topography and compensation, then we have for each station $g = \gamma_o + Z + v$

where v is the residual obtained from the solution for the station,

or $g = \gamma_o + Z_1 + \frac{dZ}{dt} \Delta t + v$,

where Z_1 is the correction for some definite depth of compensation t, and Δt represents a small change in this depth.

$$\frac{dZ}{dt} \Delta t = g - (\gamma_o + Z_1) + v$$
$$= (\text{gravity anomaly at depth } t) + v \text{ or}$$
$$\frac{dZ}{dt} \Delta t - \text{gravity anomaly} = v.$$

As the elevation correction is the same for all depths of compensation, $\frac{dZ}{dt}$ represents the rate of change with the depth of the correction for topography and compensation. The value of this for each station may be obtained from Table V.

Taking 28·4 km. as the unit for Δt and ·01 dyne as the unit anomaly, the following observation equations for the nine field stations are obtained from Helmert's formula for a depth of compensation of 65 km.

$$- \cdot 31 \Delta t - 0 \cdot 9 = v$$
$$- \cdot 19 \Delta t + 0 \cdot 9 = v$$
$$- \cdot 23 \Delta t + 0 \cdot 1 = v$$
$$- \cdot 41 \Delta t - 0 \cdot 5 = v$$
$$- \cdot 51 \Delta t + 0 \cdot 7 = v$$
$$- \cdot 52 \Delta t + 2 \cdot 0 = v$$
$$- \cdot 47 \Delta t - 1 \cdot 0 = v$$
$$- \cdot 42 \Delta t - 1 \cdot 8 = v$$
$$- \cdot 26 \Delta t + 0 \cdot 8 = v$$

*Chapter VIII, Special Publication No. 40 U. S. C. & G. S.

The depth of compensation obtained from these equations is approximately 67 km., with a probable error of 20 km.

For a depth of compensation of 85·3 km. the observation equations resulting from Bowie's formula are as follows:—

$$
\begin{aligned}
-\cdot 22\ \Delta t - 0\cdot 7 &= v \\
-\cdot 18\ \Delta t + 1\cdot 1 &= v \\
-\cdot 185\ \Delta t + 0\cdot 3 &= v \\
-\cdot 34\ \Delta t - 0\cdot 4 &= v \\
-\cdot 325\ \Delta t + 0\cdot 6 &= v \\
-\cdot 35\ \Delta t + 1\cdot 9 &= v \\
-\cdot 325\ \Delta t - 1\cdot 0 &= v \\
-\cdot 320\ \Delta t - 1\cdot 8 &= v \\
-\cdot 195\ \Delta t + 1\cdot 1 &= v
\end{aligned}
$$

From these the depth of compensation obtained is 91 kilometres with a probable error of 29 kilometres.

On account of the small number of stations no great significance can be attached to these two results. They are, however, a rough confirmation of the order of magnitude that has already been found for the depth of compensation.

In concluding this report the writer wishes to acknowledge his indebtedness and at the same time to express his gratitude for the assistance and many valuable suggestions he has received from Mr. R. Meldrum Stewart, Assistant Director of this Observatory.

Dominion Observatory,
Ottawa,
December, 1923.

The depth of compensation obtained from these stations is [illegible] km. with a probable error of 50 km.

For a depth of compensation of 56·6 km. the observation equations resulting from Bowie's formula are as follows:—

[illegible]

$-134\,\Delta\gamma - 0{\cdot}4 = a$

[illegible]

From these the depth of compensation obtained is 91 kilometres with a probable error of 50 kilometres.

On account of the small number of stations no great confidence can be attached to these two results. They are, however, a rough confirmation of the order of magnitude that has already been found for the depth of compensation.

In concluding this report the writer wishes to acknowledge his indebtedness and at the same time to express his gratitude for the many suggestions and many valuable criticisms received from Dr. R. Meldrum Stewart, Assistant Director of the Observatory.

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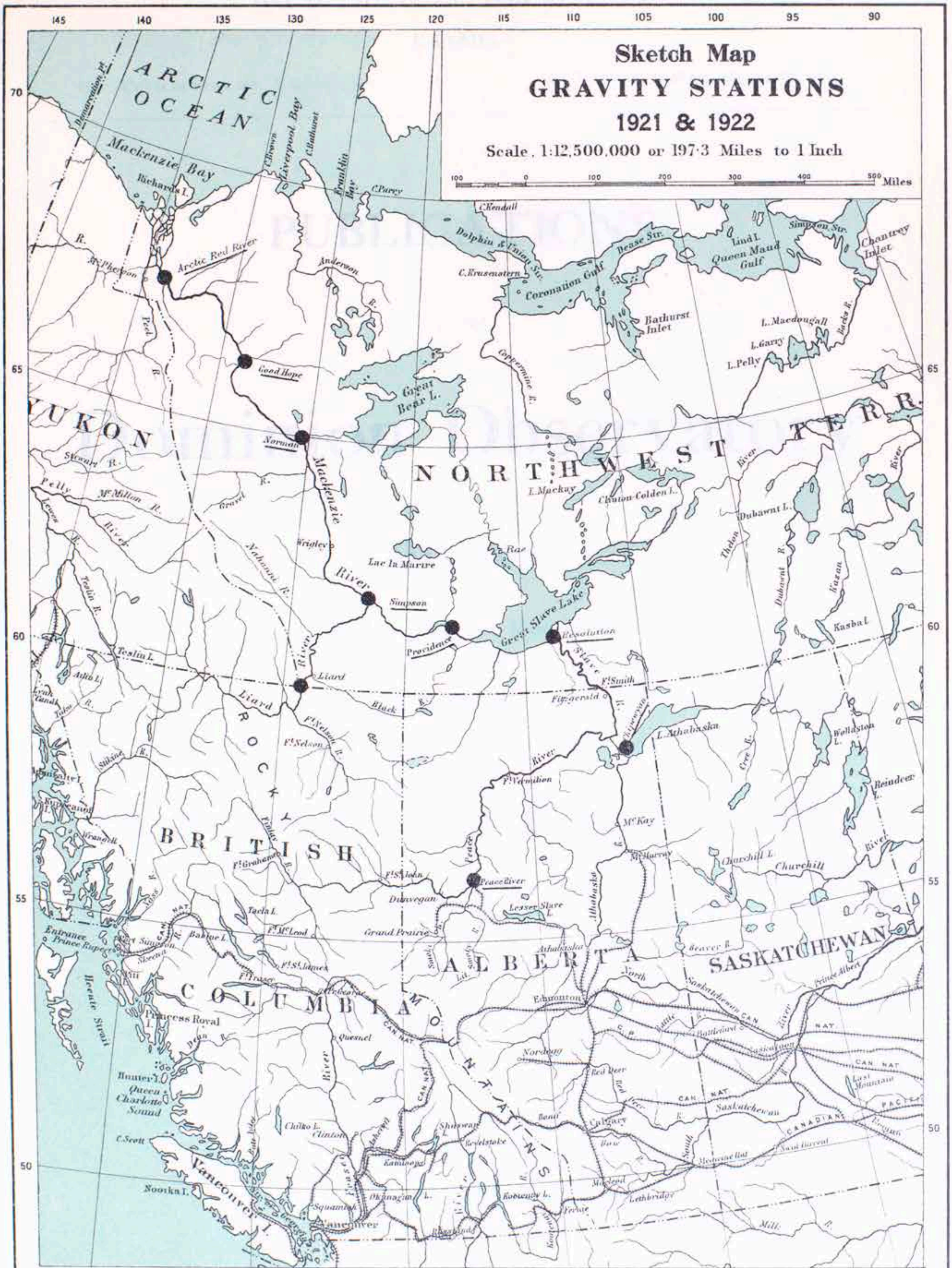

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