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Gravity

BY

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FOREWORD

With the view of reducing the cost of publication the greater part of the tabular matter, the illustrations and the formulæ have been omitted.

OTTO KLOTZ
Director.

November, 1917.

GRAVITY

By F. A. McDIARMID, B.A.

During the season of 1915 there were observed in Canada twenty-four gravity stations as follows:—St. John, N.B.; Moncton, N.B.; Charlottetown, P.E.I.; Sydney, N.S.; Truro, N.S.; Halifax, N.S.; Yarmouth, N.S.; Woodstock, N.B.; Edmundston, N.B.; Bathurst, N.B.; Percé, Que.; Kenora, Ont.; Winnipeg, Man.; Brandon, Man.; Moosejaw, Sask.; Medicine Hat, Alta.; Calgary, Alta.; Banff, Alta.; Field, B.C.; Glacier, B.C.; Revelstoke, B.C.; Kamloops, B.C.; North Bend, B.C.; and Vancouver, B.C. Two other stations—Dunmore, Alta., and Yale, B.C.—were on the observing programme prepared by Dr. Klotz, Assistant Chief Astronomer, under whose supervision the gravity work is carried on, but the difficulty of securing suitable observing rooms led to their abandonment.

The first observations were made at St. John on the eleventh of May, and the last at Vancouver on the seventh of September. During that interval more than two weeks were spent in Ottawa standardizing the pendulums. The eleven stations in eastern Canada were observed in six weeks, and the thirteen in western Canada in less than eight weeks.

The instruments, their use, the method of observing, the determination of the instrumental coefficients are all described in the *Publications of the Dominion Observatory*, Vol. II, No. 10. In the observing, only knife-edge No. 1 was used and the pendulums were all swung with the direct face toward the flash apparatus. The flexure was determined by the same method as in 1914.

The observing chronometers were rated by comparisons with standard sidereal clocks. Through the kindness of Mr. D. L. Hutchinson, Director of the St. John, N.B., meteorological observatory, clock signals were sent twice a day from the St. John clock to the stations occupied in eastern Canada, and for the work in western Canada time signals were obtained from the Dominion Observatory Riefler standard sidereal clock. The St. John clock is a Riefler of the latest type, is splendidly mounted in a constant temperature room, and is enclosed under constant pressure. Its rate during the whole of the gravity campaign in the east was very nearly zero, and very constant. Mr. Hutchinson, largely on his own initiative, had built a splendid observatory. It is well equipped with modern instruments and the excellent results show a thorough knowledge of practical observing.

STANDARDIZING OF PENDULUMS

During the season of 1914 considerable difficulty was experienced due to changes in the lengths of the pendulums. On account of some injury to

pendulum No. 2, it would only swing a very few hours, and the observations of that year were carried on with the two pendulums Nos. 1 and 3. Previous to commencing the 1915 work, pendulum No. 2 was repaired by slightly grinding the head of the pendulum where it rests on the lifter, and it has behaved very satisfactorily since. The periods of the three pendulums were determined in April, before commencing the season's campaign, again in July between the eastern and western work, and also in September after completing the season's work. There were changes in the lengths of the different pendulums during the summer, and these will be referred to later under "Variation in lengths of pendulums."

DESCRIPTIONS OF STATIONS

The pendulum stations observed in 1915 were referred, when possible to astronomic stations, and when no astronomic station was available, to survey posts. They are described as follows:—

St. John, N.B.—The pendulum pier was in the basement of the meteorological observatory, Douglas Ave., 109 ft. above mean sea-level, and 3284 ft. south and 4476 ft. west of astronomic station near corner of Lombard and Southwark streets, distance to astronomic station scaled from map of the city of St. John.

Moncton, N.B.—The pendulum pier was in the basement of the general offices of the Intercolonial railway, 7 ft. below the level of the G.S.C. (Geodetic Survey of Canada) bench-mark on the east wall of the general office building, and 200 ft. north and 1000 ft. east of astronomic station, distance to astronomic station measured.

Charlottetown, P.E.I.—The pendulum pier was in the battery room of the Western Union Telegraph company, 25 ft. above mean sea-level, and 329 ft. south and 57 ft. west of astronomic station, distance to astronomic station measured.

Sydney, N.S.—The pendulum pier was in the basement of the Maritime Telephone and Telegraph office on Pitt street, 42 ft. above mean tide water, and 674 ft. south and 679 ft. east of astronomic station, distance to astronomic station scaled from map of the town of Sydney.

Truro, N.S.—The pendulum pier was in the Western Union Telegraph stores, nearly opposite the I. C. R. station, on level with rail opposite station, and 722 ft. south and 785 ft. west of astronomic station, distance to astronomic station scaled from map of the town of Truro.

Halifax, N.S.—The pendulum pier was in the battery room of the Western Union Telegraph company, near corner of Sackville and Hollis streets, 30 ft.

above mean sea-level, and 4029 ft. north and 10730 ft. east of astronomic station, distance to astronomic station scaled from map of the city of Halifax.

Yarmouth, N.S.—The pendulum pier was in the battery room of the Western Union Telegraph company, 30 ft. above mean sea-level, and 66 ft. east and 787 ft. south of astronomic station, distance to astronomic station scaled from map of the town of Yarmouth.

Woodstock, N.B.—The pendulum pier was in the furnace room of the armoury, 14 ft. below the level of the G. S. C. bench-mark in the Woodstock post-office, and 2887 ft. north and 1403 ft. east of astronomic station, distance to astronomic station scaled from map of the town of Woodstock.

Edmundston, N.B.—The pendulum pier was in the basement of the Edmundston hotel, 2 ft. above the G. S. C. bench-mark near the C. P. R. station, and 415 ft. north and 421 ft. east of astronomic station, distance to astronomic station measured.

Bathurst, N.B.—The pendulum pier was in the basement of the Bathurst post-office, 15 ft. above mean sea-level, and 268 ft. south and 734 ft. east of astronomic station, distance to astronomic station measured.

Percé, Que.—The pendulum pier was in the cellar of Mr. Biard's house, 20 ft. above mean sea-level, 4118 ft. north and 1717 ft. east of astronomic station, distance to astronomic station measured.

Kenora, Ont.—The pendulum pier was in the battery room of the C. P. R. Telegraph company, in the basement of the C. P. R. station, 8 ft. below the G. S. C. bench-mark in the wall of the C. P. R. station. Geographical position, as scaled from the Department of Interior large scale map of the Northwest, is latitude 49° 46′ and longitude 94° 30′.

Winnipeg, Man.—The pendulum pier was in the terminal room of the C. P. R. Telegraph company in the C. P. R. station, 10 ft. below the G. S. C. bench-mark in the Union station, and 7280 ft. north and 3500 ft. west of astronomic station, distance to astronomic station scaled from map of the city of Winnipeg.

Brandon, Man.—The pendulum pier was in the battery room of the C. P. R. Telegraph company, near corner of Rosser avenue and Tenth street, 10 ft. above rail in front of C. P. R. station, and 60 ft. west and 40 ft. north of northwest corner of Rosser avenue and Tenth street, city of Brandon.

Moosejaw, Sask.—The pendulum pier was in the terminal room of the C. P. R. Telegraph company, 5 ft. below the G. S. C. bench-mark in the C. P. R. station, and 50 ft. east and 2640 ft. south of the northwest corner of section 33, township 16, range 26, west of the second meridian, distance measured.

Medicine Hat, Alta.—The pendulum pier was in the battery room of the C. P. R. Telegraph company in the C. P. R. station, 5 ft. below the level of the bench-mark in the C. P. R. station, and 900 ft. east and 270 ft. south of the northwest corner of the southeast quarter of section 31, township 12, range 5, west of the fourth meridian, distance scaled from map of the town of Medicine Hat.

Calgary, Alta.—The pendulum pier was in the terminal room of the C. P. R. Telegraph company in the C. P. R. station, 7 ft. below the level of the G. S. C. bench-mark in the station, and 350 ft. north and 400 ft. east of the astronomic station, distance to astronomic station scaled from map of the city of Calgary.

Banff, Alta.—The pendulum pier was in the cellar of the C. P. R. station, 4 ft. below the level of the G. S. C. bench-mark in bridge over the stream just west of Banff station, and 900 ft. south and 8880 ft. west of the northwest corner of township 25, range 12, west of the fifth meridian, distance scaled from map of the town of Banff.

Field, B.C.—The pendulum pier was in the basement of the Mount Stephen hotel, 6 ft. above the rail in front of the C. P. R. station, 645 ft. north and 700 ft. west of astronomic station, distance to astronomic station measured.

Glacier, B.C.—The pendulum pier was in the furnace room of the Glacier house, 4 ft. above the level of the rail in front of the C. P. R. station, and 396 ft. west and 3234 ft. south of the northeast corner of section 36, township 26, range 26, west of the fifth meridian, distance scaled from map of the township.

Revelstoke, B.C.—The pendulum pier was in the battery room of the C. P. R. Telegraph company, 10 ft. below the level of the rail in front of the C. P. R. station, and 1552 ft. west and 262 ft. north of astronomic station, distance to astronomic station measured.

Kamloops, B.C.—The pendulum pier was in the battery room of the C. P. R. company in the C. P. R. station, 5 ft. below the level of the rail in front of the station, and 660 ft. south and 640 ft. east of astronomic station, distance to astronomic station measured.

North Bend, B.C.—The pendulum pier was in the basement of the Fraser Canyon hotel, 4 ft. above the level of the rail in front of the C. P. R. station, and 794 ft. south and 14200 ft. west of the northeast corner of township 10, range 26, west of the sixth meridian, distance scaled from map of the township.

Vancouver, B.C.—The pendulum pier was in the terminal room of the C. P. R. Telegraph company in the C. P. R. station, 15 ft. above the rail in front of the station, and 1409 ft. east and 5755 ft. south of the astronomic station at Brockton Point, distance to astronomic station scaled from the map of the city of Vancouver.

In the following table are given brief descriptions of the pendulum piers, the longitude, the latitude, and the altitude of each station. At every station the pendulum apparatus was mounted on a concrete floor, on three stones set in plaster of Paris. The method of mounting and the description of instruments are given in the *Publications of the Dominion Observatory*, Vol. II, No. 10. The temperature conditions were very satisfactory at all the stations, the temperature rarely having a range exceeding three degrees Centigrade.

Station	Longitude			Latitude			Altitude	Description of Station
	h.	m.	s.	°	′	″	metres	
St. John	4	24	20	45	16	03	33	Pier in basement of meteorological observatory.
Moncton	4	19	09	46	05	04	14	Pier in basement of I.C.R. offices.
Charlottetown	4	12	30	46	13	55	8	Pier in cellar of Western Union Telegraph office.
Sydney	4	00	47	46	08	21	12	Pier in basement of Maritime Telegraph and Telephone company's office.
Truro	4	13	06	45	21	40	18	Pier in Western Union Telegraph stores.
Halifax	4	14	15	44	40	47	9	Pier in battery room of Western Union Telegraph company.
Yarmouth	4	24	29	43	50	07	9	Pier in battery room of Western Union Telegraph company.
Woodstock	4	30	18	46	09	02	56	Pier in furnace room of armoury.
Edmundston	4	33	18	47	22	11	148	Pier in cellar of Edmundston hotel.
Bathurst	4	22	36	47	37	10	5	Pier in cellar of Bathurst post-office.
Percé	4	16	51	48	31	33	6	Pier in cellar of Mr. Biard's house.
Kenora	6	18	00	49	46	00	330	Pier in battery room of C.P.R. Telegraph company.
Winnipeg	6	28	32	49	54	23	231	Pier in terminal room of C.P.R. Telegraph company.
Brandon	6	39	47	49	50	54	366	Pier in battery room of C.P.R. Telegraph company.
Moosejaw	7	02	07	50	23	26	541	Pier in battery room of C.P.R. Telegraph company.
Medicine Hat	7	22	40	50	02	25	664	Pier in battery room of C.P.R. Telegraph company.
Calgary	7	36	15	51	02	43	1044	Pier in terminal room of C.P.R. Telegraph company.
Banff	7	42	18	51	10	53	1376	Pier in basement of C.P.R. station.
Field	7	45	59	51	23	42	1239	Pier in basement of Mount Stephen hotel.
Glacier	7	49	58	51	15	44	1248	Pier in furnace room of Glacier house.
Revelstoke	7	52	47	50	59	48	453	Pier in battery room of C.P.R. Telegraph company.
Kamloops	8	01	18	50	40	42	352	Pier in battery room of C.P.R. Telegraph company.
North Bend	8	05	48	49	52	17	152	Pier in basement of Fraser Canyon hotel.
Vancouver	8	12	27	49	16	49	6	Pier in terminal room of C.P.R. Telegraph company.

RATING OF CHRONOMETERS

To all the stations, as stated above, clock signals were sent from standard sidereal clocks, time being secured for the eastern work from the St. John meteorological observatory, and for the western work from the Dominion Observatory.

Below follow tables of chronometer comparisons, the deduced daily rates, and the corrections to the periods of the pendulums due to clock rates. An examination of the corrections to the periods of the pendulums due to clock rates will show the absolute necessity of not depending on the chronometers for more than a very few minutes. The rates of the two observing chronometers, Bond 519 and Dent 48419, were constantly changing with changes of temperature and from other causes. Both of these chronometers, the best procurable, occasionally changed their daily rates as much as two seconds in a couple of hours. The rate of the observing chronometers is one of the most important considerations in pendulum observations, hence the necessity of making the time of observing coincidences coincide nearly with the time of clock comparisons. The standard clocks both at St. John and Ottawa have very constant rates, and the errors from these sources are nearly zero.

CHRONOMETER COMPARISONS AND DEDUCED CORRECTIONS TO PENDULUM PERIOD

Station	Date	Comparison of Chronometers		Relative daily rate B to R	Daily Rates		Corrections to 7th place of period	
		Bond	Riefler		Riefler	Bond	Riefler	Bond
	1915	h. m. s.	h. m. s.					
Ottawa	April 7	4 08 00	4 07 58·16	−1·673	−0·140	−1·813	−8	−105
	" 7	10 44 00	10 43 57·70	−2·128	−0·140	−2·268	−8	−132
	" 7	18 17 00	18 16 57·03	−2·108	−0·140	−2·248	−8	−130
	" 8	3 46 00	3 45 56·22	−1·690	−0·140	−1·830	−8	−106
	" 8	11 09 00	11 08 55·68	−1·559	−0·140	−1·699	−8	− 99
	" 8	18 14 00	18 13 55·22	−1·899	−0·140	−2·039	−8	−118
	" 9	3 35 00	3 34 54·48	−1·865	−0·140	−2·005	−8	−116
	" 9	10 32 00	10 31 53·94	−1·928	−0·140	−2·068	−8	−120
	" 9	18 23 00	18 22 53·31	−2·223	−0·140	−2·363	−8	−137
	" 10	4 06 00	4 05 52·41					

CHRONOMETER COMPARISONS AND DEDUCED CORRECTIONS TO PENDULUM PERIOD—*Con.*

Station	Date	Comparison of Chronometers		Relative daily rate	Daily Rates		Corrections to 7th place of period	
		Bond	Riefler	B to R	Riefler	Bond	Riefler	Bond
	1915	h. m. s.	h. m. s.					
Ottawa	April 19	17 00 00	17 00 14·77					
				−2·513	−0·140	−2·653	−8	−154
	" 19	0 27 00	0 27 13·99					
				−2·532	−0·140	−2·672	−8	−155
	" 20	8 59 00	8 59 13·09					
				−1·976	−0·140	−2·116	−8	−123
	" 20	16 09 00	16 09 12·50					
				−2·090	−0·140	−2·230	−8	−129
	" 20	23 23 00	23 23 11·87					
				−2·179	−0·140	−2·319	−8	−135
	" 21	8 38 00	8 38 11·03					
				−1·758	−0·140	−1·898	−8	−110
	" 21	15 44 00	15 44 10·51					
				−1·800	−0·140	−1·940	−8	−113
	" 21	23 36 00	23 36 9·92					
				−2·206	−0·140	−2·346	−8	−138
	" 22	8 51 00	8 51 9·07					
				−1·906	−0·140	−2·046	−8	−119
	" 22	16 24 00	16 24 8·47					

REDUCTION OF OBSERVATIONS

The formulae and methods of reduction of the observations are given in the *Publications of the Dominion Observatory*, Vol. II, No. 10, and will not be repeated here.

VARIATION IN LENGTHS OF PENDULUMS

During the season of 1914 the pendulums changed their lengths at least three times. Fortunately, it was possible to secure frequent observations at Ottawa, the base point, and so from the periods obtained at the different stations, a reliable gravity result was secured. Also, during 1914, only pendulums Nos. 1 and 3 were used, some accident rendering No. 2 useless. The changes in the periods of the pendulums always showed themselves after a trip where there was frequent handling of the boxes. This led to the conclusion that better packing boxes might greatly lessen the trouble. During the winter new and more substantial boxes were made, the small box holding the pendulums was placed in a large box fitted with three-inch hair pads. This made a splendid carrying case, and as a result there has been very little trouble during the past

summer. Pendulum No. 2 has been repaired by grinding out a small portion of the head, and the complete set has been used all the past season.

The pendulums were standardized at the Dominion Observatory in April, and after observing at all the stations in eastern Canada it was found that the differences of the periods of the pendulums agreed with the differences obtained at Ottawa. Observations were again made at Ottawa in July, and it was found that there were slight changes in the periods from those obtained in April. Pendulum No. 1 had changed its period from 0.5013225 second to 0.5013240 second, and pendulum No. 2 from 0.5014422 second to 0.5014408 second, while pendulum No. 3 remained constant at 0.5014109 second. The outfit was then taken to Kenora, and here another change was detected. Special precautions were then taken in handling the pendulums for the rest of the summer, and there were no further changes. On restandardizing at Ottawa in September, the periods of the three pendulums Nos. 1, 2 and 3 were 0.5013244 second, 0.5014431 second and 0.5014102 second respectively. These changes although small are very troublesome to good work, and if they had occurred in the middle of a trip would have necessitated the repetition of a part of the work.

The pendulum apparatus of the United States Coast and Geodetic Survey gave considerable trouble due to changing lengths of the pendulum. A careful examination of the pendulums failed to reveal any faults in construction, but on account of the trouble appearing frequently, the experiment was tried of putting a rivet through the bob of the pendulum and the stem. This seems to have removed the trouble, and there have been no further changes. Mr. Bowie, chief of the Department of Geodesy of the Coast and Geodetic Survey, recently informed the writer that it was the intention to treat all their pendulums in the same manner, and certainly some steps must be taken to provide pendulums of constant length, if satisfactory results are to be obtained. The three Ottawa pendulums have now each had the bob and stem rigidly connected by means of a rivet.

DEDUCTION OF ABSOLUTE GRAVITY

The ratio of gravity at two places is readily obtained from the fundamental formula of the simple pendulum, $P = 2\pi\sqrt{\frac{l}{g}}$, where P is the period, and l the length of the corresponding pendulum, and g is the force of gravity. There is then obtained the relation $P^2 : P_o^2 = g_o : g$, or $g_o = \frac{P^2}{P_o^2} g$, where P and g are the period and gravity at the base point, and P_o is the period at the field station.

The gravity at Ottawa as determined from Washington in 1914 is 980.615 dynes, and all our field stations are based on this value for Ottawa. In deducing

the gravity for the field stations, two different sets of values for the periods of the pendulums at Ottawa were used. The changes in the periods of the pendulums have already been discussed. For the stations, St. John, Moncton, Charlottetown, Sydney, Truro, Halifax, Yarmouth, Woodstock, Edmundston, Bathurst and Percé the periods obtained at Ottawa in April were used; and for the stations, Kenora, Winnipeg, Brandon, Moosejaw, Medicine Hat, Calgary, Banff, Field, Glacier, Revelstoke, Kamloops, North Bend and Vancouver the values obtained in September were used. The periods of the pendulums obtained in Ottawa in July were discarded entirely, as there were changes in the lengths of the pendulums between Percé and Ottawa, and also between Ottawa and Kenora.

In the following table are given the periods of the three pendulums for the different stations, and the deduced value of gravity in dynes.

Station	Periods of Pendulums in Seconds			Value of g in dynes			
	1	2	3	1	2	3	Mean
Ottawa	·5013226	·5014422	·5014109	.....	.....	.....	980·615
St. John	·5013108	·5014306	·5013997	980·660	980·660	980·659	980·660
Moncton	·5012945	·5014140	·5013830	980·725	980·725	980·724	980·725
Charlottetown	·5012930	·5014125	·5013814	980·730	980·731	980·730	980·730
Sydney	·5012938	·5014130	·5013818	980·727	980·729	980·729	980·728
Truro	·5013112	·5014309	·5013997	980·659	980·659	980·659	980·659
Halifax	·5013339	·5014531	·5014221	980·570	980·575	980·571	980·571
Yarmouth	·5013418	·5014610	·5014300	980·540	980·541	980·540	980·540
Woodstock	·5013018	·5014212	·5013901	980·696	980·697	980·696	980·696
Edmundston	·5012825	·5014023	·5013713	980·772	980·771	980·771	980·771
Bathurst	·5012667	·5013863	·5013553	980·834	980·834	980·832	980·833
Percé	·5012378	·5013572	·5013265	980·946	980·948	980·946	980·947
Kenora	·5012331	·5013522	·5013195	980·972	980·971	980·971	980·971
Winnipeg	·5012293	·5013479	·5013151	980·987	980·987	980·987	980·987
Brandon	·5012381	·5013568	·5013239	980·952	980·953	980·953	980·953
Moosejaw	·5012409	·5013603	·5013276	980·942	980·939	980·938	980·940
Medicine Hat	·5012606	·5013795	·5013465	980·865	980·864	980·865	980·865
Calgary	·5012725	·5013906	·5013579	980·819	980·820	980·820	980·820
Banff	·5012900	·5014089	·5013758	980·750	980·749	980·750	980·750
Field	·5012911	·5014100	·5013775	980·745	980·745	980·744	980·745
Glacier	·5012928	·5014117	·5013788	980·739	980·738	980·738	980·738
Revelstoke	·5012515	·5013705	·5013377	980·900	980·900	980·899	980·900
Kamloops	·5012407	·5013590	·5013264	980·943	980·944	980·944	980·944
North Bend	·5012551	·5013740	·5013412	980·886	980·886	980·885	980·886
Vancouver	·5012398	·5013584	·5013254	980·946	980·946	980·947	980·946
Ottawa	·5013244	·5014431	·5014102	.....	.....	.....	980·615

COMPUTATION OF THE INTENSITY OF GRAVITY AT ANY SELECTED STATION

To compute the intensity of gravity at any point on the earth, account must be taken of the altitude of the point, of the effect of the attraction of all the topography upon the earth upon a unit mass at the point, and of the isostatic compensation of that topography.

This problem has been very fully and ably dealt with in Hayford and Bowie's publication*, "The Effect of Topography and Isostatic Compensation upon the Intensity of Gravity"; and the method there set forth has been followed in the reduction of the Canadian observations.

There are two other methods of reducing the value of the force of gravity from sea-level to the observing station. These are known as the "free-air" method and Bouguer's method. As stated in the *Publications of the Dominion Observatory*, Vol. II, No. 10, the free-air method takes account only of the elevation above sea-level. The station is considered as if it were suspended in the air at a height equal to the elevation. In Bouguer's method $dg = -\frac{2gH}{r}(1-\frac{3\delta}{4\Delta})$, on the supposition that the station is situated on an indefinitely extended plain. Here dg is the correction to computed gravity g, at sea-level, H is the elevation above sea-level, r is the radius of the earth, δ is the density of the matter lying above sea-level and Δ is the mean density of the earth. The Bouguer method takes no account of the isostatic compensation and neglects all curvature of the sea-level surface, the topography being treated as if it were on a plain of indefinite extent. The results from applying these two methods seem to lead to the conclusion that general continental elevations are compensated for by a deficiency of density in the matter below sea-level, but that local topographical irregularities, whether elevations or depressions, are not compensated for, such irregularities being maintained by the partial rigidity of the earth's crust.

A comparison of the anomalies from the three methods of reduction will be given in the table entitled "Table of anomalies from different methods of reduction." A comparison of the anomalies by the new method of Hayford and Bowie, on the one hand, with those by the two older methods on the other hand will show the merits of the Hayford and Bowie method in comparison with the Bouguer and free-air methods.

The means of the anomalies with regard to sign from the new method, the Bouguer and the free-air method are respectively -0.001, -0.042 and -0.011

*Special Publication No. 10, Coast and Geodetic Survey, Washington.

dynes; and the means without regard to sign are 0.012, 0.049 and 0.026 dynes respectively, thus showing that as far as our Canadian work is concerned the new method is vastly superior to the other two methods.

PRINCIPAL FACTS FOR GRAVITY STATIONS OBSERVED IN 1914 AND 1915

Station	Longitude	Latitude	Altitude	Computed g at sea-level	Corrections		Computed Gravity	Observed Gravity	Anomaly O−C
					Altitude	Topography and Isostatic Compensation			
	h. m. s.	° ′ ″	metres	dynes	dynes	dynes	dynes	dynes	dynes
1. Ottawa	5 02 52	45 23 39	83	980·651	−·026	·000	980·625	980·615	−·010
2. Maniwaki	5 03 55	46 22 28	169	980·740	−·052	−·001	980·687	980·685	−·002
3. Kingston	5 05 55	44 14 37	79	980·547	−·024	·008	980·531	980·527	−·004
4. Roberval	4 48 54	48 30 54	107	980·933	−·033	−·015	980·885	980·865	−·020
5. Tadoussac	4 38 52	48 08 25	12	980·900	−·004	−·004	980·892	980·901	·009
6. Portneuf	4 47 35	46 42 32	59	980·770	−·018	·005	980·757	980·760	·003
7. St. Jérôme	4 56 00	45 46 34	107	980·686	−·033	·006	980·659	980·678	·019
8. Ste. Anne-de-Bellevue	4 55 46	45 24 27	34	980·653	−·010	·003	980·646	980·660	·014
9. Mattawa	5 14 49	46 18 43	170	980·734	−·052	−·013	980·669	980·647	−·022
10. Liskeard	5 18 41	47 30 34	194	980·843	−·060	−·004	980·779	980·785	·006
11. Cochrane	5 24 05	49 03 44	277	980·983	−·085	−·004	980·894	980·880	−·014
12. Sault Ste. Marie	5 37 18	46 30 26	186	980·752	−·057	−·005	980·690	980·677	−·013
13. Chapleau	5 33 37	47 50 27	430	980·872	−·133	·012	980·751	980·763	·012
14. Port Arthur	5 56 52	48 26 00	189	980·926	−·058	−·014	980·854	980·817	−·037
15. Rose Point	5 20 10	45 19 02	183	980·644	−·056	·001	980·589	980·603	·014
16. Whitby	5 15 46	43 52 43	84	980·514	−·026	−·004	980·484	980·458	−·026
17. Woodstock (Ont.)	5 23 08	43 08 33	299	980·448	−·093	−·002	980·353	980·349	−·004
18. Windsor	5 32 10	42 19 16	178	980·373	−·055	·000	980·318	980·338	·020
19. St. John	4 24 20	45 16 03	33	980·640	−·010	·016	980·646	980·660	·014
20. Moncton	4 19 09	46 05 04	14	980·713	−·004	·014	980·723	980·725	·002
21. Charlottetown	4 12 30	46 13 55	8	980·727	−·002	·013	980·738	980·730	−·008
22. Sydney	4 00 47	46 08 21	12	980·719	−·004	·014	980·729	980·728	−·001
23. Truro	4 13 06	45 21 40	18	980·649	−·006	·014	980·657	980·659	·002
24. Halifax	4 14 15	44 40 47	9	980·587	−·003	·008	980·592	980·571	−·021
25. Yarmouth	4 24 29	43 50 07	9	980·510	−·003	·014	980·521	980·540	·019
26. Woodstock (N.B.)	4 30 18	46 09 02	56	980·720	−·017	·008	980·711	980·696	−·015
27. Edmundston	4 33 18	47 22 11	148	980·830	−·046	−·010	980·774	980·771	−·003
28. Bathurst	4 22 36	47 37 10	5	980·853	−·002	·000	980·851	980·833	−·018
29. Percé	4 16 51	48 31 33	6	980·935	−·002	−·002	980·931	980·947	·016
30. Kenora	6 18 00	49 46 00	330	981·046	−·102	·018	980·962	980·971	·009
31. Winnipeg	6 28 52	49 54 23	231	981·057	−·071	·002	980·988	980·987	−·001
32. Brandon	6 39 47	49 50 54	366	981·053	−·113	−·002	980·938	980·953	·015

PRINCIPAL FACTS FOR GRAVITY STATIONS OBSERVED IN 1914 AND 1915—*Concluded*

Station	Longitude	Latitude	Altitude	Computed g at sea-level	Corrections		Computed Gravity	Observed Gravity	Anomaly O—C
					Altitude	Topography and Isostatic Compensation			
	h. m. s.	° ′ ″	metres	dynes	dynes	dynes	dynes	dynes	dynes
33. Moosejaw	7 02 07	50 23 26	541	981·101	—·167	·003	980·937	980·940	·003
34. Medicine Hat	7 22 40	50 02 25	664	981·070	—·205	—·002	980·863	980·865	·002
35. Calgary	7 36 15	51 02 43	1044	981·160	—·322	—·022	980·816	980·820	·004
36. Banff	7 42 18	51 10 53	1376	981·172	—·425	—·012	980·735	980·750	·015
37. Field	7 45 59	51 23 42	1239	981·190	—·382	—·060	980·748	980·745	—·003
38. Glacier	7 49 58	51 15 44	1248	981·179	—·385	—·066	980·729	980·738	·010
39. Revelstoke	7 52 47	50 59 48	453	981·155	—·140	—·080	980·935	980·900	—·035
40. Kamloops	8 01 18	50 40 42	352	981·127	—·109	—·073	980·945	980·944	—·001
41. North Bend	8 05 48	49 52 17	152	981·055	—·047	—·122	980·886	980·886	·000
42. Vancouver	8 12 27	49 16 49	6	981·002	—·002	—·046	980·954	980·946	—·008

TABLE OF ANOMALIES FROM DIFFERENT METHODS OF REDUCTION

Station	Anomaly		
	Hayford and Bowie's new method	Bouguer method	Free-air method
1. Ottawa	−·010	−·020	−·010
2. Maniwaki	−·002	−·022	−·003
3. Kingston	−·004	−·005	·004
4. Roberval	−·020	−·047	−·035
5. Tadoussac	·009	·003	·005
6. Portneuf	·003	·001	·008
7. St. Jérôme	·019	·013	·025
8. Ste. Anne-de-Bellevue	·014	·013	·017
9. Mattawa	−·022	−·054	−·035
10. Liskeard	·006	−·021	·002
11. Cochrane	−·014	−·050	−·018
12. Sault Ste. Marie	−·013	−·039	−·018
13. Chapleau	·012	−·026	·024
14. Port Arthur	−·037	−·073	−·051
15. Rose Point	·014	−·006	·015
16. Whitby	−·026	−·040	−·030
17. Woodstock (Ont.)	−·004	−·039	−·006
18. Windsor	·020	−·001	·020
19. St. John	·014	·026	·030
20. Moncton	·002	·015	·016
21. Charlottetown	−·008	·005	·005
22. Sydney	−·001	·011	·013
23. Truro	·002	·013	·016
24. Halifax	−·021	−·014	−·013
25. Yarmouth	·019	·032	·033
26. Woodstock (N.B.)	−·015	−·013	−·007
27. Edmundston	−·003	−·030	−·013
28. Bathurst	−·018	−·019	−·018
29. Percé	·016	·013	·014
30. Kenora	·009	−·011	·027
31. Winnipeg	−·001	−·025	·001
32. Brandon	·015	−·029	·013
33. Moosejaw	·003	−·057	·006
34. Medicine Hat	·002	−·077	·000
35. Calgary	·004	−·139	−·018
36. Banff	·015	−·156	·003
37. Field	−·003	−·206	−·063
38. Glacier	·010	−·200	−·056
39. Revelstoke	−·035	−·168	−·115
40. Kamloops	−·001	−·115	−·074
41. North Bend	·000	−·140	−·122
42. Vancouver	−·008	−·055	−·054
Mean with regard to sign	−·001	−·042	−·011
Mean without regard to sign	·012	·049	·026

Canada has now a line of gravity stations right across the continent covering more longitude than is covered by any other series of stations on the American continent. These in conjunction with the gravity observations taken in other parts of the world will give valuable additional information for the determination of the figure of the earth, and in a few years, if the gravity observations are continued, Canada will be able to supply to the world valuable scientific knowledge concerning the earth. Mr. Wm. Bowie, Chief of the Department of Geodesy of the United States Coast and Geodetic Survey, is at present combining the Canadian observations with those of the United States in his new publication on the " Figure of the Earth."

Dominion Observatory
Ottawa
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