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Survey of India

INVESTIGATIONS

REGARDING

GRAVITY AND ISOSTASY

BY

W. HEISKANEN

(Translated by V. PELTS Esq.)

REVISED AND COMPLETED BY

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SUPERINTENDENT, SURVEY OF INDIA

PUBLISHED BY ORDER OF

BRIGADIER E. A. TANDY, R.E.

SURVEYOR GENERAL OF INDIA

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W. HEISKANEN

Dedicated

to

Professor Emeritus ANDERS DONNER,

the gifted founder of the Geodetic Institute at Helsingfors and Chancellor of the University, on the occasion of his 70th birthday.

Translation from the German

by
V. Pelts Esq.

Revised and completed by Major. C.M.Thompson I.A.

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No. Contents.

I Introduction.

Up to the present two theories of isostatic compensation have been put forward. There is one theory to the effect that the density of the material beneath any hill range is in defect to the extent necessary to produce "hydrostatic" equilibrium at a certain depth below surface.

The other theory is to the effect that beneath the earth's crust a denser layer of lava is met with, in which the continents float in the manner of icebergs at sea. According to this assumption, isostatic compensation is effected only at much greater depths and is not uniform.

Accordingly the depth of compensation of the first theory is replaced, in the second theory, by the thickness of the earth's crust and the difference in density between the earth's crust and the lava-layer.

The first theory was originated by Archdeacon I.H.Pratt,[1)] who calculated the influence of the Himalaya in India on the declination of the plumb-line. He found the calculated deflections of the plumb-line to be much larger than those actually ....

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1) J.H.Pratt, On the attraction of the Himalaya Mountains and of the elevated regions beyond upon the plumb-line in India. Transactions of the Royal Society of Lond. 1855, B.145, p. 53.

observed. This led him to the conclusion that underneath those mountains a defect of mass existed, which partly compensated the attraction produced by the mountains themselves. The first man who suggested the other theory was the English astronomer G.B. Airy.[1]

A new era in the theory of isostatic compensation started in 1909, when J.F. Hayford[2] and F.R. Helmert[3] published their important researches. Before the publication of the work of Hayford and Helmert some remarkable researches had already been published by O.E. Schiötz[4] on the same question, in which he suggested subterranean compensation. Also Hayford himself had published some minor articles on Isostasy in 1906 & 1907.

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1) G.B.Airy, On the computation of the effect of the attraction of mountain masses as disturbing the apparent astronomical latitude of stations in Geodetic surveys, Phill. Trans. of the R.S. of London, 1855. B. 145, S. 101. 2) J.F. Hayford, The figure of the earth and isostasy, from measurements in the United - States, U.S. Coast and Geodetic Survey, 1909. 3) F.R. Helmert, The depth of compensation on Pratt's theory for equilibrium of earth's crust and gravity distribution from the interior of continents and oceans towards coasts. Reports of the K.Pr. Akad. d. Wissenschaften. No. XLVIII, S. 1192.1909. 4) O.E. Schiötz, Results of the pendulum observations and some remarks on the constitution of the earth's crust 1900 (The North polar expedition 1893-96 by Fridjof Nansen, London.) 4) O.E. Schiötz, Gravity at sea and descent of continents seawards 1907, Christiania.

Of the geodetic works published in 1903, those on Isostasy by Hayford[1] and Bowie[2] are the most important beyond doubt. I refer particularly to the publication: "Investigations of gravity and isostasy" 1914 by W. Bowie.

The results of the researches, so far published by geodesists, have shown beyond doubt that the assumption of an isostatic compensation of the masses above surface reduces the anomalies in the plumb-line deflections, and gravity observations to a greater extent than a reduction without such an assumption.

To-day Isostasy is no longer a theory but a confirmed fact. One can now only enquire how complete isostatic compensation is in different parts of the world, and whether the theory of Pratt, or of Airy or any other isostatic theory gives better accordance with actual facts.

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1) J.F. Hayford, The Figure of the earth and isostasy from measurements in the United States, U. S. Coast and Geodetic Survey. 1909.

1) J.F. Hayford and William Bowie, The effect of topography and isostatic compensation upon the intensity of gravity U. S. Coast and Geodetic Survey. 1910.

2) William Bowie, Investigations of gravity and isostasy, U. S. C. and G. S. 1917.

Also we may try to ascertain how great the depth of compensation is, according to the hypothesis of Hayford; or the thickness of the Earth's crust and the lava is, according to the hypothesis of Airy.

Geodesists nearly all follow the hypothesis of Pratt, because, in its geodetic aspect, it leads to about the same results as the hypothesis of Airy and it is at the same time, much easier to deal with mathematically. The geodesists, especially Hayford and Bowie, adopt the simple assumption that compensation is complete; that is to say, that for each elevation or each valley, no matter how small, there is a corresponding defect or excess of mass. On this assumption Hayford in 1909 calculated, from the plumb-line deviations in the U.S.A., that the depth of compensation was 113 Km.[1]; and again, from U.S.A. data in 1910, that the depth was 122 Km.[2] Bowie thinks the most reasonable value for the depth of compensation is 96 Km.[3] and the basis of plumb-line deviations and gravity anomalies in the U.S.A. Helmert obtained a value 118 Km.[4] in a quite a different manner. He investigated the course of gravity anomalies from the centres of continents and oceans towards the coasts, by means of a formula involving the depth of compensation, and thereby finding the depth of compensation best explaining the anomalies.

1) Hayford Fig. of Earth p 146. 2) Hayford Suppy. Invest. p 58. 3) Bowie Invest. of gr. & is. p 133. 4) Helmert p 1196.

It is surprising how all these values obtained in different ways for the depth of compensation, agree, considering that the depth of compensation may vary within pretty wide limits, without the force of gravity being noticeably affected either in magnitude or direction.

Hayford has calculated the factors by which we have to multiply the topographical reduction of pendulum anomalies in order to obtain the Topographic-isostatic" reduction. (for short "Topo. isostatic" reduction) Vide Hayford Figure of Earth p. 70.

In connection with the reduction of gravity, Hayford and Bowie have constructed tables by means of which the topographic and isostatic reductions of gravity can be calculated from zone to zone for a depth of compensation of 113.1 Km., if the average height of the zones is known. Vide Hayford and Bowie p. 30-47.

Bowie moreover has calculated the factors, by which isostatically reduced values for the depth 113.1 Km. have to be multiplied in the different zones, in order to obtain the corres-ponding values for other depths; of compensation. Bowie's tables are calculated for the depths; 42.6 Km., 56.9 Km.85.3 Km. 156.25 Km. and 184.8 Km. Vide Bowie's Investigations p.98-99

The objection against Pratt's hypothesis is that it is difficult of explanation from a geophysical or geological point of view, because the depth of compensation appears to be far in excess of values acceptable geologically or geophysically.

However this assumption is a very useful one for the geodesist because it treats the isostatic compensation in the simplest possible manner mathematically. The geodesist has little concern as to how the hypothesis used by him may be explained geophysically or geologically.

It is quite natural that geologists have a different point of view. They start with geological facts and theories and proceed afterwards to investigate to what extent geodetic conclusions may support their results. Geologists in general seem to arrive at the conclusion that Airy's hypothesis is more correct than Pratt's.

From the works of L.Koeber, F.Kossmat and A. Born, it is evident how generally geologists are in favour of Airy's hypothesis, which they consider the only correct isostatic hypothesis.

Vide L. Koeber, The Building of the Earth 1921.
F. Kossmat, The formation of the Mediterranean. mountain chains etc. A.Born Isostasy & gravity.

Also geophysicists consider Airy's hypothesis far more correct than Pratt's. For example the German geophysicist A. Wegener bases his theory of continental drift on Airy's hypothesis.

A. Wegener, The formation of Continents and Oceans, 1912.

However up to now, I am not aware of any one having made an attempt to test Airy's hypothesis mathematically by means of the gravity anomalies or plumb-line deflections and to compare it with Pratt's.

Pratt's hypothesis, as perfected by Hayford and Bowie, explains gravity anomalies and pendulum deviations in the U.S.A. quite well.

However, even a superficial review of the anomalies in Europe and the Caucasus discloses large areas in which the anomalies can not be well explained by isostasy. We mean those gravity anomalies in Europe and the Caucasus which remain after the orographical reduction,. For instance nearly the whole of the Mediterranean shows positive gravity anomalies up to 0.1 cm/Sec^2 and the whole of the Caspian Sea shows equally large negative anomalies.

In any case Europe and the Caucasus are areas so interesting from the geophysical point of view that they certain -ly deserve a more comprehensive and detailed investigation.

The aim of this paper is (I) to investigate the gravity anomalies in the Caucasus and some other interesting areas in Europe under the assumption of the Isostatic theory. (II) To show whether Airy's hypothesis explains the gravity - anomalies better than Pratt's. (III) By means of all the gravity stations which have been reduced isostatically up to the present, to review the distribution of gravity and calculate the flattening of the Earth-spheroid.

II Reduction of Gravity

Maps and materials used in the investigations.

For the investigations I was able to use the following maps;-

1. Map of the High Mountains of the Caucasus on the scale 1 : 140,000 (3 sheets). These sheets belong to the big work in two volumes by G. Merzbacher. "The High Regions of the Caucasus".

2. Map of the Caucasus Main Ranges on the scale 1 : 400,000 by M. Von Dechy (2 sheets).

3. The Caspian Sea with 100 metre contours, on the scale of approximately 1 : 1,480,000, (to be found in the work on the Caspian Expedition of 1914-1915 by N.W. Knipodwich).

4. The Russian Topographical Maps of the Caucasus and surrounding regions on the scale of 1 : 420,000.

5. Do. ... Do. on the scale 1 : 1,680,000.

6. Some sheets of the International maps on the scale 1 : 800,000.

7. The maps of the Caucasus and Turkey in Asia from "Andrée's Hand Atlas" scales 1 : 3,500,000 and 1 : 5,000,000.

8. The Physical Map of Europe 1 : 12000000 from Andrée's Hand Atlas.

9. Charts of Ocean soundings by Groll, scale at the centre, 1 : 40,000,000.

10. The Physical Map of the world by H.Haack Justus Perthes, (Gotha), scale at the centre, 1 : 20,000,000.

11. Topographical Maps of the Riesengebirge, scale 1 : 25,000.

12. Do. ... Do. and surroundings, scale 1 : 200,000.

13. A Topographical Map of the Harz Mountains, scale 1 : 100,000.

14. Austrian Topographical Maps of the Austrian Alps and Carpathians on the scale 1 : 75,000.

15. Maps of the surroundings of Munich, Vienna, Nurnberg, Leipzig, Bonn and Madrid on the scale 1:200,000.

16. Maps from Andrées Hand Atlas for different parts of Europe on the scales 1 : 750,000 to 1 : 3,000,000.

17. The Physical Map of Central Europe on the scale 1 : 3,500,000.

Of these maps, Numbers 12, 13, 14 show altitudes by contours as well as by figures denoting heights. Maps Nos. 3, 8, 9, 10 and 17 use layers of different colours, and all other maps altitude figures denoting height, and hill shading. The altitudes on the Russian maps are in Russian feet —

(1 metre 3.281 Russian feet) and the altitudes and depressions on the other maps in metres. Also the Russian Map No. 3 of the Caspian Sea uses metres.

With the aid of these maps the average heights of the different areas surrounding the gravity station were determined, and the Topographic and Topo-isostatic reductions were calculated. The results of the gravity measurements of the stations, reduced by me, were taken from the papers of Borras, to which reference will be made later. In these papers, Borras reduces the results at all gravity stations, known to him, in accordance with one system (the so called "Potedam system"), so that all these gravity measurements are comparable, one with another.

The methods of reduction and tables required for this purpose.

In order that the observed value of gravity "g" may be comparable with the theoretical value γ_o, it is necessary to apply certain reductions to the value of "g". There are four methods of reduction, corresponding to the exact manner in which we treat the different influences affecting the observed values of gravity.

(1) The Free-air reduction, (2) The Bouguer reduction, (3) The purely Topographic reduction and (4) The Topo-isostatic reduction*)

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*) The often mentioned Orographical reduction is only a part of the Bouguer reduction.

By means of the Free-air reduction, also called the Altitude reduction or reduction to sea-level, the observed values are reduced from observation level to sea-level, taking into consideration the altitude of the station of observation only. This correction amounts to $\frac{2H}{R}g = 0.0003086xH$, where H denotes the height at which the observation was taken in metres, and R the radius of the earth, expressed in terms of the same unit. The value of the gravity reduced by this correction is usually designated by "g_0"

To obtain the correct value of gravity reduced to sea-level, the attraction of the strata lying between the observation point and sea-level must be taken into account.

In addition the uneven distribution of the land masses in the immediate neighbourhood of the station must be considered - that is to say the orographical reduction (or correction) must be applied.

The correction results from the fact that on a hill top the value of gravity is less than on a high plateau of the same altitude, because in the first case the rocky masses in the surrounding area do not reach up to the altitude of the station itself, and hence a positive correction must be applied.

The observation will however also be positive for stations situated in valleys, because the surrounding masses which are higher than the station itself, also tend to diminish the value of the force of gravity actually observed at the station. This correction, $(g' - g)$, which is always positive, can generally be omitted in localities which show little or no relief of surface, but in the case of mountain chains and small conical mountain peaks, the value may even exceed 0.030 cm/sec^2.

Taking into account the whole three corrections already mentioned, we obtain the formula for the Bouguer reduction viz:-

$$g_c'' = g + \frac{2H}{R} g\left(1 - \frac{3D}{4D_m}\right) + (g' - g)$$

where D denotes the density of the strata and D_m the average density of the earth.

The Bouguer reduction is preferable to the Free-air reduction, because it takes into account the attraction of the strata situated between the station and sea-level. The calculation of this reduction is also nearly as easy as the Free-air reduction, because, except for the orographical reduction, which often can be neglected, we have only to multiply the results of the Free-air reduction by the factor $1 - \frac{3D}{4D_m}$

in order to obtain the Bouguer reduction.

It is found that the Bouguer reduction gives better results, when the orographical reduction is calculated for a more extended area round the station of observation. As however the orographical reduction is only calculated for an area of radius about 100-200 Km. or even less, and the curvature of the Earth is not taken into account, the Bouguer reduction cannot be considered as quite correct.

In order to design a form of reduction which takes into account all features of the relief, the continents as well as the oceans of the whole globe, it becomes necessary to determine the average heights of different zones reckoned from the station under consideration as centre, and extending round the globe, and to calculate the combined influence of the masses in each zone on gravity.

This reduction is the purely Topographic reduction. The formula for the Purely Topographic reduction is :-

$$g_t = g + \frac{2H}{R} g + \delta g_t ,$$

where g_t denotes the combined effect of the topography of the entire globe.

If, in addition to the attraction of the superficial masses, we take into consideration the compensation of subterranean defects and excesses of mass, we obtain the "Topo-Isostatic reduction". The formula for this reduction is

$$g_i = g + \frac{2H}{R} g + \delta g_t + \delta g_i$$

in which δg_i represents the attraction of the compensating subterranean mass anomalies. According as we follow the isostatic theory of Hayford or that of Airy, we will have to adopt a reduction for this on the Hayford or Airy system.

For a preliminary discussion we may take for γ_0 the value found by Helmert, which Borras used for his reduction of gravity measurements on the Potsdam system viz.

$$\gamma_0 = 978.030 \quad (1 + 0.005302 \sin^2\varphi - 0.000007 \sin^2 2\varphi)$$

where φ represents the geographical latitude of the station.

It will be shown later that this value of γ_0 is too small and requires correction. According as we compare γ_0 with g_0, g_0'', g_t or g_i ...., we obtain the gravity anomalies under the assumption of the Free-air reduction, the Bouguer reduction, the Purely topographical reduction or the Topo-Isostatic reduction.

In the present paper we shall follow Hayford's procedure for calculating the Topographic Isostatic reduction, His procedure consists in dividing the whole earth up into concentric zones, with the gravity station under investigation as centre and further subdividing the zones into sectors, for each of which the average altitude (or depression) is determined.

From these the influence or gravity of the whole area is calculated by means of tables.

It may be here noted that the depth of compensation of Hayford's tables viz. 113.7 Km. is not to be measured from sea-level but from the actual surface of the earth.

The zones and sectors used in this method of compensation are the following :-

VIDE TABLE ON NEXT PAGE.

Table I

Zone	Outer radius	n	Zone	Outer radius	n 1)
A	2 m	1	18	1° 41′ 13″	1
B	68	4	17	1 54 52	1
C	230	4	16	2 11 53	1
D	590	6	15	2 33 46	1
E	1280	8	14	3 03 05	1
F	2290	10	13	4 19 13	16
G	3520	12	12	5 46 34	10
H	5240	16	11	7 51 30	8
I	8440	20	10	10 44	6
J	12400	16	9	14 09	4
K	18800	20	8	20 41	4
L	28800	24	7	26 41	2
M	58800	14	6	35 53	18
N	99000	16	5	51 04	16
O	166700	28	4	72 13	12
			3	105 48	10
			2	150 56	6
			1	180	1

n denotes the no of divisions of the zones.

1) I have divided the zones 18-14 into 8 sectors.

2) In Hayford & Bowie's tables the table for zone C is somewhat erroneous, as pointed out in Bowie's "Investigations" p 9. I had carried out nearly all my computations, before I received this book, using the erroneous table. As the mistake was trifling, I have not recomputed my results.

The average height and depths of the zones were determined in the usual manner by applying to each map a transparent piece of paper with zones and sectors marked on it, to suit the scale of the map. The average height of each zone was estimated with the help of the heights, shown on the maps.

The heights of zones A-M for all stations, and occasionally also the height of zone N, were obtained from various special maps.

For European stations the heights of zones N-13 were obtained from the Physical Map of Central Europe on the scale 1 : 12. Mill. In order to estimate the height of zones N-13 for the Caucasian stations, I myself prepared a special map of the Caucasus and surrounding country on the scale 1 : 3,500,000, on which the average heights of 15-minute squares were calculated from the whole of the altitude data (heights, depths, contours, etc.), in my possession. In order to determine the height of zones 8-1 for all stations, I worked out the altitudes and depths of squares of 5° lat. X 5° long. by means of the Physical Map of the World and Groll's charts of Ocean Soundings.

The influence of zones A-D has nearly always been determined independently for each station. Very often also the influence of zones 18-9 has been obtained independently.

Only in the case of reduction of several stations, in close proximity one to another, was interpolation resorted to, to any great extent.

Since the influence of zones 8-1 is very small and varies but little from point to point, it is necessary to calculate the influence of these zones for a few stations only. For all the others they may be found by interpolation.

In cases, when, in the neighbourhood of stations reduced by me, there were already stations reduced by Bowie (for instance in the Harz mountains, Riesengebirge etc.), the following procedure was adopted. The distant zones were interpolated from the data of Bowie occasionally, starting from zone 13 onward. Such interpolated values have been marked with an asterisk.

The Topo-Isostatic reduction for zones A-O can be obtained separately from the tables of Hayford and Bowie.

But in zones 18-1 both corrections have been lumped together, and so we get only the sum of the Topographic and Isostatic reductions.

Hence the Topographic reduction of the influences of the whole globe, by itself, is unobtainable from his tables.

Neverthless it is interesting and also important to determine the purely Topographic reduction, because this reduction is capable of showing more clearly what gravity anomalies we actually get, if we neglect isostatic theories, than the simplified reduction of Bouguer. It is necessary however to calculate a few tables for this purpose.

On page 25 of Hayford and Bowie's book, proportionate factors E_T, E_C, E_R are given for the Topographic, the Isostatic and the Topo-Isostatic reductions corresponding to the influence of the mass unit at different distances from a station.

The Topo-Isostatic reduction derived by means of Hayford's tables for any zone gives the Topographic or Isostatic reduction of that zone, if multiplied by the quotient $E_T : E_R$ or $E_C : E_R$ respectively, provided the values of E_T, E_C and E_R do not vary too much within that zone. This is sufficiently the case in zones 18-8.

The value of $E_T : E_R$ for these zones are in the order stated 0.00, 0.01, 0.09, 0.10, 0.15, 0.24, 0.43, 0.78, 1.44, 2.74 and 4.48.

But after zone 7, the zones become so broad that it becomes impossible to determine the Topographic reduction with sufficient accuracy. Therefore the area of this zone has been subdivided into smaller zones. The method of subdivision is given in the following table.

In order to determine the influence of the various zones we have to multiply Hayford's factor "E_T" by the Attraction constant "k" and the mass of each zone.

If h denotes the mean height of a zone, the portion under discussion may be described as the outer rind or layer of a sector of a sphere, the thickness of the rind being h. The volume of such a portion is:-

$$\frac{2}{3}\pi\left(R'^3 - R^3\right)\left(\cos\theta_1 - \cos\theta_2\right)$$

where R is the semi-diameter, $R' = R + h$, θ_1 the inner and θ_2 the outer radius of the zone in angular measure.
The influence of the whole zone will then be:-

$$(1) \qquad \frac{2}{3}\pi k D\left(R'^3 - R^3\right)\left(\cos\theta_1 - \cos\theta_2\right) E_T$$

Table II

Zone	Outer Radius	E_T	$\cos\Theta_1 - \cos\Theta_2$	$\frac{2}{3}\pi k D' E_T(\cos\Theta_1 - \cos\Theta_2)$
1	180°	61.7×10^{-20}	0.0152	22×10^{-28}
2	170	62.2	.0451	64
3	160	63.2	.0737	107
4	150	64.7	.1000	148
5	140	66.8	.1232	189
6	130	69.6	.1428	228
7	120	73.2	.1580	265
8	110	77.8	.1684	300
9	100	83.8	.1736	333
10	90	91.5	.1736	364
11	80	101.6	.1684	392
12	70	115.3	.1580	417
13	60	128.3	.0736	216
14	55	139.6	.0692	221
15	50	153.4	.0643	226
16	45	170.6	.0589	230
17	40	192.5	.0532	235
18	35	221.5	.0469	238
19	30	261.4	.0403	241
20	25	311.4	.0292	208

where $k = 667 \times 10^{-10}$ and the mean thickness of the crust of the earth D is 2.67.
In this expression only the factor $(R'^3 - R^3) =$
$= R^2\left(3h + 3\frac{h^2}{R} + \frac{h^3}{R^2}\right)$ depends on the height of the zone.

[1]) J. F. Hayford und William Bowie, l. c., P. 14

The third term of this expression can always be neglected and the second also could usually be omitted; consequently this factor varies practically at a linear rate with the thickness h of the zone. As the more distant zones are mostly situated in the ocean, table II has been computed with the factor $D^1 = D - 1.03 = 1.64$, instead of D, in which the figure 1.03 expresses the average density of sea water.

In the case of solid ground the values obtained from the table should be multiplied by the factor 1.63. The results obtained are given in the last column of Table II, and these when multiplied by (R' - R), give the influence of the various zones.

In determining the influence of these zones on gravity, it is not necessary to actually estimate the altitude and carry out the computations for each station. The majority of the stations can be dealt with by interpolation.

Besides investigating the isostatic hypothesis in its strictly limited sense (viz:- that for every single elevation or even the smallest valley there is a corresponding subterranean defect or excess of mass), Hayford and Bowie have further investigated whether the isostatic compensation only relates to large areas.

In this theory of isostatic compensation for whole regions, it is asserted that large areas are compensated as a whole, and not each small portion by itself. Bowie has put forward three assumptions in which it is supposed that regional compensation extends up to 18.8, 58.8 and 166.7 Km. respectively from a station, and that outside these limits ordinary local compensation acts. He arrives at the conclusion that the first two assumptions lead nearly to the same result, whilst the third shows a worse agreement with the observations than local compen-sation. As the regional compensation in the U.S.A., up as far as 18.8 and 58.8 Km. from the stations, gives practically the same results as the local compensation, it is of no interest to pursue this point further.

I have however used Bowie's third assumption in order to find out to what extent the anomalies based on "regional compensation" agree with the observed anomalies.

It is obvious a priori that for stations in the plains theories of local and regional compensation are of equivalent value and that remarkable differences are likely to be met with only in high mountains, intersected by many valleys. Since the Caucasus is a promising area in this respect, this method will only be applied to the Caucasian data.

In order to obtain this reduction, we have first to calculate the topographic correction for zones A-O. Next we determine from its average height the compensating action produced by a circle, whose centre is at the station, and whose radius is 166.7 Km. The values of these influences, when added together, gives us the values of the influences due to topography and regional compensation in zones A-O.

The influence of the more distant zones is calculated as usual.

The procedure is however, strictly speaking, not quite correct, because we assume regional compensation to exist in zones A-O and local compensation in the other zones.

On either of the 2 assumptions it can be easily seen that the extreme zones have almost the same influence on the gra-vity reduction and that it is only the topography near the station which produces a difference in the results. For these reasons, the method leads practically to the same results as the theory of regional compensation.

I propose now turning from the examination of Pratt's theory, as elaborated by Hayford, to a discussion of that of Airy. In order to do so, it is necessary to enter into the preliminary assumptions and method of reduction in some detail and to work out the tables necessary for the computations.

As already stated in the introduction, Airy's theory can be expressed by the statement that the lighter crust of the earth floats on the denser lava layer below in the manner of ice-bergs on the sea. The first (i.e:- the crust of the earth) is usually designated the SAL-LAYER, and the second, the SIMA-LAYER, in accordance with the predominance of the chemical elements which enter into their composition. The crust of the earth is less deep-ly embedded in the Sima-layer beneath the oceans than it is be-neath high mountains.

If we assume that sea-level corresponds with the ab-sence of all compensation, then it follows that beneath the oceans the compensation for mass is positive, whilst beneath mountains it is negative.

To simplify the calculation as much as possible, it was merely assumed that the densities of the Sal- and Sima-layers are constant and that the change from one substance to the other is made, as it were, in one sharply defined jump. It was assumed that the average density of the earth's crust is 2.67 and that the differences between sal- and sima-layers have the values 0.2, 0.3 and 0.6.

It could be contended that this assumption of homo-geneity either in the sal or sima-layers does not correspond with the true facts of the case, and that the density is rather a li-near function of the depth.

However, even if it be true that the density changes continuously with the depth, this cannot materially affect the results calculated on this assumption.

I have adopted the following 4 assumptions in turn:-
That sea-level corresponds to a thickness of the earth's crust of 77.2 Km. and that the difference in density between the sal and sima layers is 0.2. If the average depth of oceans is assumed to be 3,680 m. and the average heightof continental masses to be 800 m and it is taken into consideration that 2/3rds of the earth's surface are covered by sea, then the average thickness of the earth's crust will be 60.6 Km., and the thickness of the crust beneath oceans 47.0 Km., whilst that of the crust beneath continents will be 87.9 Km.

2. Alternatively that sea-level corresponds to a thickness of the earth's crust of 63.8 Km. and that the difference in density between the crust and the lava layer is 0.3. In this case the average thickness of the earth's crust will be 52.4 Km., the mean thickness beneath continents 70.9 Km. and that beneath oceans 43.6 Km.

3. Alternatively that the two values determining the compensation are 63.8 Km. and 0.6. The average thickness of the earth's crust will then be 58.2 Km., the thickness under continents 67.3Km. and that beneath oceans 53.7 Km.

4. Alternatively that the two values are 40 Km. and 0.6. The average thickness of the Earth's crust will then be 34.5 Km., the thickness beneath continents 43.6 and that beneath oceans 29.9 Km.

It may be seen that in these assumptions the average thickness of the crust of the earth has been taken as varying between 35 Km. and 60 Km., values which appear to be the most plausible and likely.

Neglecting the curvature of the earth, the compensation areas in the different zones are simple concentric cylindrical rings whose height H = $2.67/\delta D \times H$ or $1.64/\delta D \times H$, where H is the height or depth of the zone and δD represents the difference of density of the sal and sima layers, the density of them being δD in each case.

The influence of zones A-O can be calculated, disregarding the curvature of the earth. The vertical attraction F of a compensated cylindrical ring of radii c_2 and c_1 and height t upon a point on the axis of the cylinder at a height h above the ring is :-

Formula (2)

$$F = 2\pi \delta D K \left(\sqrt{c_2^2 + h^2} - \sqrt{c_1^2 + h^2} - \sqrt{c_2^2 + (h+t)^2} + \sqrt{c_1^2 + (h+t)^2} \right),$$

where D is the density of the zone.

In zones 18-13 however, the curvature of the earth has to be considered. To ascertain the influences of these zones it is necessary to calculate the factors E_C' and E_R' corresponding to Airy's assumptions and multiply the Hayford reduction values for the various zones by the quotient $E_R' : E_R$ where E_R is the corresponding Hayford factor. E_C' will be calculated by the formula[1]

$$Ec' = \frac{\sin\left[\frac{\theta}{2} + \arc\sin \frac{h \cos\frac{\theta}{2}}{\sqrt{a^2 + h^2 - 2ah \sin\frac{\theta}{2}}}\right]}{a^2 + h^2 - 2ah \sin\frac{\theta}{2}},$$

Where a is the chord corresponding to the angle θ, and h the depth of the compensating element of mass. To obtain the factor E corresponding to a cylindrical ring one must integrate the expression E_C' with regard to a and h, and thus determine the value of E .

However sufficiently accurate values can be obtained by calculating E with the average depth of the compensated ring and with the value $\theta_0 = \sqrt{\frac{\theta_1^2 + \theta_2^2}{2}}$ in which θ_1 and θ_2 represent the radii of the ring.

If we add the factor E_T (which is proportional to the topographical reduction and obviously identical in case of both the assumptions) to E_C' we get the factor E_R'

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1) J.F. Hayford and W. Bowie, L.c. p. 16-17.

In zones 12-1 the values for the reduction under Hayford's theory for a depth of compensation 2 T so nearly correspond with those under the Airy theory for a depth of compensation T, that we are able to use the tables calculated by Hayford[1] and Bowie for computing the Airy reduction. As the influence of the compensation under the Airy hypothesis is very small in the immediate vicinity of a station, we are able, for the first 3 assumptions, to combine zones A-K into one zone, and, for the 4th assumption, to combine A-G into one zone. If now we calculate the influence of the different zones on gravity as a function of the average height of the zones, we get the following tables (III and IV).

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1) J.F. Hayford and W. Bowie, I.c.S. 16-17.

Table III

h etres	A—K I	A—K II	A—K III	A—J IV	K IV	L I	L II	L III	L IV	M I	M II	M III	M IV
3000	+64	+98	+114	+118	+129	+80	+119	+137	+258	+353	+481	+532	+771
2900	+62	+96	+111	+115	+126	+78	+117	+133	+251	+344	+467	+516	+747
2800	+60	+93	+108	+111	+123	+76	+114	+129	+244	+335	+454	+500	+723
2700	+59	+91	+105	+107	+120	+74	+111	+125	+237	+326	+440	+483	+699
2600	+58	+89	+101	+104	+116	+72	+107	+121	+230	+317	+427	+467	+675
2500	+56	+86	+ 98	+101	+112	+71	+104	+117	+222	+308	+413	+451	+651
2400	+55	+84	+ 95	+ 97	+108	+69	+101	+113	+215	+298	+399	+434	+627
2300	+53	+81	+ 91	+ 94	+104	+67	+ 97	+109	+207	+288	+385	+417	+602
2200	+52	+78	+ 87	+ 90	+101	+65	+ 94	+104	+199	+278	+371	+400	+577
2100	+50	+75	+ 84	+ 86	+ 97	+62	+ 91	+100	+191	+268	+356	+384	+553
2000	+48	+72	+ 80	+ 83	+ 94	+60	+ 87	+ 96	+183	+258	+342	+367	+528
1900	+46	+69	+ 77	+ 79	+ 90	+58	+ 84	+ 92	+175	+247	+327	+350	+503
1800	+44	+66	+ 73	+ 76	+ 86	+56	+ 80	+ 87	+167	+236	+312	+332	+478
1700	+42	+63	+ 69	+ 72	+ 81	+53	+ 76	+ 82	+159	+225	+296	+315	+453
1600	+40	+60	+ 65	+ 68	+ 77	+51	+ 72	+ 77	+151	+214	+281	+297	+427
1500	+38	+57	+ 61	+ 65	+ 73	+48	+ 69	+ 73	+142	+203	+265	+280	+402
1400	+36	+54	+ 57	+ 61	+ 69	+45	+ 65	+ 68	+134	+191	+249	+262	+376
1300	+34	+51	+ 54	+ 57	+ 64	+42	+ 61	+ 64	+125	+179	+233	+245	+350
1200	+32	+47	+ 50	+ 54	+ 60	+39	+ 57	+ 60	+116	+167	+217	+227	+324
1100	+30	+44	+ 46	+ 50	+ 56	+37	+ 52	+ 55	+107	+155	+201	+209	+298
1000	+27	+40	+ 42	+ 46	+ 51	+34	+ 47	+ 50	+ 98	+142	+184	+191	+272
900	+25	+37	+ 38	+ 42	+ 46	+31	+ 43	+ 45	+ 88	+129	+166	+172	+245
800	+23	+33	+ 34	+ 37	+ 41	+28	+ 38	+ 40	+ 79	+116	+148	+153	+218
700	+20	+29	+ 30	+ 33	+ 36	+25	+ 34	+ 35	+ 70	+103	+131	+135	+191
600	+18	+25	+ 26	+ 29	+ 31	+21	+ 29	+ 30	+ 60	+ 89	+113	+116	+164
500	+15	+21	+ 22	+ 24	+ 27	+18	+ 25	+ 26	+ 50	+ 75	+ 95	+ 97	+137
400	+12	+17	+ 17	+ 20	+ 22	+15	+ 20	+ 20	+ 40	+ 61	+ 76	+ 77	+110
300	+ 9	+13	+ 13	+ 15	+ 16	+11	+ 15	+ 15	+ 30	+ 47	+ 57	+ 58	+ 83
200	+ 6	+ 9	+ 9	+ 10	+ 11	+ 7	+ 10	+ 10	+ 20	+ 32	+ 38	+ 38	+ 55
100	+ 3	+ 5	+ 5	+ 5	+ 5	+ 4	+ 5	+ 5	+ 10	+ 16	+ 19	+ 19	+ 28
— 100	— 2	— 3	— 3	— 3	— 3	— 2	— 3	— 3	— 6	— 10	— 13	— 13	— 17
— 200	— 4	— 6	— 6	— 6	— 7	— 5	— 7	— 7	— 13	— 20	— 25	— 25	— 34
— 300	— 6	— 9	— 9	— 10	— 10	— 7	— 10	— 10	— 19	— 30	— 38	— 38	— 52
— 400	— 8	—12	— 12	— 13	— 14	—10	— 14	— 14	— 26	— 40	— 50	— 49	— 69
— 500	—10	—15	— 15	— 16	— 18	—12	— 17	— 17	— 32	— 50	— 62	— 61	— 86
— 600						—15	— 20	— 20	— 39	— 60	— 75	— 73	—104
— 700						—17	— 24	— 24	— 46	— 71	— 87	— 85	—121
— 800						—20	— 28	— 28	— 53	— 82	—100	— 98	—139
— 900						—23	— 32	— 31	— 60	— 93	—113	—111	—156
—1000						—26	— 35	— 34	— 67	—104	—127	—124	—174
—1100										—115	—140	—137	—192
—1200										—126	—153	—150	—209
—1300										—138	—167	—163	—227
—1400										—150	—180	—175	—245
—1500										—161	—194	—188	—262
—1600										—173	—208	—201	—279
—1700										—185	—223	—209	—297
—1800										—197	—237	—228	—314
—1900										—210	—252	—241	—337
—2000										—222	—265	—253	—350

Table III

h	N				O			
Metres	I	II	III	IV	I	II	III	IV
3000	+521	+605	+630	+657	+650	+652	+642	+524
2900	+506	+586	+609	+634	+630	+630	+620	+507
2800	+191	+567	+589	+611	+609	+608	+598	+489
2700	+476	+549	+569	+588	+588	+586	+577	+472
2600	+461	+530	+548	+565	+568	+563	+555	+454
2500	+446	+511	+528	+542	+547	+541	+533	+437
2400	+430	+492	+508	+520	+528	+519	+511	+419
2300	+414	+472	+487	+497	+506	+497	+489	+402
2200	+398	+453	+466	+475	+484	+475	+467	+384
2100	+382	+434	+446	+452	+462	+453	+446	+367
2000	+367	+414	+425	+430	+440	+431	+424	+349
1900	+351	+395	+404	+408	+418	+409	+402	+331
1800	+332	+375	+383	+386	+396	+387	+381	+312
1700	+316	+355	+362	+364	+374	+365	+359	+294
1600	+299	+335	+341	+342	+352	+343	+337	+275
1500	+282	+315	+320	+320	+330	+321	+316	+257
1400	+263	+295	+299	+298	+308	+299	+294	+239
1300	+245	+274	+278	+277	+286	+277	+272	+221
1200	+227	+254	+257	+255	+264	+255	+251	+204
1100	+211	+234	+236	+234	+242	+234	+230	+186
1000	+193	+212	+214	+212	+220	+212	+209	+168
900	+174	+191	+193	+191	+198	+191	+188	+151
800	+155	+170	+172	+169	+176	+169	+167	+134
700	+136	+149	+150	+148	+154	+148	+146	+116
600	+118	+128	+129	+126	+132	+126	+125	+ 99
500	+ 99	+107	+108	+105	+110	+105	+104	+ 82
400	+ 79	+ 86	+ 87	+ 84	+ 88	+ 84	+ 83	+ 66
300	+ 59	+ 65	+ 65	+ 63	+ 66	+ 63	+ 62	+ 49
200	+ 40	+ 43	+ 43	+ 42	+ 44	+ 42	+ 42	+ 33
100	+ 20	+ 22	+ 22	+ 21	+ 22	+ 21	+ 21	+ 16

Table III

h Metres	N I	N II	N III	N IV	O I	O II	O III	O IV
— 100	— 12	— 13	— 13	— 13	— 13	— 13	— 13	— 10
— 200	— 24	— 27	— 27	— 26	— 26	— 26	— 26	— 20
— 300	— 36	— 40	— 40	— 39	— 40	— 38	— 38	— 30
— 400	— 49	— 54	— 54	— 52	— 53	— 51	— 51	— 40
— 500	— 63	— 67	— 67	— 65	— 66	— 64	— 64	— 49
— 600	— 75	— 81	— 81	— 78	— 79	— 76	— 77	— 58
— 700	— 88	— 94	— 93	— 90	— 92	— 89	— 90	— 68
— 800	—101	—107	—106	—103	—105	—101	—102	— 77
— 900	—114	—121	—120	—116	—118	—113	—115	— 87
—1000	—127	—135	—134	—128	—130	—125	—127	— 96
—1100	—140	—148	—147	—141	—143	—137	—139	—106
—1200	—153	—162	—161	—154	—156	—150	—152	—115
—1300	—166	—175	—174	—166	—169	—162	—165	—124
—1400	—179	—189	—188	—179	—182	—174	—177	—133
—1500	—192	—203	—202	—192	—195	—186	—189	—142
—1600	—205	—216	—115	—204	—208	—198	—201	—152
—1700	—219	—230	—220	—216	—221	—210	—213	—161
—1800	—232	—243	—242	—228	—234	—222	—225	—171
—1900	—245	—257	—255	—240	—246	—234	—238	—180
—2000	—259	—270	—268	—252	—260	—246	—250	—190
—2500	—327	—338	—336	—312	—324	—305	—310	—238
—3000	—395	—405	—405	—371	—383	—358	—372	—277
—3500	—462	—472	—473	—429	—442	—411	—433	—317
—4000	—528	—540	—542	—485	—497	—464	—495	—358
—5000	—659	—677	—676	—592	—594	—566	—609	—403

Table IV

Zone 18

h Metre	Hayford-reduction	Airy-reduction I	II	III	IV
2000	+66	+98	+86	+83	+60
1500	+49	+71	+64	+61	+44
1000	+33	+47	+42	+40	+29
500	+16	+23	+20	+20	+14
−500	−10	−13	−12	−12	−8
−1000	−20	−26	−23	−23	−16
−1500	−30	−39	−35	−35	−25
−2000	−40	−51	−46	−47	−32
−3000	−60	−73	−66	−70	−46
−4000	−81	−93	−87	−92	−59

Zone 17

h Metre	Hayford-reduction	Airy-reduction I	II	III	IV
2000	+66	+100	+85	+83	+59
1500	+49	+72	+63	+61	+43
1000	+33	+47	+41	+40	+29
500	+16	+23	+20	+20	+14
−500	−10	−13	−12	−12	−8
−1000	−20	−26	−23	−23	−16
−1500	−30	−39	−34	−35	−24
−2000	−40	−51	−45	−46	−31
−3000	−60	−73	−65	−69	−45
−4000	−81	−92	−84	−90	−58

Zone 16

h Metre	Hayford-reduction	Airy-reduction I	II	III	IV
2000	+66	+102	+85	+83	+57
1500	+49	+73	+63	+61	+42
1000	+33	+48	+41	+40	+27
500	+16	+23	+20	+20	+13
−500	−10	−13	−12	−12	−8
−1000	−20	−26	−23	−23	−16
−1500	−30	−39	−34	−34	−24
−2000	−40	−51	−44	−45	−30
−3000	−60	−72	−63	−67	−44
−4000	−81	−91	−81	−89	−57

Zone 15

h Metre	Hayford-reduction	Airy-reduction I	II	III	IV
2000	+66	+103	+84	+82	+55
1500	+49	+73	+62	+61	+40
1000	+33	+48	+41	+40	+26
500	+16	+24	+20	+20	+13
−500	−10	−13	−12	−12	−8
−1000	−20	−26	−22	−23	−16
−1500	−30	−39	−33	−34	−23
−2000	−40	−50	−44	−45	−29
−3000	−60	−71	−62	−66	−42
−4000	−81	−90	−79	−88	−55

Zone 14

h Metre	Hayford-reduction	Airy-reduction I	II	III	IV
2000	+66	+103	+83	+79	+54
1500	+49	+74	+61	+58	+40
1000	+33	+48	+40	+38	+26
500	+16	+24	+20	+19	+13
−500	−10	−13	−11	−11	−8
−1000	−20	−25	−22	−22	−15
−1500	−30	−38	−33	−33	−22
−2000	−40	−49	−43	−44	−28
−3000	−60	−69	−61	−65	−41
−4000	−81	−88	−78	−85	−53

Zone 13

h Metre	Hayford-reduction	Airy-reduction I	II	III	IV
2000	+105	+165	+133	+127	+85
1500	+79	+119	+97	+92	+62
1000	+52	+77	+63	+61	+40
500	+26	+37	+31	+30	+20
−500	−16	−21	−18	−18	−12
−1000	−32	−42	−35	−36	−23
−1500	−48	−61	−52	−53	−34
−2000	−64	−78	−68	−70	−44
−3000	−97	−110	−97	−103	−64
−4000	−129	−139	−122	−135	−83

In Table III the meaning of the columns is as follows:- The first column shows the height of the zone. The roman figures I, II, III, IV refer to the first, second, third and fourth assumptions and the figures below the letters A.G.K.L.M.N and O denote the effects of compensation corresponding to the different heights of the zones - expressed in units of 0.0001 cm/sec^2.

The range of heights is from +3000 to -5000 m. In zones A-K, I have only given the tabular values as far as the depth 500 m, in zone L, only as far as 100 m, and in zone M only as far as 200 m., as greater depths are hardly ever met with in these zones.

It is evident from the table that the influences vary almost linearly with the heights.

For this reason the effects have only been calculated for a few heights : viz. + 500 +1000 +1500 +2000 +2500 +3000 -500 -1000 -1500 -2000 -2500 -3500 -5000m. and the intermediate values can be interpolated. Zones 18-13 are disposed of in table IV.

In order to economise space, and also for the reason that the effects of these zones are but small in comparison with those of zones M-O and vary almost linearly, I have only included the effects of the altitudes +2000 +1500 +1000 +500 -500 -1000 -1500 -2000 -3000 and -4000 in the tables.

The first column gives the height of the zone, and the second the Hayford reduction (for depth of compensation 113.7), and the third, fourth, fifth and sixth columns, the reductions corresponding to our fourth assumptions.

The figures given in table IV have been obtained in the following manner :- The factors E_C' have been calculated corresponding to values of 37.3 42.2 58.2 68.2 and 83.9 for the mean depth of compensation, by means of formula (3) and from these the quotients $E_C' : E_C$ for these depths were obtained, and from these again the further quotients $E_{R'} : E_R$. It now became apparent that $E_C' : E_C$ could be found for all intermediate depths of compensation by interpolation from these values. This interpolation was effected by graphic methods. Tables III and IV are valid for a height of observation of 0. For other heights of observation, corrections have to be applied. These corrections were calculated for heights of observation of 1000 and 2000 m. and for heights of zones of +3000 +2000 +1000 -1000 -2500 and -5000 m. and incorporated in Table V.

These corrections are to be added to the values computed for a height of observation of 0.

Table V

Assumption I

H	Height of Observation 1000 m					Height of Observation 2000 m				
Meter	A–K	L	M	N	O	A–K	L	M	N	O
3000	−2	−2	−6	−4	0	−4	−3	−12	−9	+ 1
2000	−1	−1	−4	−2	0	−3	−2	− 9	−5	+ 1
1000	−1	−1	−2	−1	0	−1	−1	− 5	−2	− 0
0	0	0	0	0	0	0	0	0	0	0
−1000	+1	0	+2	+1	0	+1	+1	+ 3	+2	− 1
−2500	—	—	—	—	−2	—	—	—	—	− 4
−5000	—	—	—	—	−6	—	—	—	—	−11

Assumption II

	A–K	I	M	N	O	A–K	L	M	N	O
3000	−3	−3	− 8	−3	+2	−7	−5	−15	−8	+ 3
2000	−2	−2	−6	−2	+1	−4	−4	−10	−6	+ 2
1000	−1	−1	−3	−1	+1	−4	−3	− 6	−3	+ 2
0	0	0	0	0	0	0	0	0	0	0
−1000	+1	+1	+2	0	−1	+2	+2	+ 4	0	− 2
−2500	—	—	—	—	−2	—	—	—	—	− 5
−5000	—	—	—	—	−6	—	—	—	—	−13

Assumption IV

	A–J	K	L	M	N	O	A–J	K	L	M	N	O
3000	−6	−5	−12	−11	+2	+ 7	−12	−9	−24	−22	+4	+15
2000	−4	−4	− 9	− 9	+3	+ 5	− 9	−6	−17	−17	+6	+10
1000	−2	−2	− 4	− 5	+1	+ 2	− 5	−4	− 7	−10	+3	+ 5
0	0	0	0	0	0	0	0	0	0	0	0	0
−1000	+1	+1	+1	+ 3	0	− 1	+ 2	+2	+ 3	+ 6	−1	− 2
−2500	—	—	—	—	—	− 5	—	—	—	—	—	− 9
−5000	—	—	—	—	—	−10	—	—	—	—	—	−20

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1) As according to Tables III & IV my 2nd and 3rd assumption lead almost to the same result, and as, on that account, no station was reduced on the third assumption, I have accordingly not computed the correction corresponding to the 3rd assumption.

The effect of the height of observation on the results of the reduction have been disregarded in the further zones 18-1.
For zones 12-1, whose influence on the whole is very small, there is no need, as already stated, to calculate new tables, but the following table by Bowie can be used(vide:- Bowie Investigations p 99.

Table VI

Depth of compensation

Zone	42.6 km	56.9 km	85.3 km	127.9 km	156.25 km	184.6 km
12	0.38	0.51	0.76	1.12	1.34	1.54
11	.38	.51	.76	1.12	1.35	1.57
10	.38	.50	.76	1.13	1.36	1.59
9	.38	.50	.76	1.13	1.37	1.62
8	.37	.50	.75	1.13	1.38	1.63
7	.37	.50	.75	1.13	1.38	1.63
6	.37	.50	.75	1.13	1.38	1.63
5	.37	.50	.75	1.13	1.38	1.63
4	.37	.50	.75	1.13	1.38	1.63
3	.37	.50	.75	1.13	1.38	1.63
2	.37	.50	.75	1.13	1.38	1.63
1	.37	.50	.75	1.13	1.38	1.63

This Table gives the factors by which the values, corresponding to a depth of compensation of 113.7 Km, have to be multiplied in order to obtain the values corresponding to other depths of compensation. This Table is used as follows:-
If the mean compensation depth on the Airy theory is T, the figures corresponding to 2T should be taken, (2T being the depth of compensation on the Hayford theory), in order to get the Airy reduction.

Accuracy of the Reduction

The accuracy of the Reduction depends primarily on the reliability and quality of the topographical maps used, and the adoption of a correct value for the density of the earth's crust for purposes of the calculations.

In the present paper the value 2.67 was adopted for the density of the earth's crust, a value which is most probable

There is no denying that there are places where considerable irregular density anomalies occur both above and below sea-level, and these may considerably alter the force of gravity and cause gravity anomalies. There is however no method of reduction whereby such anomalies can be eliminated.

The errors due to the maps used is greater at hill stations than at plain stations.

In order to obtain sufficient accuracy, it is necessary to have a good knowledge of the distribution of heights in the immediate vicinity of a hill station. If this distribution of height in the immediate vicinity of a station is unknown, then the orographic reduction for local topography must be neglected, and the height of observation has to be accepted as the mean height of the zone. In order to get an idea as to how much the orographic reduction depends on the height of the zones, we may take the case of a hill station with a height of observation of 1000 m. Our example will show to what extent the average height of a zone may differ from the height of obser -vation in order, that the topographical reduction of a zone may be less than 0,001 cm/sec^2.

The radius of zone A is only 2m. so that the orographic reduction of this zone is negligible, its influence not exceeding 0.0002 cm/sec^2.

For the other zones, I give the results in the small table below:-

Height of station 1000 m.

Zone	Outer Radius m	Height of m	Zones m	Orographic reduction cm/sec^2
		1000	1000-	
B	68	12	12	0.001
C	230	47	38	"
D	590	88	67	"
E	1280	130	130	"
F	2290	255	245	"
G	3520	300	300	"

It will be seen from this table, that the orographical reduction only produces a noticeable error in the reduction in zones B.C.D., whilst the altitudes of zones E-G can easily be determined with such accuracy as to keep the error well below 0.001 cm/sec^2.[1)]

The influence of zones H-L is, in general, very small, and the error in reduction due to these zones is insignificant in comparison with the error due to zones B-D.

In zones M-O the reduction is again sensibly more dependent on the heights of the zones. It is just these zones that sometimes contribute 900-1300 units towards the isostatic reduction. In these zones there are altogether $14 + 16 + 28 = 58$ subdividing sectors.

In order to keep the average error originating from these zones below 0.003 cm/sec^2, it is necessary to take care that the error originating from any sector lies between the limits $\frac{30}{\sqrt{58}}$ and $\frac{30}{58}$, that is to say, between 4.0 and 0.5 units.

An error of 0.5 in the reduction corresponds to an error of between 40 and 75 metres in the height of a sector in zone M, or between 50-75 metres in zone N, or of between 75 and 150 metres in zone O, according to the magnitude of the mean height of the sector.

1) It may be noted that the orographical reduction is more sensibly dependent on the altitude of the zones when the height of observation is smaller.

Although the maps of Caucasia used in this work were not as good as might be desired (topographical maps on the scale 1 : 42.000 were unobtainable owing to the present condition of Russia), the heights of the zones are determinable with an accuracy such that the average error in the reduction, originating from zones M-O, will hardly ever exceed 0.006 cm/sec^2.

Zones 18-14 have been divided into 8 sectors and zone 13 into 16 sectors and the average height of each sector has been calculated. In zones 18-14 an error of reduction of 0.00005 cm/sec^2 corresponds to an error of 120 m. in the height of a sector, and in zone 13, to an error of 150 m. in the height of a sector, consequently it is unlikely that one may make an error exceeding 0.00005 in a sector. Hence the error from these six zones is in any case bound to be less than 56 X 0.00005 = 0.0028 cm/sec^2.

The error arising from the outer zones 12-1 may be neglected.

If we take the most unfavourable case, in which the height of all the sectors are systematically incorrect, and the errors all act in one direction, then the limits of the error of heights in sectors M.N.O. must not exceed 120 m. and 60.75 respectively, those in zones 18-14 must not exceed 120 m. and those in zones 13 must not exceed 150 m., if the reduction of the zones is to be effected with an accuracy of 0.006 cm/sec^2.

For a station on a high plateau, where the immediate surroundings are flat, and hence unlikely to cause any appreciable error in the estimates, reduction can be carried out with a precision of about 0.006 cm/sec^2. At plain stations, the accuracy will be even greater. On the contrary, at stations in high mountains, where the immediate surroundings consist of broken ground, the accuracy will be less, decreasing in proportion as the height of the station is lower than that of the surrounding country.

For the reduction of most of the Caucasian stations, I had maps on the scale of 1:140000, with many heights recorded on them, by means of which the mean heights of the inner zones could be determined. Therefore at these stations the error from the inner zones hardly exceeds 0.002 cm/sec^2. The opposite was the case when I was dealing with the stations in the Armenian highlands, for which I only had maps on scales of 1 : 420,000, 1 : 800,00 (0) and less.

Still even here the error is not appreciably greater, because the immediate surroundings of most of the stations are moderately level.

The most unreliable station is Artwin, which is situated in a deep valley at an altitude of only 182 m., but, at a distance of only 4 Km. from the station, the tops of the mountains attain a height of 2000 metres. It is difficult to say exactly how great the error is in this case, but anyhow it cannot exceed 0.015 cm/sec^2. As the reduction of this station is unreliable, it has been shown in brackets.

In conclusion, we may say that the errors of the reduction rarely exceed 0.010 cm/sec^2, and generally they were considerably less. The figure of precision applies to the stations in the Caucasia, Greater accuracy was obtained in reducing the values for the European stations, as better maps were available. If we omit the station Madrid, the error (in Europe) hardly ever exceeds 0.005 cm/sec^2. The errors in the results depend of course on errors in the gravity determinations as well as on those in the reduction. Borras does not state how accurate the Russian determinations in the Caucasus are. However it is probable that the precision is somewhat less than that usually obtained in European measurements, in which the average error is about 0.003 cm/sec^2.

The Results of the Reductions

In the following table, beneath the numbers and names of the stations, the figures in the first column denote the topographic reduction and then in the second, the topo-isostatic reduction (depth of compensation 113.7), the values being given by zones. Zone A, which contributes not more than 0.0002 cm/sec^2 to the reduction, has been added to zone B; and the more distant zones 7-1, whose influence also is small, and varies but little from place to place, have been combined into one zone. The figures denote units of 0.0001 cm/sec^2. Interpolated values are marked with an asterisk. The plain isostatic reduction by itself, from zone to zone, is obtainable by subtracting the figures of the first column from the second. In the case of the European stations, I have determined the topographic reduction for zones A-O, only where it was necessary to do so, in order to obtain the topographic isostatic reduction by means of Hayford's Tables.

The following stations reduced by Bowie, (viz:- Brocken, Scharfenstein, Schneekoppe and Alter Bruch), are shown in Table VII, as values for the more distant zones were interpolated from them. The purely topographic reduction of zones 7-1 for the Caucasian stations has been interpolated from the stations Shiloi Ostrow, Sary-Kamysch, Wladikawkas and Kertsch. The reductions of these stations by zones are shown in table VIII.

Table VII

1. The Stations in the Caucasus

	1 Lenkoran.		2 Dschulfa.		3 Schachtachty.		4 Karmalinowka.		5 Schuscha.		6 Alat.		7 Eriwan.	
A–B	+ 18	+ 18	− 68	− 68	− 70	− 70	− 67	− 67	− 70	− 70	+ 10	+ 10	− 64	− 64
C	+ 2	+ 2	− 137	− 137	− 141	− 141	− 161	− 157	− 160	− 158	0	0	− 144	− 144
D	0	0	− 196	− 192	− 212	− 209	− 304	− 298	− 288	− 282	0	0	− 243	− 241
E	0	0	− 172	− 164	− 186	− 178	− 390	− 378	− 344	− 336	0	0	− 244	− 236
F	0	0	− 95	− 85	− 104	− 94	− 312	− 292	− 248	− 238	0	0	− 150	− 140
G	− 2	− 2	− 48	− 36	− 48	− 36	− 185	− 161	− 136	− 122	0	0	− 75	− 63
H	− 3	0	− 20	− 3	− 28	− 12	− 120	− 88	− 91	− 63	0	0	− 43	− 25
I	0	+ 2	− 6	+ 29	− 17	+ 13	− 100	− 45	− 73	− 33	0	+ 2	− 28	+ 12
J	+ 5	+ 10	− 14	+ 29	− 17	+ 23	− 40	+ 38	− 26	+ 33	0	+ 2	− 28	+ 16
K	+ 3	+ 11	+ 10	+ 83	− 3	+ 74	− 36	+ 90	− 14	+ 47	0	+ 2	− 5	+ 68
L	+ 2	+ 20	+ 11	+ 131	+ 2	+ 110	− 24	+ 127	− 8	+ 81	0	+ 5	− 3	+ 103
M	+ 4	+ 85	+ 12	+ 372	+ 8	+ 347	− 14	+ 398	+ 1	+ 217	0	+ 22	+ 5	+ 375
N	0	+ 82	− 11	+ 294	− 6	+ 366	− 12	+ 304	− 4	+ 220	0	+ 12	− 14	+ 345
O	− 2	+ 63	− 8	+ 280	− 9	+ 296	− 7	+ 225	− 5	+ 175	0	+ 13	− 9	+ 296
18	− 1	+ 20	− 3	+ 52	− 3	+ 52	− 2	+ 41	− 2	+ 41	0	+ 6	− 3	+ 53
17	− 1	+ 24	− 3	+ 50	− 3	+ 50	− 3	+ 43	− 3	+ 47	− 1	+ 10	− 3	+ 49
16	− 3	+ 32	− 4	+ 50	− 4	+ 50	− 4	+ 48	− 3	+ 45	− 1	+ 15	− 4	+ 50
15	− 3	+ 34	− 5	+ 48	− 5	+ 49	− 6	+ 57	− 4	+ 42	− 2	+ 19	− 6	+ 60
14	− 4	+ 27	− 8	+ 52	− 8	+ 53	− 8	+ 52	− 7	+ 37	− 3	+ 23	− 8	+ 52
13	− 13	+ 56	− 14	+ 59	− 12	+ 48	− 12	+ 48	− 10	+ 41	− 11	+ 46	− 12	+ 49
12	− 13	+ 31	− 8	+ 18	− 8	+ 18	− 8	+ 18	− 8	+ 18	− 13	+ 32	− 6	+ 15
11	− 12	+ 15	− 9	+ 12	− 9	+ 12	− 9	+ 12	− 9	+ 12	− 14	+ 18	− 7	+ 9
10	− 11	+ 8	− 11	+ 8	− 11	+ 8	− 11	+ 8	− 11	+ 8	− 13	+ 9	− 11	+ 8
9	− 19	+ 7	− 16	+ 6	− 16	+ 6	− 16	+ 6	− 16	+ 6	− 22	+ 8	− 14	+ 5
8	− 37	+ 8	− 32	+ 7	− 30*	+ 7*	− 31*	+ 7*	− 33*	+ 7*	− 42	+ 9	− 28*	+ 6*
7–1	+ 1007*	− 9	+ 1020*	− 9*	+ 1019*	− 9*	+ 1016*	− 9*	+ 1014*	− 9*	+ 1005*	− 8*	+ 1021*	− 9*
	+ 917	+ 544	+ 165	+ 886	+ 79	+ 833	− 867	+ 27	− 558	− 234	+ 893	+ 255	− 126	+ 649

	8 Alagös.		9 Shiloi Ostrow.		10 Sary-Kamysch.		11 Baku.		12 Surachany.		13 Baladschary.		14 Jelenowka.	
A–B	− 70	− 70	+ 14	+ 14	− 70	− 70	− 6	− 6	− 38	− 38	− 26	− 26	− 66	− 66
C	− 160	− 160	+ 4	+ 4	− 168	− 164	0	0	− 12	− 12	− 5	− 5	− 164	− 160
D	− 276	− 270	0	0	− 324	− 318	0	0	− 3	− 3	+ 2	+ 2	− 313	− 307
E	− 315	− 307	0	0	− 465	− 449	0	0	0	0	+ 2	+ 2	− 434	− 418
F	− 210	− 200	0	0	− 406	− 386	0	0	0	0	0	0	− 376	− 356
G	− 108	− 96	0	0	− 274	− 250	0	0	0	0	0	0	− 235	− 211
H	− 64	− 48	0	0	− 207	− 175	0	0	0	0	0	0	− 166	− 134
I	− 60	− 20	0	0	− 177	− 117	0	+ 1	0	0	+ 2	+ 5	− 140	− 87
J	− 32	+ 16	0	0	− 92	− 12	0	+ 3	0	0	+ 1	+ 5	− 76	+ 1
K	− 20	+ 48	0	0	− 88	+ 45	0	+ 3	0	0	0	+ 4	− 66	+ 57
L	− 11	+ 105	0	− 2	− 60	+ 129	0	+ 3	0	+ 3	0	+ 4	− 44	+ 128
M	− 5	+ 341	0	− 11	− 46	+ 366	0	+ 18	0	+ 10	0	+ 19	− 35	+ 346
N	− 16	+ 361	0	− 29	− 18	− 345	0	+ 18	0	+ 14	0	+ 18	− 13	+ 275
O	− 15	+ 331	0	− 22	− 14	+ 328	0	+ 6	0	− 3	0	+ 7	− 7	+ 241
18	− 3	+ 59	0	− 2	− 3	+ 57	0	− 1	0	− 2	0	0	− 3	+ 49
17	− 4	+ 56	0	0	− 3	+ 46	0	+ 4	0	+ 3	0	+ 4	− 4	+ 59
16	− 4	+ 53	0	+ 1	− 4	+ 44	− 1	+ 7	0	+ 6	− 1	+ 8	− 5	+ 58
15	− 5	+ 54	0	+ 2	− 5	+ 46	− 1	+ 12	1	+ 11	− 1	+ 13	− 5	+ 54
14	− 7	+ 48	− 1	+ 9	− 7	+ 46	− 3	+ 17	− 2	+ 16	− 2	+ 17	− 7	+ 45
13	− 11	+ 47	− 2	+ 10	− 11	+ 47	− 8	+ 35	− 8	+ 34	− 8	+ 36	− 7	+ 32
12	− 6*	+ 17*	− 15	+ 34	− 8	+ 18	− 14*	+ 33*	− 14	+ 33	− 14*	+ 32*	− 6	+ 14
11	− 8*	+ 10*	− 18	+ 24	− 8	+ 11	− 16*	+ 21*	− 17	+ 22	− 16*	+ 21*	− 8	+ 10
10	− 11*	+ 8*	− 10	+ 8	− 13	+ 9	− 13*	+ 9*	− 11	+ 8	− 11*	+ 8*	− 13	+ 9
9	− 14*	+ 5*	− 22	+ 8	− 11	+ 4	− 22*	+ 8*	− 22	+ 8	− 22*	+ 8*	− 14	+ 5
8	− 27*	+ 6*	− 45	+ 10	− 25	+ 6	− 43*	+ 10*	− 44*	+ 10*	− 43*	+ 9*	− 30*	+ 7*
7–1	+ 1023*	− 9*	+ 1002	− 8	+ 1025	− 9	+ 1004*	− 8*	+ 1004*	− 8*	+ 1004*	− 8*	+ 1020*	− 9*
	− 439	+ 385	+ 907	+ 50	− 1482	− 408	+ 877	+ 193	+ 832	+ 112	+ 862	+ 183	− 1217	− 358

	15 Kars.		16 Jewlach.		17 Schemacha.		18 Jelisawetpol.		19 Jelisawetpol.		20 Alexandropol.		21 Karaklis.	
A—B	— 70	— 70	— 14	— 14	— 62	— 62	— 66	— 66	— 66	— 66	— 70	— 70	— 67	— 67
C	— 164	—160	— 2	— 2	— 134	—134	— 120	—120	— 108	—108	— 164	—160	— 157	—155
D	— 306	—300	0	0	— 202	—200	— 132	—132	— 102	—102	— 300	—294	— 280	—274
E	— 413	—401	0	0	— 168	—160	— 72	— 68	— 48	— 45	— 369	—361	— 319	—311
F	— 331	—311	0	0	— 86	— 76	— 30	— 27	— 20	— 18	— 278	—260	— 228	—216
G	— 204	—180	0	0	— 42	— 30	— 12	— 9	— 8	— 6	— 165	—144	— 121	— 98
H	— 139	—107	0	+ 1	— 30	— 14	— 12	0	— 8	0	— 113	— 81	— 80	— 48
I	— 120	— 79	0	+ 1	— 25	0	— 20	0	— 15	0	— 91	— 51	— 33	+ 9
J	— 51	+ 8	0	+ 1	— 16	+ 14	— 3	+ 17	— 2	+ 14	— 50	+ 4	— 36	+ 31
K	— 60	+ 47	0	+ 4	+ 8	+ 52	0	+ 24	0	+ 23	— 44	+ 47	— 19	+ 94
L	— 28	+101	0	+ 10	+ 2	+ 88	0	+ 40	0	+ 35	— 19	+114	— 5	+139
M	— 17	+386	0	+ 66	+ 8	+174	+ 10	+211	+ 10	+205	— 14	+406	— 2	+382
N	— 15	+348	0	+159	0	+ 82	— 3	+184	— 3*	+180*	— 15	+315	— 13	+269
O	— 14	+316	— 5	+103	— 2	+ 51	— 5	+247	— 5*	+245*	— 13	+280	— 13	+262
18	— 3	+ 50	— 2	+ 40	— 1	+ 12	— 3	+ 51	— 3*	+ 50*	— 3	+ 58	— 3	+ 58
17	— 3	+ 46	— 2	+ 38	— 1	+ 16	— 3	+ 43	— 3*	+ 43*	— 3	+ 56	— 4	+ 61
16	— 4	+ 48	— 2	+ 33	— 2	+ 19	— 4	+ 43	— 4*	+ 43*	— 4	+ 59	— 5	+ 59
15	— 5	+ 53	— 3	+ 31	— 2	+ 23	— 4	+ 39	— 4*	+ 39*	— 4	+ 49	— 5	+ 55
14	— 7	+ 45	— 4	+ 29	— 3	+ 23	— 5	+ 36	— 5*	+ 36*	— 6	+ 39	— 7	+ 44
13	— 10	+ 44	— 9	+ 38	— 9	+ 40	— 10	+ 42	— 10*	+ 42*	— 10	+ 44	— 8	+ 35
12	— 6	+ 16	— 9	+ 21	— 13	+ 31	— 7	+ 18	— 7*	+ 18*	— 6	+ 13	— 6	+ 13
11	— 8	+ 11	— 9	+ 12	— 12	+ 17	— 9	+ 12	— 9*	+ 12*	— 8*	+ 10*	— 8	+ 10
10	— 13	+ 9	— 10	+ 7	— 14	+ 10	— 8	+ 6	— 8*	+ 6*	— 13*	+ 9*	— 13	+ 9
9	— 11	+ 4	— 16	+ 6	— 22	+ 8	— 16	+ 6	— 16*	+ 6*	— 11*	+ 4*	— 13	+ 5
8	— 26*	+ 6*	— 35*	+ 8*	— 39	+ 9	— 33	+ 7	— 33*	+ 7*	— 27*	+ 6*	— 28*	+ 6*
7—1	+1023*	— 9*	+1012*	— 8*	+1008*	— 8*	+1014*	— 9*	+1014*	— 9*	+1020*	— 9*	+1018*	— 9*
	—1005	— 79	+ 890	+674	+ 136	— 15	+ 443	+595	+ 547	+650	— 780	+ 83	— 455	+363

	22 Ardagan.		23 Akstafa.		24 Artwin.		25 Diwitschi.		26 Achalkalaki.		27 Achalzich.		28 Batum.	
A—B	— 70	— 70	— 58	— 58	— 42	— 42	— 10	— 10	— 70	— 70	— 64	— 64	0	0
C	— 168	—164	— 108	—108	— 59	— 59	— 1	— 1	— 164	—160	— 143	—142	0	0
D	— 312	—306	— 94	— 94	— 26	— 26	0	0	— 306	—300	— 247	—241	0	0
E	— 423	—407	— 48	— 48	+ 1	+ 2	0	0	— 400	—392	— 256	—248	0	0
F	— 358	—338	— 20	— 18	+ 8	+ 11	0	0	— 324	—304	— 154	—144	0	0
G	— 224	—200	— 8	— 7	+ 5	+ 13	0	0	— 196	—172	— 83	— 71	— 1	— 1
H	— 148	—116	— 5	+ 1	+ 1	+ 14	0	+ 2	— 139	—107	— 48	— 24	— 3	— 3
I	— 127	— 72	— 7	+ 5	+ 14	+ 44	0	+ 4	— 108	— 58	— 37	+ 3	0	+ 4
J	— 66	+ 11	— 1	+ 16	+ 15	+ 53	+ 4	+ 10	— 57	+ 15	— 31	+ 20	— 2	+ 4
K	— 71	+ 50	+ 5	+ 28	+ 40	+ 143	+ 5	+ 14	— 49	+ 69	— 3	+ 98	+ 10	+ 19
L	— 37	+128	+ 1	+ 54	+ 32	+ 171	0	+ 32	— 31	+133	0	+158	+ 12	+ 41
M	— 36	+386	+ 6	+197	+ 31	+ 361	+ 9	+114	— 21	+365	0	+389	+ 26	+138
N	— 16	+332	— 4	+222	0	+ 247	0	+ 85	— 12	+279	— 11	+251	+ 3	+135
O	— 11	+228	— 10	+285	— 3	+ 181	0	+ 48	— 12	+261	— 11	+260	— 2	+145
18	— 2	+ 44	— 3	+ 60	— 2	+ 38	0	+ 7	— 3	+ 56	— 2	+ 49	— 2	+ 44
17	— 3	+ 51	— 4	+ 57	— 2	+ 44	0	+ 7	— 4	+ 55	— 3	+ 42	— 3	+ 49
16	— 4	+ 50	— 4	+ 44	— 4	+ 49	— 1	+ 8	— 4	+ 48	— 3	+ 39	— 3	+ 44
15	— 5	+ 47	— 4	+ 40	— 5	+ 49	— 2	+ 15	— 5	+ 45	— 4	+ 38	— 4	+ 36
14	— 6	+ 39	— 5	+ 33	— 6	+ 38	— 3	+ 19	— 5	+ 39	— 6	+ 37	— 4	+ 30
13	— 10	+ 42	— 10	+ 41	— 11	+ 47	— 7	+ 31	— 8	+ 35	— 9	+ 39	— 10	+ 43
12	— 6	+ 14	— 6	+ 13	— 6	+ 14	— 9	+ 21	— 6	+ 13	— 6	+ 13	— 6	+ 15
11	— 8	+ 10	— 8	+ 10	— 8	+ 10	— 13	+ 16	— 8	+ 10	— 9	+ 11	— 8	+ 10
10	— 11	+ 8	— 13	+ 9	— 10	+ 7	— 13	+ 9	— 11	+ 8	— 11	+ 8	— 10	+ 7
9	— 13	+ 5	— 16	+ 6	— 13	+ 5	— 22	+ 8	— 13	+ 5	— 13	+ 5	— 11	+ 4
8	— 25	+ 6	— 30	+ 7	— 22*	+ 5*	— 41*	+ 9*	— 26*	+ 6*	— 27*	+ 6*	— 21	+ 5
7—1	+1024*	— 9*	+1015*	— 8*	+1028*	— 9*	+1004*	— 8*	+1019*	— 9*	+1017*	— 9*	+1028*	— 10
	—1130	—231	+ 537	+787	+ 956	+1410	+ 900	+440	— 963	—130	— 164	+523	+ 989	+759

	29 Tiflis.		30 Tiflis, Phys. Obs.		31 Sekar-Pass.		32 Gori.		33 Michailowa.		34 Derbent.		35 Duschet.	
A—B	− 59	− 59	− 58	− 58	− 64	− 64	− 68	− 68	− 68	− 68	+ 22	+ 22	− 66	− 66
C	− 124	− 124	− 115	− 115	− 164	− 160	− 121	− 121	− 140	− 140	+ 2	+ 2	− 140	− 140
D	− 144	− 144	− 118	− 118	− 312	− 306	− 174	− 172	− 198	− 195	0	0	− 226	− 224
E	− 88	− 88	− 66	− 66	− 440	− 424	− 128	− 122	− 168	− 160	0	0	− 216	− 208
F	− 42	− 40	− 23	− 21	− 387	− 367	− 60	− 50	− 80	− 70	+ 1	+ 1	− 116	− 106
G	− 16	− 12	− 12	− 9	− 251	− 227	− 31	− 19	− 38	− 26	0	0	− 62	− 50
H	− 16	0	− 12	0	− 174	− 140	− 16	0	− 20	0	− 3	0	− 38	− 22
I	− 17	+ 3	− 15	+ 4	− 149	− 89	− 17	+ 4	− 16	+ 2	+ 2	+ 5	− 27	+ 3
J	− 2	+ 16	− 2	+ 16	− 84	− 1	− 8	+ 9	− 6	+ 15	+ 4	+ 11	− 16	+ 17
K	+ 3	+ 27	+ 4	+ 29	− 69	+ 27	+ 9	+ 49	+ 7	+ 54	+ 4	+ 14	− 8	+ 43
L	+ 1	+ 67	+ 1	+ 68	− 38	+ 63	+ 6	+ 92	+ 4	+ 88	+ 4	+ 26	+ 2	+ 92
M	+ 3	+ 202	+ 3	+ 198	− 29	+ 225	+ 12	+ 318	+ 5	+ 285	+ 4	+ 77	+ 6	+ 297
N	− 8	+ 275	− 8*	+ 272*	− 14	+ 228	− 8	+ 310	− 10	+ 272	+ 1	+ 121	− 7	+ 278
O	− 5	+ 272	− 5*	+ 274*	− 10	+ 254	− 6	+ 256	− 7	+ 257	− 1	+ 108	− 6	+ 210
18	− 2	+ 45	− 2*	+ 45*	− 2	+ 48	− 2	+ 47	− 2	+ 48	− 1	+ 10	− 2	+ 45
17	− 3	+ 45	− 3*	+ 45*	− 2	+ 36	− 2	+ 44	− 2	+ 41	0	+ 7	− 2	+ 43
16	− 4	+ 46	− 4*	+ 46*	− 3	+ 38	− 3	+ 40	− 3	+ 39	− 1	+ 7	− 3	+ 40
15	− 4	+ 38	− 4*	+ 38*	− 4	+ 35	− 4	+ 39	− 4	+ 38	− 1	+ 12	− 4	+ 36
14	− 4	+ 28	− 4*	+ 28*	− 5	+ 33	− 5	+ 34	− 5	+ 34	− 3	+ 18	− 4	+ 29
13	− 9	+ 37	− 9*	+ 37*	− 9	+ 38	− 8	+ 34	− 8	+ 36	− 7	+ 32	− 7	+ 31
12	− 6	+ 13	− 6*	+ 13*	− 6	+ 13	− 6	+ 13	− 6*	+ 13*	− 7	+ 19	− 6	+ 13
11	− 8	+ 11	− 8*	+ 11*	− 8	+ 10	− 8	+ 11	− 8*	+ 10*	− 12	+ 15	− 10	+ 13
10	− 11	+ 8	− 11*	+ 8*	− 10	+ 7	− 11	+ 8	− 10*	+ 7*	− 13	+ 9	− 11	+ 8
9	− 16	+ 6	− 16*	+ 6*	− 11	+ 4	− 13	+ 5	− 13*	+ 5*	− 22	+ 8	− 13	+ 5
8	− 28	+ 6	− 28*	+ 6*	− 24	+ 5	− 27*	+ 6*	− 26*	+ 6*	− 36	+ 8	− 28	+ 6
7—1	+ 1017*	− 9*	+ 1017*	− 9*	+ 1022*	− 9*	+ 1016*	− 9*	+ 1019*	− 8*	+ 1005*	− 9*	+ 1014*	− 8*
	+ 408	+ 669	+ 496	+ 748	− 1247	− 723	+ 317	+ 758	+ 197	+ 583	+ 962	+ 523	+ 4	+ 385

	36 Landschhuty.		37 Poti.		38 Samtredi.		39 Ananur.		40 Kutais.		41 Darkweti.		42 Passanur.	
A—B	− 12	− 12	0	0	− 18	− 18	− 60	− 60	− 58	− 58	− 60	− 60	− 65	− 65
C	− 2	− 2	0	0	− 4	− 4	− 139	− 139	− 60	− 60	− 108	− 108	− 152	− 150
D	0	0	0	0	0	0	− 203	− 201	− 26	− 26	− 107	− 107	− 256	− 250
E	0	0	0	0	0	0	− 202	− 194	− 15	− 15	− 50	− 48	− 270	− 262
F	+ 4	+ 4	0	0	0	0	− 108	− 98	− 8	− 8	− 14	− 5	− 166	− 156
G	+ 3	+ 6	0	0	0	0	− 57	− 45	− 3	− 2	− 5	+ 7	− 80	− 61
H	+ 2	+ 7	0	0	0	0	− 34	− 15	− 3	0	− 6	+ 10	− 45	− 17
I	+ 1	+ 6	0	0	0	+ 1	− 22	+ 14	0	0	0	+ 24	− 6	+ 44
J	0	+ 7	0	0	0	+ 3	− 28	+ 24	0	+ 13	0	+ 30	− 26	+ 42
K	+ 1	+ 10	0	0	+ 3	+ 9	0	+ 88	+ 4	+ 15	+ 18	+ 70	+ 1	+ 109
L	+ 2	+ 17	0	− 6	+ 2	+ 23	+ 2	+ 117	+ 2	+ 28	+ 8	+ 98	+ 3	+ 157
M	+ 10	+ 115	+ 7	+ 3	+ 13	+ 190	+ 10	+ 326	+ 5	+ 206	+ 16	+ 293	+ 2	+ 371
N	0	+ 152	− 3	+ 72	+ 2	+ 205	− 10	+ 275	− 1	+ 263	− 7	+ 320	− 9	+ 269
O	− 3	+ 213	− 2	+ 165	− 4	+ 230	− 5	+ 208	− 4	+ 244	− 6	+ 242	− 5	+ 204
18	− 2	+ 43	− 2	+ 42	− 2	+ 42	− 2*	+ 44*	− 2	+ 38	− 2	+ 39	− 2	+ 43
17	− 2	+ 38	− 2	+ 40	− 2	+ 37	− 2*	+ 43*	− 2	+ 35	− 2	+ 38	− 2	+ 42
16	− 3	+ 33	− 3	+ 32	− 3	+ 32	− 3*	+ 40*	− 3	+ 32	− 3	+ 32	− 3	+ 38
15	− 3	+ 29	− 3	+ 28	− 3	+ 31	− 4*	+ 35*	− 3	+ 29	− 3	+ 29	− 3	+ 33
14	− 4	+ 27	− 4	+ 25	− 4	+ 28	− 4*	+ 29*	− 4	+ 28	− 4	+ 27	− 4	+ 28
13	− 8	+ 35	− 9	+ 37	− 8	+ 34	− 7*	+ 31*	− 8	+ 35	− 8	+ 34	− 7	+ 29
12	− 6*	+ 15*	− 7	+ 16	− 6*	+ 15*	− 6*	+ 13*	− 6*	+ 14*	− 6	+ 13	− 6	+ 13
11	− 7*	+ 9*	− 7	+ 9	− 7*	+ 9*	− 10*	+ 13*	− 8*	+ 10*	− 9	+ 11	− 9	+ 12
10	− 10*	+ 7*	− 10	+ 7	− 10*	+ 7*	− 11*	+ 8*	− 10*	+ 7*	− 11	+ 8	− 11*	+ 8*
9	− 11*	+ 4*	− 11	+ 4	− 11*	+ 4*	− 13*	+ 5*	− 11*	+ 4*	− 13*	+ 5*	− 13*	+ 5*
8	− 22*	+ 5*	− 22*	+ 5*	− 23*	+ 5*	− 28*	+ 6*	− 24*	+ 5*	− 25*	+ 6*	− 28*	+ 6*
7—1	+ 1028*	− 9*	+ 1030*	− 10*	+ 1026*	− 10*	+ 1014*	− 8*	+ 1023*	− 9*	+ 1019*	− 9*	+ 1014*	− 8*
	+ 956	+ 758	+ 952	+ 469	+ 941	+ 873	+ 68	+ 559	+ 775	+ 828	+ 612	+ 999	− 148	+ 484

	43 Mlety.		44 Gudaursk.		45 Gudaursk.		46 Alpani.		47 Kobi.		48 Oni.		49 Kasbek.	
A—B	— 66	— 66	— 66	— 66	— 70	— 70	— 60	— 60	— 70	— 70	— 70	— 70	— 70	— 70
C	— 158	—157	— 168	—164	— 169	—165	— 106	—106	— 168	—164	— 144	—144	— 164	—160
D	— 292	—286	— 308	—302	— 306	—300	— 109	—107	— 308	—302	— 213	—211	— 302	—296
E	— 354	—346	— 453	—437	— 463	—447	— 52	— 48	— 439	—423	— 188	—180	— 405	—393
F	— 262	—242	— 407	—384	— 409	—386	— 19	— 13	— 354	—332	— 84	— 73	— 320	—300
G	— 131	— 96	— 230	—201	— 225	—196	— 10	— 1	— 218	—188	— 47	— 32	— 169	—141
H	— 60	— 27	— 214	—173	— 206	—163	— 3	+ 13	— 154	—109	— 20	— 4	— 90	— 46
I	— 46	— 23	— 159	— 85	— 150	— 71	— 12	+ 38	— 120	— 40	— 12	+ 27	— 57	+ 24
J	— 20	+ 69	— 97	— 10	— 93	— 3	0	+ 35	— 59	+ 36	— 10	+ 51	— 19	+ 84
K	— 9	+122	— 76	+ 64	— 74	+ 69	+ 22	+ 79	— 44	+110	+ 11	+113	— 27	+132
L	— 2	+165	— 52	+135	— 49	+143	+ 15	+114	— 36	+164	+ 10	+154	— 19	+188
M	— 13	+347	— 42	+325	— 43	+319	+ 21	+307	— 32	+324	+ 6	+355	— 23	+328
N	— 10	+228	— 17	+218	— 17*	+220*	— 3	+304	— 12	+221	— 9	+280	— 8	+225
O	— 8*	+192*	— 8	+192	— 8*	+192*	— 4	+194	— 8	+190	— 6	+216	— 7	+177
18	— 2*	+ 42*	— 2	+ 41	— 2*	+ 42*	— 2	+ 32	— 2	+ 41	— 2	+ 40	— 2*	+ 37*
17	— 2*	+ 40*	— 2	+ 40	— 2*	+ 40*	— 2	+ 31	— 2	+ 40	— 2	+ 37	— 2*	+ 38*
16	— 3*	+ 37*	— 3	+ 36	— 3*	+ 36*	— 2	+ 30	— 3	+ 36	— 3	+ 32	— 3*	+ 34*
15	— 3*	+ 30*	— 3	+ 30	— 3*	+ 30*	— 3	+ 25	— 3	+ 29	— 3	+ 30	— 3*	+ 30*
14	— 4*	+ 28*	— 4	+ 28	— 4*	+ 28*	— 4	+ 23	— 4	+ 27	— 4	+ 27	— 4*	+ 26*
13	— 7*	+ 27*	— 7	+ 27	— 7*	+ 27*	— 8	+ 33	— 7	+ 27	— 8	+ 35	— 7*	+ 28*
12	— 6*	+ 13*	— 6	+ 13	— 6*	+ 13*	— 7	+ 15	— 6	+ 13	— 6	+ 14	— 6*	+ 13*
11	— 9*	+ 12*	— 9	+ 12	— 9*	+ 12*	— 8	+ 10	— 9	+ 12	— 8	+ 11	— 8*	+ 11*
10	— 11*	+ 8*	— 11	+ 8	— 11*	+ 8*	— 11	+ 8	— 11*	+ 8*	— 13	+ 9	— 11*	+ 8*
9	— 13*	+ 5*	— 13	+ 5	— 13*	+ 5*	— 13	+ 5	— 13*	+ 5*	— 13	+ 5	— 13*	+ 5*
8	— 28*	+ 6*	— 28	+ 6	— 28*	+ 6*	— 24*	+ 5*	— 28*	+ 6*	— 26	+ 6	— 28*	+ 6*
7—1	+1014*	— 7*	+1013*	— 7*	+1013*	— 7*	+1022*	— 7*	+1013*	— 7*	+1018*	— 8*	+1011*	— 7*
	— 505	+141	—1378	—649	—1357	—618	+ 618	+959	—1065	—346	+ 154	+720	— 756	— 19

	50 Severn. Prijut.		51 Glola.		52 Lars.		53 St. Nikolaus Pass.		54 Petrowsk.		55 Suchum.		56 Wladikawkas.	
A—B	— 70	— 70	— 60	— 60	— 70	— 70	— 60	— 60	+ 10	+ 10	— 18	— 18	— 70	— 70
C	— 168	—164	— 148	—148	— 156	—154	— 146	—144	+ 1	+ 1	— 2	— 2	— 136	—136
D	— 321	—315	— 266	—260	— 262	—256	— 265	—259	+ 4	+ 4	0	0	— 184	—184
E	— 475	—459	— 312	—304	— 272	—264	— 278	—270	0	0	0	0	— 168	—160
F	— 422	—401	— 216	—196	— 210	—191	— 154	—135	0	0	0	0	— 80	— 70
G	— 286	—258	— 107	— 83	— 35	— 12	— 60	— 37	0	0	0	0	— 42	— 30
H	— 210	—167	— 43	— 8	— 6	+ 30	— 5	+ 32	0	0	0	0	— 20	0
I	— 173	— 91	— 5	+ 64	+ 13	+ 75	+ 4	+ 68	0	+ 2	0	+ 2	— 20	+ 10
J	— 86	+ 25	— 4	+ 92	+ 11	+118	+ 18	+111	— 3	+ 1	0	+ 7	— 12	+ 19
K	— 84	+ 63	— 3	+142	+ 14	+156	+ 14	+157	0	+ 9	+ 7	+ 20	+ 9	+ 57
L	— 50	+134	— 10	+174	+ 6	+176	+ 1	+190	0	+ 13	+ 8	+ 40	+ 3	+ 98
M	— 50	+325	— 13	+370	— 1	+339	0	+367	0	+ 57	+ 20	+164	+ 10	+280
N	— 10	+249	— 8	+247	— 5	+223	— 9	+236	0	+ 76	+ 4	+105	— 5	+239
O	— 8	+200	— 8	+210	— 5	+163	— 6	+186	— 1	+108	0	+ 54	— 4	+174
18	— 2	+ 37	— 2*	+ 37*	— 2	+ 34	— 2	+ 36	— 1	+ 19	0	+ 11	— 1	+ 30
17	— 2	+ 38	— 2*	+ 33*	— 2	+ 36	— 2	+ 37	— 1	+ 15	— 1	+ 10	— 2	+ 30
16	— 3	+ 33	— 2*	+ 28*	— 3	+ 33	— 3	+ 34	— 1	+ 12	— 1	+ 11	— 2	+ 31
15	— 3	+ 30	— 3*	+ 28*	— 3	+ 30	— 3	+ 30	— 1	+ 10	— 2	+ 15	— 3	+ 28
14	— 4	+ 25	— 3*	+ 22*	— 4	+ 26	— 4	+ 24	— 2	+ 16	— 2	+ 17	— 4	+ 24
13	— 7	+ 32	— 8*	+ 33*	— 7	+ 29	— 7	+ 30	— 7	+ 31	— 6	+ 26	— 6	+ 25
12	— 6	+ 14	— 6*	+ 14*	— 6	+ 14	— 6	+ 14	— 7	+ 16	— 9	+ 20	— 6	+ 14
11	— 8	+ 11	— 8*	+ 11*	— 8	+ 10	— 8	+ 10	— 10	+ 13	— 9	+ 12	— 7	+ 9
10	— 13	+ 9	— 13*	+ 9*	— 11	+ 8	— 11	+ 8	— 13	+ 9	— 13	+ 9	— 11	+ 8
9	— 13	+ 5	— 13*	+ 5*	— 16	+ 6	— 16	+ 6	— 19	+ 7	— 11	+ 4	— 16	+ 6
8	— 26*	+ 6*	— 25*	+ 6*	— 29*	+ 6*	— 27*	+ 6*	— 32*	+ 7*	— 22*	+ 5*	— 29	+ 6
7—1	+1015*	— 7*	+1017*	— 7*	+1009*	— 7*	+1013*	— 7*	+1006*	— 7*	+1030*	— 7*	+1008	— 7
	—1486	—696	— 271	+459	— 60	+558	— 24	+670	+ 923	+429	+ 973	+505	+ 202	+431

	57 Alagirsk.		58 Wladikawkas.		59 Grosny.		60 Kislowodsk.		61 Pjatigorsk.		62 Toipse.		63 Batalbaschinskoja.	
A—E	— 65	— 65	— 70	— 70	— 55	— 55	— 65	— 65	— 64	— 64	— 18	—18	— 67	— 67
C	— 132	—132	— 140	—140	— 52	— 52	— 143	—141	— 124	—124	— 3	— 3	— 129	—129
D	— 180	—178	— 192	—190	— 24	— 24	— 214	—211	— 147	—146	+ 2	+ 2	— 168	—166
E	— 141	—133	— 160	—152	— 8	— 8	— 200	—192	— 88	— 83	0	0	— 112	—109
F	— 67	— 57	— 78	— 68	— 5	— 4	— 115	—105	— 40	— 33	0	0	— 46	— 42
G	— 34	— 22	— 42	— 30	0	0	— 55	— 43	— 18	— 10	0	0	— 22	— 17
H	— 12	+ 4	— 16	0	0	+ 2	— 40	— 24	— 14	+ 2	0	0	— 16	— 0
I	— 14	+ 14	— 20	+ 4	0	+ 2	— 30	0	— 9	+ 14	0	0	— 16	+ 4
J	— 9	+ 24	— 10	+ 17	0	+ 4	— 22	+ 16	— 8	+ 16	0	+ 6	— 7	+ 12
K	+ 5	+ 65	+ 7	+ 51	0	+ 7	— 1	+ 63	— 8	+ 19	0	— 1	+ 3	+ 28
L	+ 10	+114	+ 1	+ 88	0	+ 24	— 2	+ 94	— 11	+ 42	+ 3	+ 7	0	+ 65
M	+ 17	+332	+ 10	+273	+ 2	+115	0	+238	— 3	+150	+ 11	+ 9	— 2	+178
N	— 5	+254	— 5*	+225*	0	+154	— 5	+209	— 7	+160	0	—17	— 5	+179
O	— 4	+188	— 4*	+178*	— 1	+143	— 4	+165	— 3	+168	0	—39	— 4	+158
18	— 2	+ 35	— 1*	+ 29*	— 1	+ 28	— 1	+ 19	— 1	+ 26	0	— 7	— 1	+ 15
17	— 2	+ 33	— 2*	+ 30*	— 1	+ 25	— 1	+ 16	— 1	+ 20	+ 1	— 9	— 1	+ 9
16	— 3	+ 32	— 2*	+ 31*	— 2	+ 25	— 1	+ 12	— 1	+ 15	+ 1	—10	0	+ 3
15	— 3	+ 27	— 3*	+ 28*	— [illegible]	+ 24	— 1	+ 10	— 1	+ 12	+ 1	— 7	0	+ 4
14	— 3	+ 22	— 4*	+ 24*	— 4	+ 26	— 1	+ 9	— 1	+ 11	+ 1	— 4	— 1	+ 5
13	— 6	+ 26	— 6*	+ 25*	— 6	+ 27	— 5*	+ 21*	— 2	+ 17	— 6	+26	— 4	+ 18
12	— 6	+ 14	— 6*	+ 14*	— 6*	+ 13*	— 7*	+ 17*	— 7	+ 16	— 10	+23	— 7	+ 18
11	— 8	+ 10	— 7*	+ 9*	— 7*	+ 9*	— 9*	+ 12*	— 9	+ 11	— 12	+16	— 9	+ 12
10	— 11	+ 8	— 11*	+ 8*	— 14*	+ 10*	— 11*	+ 8*	— 11	+ 8	— 10	+ 7	— 11	+ 8
9	— 16	+ 6	— 16*	+ 6*	— 19*	+ 7*	— 16*	+ 6*	— 16	+ 6	— 11	+ 4	— 16	+ 6
8	— 28*	+ 6*	— 29*	+ 6*	— 30*	+ 7*	— 25*	+ 6*	— 26*	+ 6*	— 19	+ 4	— 24*	+ 5*
7—1	+1011*	— 7*	+1008*	— 7*	+1008*	— 8*	+1018*	— 8*	+1017*	— 8*	+1034*	— 9*	+1022*	— 9*
	+ 292	+620	+ 202	+389	+ 773	+501	+ 44	+132	+ 397	+251	+ 965	—20	+ 357	+188

	64 Maïkop.		65 Noworossijsk.		66 Anapa.		67 Armawir.		68 Stawropol.		69 Jekaterinodar.		70 Kertsch.		71 Tichoretzkaja.	
A—E	— 62	—62	— 21	— 21	— 15	— 15	— 53	— 53	— 70	— 70	— 26	—26	— 34	— 34	— 46	—46
C	— 88	—88	— 2	— 2	— 1	— 1	— 68	— 68	— 136	—136	— 4	— 4	— 8	— 8	— 24	—24
D	— 60	—60	+ 2	+ 2	0	0	— 38	— 38	— 180	—178	0	0	— 1	— 1	— 10	—10
E	— 24	—24	+ 2	+ 2	0	0	— 16	— 16	— 160	—152	0	0	0	0	— 4	— 4
F	— 10	—10	+ 2	+ 2	0	0	— 8	— 7	— 70	— 60	0	0	0	0	— 2	— 2
G	— 6	— 5	0	0	0	0	0	0	— 36	— 24	0	0	0	0	0	0
H	— 4	— 1	0	0	0	0	— 2	0	— 16	0	0	0	0	0	0	0
I	— 3	+ 1	0	+ 9	0	0	0	+ 5	— 20	0	0	0	0	0	0	0
J	— 2	+ 6	0	+ 10	0	+ 2	0	+ 10	— 2	+ 16	0	0	0	0	0	0
K	0	+13	+ 5	+ 15	0	+ 5	— 2	+ 13	0	+ 20	0	0	0	0	0	+ 3
L	0	+27	+ 6	+ 6	0	+ 4	0	+ 18	0	+ 42	0	0	0	0	0	+ 4
M	+ 1	+97	0	— 44	0	— 30	— 2	+ 51	0	+ 68	0	+22	0	+ 2	0	+ 9
N	— 3	+97	+ 5	— 45	0	— 41	0	+ 60	0	+ 32	0	+31	0	— 9	0	+ 9
O	0	+38	0	— 65	0	— 64	— 2	+ 77	— 2	+ 73	0	— 8	0	— 40	0	+15
18	0	0	+ 1	— 12	+ 1	— 14	— 1	+ 20	— 1	+ 22	0	— 3	0	— 8	0	+ 7
17	0	— 3	+ 1	— 13	+ 1	— 14	— 1	+ 15	— 1	+ 24	0	0	+ 1	— 8	— 1	+10
16	0	— 3	+ 1	— 11	+ 1	— 13	0	+ 6	— 1	+ 16	0	— 3	+ 1	— 8	— 1	+ 9
15	0	— 3	+ 1	— 9	+ 1	— 11	0	+ 1	— 1	+ 9	0	— 3	+ 1	— 10	— 1	+ 5
14	+ 1	— 8	+ 1	— 7	+ 1	— 12	0	+ 3	0	0	0	— 4	+ 1	— 11	0	+ 5
13	— 3	+12	0	+ 2	0*	0*	— 1	+ 4	— 2	+ 7	0	— 1	+ 1	— 7	0	— 5
12	— 10	+22	— 9	+ 21	— 8*	+ 19*	— 7*	+ 17*	— 6	+ 15	— 8	+18	— 6	+ 14	— 4	+10
11	— 9	+12	— 12	+ 16	— 13*	+ 17*	— 10*	+ 13*	— 10	+ 13	— 12	+16	— 15	+ 19	— 12	+15
10	— 11	+ 8	— 11	+ 8	— 13*	+ 9*	— 10*	+ 7*	— 10	+ 7	— 11	+ 8	— 14	+ 10	— 11	+ 8
9	— 11	+ 4	— 8	+ 3	— 8*	+ 3*	— 19*	+ 7	— 16	+ 6	— 13	+ 5	— 5	+ 2	— 13	+ 5
8	— 20*	+ 4*	— 20*	+ 4	— 19	+ 4*	— 22*	+ 5	— 22	+ 5	— 21	+ 5*	— 19	+ 4	— 8*	+ 4*
7—1	+1029*	—10*	+1038	— 10*	+1040*	— 10	+1027*	— 10*	+1026*	— 10	+1036	—10*	+1043	— 10	+1041*	—11*
	+ 705	+64	+ 982	— 139	+ 968	—162	+ 785	+140	+ 264	—255	+ 941	+43	+ 946	—103	+ 904	+16

II. The Stations in Europe

	72 Duderstadt.		73 Stollberg a. H.		74 Walkenried.		75 Harzgerode.		76 Osterode.		77 St. Andreasberg.		78 Brocken.		79 Scharfenstein.	
A—B	−58	−58	−56	−56	−59	−59	−57	−57	−62	−62	−60	−60	−70	−70	−63	−63
C	−68	−68	−98	−98	−93	−93	−116	−116	−88	−88	−130	−130	−154	−154	−133	−133
D	−36	−36	−76	−76	−71	−71	−120	−120	−57	−57	−176	−176	−258	−252	−181	−181
E	−16	−16	−43	−43	−32	−32	−64	−64	−24	−24	−126	−124	−278	−270	−143	−136
F	−5	−5	−12	−12	−10	−10	−20	−20	−10	−10	−67	−62	−167	−157	−70	−62
G	−2	−2	0	0	−3	−3	−7	−7	−4	−4	−34	−25	−85	−73	−33	−24
H	−4	0	−11	0	−6	0	−10	−3	−5	0	−20	−4	−49	−33	−18	−2
I	0	+3	−9	+3	−6	+5	−8	+1	−3	+5	−16	+3	−52	−32	−18	−4
J	0	+13	−2	+14	0	+13	0	+13	+1	+13	+1	+18	−21	−5	+1	+16
K	0	+19	0	+18	+8	+28	0	+18	+6	+27	0	+19	0	+10	0	+13
L	0	+28	0	+26	0	+38	0	+24	0	+32	0	+24	0	+18	0	+18
M	0	+67	0	+46	0	+49	0	+42	0	+59	0	+49	−5	+30	0	+35
N	0	+48	0*	+43*	0	+43	0	+40	0*	+40*	0*	+36*	0	+31	0	+31
O	0	+41	0*	+41*	0	+40	0	+42	0*	+41*	0*	+39*	0	+36	0	+38
18		+7		+9*		+8*		+10*		+6*		+6*		+6		+6
17		+7		+8*		+7*		+8*		+6*		+6*		+6		+6
16		+7		+7*		+7*		+7*		+7*		+7*		+7		+7
15		+8		+7*		+8*		+7*		+7*		+6*		+6		+6
14		+7*		+7*		+7*		+7*		+7*		+7*		+7		+7
13		+13*		+14*		+13*		+14*		+13*		+13*		+13		+13
12		+15*		+15*		+15*		+15*		+15*		+15*		+15		+15
11		+6*		+6*		+6*		+6*		+6*		+6*		+6		+6
10		+3*		+3*		+3*		+3*		+3*		+3*		+3		+3
9		−3*		−3*		−3*		−3*		−3*		−3*		−3		−3
8		−6*		−6*		−6*		−6*		−6*		−6*		−6		−6
7—1		−20*		−20*		−20*		−20*		−20*		−20*		−20		−20
		+75		−47		−7		−161		+13		−353		−879		−414

	80 Elbingerode.		81 Wegeleben.		82 Goslar.		83 Schneekoppe.		84 Alter Bruch.		85 Querseifen.		86 Giersdorf.		87 Stonsdorf.	
A—B	−67	−67	−50	−50	−62	−62	−64	−64	−64	−64	−60	−60	−60	−60	−66	−66
C	−128	−128	−32	−32	−90	−90	−145	−141	−148	−148	−126	−126	−134	−134	−112	−112
D	−148	−148	−12	−12	−64	−64	−262	−256	−231	−231	−191	−191	−197	−197	−113	−113
E	−85	−85	−6	−6	−24	−24	−333	−325	−226	−218	−168	−161	−167	−163	−62	−62
F	−38	−38	−4	−4	−7	−7	−266	−256	−126	−116	−92	−84	−88	−83	−22	−20
G	−12	−8	0	0	−10	−9	−150	−138	−61	−49	−52	−42	−43	−38	−6	−5
H	−16	0	0	0	−7	+2	−98	−82	−28	−12	−22	−7	−26	−15	−5	0
I	−17	0	0	0	−5	+4	−80	−52	−35	−13	−18	+7	−29	−4	−9	+3
J	+1	+18	0	0	0	+13	−35	−13	−20	+4	−12	+15	−13	+14	0	+22
K	+2	+23	0	+10	+6	+27	−16	+4	−9	+12	−2	+27	−1	+28	+11	+40
L	0	+27	0	+12	0	+29	−11	+27	0	+34	−2	+42	−2	+40	0	+44
M	0	+40	0	+41	0	+37	−14	+49	−13	+52	−3	+63	−4	+63	0	+69
N	0*	+33*	0	+31	0	+30	0	+44	0	+45	0	+46	0*	+46*	0	+47
O	0*	+37*	0	+36	0	+37	0	+51	0	+51	0*	+50*	0*	+50*	0*	+49*
18		+8*		+6		+5		+8		+8		+8*		+8*		+8*
17		+7*		+8		+5		+7		+7		+7*		+7*		+7*
16		+7*		+7		+7		+7		+7		+7*		+7*		+8*
15		+7*		+6		+6		+8		+8		+8*		+8*		+9*
14		+7*		+7		+6		+8		+8		+8*		+9*		+9*
13		+13*		+12		+12		+20		+20		+20*		+20*		+19*
12		+15*		+15*		+15*		+12		+12		+12*		+13*		+13*
11		+6*		+6*		+6*		+8		+8		+8*		+8*		+8*
10		+3*		+3*		+3*		+4		+4		+4*		+4*		+4*
9		−3*		−3*		−3*		−2		−2		−2*		−2*		−2*
8		−6*		−6*		−6*		−4		−4		−4*		−4*		−4*
7—1		−20*		−20*		−20*		−20		−20		−20*		−20*		−20*
		−252		+67		−41		−1096		−597		−365		−395		−45

	88 Cunersdorf.		89 Grunau.		90 Ludwigsdorf.		91 **Vienna**		92 Wels.		93 Traunstein.		94 **Munich**		95 Hohenpeissenberg.	
A—B	— 66	— 66	— 64	— 64	— 67	— 67	— 58	— 58	— 62	— 62	— 66	— 66	— 64	— 64	— 70	— 70
C	—108	—108	—111	—111	—134	—134	—70	— 70	—101	—101	—132	—132	—127	—127	—148	—148
D	— 95	— 95	—107	—107	—299	—299	—42	— 42	— 87	— 87	—174	—174	—152	—152	—248	—242
E	— 49	— 49	— 58	— 58	—118	—118	—16	— 16	— 37	— 37	—136	—128	— 99	— 99	—248	—240
F	— 17	— 16	— 22	— 20	— 54	— 52	— 8	— 8	— 18	— 18	— 70	— 60	— 50	— 47	—140	—130
G	— 6	— 5	— 7	— 5	— 19	— 16	— 4	— 4	— 3	— 3	— 36	— 24	— 24	— 18	— 66	— 54
H	— 9	0	— 8	+ 2	— 14	— 1	— 5	0	— 10	— 0	— 16	0	— 16	0	— 34	— 18
I	— 16	+ 4	— 9	0	— 11	— 0	— 5	+ 3	— 16	+ 6	— 18	+ 2	— 20	0	— 40	— 20
J	0	+ 16	— 3	+ 13	0	+ 16	0	+ 11	0	+ 16	— 5	+ 17	— 4	+ 11	— 16	+ 2
K	+ 12	+ 38	+ 1	+ 20	0	+ 20	+ 1	+ 14	0	+ 20	— 6	+ 37	0	+ 20	— 16	+ 7
L	0	+ 45	+ 2	+ 46	0	+ 37	0	+ 21	0	+ 25	+ 2	+ 68	0	+ 41	— 6	+ 58
M	0	+ 70	0	+ 72	— 2	+ 72	0	+ 62	+ 2	+130	+ 4	+191	+ 1	+111	— 2	+198
N	0	+ 47	0*	+ 48*	0	+ 48	— 2	+ 84	— 6	+166	— 6	+191	— 4	+132	— 3	+200
O	0	+ 48	0*	+ 47*	0	+ 46	— 2	+ 85	— 5	+159	— 6	+180	— 6	+185	— 6	+191
18		+ 8*		+ 8*		+ 8		+ 19		+ 27		+ 38		+ 40		+ 43
17		+ 7*		+ 8*		+ 8		+ 20		+ 28		+ 35		+ 39		+ 36
16		+ 8*		+ 8*		+ 8		+ 21		+ 22		+ 28		+ 37		+ 30
15		+ 9*		+ 10*		+ 10		+ 21		+ 22		+ 22		+ 28		+ 22
14		+ 9*		+ 10*		+ 10		+ 20		+ 21		+ 20		+ 19		+ 20
13		+ 19*		+ 19*		+ 19		+ 22		+ 23		+ 26		+ 25		+ 22
12		+ 13*		+ 13*		+ 13		+ 12		+ 11		+ 10*		+ 10		+ 10*
11		+ 8*		+ 8*		+ 8		+ 9		+ 5		+ 4*		+ 2		0*
10		+ 4*		+ 4*		+ 4		+ 1		— 2*		0*		0		— 1*
9		— 2*		— 2*		— 2*		— 1*		— 1*		— 1*		— 1		0*
8		— 4*		— 4*		— 4*		— 3*		— 3*		— 4*		— 4*		— 4*
7—1		— 20*		— 20*		— 20*		— 19*		— 19*		— 22*		— 22*		— 22*
		— 12		— 55		—386		+204		+348		+258		+166		—110

	96 Augsburg.		97 Konstanz.		98 Ludwigshafen a. S.		99 Waldshut.		100 Freiburg i. B.		101 Lemberg.		102 Stryj.		103 Munkács.	
A—B	— 65	— 65	— 66	— 66	— 64	— 64	— 62	— 62	—62	— 62	— 66	— 66	— 62	— 62	—54	— 54
C	—124	—124	—116	—116	—116	—116	—105	—105	—92	— 92	—104	—104	—100	—100	—44	— 44
D	—146	—146	—120	—120	—116	—116	— 94	— 94	—69	— 69	— 84	— 84	— 78	— 78	—16	— 16
E	— 88	— 88	— 64	— 64	— 56	— 56	— 46	— 46	—32	— 32	— 40	— 40	— 40	— 40	— 6	— 6
F	— 40	— 40	— 20	— 20	— 20	— 20	— 20	— 20	— 8	— 8	— 15	— 15	— 12	— 12	0	0
G	— 12	— 10	— 8	— 6	— 9	— 9	— 9	— 9	— 3	+ 3	— 3	— 3	— 3	— 3	0	0
H	— 16	0	— 10	+ 2	— 12	+ 2	— 12	+ 1	— 2	+ 7	— 2	+ 2	— 2	+ 1	0	+ 2
I	— 20	0	— 12	+ 4	— 12	+ 7	— 12	+ 5	— 1	+ 12	— 5	+ 8	— 5	+ 3	0	+ 4
J	— 6	+ 11	+ 5	+ 20	0	+ 16	— 1	+ 16	+ 7	+ 21	0	+ 14	0	+ 16	+ 2	+ 6
K	— 2	+ 18	+ 6	+ 24	+ 3	+ 23	+ 12	+ 36	+11	+ 35	0	+ 20	0	+ 20	0	+ 10
L	0	+ 36	0	+ 40	0	+ 40	+ 2	+ 48	+ 2	+ 46	0	+ 24	0	+ 27	+ 2	+ 18
M	0	+ 92	0	+130	0	+116	0	+ 93	0	+ 87	0	+ 60	0	+100	— 2	+ 89
N	— 2	+ 89	— 6	+169	— 4	+134	— 3	+139	0	+ 88	0	+ 59	— 3	+ 97	— 4	+ 91
O	— 4	+153	— 5	+183	— 5	+182	— 4	+162	— 2	+123	— 1	+ 98	— 1	+ 88	— 1	+ 98
18		+ 34		+ 33		+ 37		+ 32		+ 28		+ 14		+ 14		+ 17
17		+ 35		+ 29		+ 30*		+ 33		+ 29		+ 13		+ 14		+ 18
16		+ 33		+ 27		+ 29*		+ 29		+ 28		+ 12		+ 13		+ 16
15		+ 21		+ 25		+ 27*		+ 25		+ 23		+ 12		+ 13		+ 12
14		+ 25		+ 20		+ 22*		+ 22		+ 22		+ 12		+ 12		+ 11
13		+ 21		+ 22		+ 23*		+ 24		+ 25		+ 15		+ 17*		+ 17
12		+ 9		+ 6		+ 6*		+ 5		+ 2		+ 6		+ 6*		+ 10
11		+ 2*		— 1		— 1*		0		0		+ 9		+ 9*		+ 7
10		— 1*		— 3		— 3*		— 3		— 3		+ 3		+ 3*		+ 3
9		— 1*		— 1		— 1*		— 1		— 1		0		0*		+ 1
8		— 4*		— 6*		— 5*		— 6*		— 6*		— 2		— 2*		— 2*
7—1		— 22*		— 22*		— 22*		— 23*		— 23*		— 17		— 17*		— 17*
		+ 78		+309		+281		+301		+283		+ 40		+139		+291

	104 Karczag.		105 Sadská.		106 Nürnberg.		107 Karlsruhe.		108 Leipzig.		109 Hohendodeleben.		110 Ballstädt.		111 Lüdenhausen.	
A–B	−50	−50	−62	−62	−62	−62	−54	−54	−54	−54	−57	−57	−66	−66	−62	−62
C	−32	−32	−80	−80	−104	−104	−40	−40	−40	−40	−47	−47	−96	−96	−76	−76
D	−12	−12	−60	−60	−92	−92	−18	−18	−18	−18	−12	−12	−72	−72	−64	−64
E	−4	−4	−20	−20	−40	−40	−8	−8	−6	−6	−6	−6	−32	−32	−18	−18
F	0	0	−12	−12	−15	−15	−3	−3	−3	−3	0	0	−10	−10	−6	−6
G	0	0	0	0	−6	−6	−2	−2	−2	−2	0	0	−4	−4	−5	−5
H	0	0	0	0	−8	0	−2	0	0	0	0	0	−6	0	−6	0
I	0	+2	0	0	−10	0	−1	+2	0	0	0	0	−8	0	−6	+3
J	0	+4	0	0	0	+16	0	+5	0	+3	0	0	−2	+13	0	+10
K	0	+5	0	+12	+2	+22	0	+9	0	+6	0	+3	0	+20	0	+12
L	0	+14	0	+26	0	+32	0	+15	0	+8	0	+4	0	+29	0	+16
M	0	+22	0	+70	0	+87	0	+62	0	+33	0	+28	0	+82	0	+24
N	−2	+46	0	+86	0	+85	0	+68	0	+41	0	+26	0	+71	0	+29
O	0	+11	−2	+82	−2	+95	−1	+82	−1	+61	0	+27	0	+50	0	+29
18		+14		+15		+16		+14		+8		+6		+10		+4
17		+16		+12		+17		+17		+8		+7		+9		+4
16		+16		+10		+22		+22		+8		+6		+8		+3
15		+11		+12		+26		+25		+9		+6		+8		+4
14		+25		+17		+26		+22		+9		+6		+8		+5
13		+14		+25		+30		+27		+17		+11		+21		+9
12		+1		+10		+9		+10		+14		+12		+12		+9
11		+5		+8		+3		+1		+5*		+6		+5		+7
10		+1		+2*		0		−3		+3*		+3		+2		+1
9		−1		−2*		−1		−1		−3*		−3		−3		−5
8		−3*		−4*		−4*		−6*		−6*		−6*		−6*		−6*
7–1		−18*		−21*		−21*		−23*		−20*		−20*		−20*		−20*
		+87		+126		+141		+223		+81		−2		+39		−93

	112 Harsewinkel.		113 Bonn.		114 Madrid.		115 Brindisi.		116 Telfs.		117 Steinach.		118 Spittal.		119 Hohenmauthen.	
-B	−42	−42	−40	−40	−70	−70	−14	−14	−66	−66	−66	−66	−68	−68	−66	−66
	−21	−21	−16	−16	−136	−136	−2	−2	−134	−134	−152	−152	−131	−131	−109	−109
	−9	−9	−9	−9	−186	−186	0	0	−184	−184	−258	−258	−166	−166	−106	−106
	−2	−2	−2	−2	−148	−140	0	0	−143	−135	−265	−257	−112	−108	−58	−58
	0	0	0	0	−75	−65	0	0	−73	−63	−149	−136	−59	−53	−21	−21
	0	0	0	0	−38	−26	0	0	−31	−19	−72	−51	−24	−14	−9	−4
	0	0	0	0	−20	−4	0	0	+10	+32	−34	−8	−6	+13	−8	−3
	0	0	0	+2	−20	0	0	0	+34	+73	−12	+33	+8	+40	0	+19
	0	0	0	+6	−4	+12	0	0	+15	+78	−26	+38	−9	+29	0	+23
	0	+3	0	+11	−4	+20	0	0	+24	+124	+14	+130	+15	+82	+10	+45
	0	+5	0	+19	−2	+50	0	−5	+19	+155	+19	+201	+27	+160	+3	+67
	0	+23	0	+59	−6	+157	0	−49	+20	+368	+7	+425	+17	+360	+1	+139
	0	+32	0	+53	−8	+141	0	−28	−1	+261	−5	+291	−5	+220	−6	+156
	0	+29	0	+45	−3	+154	0	+4	−6	+189	−6	+194	−5	+144	−2	+122
		+5		+8		+31		+8		+33		+32		+24		+17
		+5		+7		+33		+5		+27		+26		+22		+18
		+6		+7		+28		+12		+23		+23		+20		+19
		+5		+7		+28		−2		+20		+19		+18		+19
		+5		+7		+33		−5		+19		+18		+18		+18
		+6		+13		+13		−8		+21		+21		+23		+22
		+9		+15		−22		−3		−4*		−4*		−3		−2*
		+7		+5		−26		+3		0*		0*		+1		+1*
		+1		−1		−13		−1		−1*		−1*		0*		0*
		−5		−4		−12		+2		0*		0*		−1*		−1*
		−6*		−7*		−10		+3		−6*		−6*		−6*		−6*
-1		−20*		−23*		−35		−18		−20*		−20*		−20*		−19*
		+36		+162		−45		−98		+801		+492		+604		+290

Table VIII

Zone	9 Shiloi Ostrow	10 Sary-Kamysch	58 Wladikawkas	70 Kertsch
20	-27	-29	-26	-20
19	-37	-23	-20	-17
18	-26	-23	-20	0
17	+ 5	+ 3	- 5	+2
16	+14	+15	+7	+ 5
15	+20	+17	+17	+15
14	+24	+ 24	+18	+25
13	+32	+ 31	+ 29	+34
12	+110	+103	+106	+ 89
11	+150	+157	+157	+148
10	+164	+169	+ 164	+148
9	+125	+121	+124	+132
8	+ 94	+100	+ 99	+112
7	+ 72	+ 77	+ 82	+ 96
6	+ 71	+68	+70	+ 77
5	+ 54	+ 53	+53	+49
4	+ 60	+61	+55	+ 52
3	+ 55	+55	+ 54	+ 52
2	+ 32	+35	+34	+ 35
1	+ 10	+11	+10	+ 11
	+1002	+1025	+1008	+1045

In table IX the results of the reductions under the different assumptions are shown. The names and heights of stations, the theoretical values of gravity γ_0, and the observed g values have been extracted from the paper of Borras. Certain corrections, supplied by Borras in the proceedings of the 17th International Geodetic Conference, had to be applied to the observed values, which appear in the proceedings of the 16th Conference.

All the other figures in the Table were computed by me. The meaning of columns Nos. 1,2 ..... 8 in the case of Caucasian stations is as follows:-

Col. 1 gives the height reduction, Col. 2, the Bouguer reduction, Col. 3, the purely topographic reduction, Col. 4, the Hayford reduction with depth of compensation 113.7 Km, Col. 5, the same reduction with depth of compensation 156.3 Km.; Col. 6, the reduction on the basis of regional compensation and Col. 7 and 8, Airy's reduction on my 1st and 2nd assumptions.

For the European stations, the Bouguer, the purely topographic, and the regional compensation reductions are omitted and the meaning of the columns is Col. 1, the height reduction, Cols. 2 and 3, Hayford reduction with depths of compensation of 113.7 Km. and 85.3 Km. respectively, and Cols. 4,5 and 6, Airy's reduction on my 1st, 2nd and 4th assumptions.

The unit used is 0.001 cm/sec^2. In this paper the the orographical reduction, which forms part of the Bouguer reduc-tion, has been taken into consideration within a radius of 166.7 Km. from the Caucasian station.

From these figures the remaining anomalies on the various assumptions are obtained, by adding in, first, the height reduction alone, and then combining it in turn with the other reductions to the observed value of gravity, and subtracting γ_0 from the sum in each case.

The anomalies are shown in table X. The stations have been grouped according to their heights and geographical coordinates, and, in the table, the names, coordinates and heights of the stations are given first and then the values of the gravity anomalies.

The gravity anomalies of the Caucasian stations are given in the following order:- (1) The anomalies according to the Free Air reduction (2) Bouguer reduction, (3) the Purely Topographic reduction, (4) & (5) Hayford reductions with compensation depths of 113.7 and 956.3 Km. (6) the regional reduction and (7) & (8) Airy reductions on my 1st and 2nd assumptions.

The gravity anomalies of the European stations are given in the following order:- (1) The anomalies according to the Free Air reduction, (2) Bouguer reduction, (3)&(4) Hayford reductions with compensation depths of 113.7 Km. and 85.3 Km. and

(5)&(6)&(7) Airy reductions on my 1st, 2nd and 4th assumptions.

For the stations of the Harz mountains and the stations in the "Rand depression"*) of the Alps, a further column is introduced, the meaning of which will be explained later.

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*) Rand depression means Marginal depression.

Vide Table IX appears on the next page.

Table IX

I. The Stations in the Caucasus.

Number & Name of Station	h	g	1	2	3	4	5	6	7	8	γ_0
1. Lenkoran	—20	980.093	— 6	+ 3	+ 92	+ 54	+ 58	+ 65	+ 64	+ 60	980.056
2. Dschulfa	720	979.836	+221	— 74	+ 17	+ 89	+ 83	+ 98	+ 81	+ 88	.073
3. Schachtachty	781	.869	+241	— 83	+ 8	+ 83	+ 77	+100	+ 78	+ 85	.109
4. Karmalinowka	1665	.660	+514	—178	— 87	+ 3	— 9	— 18	— 26	— 18	.121
5. Schuscha	1403	.873	+433	—146	— 56	— 23	— 28	— 26	— 31	— 27	.144
6. Alat	—11	980.065	— 3	+ 1	+ 89	+ 26	+ 30	+ 27	+ 33	+ 29	.165
7. Eriwan	990	979.881	+305	—104	— 13	+ 65	+ 58	+ 83	+ 60	+ 66	.182
8. Alagös	1255	.884	+387	—136	— 44	+ 39	+ 33	+ 57	+ 33	+ 39	.195
9. Shiloi Ostrow	—16	980.075	— 5	+ 2	+ 91	+ 5	+ 8	+ 9	+ 8	+ 5	.196
10. Sary-Kamysch	2177	979.642	+672	—242	—148	— 40	— 54	— 54	— 78	— 64	.196
11. Baku	7	980.083	+ 2	— 1	+ 88	+ 19	+ 23	+ 18	+ 26	+ 22	.199
12. Surachany	57	.065	+ 18	— 9	+ 83	+ 11	+ 15	+ 12	+ 18	+ 14	.204
13. Baladschary	48	.070	+ 15	— 2	+ 86	+ 18	+ 23	+ 17	+ 24	+ 21	.205
14. Jelenowka	1947	979.723	+602	—215	—122	— 36	— 48	— 56	— 59	— 53	.214
15. Kars	1750	.744	+540	—194	—101	— 8	— 18	— 9	— 31	— 19	.220
16. Jewlach	14	980.178	+ 4	— 2	+ 89	+ 67	+ 73	+106	+ 87	+ 83	.221
17. Schemacha	715	979.996	+221	— 75	+ 14	— 2	— 4	— 22	— 12	— 10	.222
18. Jelisawetpol	427	980.088	+132	— 47	+ 44	+ 60	+ 60	+ 81	+ 70	+ 70	.226
19. Jelisawetpol	344	.120	+106	— 38	+ 55	+ 65	+ 64	+ 90	+ 79	+ 79	.231
20. Alexandropol	1519	979.786	+469	—172	— 78	+ 8	— 2	+ 4	— 13	— 6	.236
21. Karaklis	1315	.875	+406	—137	— 46	+ 36	+ 26	+ 27	+ 16	+ 23	.239
22. Ardagan	1846	.757	+570	—207	—113	— 23	— 36	— 50	— 53	— 45	.265
23. Akstafa	332	980.173	+102	— 35	+ 54	+ 79	+ 80	+116	+ 95	+ 96	.266
24. Artwin	182	.155	+ 56	+ 1	+ 96	+141	+134	+134	+129	+136	.272
25. Diwitschi	10	.181	+ 3	+ 1	+ 90	+ 44	+ 45	+ 45	+ 45	+ 45	.275
26. Achalkalaki	1717	979.841	+531	—186	— 96	— 13	— 23	— 31	— 39	— 32	980.292
27. Achalzich	1014	980.021	+313	—109	— 16	+ 52	+ 42	+ 46	+ 38	+ 45	.312
28. Batum	3	.349	+ 1	+ 5	+ 99	+ 76	+ 77	+ 97	+ 90	+ 88	.314
29. Tiflis	471	.187	+144	— 51	+ 41	+ 67	+ 65	+102	+ 75	+ 76	.317
30. Tiflis, Phys. Obs.	401	.178	+124	— 43	+ 50	+ 75	+ 73	+112	+ 83	+ 84	.320
31. Sekar-Pass	2008	979.863	+620	—219	—125	— 72	— 80	— 68	— 90	— 88	.329
32. Gori	578	980.121	+178	— 60	+ 32	+ 76	+ 72	+ 93	+ 77	+ 81	.344
33. Michàilowa	708	.107	+218	— 74	+ 20	+ 58	+ 56	+ 73	+ 61	+ 66	.346
34. Derbent	—26	.281	— 8	+ 4	+ 96	+ 52	+ 53	+ 66	+ 61	+ 58	.350
35. Duschet	888	.060	+274	— 92	0	+ 39	+ 33	+ 52	+ 31	+ 38	.353
36. Landschhuty	14	.303	+ 4	+ 1	+ 96	+ 76	+ 79	+111	+ 94	+ 91	.354
37. Poti	3	.317	+ 1	+ 3	+ 95	+ 47	+ 53	+ 85	+ 67	+ 62	.357
38. Samtredi	22	.304	+ 7	+ 0	+ 94	+ 87	+ 89	+127	+105	+105	.359
39. Ananur	823	.088	+254	— 86	+ 7	+ 56	+ 48	+ 57	+ 49	+ 58	.360
40. Kutais	157	.275	+ 48	— 16	+ 78	+ 83	+ 83	+119	+ 98	+100	.368
41. Darkweti	376	.223	+116	— 32	+ 61	+100	+ 94	+122	+100	+107	.374
42. Passanur	1065	.061	+329	—108	— 15	+ 48	+ 36	+ 29	+ 26	+ 35	.376
43. Mlety	1469	979.989	+453	—144	— 51	+ 14	— 2	— 10	— 18	— 8	.383
44. Gudaursk	2200	.857	+679	—230	—138	— 65	— 82	—110	—107	— 98	.387
45. Gudaursk	2247	.844	+693	—229	—136	— 62	— 79	—107	—104	— 95	.389
46. Alpani	375	980.231	+116	— 32	+ 62	+ 96	+ 89	+104	+ 86	+ 92	.395
47. Kobi	1973	979.910	+609	—203	—107	— 35	— 52	— 71	— 85	— 76	.395
48. Oni	810	980.153	+250	— 78	+ 15	+ 72	+ 61	+ 66	+ 51	+ 60	.397
49. Kasbek	1727	979.981	+535	—168	— 76	— 2	— 19	— 41	— 53	— 34	.404
50. Severnij Prijut	2257	.858	+696	—241	—149	— 70	— 87	—116	—115	—105	.405
51. Glola	1333	980.023	+412	—121	— 27	+ 46	+ 29	+ 17	+ 8	+ 19	.408
52. Lars	1131	.098	+349	— 98	— 6	+ 56	+ 41	+ 25	+ 20	+ 29	.415
53. St. Nikolaus Pass	1219	.059	+376	— 95	— 2	+ 67	+ 51	+ 36	+ 29	+ 39	.417
54. Petrowsk	—10	.363	— 3	+ 1	+ 92	+ 43	+ 45	+ 61	+ 52	+ 50	.434
55. Suchum	24	.392	+ 7	+ 2	+ 97	+ 51	+ 51	+ 51	+ 53	+ 54	.435

Number & Name of Station	h	g	1	2	3	4	5	6	7	8	γ_0
56. Wladikawkas	693	980.241	+213	− 72	+ 20	+ 43	+ 37	+ 37	+ 31	+ 37	980.438
57. Alagirsk	633	.232	+195	− 64	+ 29	+ 62	+ 55	+ 55	+ 52	+ 59	.439
58. Wladikawkas	679	.232	+209	− 72	+ 20	+ 39	+ 33	+ 37	+ 31	+ 37	.440
59. Grosny	140	.353	+ 43	− 14	+ 77	+ 50	+ 52	+ 67	+ 60	+ 62	.463
60. Kislowodsk	823	.293	+253	− 90	+ 4	+ 13	+ 5	+ 2	− 1	+ 10	.517
61. Pjatigorsk	488	.386	+151	− 56	+ 40	+ 25	+ 21	+ 37	+ 21	+ 25	.529
62. Toipse	29	.557	+ 9	0	+ 97	− 2	− 1	− 12	− 1	− 2	.534
63. Batalbaschinskoja	538	.415	+180	− 60	+ 36	+ 19	+ 14	+ 25	+ 14	+ 20	.547
64. Maïkop	248	.520	+ 77	− 26	+ 71	+ 6	+ 4	+ 3	+ 8	+ 10	.572
65. Noworossijsk	30	.663	+ 9	0	+ 99	− 14	− 13	− 29	− 18	− 19	.590
66. Anapa	17	.691	+ 5	− 1	+ 97	− 16	− 16	− 31	− 18	− 20	.608
67. Armawir	180	.576	+ 56	− 19	+ 77	+ 14	+ 14	+ 24	+ 17	+ 16	.616
68. Stawropol	587	477	+181	− 69	+ 26	− 26	− 28	− 25	− 28	− 27	.620
69. Jekaterinodar	34	.571	+ 10	− 3	+ 94	+ 4	+ 5	+ 3	+ 5	+ 4	.620
70. Kertsch	48	.583	+ 15	− 4	+ 95	− 10	− 10	− 21	− 11	− 12	.645
71. Tichoretzkaja	80	.694	+ 25	− 9	+ 90	+ 2	+ 2	+ 4	+ 5	+ 4	.693

II. The Stations in Europe

Number & Name of Station	h	g	1	2	3	4	5	6	γ_0
72. Duderstadt	174	981.177	+ 54	+ 8	+ 9	+ 5	+ 7	+ 11	981.201
73. Stolberg a. H.	293	.166	+ 90	− 5	− 3	− 7	− 6	− 3	.206
74. Walkenried..........	269	.176	+ 83	− 1	+ 1	− 4	− 2	+ 3	.207
75. Harzgerode..........	395	.158	+122	− 16	− 15	− 17	− 16	− 12	.212
76. Osterode	235	.191	+ 73	+ 1	+ 3	0	+ 1	+ 5	.219
77. St. Andreasberg	622	.133	+192	− 35	− 32	− 41	− 39	− 36	.219
78. Elbingerode	476	.148	+147	− 25	− 23	− 30	− 29	− 25	.223
79. Brocken	1140	.015	+352	− 88	− 85	− 93	− 93	− 90	.226
80. Scharfenstein	623	.130	+192	− 41	− 39	− 46	− 45	− 41	.229
81. Wegeleben	93	.221	+ 29	+ 7	+ 7	+ 8	+ 9	+ 9	.234
82. Goslar	264	981.191	+ 81	− 4	− 2	− 7	− 6	− 1	981.236
83. Schneekoppe	1605	980.776	+495	−110	−106	−118	−116	−109	.132
84. Alter Bruch	917	.930	+283	− 60	− 56	− 66	− 63	− 57	.134
85. Querseifen	728	.975	+225	− 37	− 33	− 46	− 43	− 37	.135
86. Giersdorf	785	.955	+242	− 40	− 37	− 45	− 43	− 36	.137
87. Stonsdorf	390	981.037	+120	− 5	− 3	− 9	− 6	0	.142
88. Cunersdorf	343	.050	+106	− 1	+ 1	− 6	− 3	+ 3	.145
89. Grunau	358	.062	+110	− 6	− 4	− 10	− 7	− 2	.149
90. Ludwigsdorf	608	.031	+188	− 39	− 37	− 44	− 41	− 35	.153
91. Wien	183	980.860	+ 56	+ 20	+ 19	+ 25	+ 24	+ 22	980.906
92. Wels	317	.796	+ 98	+ 35	+ 35	+ 42	+ 44	+ 45	.902
93. Traunstein	593	.667	+183	+ 26	+ 29	+ 23	+ 27	+ 30	.875
94. München	525	.733	+162	+ 17	+ 17	+ 23	+ 23	+ 21	.900
95. Hohenpeissenberg ..	996	.579	+307	− 11	− 8	− 8	− 6	− 2	.869
96. Augsburg	496	.775	+153	+ 8	+ 8	+ 14	+ 14	+ 12	.920
97. Konstanz	401	.715	+124	+ 31	+ 31	+ 38	+ 41	+ 42	.857
98. Ludwigshafen a. S. .	404	.744	+125	+ 28	+ 28	+ 34	+ 36	+ 36	.871
99. Waldshut	336	.768	+104	+ 30	+ 30	+ 37	+ 38	+ 37	.853
100. Freiburg i. B.	272	.847	+ 84	+ 28	+ 28	+ 32	+ 33	+ 34	.887
101. Lemberg	314	.911	+ 97	+ 4	+ 4	+ 4	+ 5	+ 6	981.051
102. Stryj	300	.885	+ 93	+ 14	+ 15	+ 17	+ 19	+ 21	.001
103. Munkács	123	.924	+ 38	+ 29	+ 28	+ 32	+ 34	+ 33	980.926
104. Karczag...........	91	.811	+ 28	+ 9	+ 8	+ 13	+ 11	+ 9	.824
105. Sadská	213	981.054	+ 66	+ 13	+ 12	+ 18	+ 19	+ 21	981.078
106. Nürnberg	312	980.942	+ 96	+ 14	+ 14	+ 15	+ 16	+ 16	.018
107. Karlsruhe	114	.967	+ 35	+ 22	+ 22	+ 30	+ 32	+ 28	980.978
108. Leipzig	115	981.180	+ 35	+ 8	+ 7	+ 12	+ 12	+ 11	981.185
109. Hohendodeleben	118	.277	+ 36	0	0	+ 3	+ 4	+ 2	.253
110. Ballstädt	275	.102	+ 85	+ 4	+ 5	+ 2	+ 4	+ 9	.159
111. Lüdenhausen	205	.242	+ 63	− 9	− 10	− 11	− 10	− 9	.250

Number & Name of Station	h	g	1	2	3	4	5	6	γ_0
112. Harsewinkel	65	981.244	+ 20	+ 4	+ 4	+ 7	+ 7	+ 7	981.241
113. Bonn	62	.122	+ 19	+ 16	+ 16	+ 16	+ 19	+ 20	.131
114. Madrid	656	979.981	+202	− 5	− 2	− 6	− 2	+ 5	980.202
115. Brindisi	16	980.337	+ 5	− 10	− 10	− 9	− 9	− 10	.222
116. Telfs	637	.538	+197	+ 80	+ 90	+ 59	+ 71	+ 97	.825
117. Steinach	1050	.418	+324	+ 50	+ 65	+ 17	+ 32	+ 61	.805
118. Spittal	538	.557	+166	+ 60	+ 69	+ 50	+ 55	+ 77	.779
119. Hohenmauthen	382	.650	+118	+ 29	+ 32	+ 27	+ 30	+ 36	.763

Table X

The Gravity Anomalies

I. The Stations in the Caucasus Mountains.

Number & Name of Station	φ	λ	h	1	2	3	4	5	6	7	8
48. Oni	42°35′	43°28′	810	+ 6	− 72	+ 21	+ 78	+ 67	+ 72	+ 57	+ 66
35. Duschet	42 05	44 41	846	− 19	−111	− 19	+ 20	+ 14	+ 33	+ 12	+ 19
39. Ananur	42 10	44 42	823	− 18	−104	− 11	+ 38	+ 30	+ 39	+ 31	+ 40
42. Passanur	42 21	44 41	1065	+ 14	− 94	− 1	+ 62	+ 50	+ 43	+ 40	+ 49
43. Mlety	42 26	44 31	1469	+ 59	− 85	+ 8	+ 73	+ 57	+ 49	+ 41	+ 51
51. Glola	42 42	43 39	1333	+ 27	− 94	0	+ 73	+ 56	+ 44	+ 35	+ 46
50. Severnij Prijut	42 40	43 50	2257	+149	− 92	0	+ 79	+ 62	+ 33	+ 34	+ 44
53. St. Nikolaus Pass	42 48	44 01	1219	+ 18	− 77	+ 15	+ 85	+ 69	+ 54	+ 47	+ 57
44. Gudaursk	42 28	44 29	2200	+149	− 81	+ 11	+ 84	+ 67	+ 39	+ 42	+ 51
45. Gudaursk	42 29	44 29	2247	+148	− 81	+ 12	+ 86	+ 69	+ 41	+ 44	+ 53
47. Kobi	42 34	44 31	1973	+124	− 79	+ 17	+ 89	+ 72	+ 53	+ 39	+ 48
49. Kasbek	42°40′	44°39′	1727	+112	− 56	+ 36	+110	+ 93	+ 71	+ 59	+ 78
52. Lars	42 47	44 38	1131	+ 32	− 66	+ 26	+ 88	+ 73	+ 57	+ 52	+ 61
Mean Value				+ 62	− 84	+ 9	+ 74	+ 60	+ 48	+ 41	+ 51
Average variation from Mean				58	12	12	16	14	10	8	10

II. The Stations in Armenia

Number & Name of Station	φ	λ	h	1	2	3	4	5	6	7	8
1. Lenkoran	38°46′	48°52′	−20	+ 31	+ 34	+123	+ 85	+ 89	+ 96	+ 95	+ 91
2. Dschulfa	38 57	45 37	720	− 16	− 90	+ 1	+ 73	+ 67	+ 82	+ 65	+ 72
3. Schachtachty	39 21	45 06	781	+ 1	− 82	+ 9	+ 84	+ 78	+101	+ 79	+ 86
4. Karmalinowka	39 30	45 48	1655	+ 53	−125	− 34	+ 56	+ 44	+ 35	+ 27	+ 35
5. Schuscha	39 45	46 44	1403	+162	+ 16	+106	+139	+134	+136	+131	+125
14. Jelenowka	40 33	44 58	1947	+111	−104	− 11	+ 75	+ 63	+ 55	+ 52	+ 58
21. Karaklis	40 50	44 29	1315	+ 42	− 95	− 4	+ 78	+ 68	+ 69	+ 58	+ 65
7. Eriwan	40 11	44 33	990	+ 4	−100	− 9	+ 69	+ 62	+ 87	+ 64	+ 70
8. Alagös	40 20	43 40	1255	+ 76	− 60	+ 32	+115	+109	+133	+109	+115
10. Sary-Kamysch	40 20	42 35	2177	+118	−124	− 30	+ 78	+ 64	+ 64	+ 40	+ 54
20. Aleksandropol	40 47	43 50	1519	+ 19	−153	− 59	+ 27	+ 17	+ 23	+ 6	+ 13
15. Kars	40 37	43 06	1750	+ 64	−130	− 37	+ 56	+ 46	+ 55	+ 33	+ 45
22. Ardagan	41 07	42 42	1846	+ 62	−145	− 51	+ 39	+ 26	+ 12	+ 9	+ 17
26. Achalkalaki	41 25	43 29	1717	+ 80	−106	− 16	+ 67	+ 57	+ 49	+ 41	+ 48
27. Achalzich	41 38	43 00	1014	+ 22	− 87	+ 6	+ 74	+ 64	+ 68	+ 60	+ 67
31. Sekar-Pass	41 49	42 52	2008	+154	− 65	+ 29	+ 82	+ 74	+ 86	+ 64	+ 66
24. (Artwin)	41 11	41 50	182	− 61	(− 60)	(+ 35)	(+ 80)	(+ 73)	(+ 73)	(+ 68)	(+ 75)
Mean Value				+ 54	− 87	+ 5	+ 75	+ 67	+ 72	+ 59	+ 65
Average variation from Mean				46	36	36	16	19	26	24	22

III. The Stations between the high mountains of the Caucasus and Armenia.

Number & Name of Station	φ	λ	h	1	2	3	4	5	6	7	8
17. Schemacha	40°38′	48°39′	715	− 5	− 80	+ 9	− 7	− 9	− 27	− 17	− 15
16. Jewlach	40 37	47 08	14	− 39	− 41	+ 50	+ 28	+ 34	+ 67	+ 48	+ 44

Number & Name of Station	φ	λ	h	1	2	3		5	6	7	8
19. Jelisawetpol	40°44′	46°22′	344	— 5	— 43	+ 50	+ 60	+ 59	+ 85	+ 74	+ 74
18. Jelisawetpol	40 41	46 21	427	— 6	— 53	+ 38	+ 54	+ 54	+ 75	+ 64	+ 64
23. Akstafa	41 07	45 26	332	+ 9	— 26	+ 63	+ 88	+ 89	+125	+104	+105
29. Tiflis	41 42	44 48	471	+ 14	— 37	+ 55	+ 81	+ 79	+116	+ 89	+ 90
30. Tiflis, Phys. Obs.	41 43	44 48	401	— 18	— 61	+ 32	+ 57	+ 55	+ 94	+ 65	+ 66
32. Gori	41 59	44 07	578	— 45	—105	— 13	+ 31	+ 27	+ 48	+ 32	+ 36
33. Michailowa..........	42 01	43 31	708	— 21	— 95	— 1	+ 37	+ 35	+ 52	+ 40	+ 45
41. Darkweti...........	42 19	43 21	376	— 35	— 67	+ 26	+ 65	+ 59	+ 87	+ 65	+ 72
46. Alpani	42 34	42 52	375	— 48	— 80	+ 14	+ 48	+ 41	+ 56	+ 38	+ 44
40. Kutais	42 15	42 44	157	— 45	— 61	+ 33	+ 38	+ 38	+ 74	+ 53	+ 55
Mean Value				— 20	— 62	+ 30	+ 48	+ 47	+ 71	+ 55	+ 57
Average variation from Mean				18	19	19	19	19	26	22	22

IV. The stations on the north side of the Caucasus.

Number & Name of Station	φ	λ	h	1	2	3		5	6	7	8
59. Grosny	43°19′	45°44′	140	— 67	— 81	+ 10	— 17	— 15	0	— 7	— 5
56. Wladikawkas........	43 02	44 42	693	+ 16	— 56	+ 36	+ 59	+ 53	+ 53	+ 47	+ 53
58. Wladikawkas........	43 03	44 42	679	+ 1	— 71	+ 21	+ 40	+ 34	+ 38	+ 32	+ 38
57. Alagirsk	43 03	44 11	633	— 12	— 76	+ 17	+ 50	+ 43	+ 43	+ 40	+ 47
61. Pjatigorsk...........	44 03	43 03	488	+ 8	— 48	+ 48	+ 33	+ 29	+ 45	+ 29	+ 33
60. Kislowodsk	43 55	42 41	823	+ 29	— 59	+ 33	+ 42	+ 34	+ 31	+ 28	+ 39
63. Batalbaschinskaja....	44 14	42 02	538	+ 48	— 12	+ 84	+ 67	+ 62	+ 73	+ 62	+ 68
68. Stawropol	45 02	41 59	587	+ 38	— 31	+ 64	+ 12	+ 10	+ 13	+ 10	+ 11
67. Armawir	45 00	41 08	180	+ 16	— 3	+ 93	+ 30	+ 30	+ 40	+ 33	+ 32
64. Maïkop	44 31	40 05	248	+ 25	— 1	+ 96	+ 31	+ 29	+ 28	+ 33	+ 35
69. Jekaterinodar	45 03	38 57	34	— 39	— 42	+ 55	— 35	— 34	— 36	— 34	— 35
71. Tichoretzkaja........	45 51	40 08	80	+ 26	+ 17	+116	+ 28	+ 28	+ 30	+ 31	+ 30
Mean Value				+ 7	— 39	+ 56	+ 28	+ 25	+ 30	+ 25	+ 29
Average variation from Mean				25	27	29	21	19	19	18	19

V. The stations on the Caspian Sea.

Number & Name of Station	φ	λ	h	1	2	3		5	6	7	8
6. Alat	39°59′	49°24′	—11	—103	—102	— 14	— 77	— 73	— 76	— 70	— 74
11. Baku	40 22	49 50	7	—114	—115	— 26	— 95	— 92	— 96	— 88	— 92
12. Surachany	40 26	50 00	57	—121	—130	— 38	—110	—106	—109	—103	—107
13. Baladschary	40 26	49 48	48	—120	—122	— 34	—102	— 97	—103	— 96	— 99
9. Shiloi Ostrow	40 20	50 37	—16	—126	—124	— 35	—121	—118	—117	—118	—121
25. Diwitschi	41 14	48 59	10	— 91	— 90	— 1	— 47	— 46	— 46	— 46	— 46
34. Derbent.............	42 03	48 19	—26	— 77	— 73	+ 19	— 25	— 24	— 11	— 16	— 19
54. Petrowsk	42 59	47 30	—10	— 74	— 73	+ 18	— 31	— 29	— 13	— 22	— 24
Mean Value				—103	—103	— 14	— 76	— 73	— 71	— 70	— 73
Average variation from Mean				17	19	19	31	30	36	31	32

VI. The Stations on the Black Sea.

Number & Name of Station	φ	λ	h	1	2	3		5	6	7	8
28. Batum	41°41′	38°03′	3	+ 36	+ 41	+135	+112	+113	+134	+126	+124
37. Poti	42 08	41 42	3	— 39	— 36	+ 56	+ 8	+ 14	+ 46	+ 28	+ 23
36. Landschhuty	42 06	42 02	14	— 47	— 46	+ 48	+ 29	+ 32	+ 64	+ 47	+ 44
38. Samtredi...........	42 10	42 20	22	— 48	— 48	+ 46	+ 39	+ 41	+ 79	+ 57	+ 57
55. Suchum	43 00	41 01	24	— 36	— 34	+ 62	+ 15	+ 15	+ 15	+ 17	+ 18
62. Toipse	44 06	39 04	29	+ 32	+ 32	+129	+ 30	+ 31	+ 20	+ 31	+ 30
65. Noworossijskaja	44 43	37 45	30	+ 82	+ 82	+181	+ 68	+ 69	+ 53	+ 64	+ 63
66. Anapa	44 54	37 18	17	+ 88	+ 87	+185	+ 72	+ 72	+ 57	+ 70	+ 68
70. Kertsch	45 19	36 30	48	— 47	— 51	+ 48	— 57	— 57	— 68	— 58	— 59
Mean value				+ 2	+ 3	+ 99	+ 35	+ 36	+ 44	+ 42	+ 41
Average variation from Mean				50	51	52	33	32	37	34	34

VII. The Stations in the Harz.

Number & Name of Station	φ	λ	h	1	2	3		5	6	7	8
72. Duderstadt	51°31′	10°15′	174	+ 30	+ 12	+ 38	+ 39	+ 35	+ 37	+ 41	+ 18
73. Stolberg a. H.	51 34	10 57	293	+ 50	+ 19	+ 45	+ 47	+ 43	+ 44	+ 47	+ 38
74. Walkenried	51 35	10 38	269	+ 52	+ 23	+ 51	+ 53	+ 48	+ 50	+ 55	+ 33

Number & Name of Station	φ	λ	h	1	2	3	4	5	6	7	8
75. Harzgerode	51°39′	11°09′	395	+ 68	+ 22	+ 52	+ 53	+ 51	+ 52	+ 56	+ 36
76. Osterode	51 43	10 15	235	+ 45	+ 21	+ 46	+ 48	+ 45	+ 46	+ 50	+ 27
77. St. Andreasberg	51 43	10 29	622	+106	+ 37	+ 71	+ 74	+ 65	+ 67	+ 70	+ 48
78. Elbingerode	51 46	10 48	476	+ 72	+ 20	+ 47	+ 49	+ 42	+ 43	+ 47	+ 31
79. Brocken	51 48	10 37	1140	+141	+ 28	+ 53	+ 56	+ 48	+ 48	+ 51	+ 35
80. Scharfenstein	51 50	10 36	623	+ 93	+ 26	+ 52	+ 54	+ 47	+ 48	+ 52	+ 30
81. Wegeleben	51 53	11 10	93	+ 16	+ 6	+ 23	+ 23	+ 24	+ 25	+ 25	+ 13
82. Goslar	51 55	10 25	264	+ 36	+ 17	+ 32	+ 34	+ 29	+ 30	+ 35	+ 16
Mean Value				+ 64	+ 21	+ 46	+ 48	+ 43	+ 45	+ 48	+ 30
Average variation from Mean				29	6	9	9	8	8	8	8

VIII. The Stations in the Riesengebirge

Number & Name of Station	φ	λ	h	1	2	3	4	5	6	7
83. Schneekoppe	50°44′	15°45′	1605	+139	− 21	+ 29	+ 33	+ 21	+ 23	+ 30
84. Alter Bruch	50 46	15 45	917	+ 79	− 16	+ 19	+ 23	+ 13	+ 16	+ 22
85. Querseifen	50 47	15 45	728	+ 65	− 11	+ 28	+ 32	+ 19	+ 22	+ 28
86. Giersdorf	50 48	15 44	785	+ 60	− 18	+ 20	+ 23	+ 15	+ 17	+ 24
87. Stonsdorf	50 51	15 44	390	+ 15	− 27	+ 10	+ 12	+ 6	+ 9	+ 15
88. Cunersdorf	50 53	15 44	343	+ 11	− 27	+ 10	+ 12	+ 5	+ 8	+ 14
89. Grunau	50 56	15 45	358	+ 23	− 11	+ 17	+ 19	+ 13	+ 16	+ 21
90. Ludwigsdorf	50 59	15 46	608	+ 66	− 02	+ 27	+ 29	+ 22	+ 25	+ 31
Mean Value				+ 57	− 17	+ 20	+ 23	+ 14	+ 17	+ 23
Average variation from Mean				31	7	6	6	5	5	5

IX. The Stations in the Marginal Depression of the Alps.

Number & Name of Station	φ	λ	h	1	2	3	4	5	6	7	8
91. Vienna	48°13′	16°22′	183	+ 10	− 9	+ 30	+ 25	+ 35	+ 34	+ 32	+ 31
92. Wels	48 10	14 02	317	− 8	− 40	+ 27	+ 27	+ 34	+ 36	+ 37	+ 30
93. Traunstein	47 52	12 39	593	− 25	− 82	+ 1	+ 4	− 2	+ 2	+ 5	+ 10
94. Munich	48 09	11 37	525	− 5	− 52	+ 12	+ 12	+ 18	+ 18	+ 16	+ 23
95. Hohenpeissenberg	47 48	11 01	996	+ 17	− 73	+ 6	+ 9	+ 9	+ 11	+ 15	+ 17
96. Augsburg	48 22	10 54	496	+ 8	− 37	+ 16	+ 16	+ 22	+ 22	+ 20	+ 26
97. Konstanz	47 40	9 10	401	− 18	− 60	+ 13	+ 13	+ 20	+ 23	+ 24	+ 16
98. Ludwigshafen a. S.	47 49	9 04	404	− 2	− 43	+ 26	+ 26	+ 32	+ 34	+ 34	+ 29
99. Waldshut	47 37	8 13	336	+ 19	− 14	+ 49	+ 49	+ 56	+ 57	+ 56	+ 51
100. Freiburg i. B.	48 00	7 51	272	+ 44	+ 19	+ 72	+ 72	+ 76	+ 77	+ 78	+ 75
Mean Value				+ 4	− 39	+ 25	+ 26	+ 30	+ 31	+ 32	+ 31
Average variation from Mean				16	23	16	15	17	16	16	13

X. Other stations reduced by me in Europe.

Number & Name of Station	φ	λ	h	1	2	3	4	5	6	7
101. Lemberg	49°50′	24°00′	314	− 43	− 76	− 39	− 39	− 39	− 38	− 37
102. Stryj	49 16	23 51	300	− 23	− 55	− 9	− 8	− 6	− 4	− 2
103. Munkács	48 26	22 43	123	+ 36	+ 23	+ 65	+ 64	+ 68	+ 70	+ 69
104. Karczag	47 18	20 56	91	+ 15	+ 7	+ 24	+ 23	+ 28	+ 26	+ 24
105. Sadská	50 08	14 59	213	+ 42	+ 21	+ 55	+ 54	+ 60	+ 61	+ 63
106. Nürnberg	49 27	11 05	312	+ 20	− 11	+ 34	+ 34	+ 35	+ 36	+ 36
107. Karlsruhe	49 01	8 25	114	+ 24	+ 14	+ 46	+ 46	+ 54	+ 56	+ 52
108. Leipzig	51 20	12 24	115	+ 30	+ 20	+ 38	+ 37	+ 42	+ 42	+ 41
109. Hohendodeleben	52 06	11 30	118	+ 60	+ 48	+ 60	+ 60	+ 63	+ 64	+ 62
110. Ballstädt	51 03	10 43	275	+ 28	− 1	+ 32	+ 33	+ 30	+ 32	+ 37
111. Lüdenhausen	52 04	9 00	205	+ 55	+ 34	+ 46	+ 45	+ 44	+ 45	+ 46
112. Harsewinkel	51 58	8 14	65	+ 23	+ 17	+ 27	+ 27	+ 30	+ 30	+ 30
113. Bonn	50 44	7 06	62	+ 10	+ 5	+ 26	+ 26	+ 26	+ 29	+ 30
114. Madrid	40 25	−3 41	656	− 19	− 90	− 24	− 21	− 25	− 21	− 14
115. Brindisi	40 38	17 57	16	+120	+118	+110	+110	+111	+111	+110
116. Telfs	47 19	11 04	637	− 90	−134	− 11	0	− 31	− 19	+ 7
117. Steinach	47 05	11 28	1050	− 63	−162	− 13	+ 2	− 46	− 31	− 2

Number & Name of Station	φ	λ	h	1	2	3	4	5	6	7
118. Spittal	46°48′	13°30′	538	— 56	—104	+ 4	+ 13	— 6	— 1	+ 22
119. Hohenmauthen	46 37	15 10	382	+ 5	— 34	+ 34	+ 37	+ 32	+ 35	+ 41
Mean value				+ 9	— 18	+ 27	+ 29	+ 24	+ 28	+ 32
Average variation from Mean				37	57	27	25	32	29	25

XI. The Stations in the Alps. 1) 2).

Number & Name of Station	φ	λ	h	1	2	3	4	5	6	7
1. Naye	46°26′	6°59′	1987	+100	— 93	+ 26	+ 36	+ 5	+ 14	+ 31
2. Villeneuve	46 24	6 56	376	— 54	— 84	+ 19	+ 26	+ 5	+ 14	+ 29
3. Chaumont	47 01	6 57	1018	+ 69	— 38	+ 44	+ 49	+ 28	+ 40	+ 48
4. Neuenburg	47 00	6 57	487	+ 6	— 46	+ 32	+ 36	+ 28	+ 32	+ 40
5. Gornergrat	45 59	7 47	3016	+218	—109	+ 53	+ 73	+ 2	+ 15	+ 45
6. Riffelberg	45 00	7 45	2566	+177	—106	+ 55	+ 74	+ 3	+ 16	+ 46
7. Zermatt	46 02	7 45	1606	+ 39	—107	+ 44	+ 63	— 5	+ 9	+ 42
8. Belalp	46 23	8 00	2132	+ 89	—127	+ 10	+ 25	— 31	— 19	+ 8
9. Brig	46 20	8 00	683	— 89	—134	— 4	+ 10	— 39	— 26	+ 1
10. Eggishorn	46 25	8 07	2187	+ 99	—123	+ 13	+ 28	— 27	— 14	+ 11
Mean Value				+ 65	— 97	+ 29	+ 42	— 3	+ 8	+ 30
Average variation from Mean				72	25	16	18	18	17	14
11. Fiesch	46 24	8 08	1049	— 43	—131	0				
12. St. Maurice	46 13	7 00	422	— 78	—109	+ 7				
13. Sitten	46 14	7 22	514	— 89	—130	— 7				
14. Visp	46 18	7 53	649	— 92	—137	— 2				
15. Iselle	46 13	8 12	630	—101	—124	+ 4				
16. Gsteig	46 23	7 16	1185	+ 20	— 96	+ 21				
17. Simplon	46 15	8 02	1998	+ 90	—131	+ 14				
18. Grand St. Bernard	45 52	7 10	2473	+141	—136	+ 10				
19. Sanetsch	46°19′	7 17	2041	+105	—112	+ 20				
20. Chanrion	45 56	7 23	2435	+158	—112	+ 45				
21. Schwarzsee	46 00	7 43	2582	+182	—104	+ 57				
22. Franzenhöhe	46 32	10 29	2188	+ 73	—128	— 14	+ 3	— 58	— 47	— 17
23. Stilfserjoch	46 32	10 27	2760	+142	—127	— 10	+ 7	— 54	— 42	— 13
*24. Telfs	47 19	11 04	637	— 90	—134	— 10	+ 1	— 31	— 19	+ 7
*25. Steinach	47 05	11 28	1050	— 63	—162	— 13	— 2	— 46	— 31	— 2
*26. Spittal	46 48	13 30	538	— 56	—104	+ 4	+ 13	— 6	— 1	+ 22
*27. Hohenmauthen	47 37	15 10	382	— 5	— 34	+ 34	+ 37	+ 32	+ 35	+ 41
Mean Value				+ 18	—118	+ 9				
Average variation from Mean				90	19	17				

XII. The Stations in Italy

Number & Name of Station	φ	λ	h	1	2	3
24. Genoa	44°29′	8°55′	98	+ 18	+ 10	+ 48
25. Arcetri	43 45	11 15	184	+ 44	+ 27	+ 69
26. Livorno	43 32	10 19	6	+ 53	+ 53	+ 72
27. Arezzo	43 28	11 56	359	+ 65	+ 51	+ 83
28. Siena	43 19	11 22	335	+ 66	+ 45	+ 72
29. Cortona	43 17	12 02	650	+ 89	+ 39	+ 72
30. Perugia	43 07	12 26	488	+ 80	+ 47	+ 82
31. Foligno	42 57	12 45	236	+ 42	+ 39	+ 76
32. Spoleto	42 44	12 47	410	+ 62	+ 39	+ 73
33. Terni	42 33	12 41	121	+ 43	+ 51	+ 84
34. Civita Castell	42 17	12 27	148	+ 56	+ 53	+ 76
35. Rome	41 54	12 30	49	+ 47	+ 43	+ 60
*36. Brindisi	40 38	17 57	16	+120	+118	+110
37. Lipari	38 28	14 57	2	+133	+134	+ 91
Mean Value				+ 66	+ 54	+ 88
Average variation from Mean				23	21	15

1) The groups XI, XII, XIII and XIV have been previously isostically reduced on the Hayford theory.

2) The stations marked * were reduced by me.

XIII. The stations on Spitzbergen

Number & Name of Station		φ	λ	h	1	2	3
38.	Hornsund	76°56'	15°57'	5	- 6	- 2	-26
39.	Whales Point ...	77 30	20 59	458	+67	+19	+13
40.	Whales Head	77 31	18 49	340	+23	-13	- 9
41.	Förväxlingsudden	78 30	20 17	198	+36	+15	+14
42.	Hellwald	78 44	20 50	660	+59	-10	- 2
43.	Kingsbay	78 57	11 51	2	+34	+34	+ 4
44.	Svarta berget ..	79 29	20 01	154	+21	+ 3	- 1
45.	Ile de Foott ...	79 32	17 55	15	+16	+14	+ 8
46.	Observ. de Sabine	79 50	11 33	4	+58	+57	+18
47.	Treurenberg bay.	79 55	16 51	22	+16	+13	-14
48.	Ile de Rosse ...	80 50	20 21	31	+71	+68	+31
Mean Value					+36	+17	+ 3
Average variation from Mean					20	19	12

XIV. The Stations in Norway

49.	Sörvaagen	67°54'	13°02'	19	+150	+148	+134

1) I have applied a small correction of -0.001 up to 0.002 cm/sec^2 to the anomalies computed by Bonsdorff, to convert his values, computed for depth of compensation 120 Km., to values for depth 113.7 Km.

First of all we will consider the Caucasian group V, which contains 8 stations situated on the Caspian sea. At all these stations the observed value of gravity is far less than the theoretical values obtained by the different methods of reduction, and hence it is an area where gravity is in defect.

We meet the largest negative gravity anomalies at Shiloi Ostrow and Baku, anomalies as great as -0.120 cm/sec^2.[1] The area of defect extends from these stations in all directions. To the south, this area of defect suddenly terminates between the station Alat, where the negative anomaly is -0.077 cm/sec^2, and the station Lenkoran, where the anomaly turns to the positive value + 0.085 cm/sec^2., although it is only 130 Km. south of Alat. To the east, the area of gravity defect does not extend as far as the eastern shore of the Caspian Sea, for at Shiloi Ostrow we already come across the positive anomaly + 0.055 cm/sec^2, as will be seen from the list on page (1). To the north, the anomaly at Petrovsk is negative, viz. -0.031, but at Astrakhan, it has already changed to the positive value +0.048 cm/sec^2.

1) These anomalies refer to the first Hayford reduction. Depth of Compensation 113.7 Km.

Small negative anomalies are also met with W. of Shiloi Ostrow and Baku at some stations inland, such as Schemacha -0.007, and Grosny (to the north of the Caucasus) -0.017 cm/sec^2.

Since the gravity anomalies show that the area of mass defect on the Caspian is a local peculiarity and that is very limited in extent, this area will not be included in the detailed discussion.

Large positive anomalies are met with at Schuscha +0.139, at Alagos +0.115, at Kasbek +0.110, and at Batum + 0.112 cm/sec^2. Of these stations the first two are in the Armenian mountains, the third in the Caucasus, near the mountain of the same name, and the fourth on the Black sea.

The large negative anomaly of -0.057 cm/sec^2 at Kertsch, in the Crimea, is not characteristic but rather exceptional, because at other stations of the Crimea the anomalies are always positive. In the same way, the anomaly of -0.035 cm/sec^2 at Jekatirinodar must be considered as an exception.

The average gravity anomalies in the Caucasus are computed in the following groups :- In group 1 the 13 stations in the Caucasus range; Group II, the 17 stations in Armenia; Group III, the 12 stations between the high ranges of the Caucasus and Armenia; Group IV, the 12 stations on the north side of the Caucasus; and Group VI, the 9 stations on the Black sea.

In the order of these groups, the average gravity anomalies are as follows:-

By the Free Air reduction:- +0.062, +0.054, -0.020, + 0.007 and +0.002 cm/sec^2.

By the Bouguer reduction:- -0.084, -0.087, -0.062 -0.039 and +0.003 cm/sec^2.

By the Purely Topographic reduction:- +0.009, +0.005, +0.030, +0.056 and +0.099 cm/sec^2.

By Hayford's topo-isostatic reduction (with depth of compensation 113.7 Km.) +0.074, +0.075, +0.048, +0.028 and +0.035 cm/sec^2.

By Hayford's topographic isostatic reduction (with depth of compensation 166.3 Km.) +0.060, +0.067, +0.047, +0.025 and +0.036 cm/sec^2.

By the Hayford topo-isostatic reduction (with depth of compensation 184.6 Km.) +0.052, +0.061, +0.044, +0.023, and +0.037 cm/sec^2.[1)]

By the regional topo-isostatic reduction (with a regional compensation extending to a radius of 166.7 Km. round each station) +0.048, +0.072, +0.071, +0.030 and +0.044 cm/sec^2.

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1) The anomalies corresponding to this reduction have not been given in table X, as table X had already been printed before the calculations necessary for this reduction were completed.

By Airy's topo-isostatic reduction on my first assumption + 0.041, + 0.059, + 0.055, + 0.025 and + 0.042 cm/sec².

By Airy's topo-isostatic reduction on my second assumption + 0.051, + 0.065, + 0.057, + 0.029 and + 0.041 cm/sec².

The total averages of all 63 anomalies by all 9 methods of reduction in the above order are:- + 0.026 − 0.060, + 0.033, + 0.053, + 0.049, + 0.045, + 0.055, + 0.045 and + 0.050 cm/sec², and the average variations of single anomalies from these mean values amount to : 0.046, 0.031, 0.037, 0.027, 0.024, 0.023, 0.026, 0.022 and 0.022 cm/sec².

Since the mountain stations give more discordant values for the anomalies by each method of reduction than stations of lower altitude, there seems good reason to examine to what extent the anomalies can be expressed as linear functions of the heights of the stations of observation. If we determine the linear relation which exists between the anomalies and the heights of the stations, we obtain the following expressions for the anomalies "A" by the 9 different methods of reduction in the order of sequence previously followed:-

1. $A = -0.024 + 0.000062 \times H$ (cm/sec².)
   $\pm 8 \qquad \pm 7$
2. $A = -0.026 - 0.000042 \times H$
   $\pm 8 \qquad \pm 7$
3. $A = +0.065 - 0.000040 \times H$
   $\pm 8 \qquad \pm 8$
4. $A = +0.037 + 0.000023 \times H$
   $\pm 7 \qquad \pm 6$

5. A $+0.037 + 0.000015 \times H$ (cm/sec^2)
$\pm 7 \qquad \pm 6$
6. A $+0.037 + 0.000010 \times H$
$\pm 7 \qquad \pm 6$
7. A $+0.055 - 0.000001 \times H$
$\pm 7 \qquad \pm 7$
8. A $+0.045 + 0.000000 \times H$
$\pm 7 \qquad \pm 6$
9. A $+0.046 + 0.000005 \times H$
$\pm 7 \qquad \pm 6$

H denotes height, at which the observation was taken in metres.

By the first three methods of reduction (viz. the Free Air, the Bouguer and the Purely Topographic reduction), the variation in the mean of each group of anomalies is much smaller; the average variation of single anomalies from the mean is much larger; and the linear relation between the anomalies and the height of observation more marked, than by the methods of reduction which take subterranean compensation into account.

<u>All this goes to prove that reductions, that are not based on the assumption of isostatic compensation, do not correspond with the gravity distribution in the Caucasus</u>.

The Bouguer and the Purely Topographic reductions give entirely different mean anomalies in the various groups, but show the same general trend dependent on altitude ($-0.000042 \times H$ and $-0.000040 \times H$ cm/sec^2 respectively). This is due to the fact that the latter method of reduction takes into account the curvature of the earth, which is neglected in the former, and also allows for the topography of the more distant zones. This has the effect of altering the anomalies of all stations in any limited area in the same direction, and hence the difference between anomalies remains practically unchanged.

Of the Topo-isostatic reductions all three of the Hayford reductions give the same absolute term +0.037 cm/sec^2, but a smaller value for the term dependent on the height of observation in proportion as the depth of compensation is increased. For instance, for a depth of compensation of 113.7Km- we get the corresponding term +0.000023 x H; for a depth of compensation of 156.3, the corresponding term +0.000015 x H; and for a depth of compensation of 184.6 Km., the corresponding term +0.000010 x H cm/sec^2. The mean values of the groups corresponding to a depth of compensation of 184.6 Km. (viz. + 0.052 +0.061 + 0.044 +0.023 and+0.037 cm/sec^2) show better accordance "inter se" than those corresponding to a depth of compensation of 156.3 Km. (viz. +0.060 + 0.067, +0.047, +0.025 and + 0.036 cm/sec^2), and a still better agreement than the values corresponding to a depth of compensation of 113.7 Km. (viz. +0.074, +0.075, +0.049, +0.028 and+0.035 cm/sec^2). Also the average variation of single anomalies from their mean is smallest for a depth of compensation of 184.6 Km.

(viz. 0.023) and largest for a depth of compensation of 113.7 Km. (viz. 0.027 cm/sec^2.). The reduction for a depth of compensation of 184.6 Km. shows a better agreement with the gravity distribution in the Caucasus than any of the other Hayford reductions. An exterpolation from these three Hayford reductions shows that a depth of compensation of about 250 Km. would reduce the term dependent on the height of observation to zero.

According to the Regional Topo-isostatic reduction, the term dependent on the height of observation entirely disappears, and the mean anomalies of the groups agree as well "inter se" as on the second assumption of Hayford, and their average variation from the mean is also quite as small.

The two reductions on the Airy theory gave a somewhat better agreement with the actual observations than any other methods, for the mean values of the groups (viz. +0.041, +0.059, +0.055, +0.025, +0.042 and +0.051, +0.065, +0.057, +0.029, +0.041 cm/sec^2 respectively), agree better "inter se". The average variation of single anomalies from the mean also is smaller (viz. 0.022), than those obtained by the other methods of reduction, and the term dependent on the height of observation disappears entirely in the case of the first assumption and almost entirely in the case of the second. Of the two reductions on the Airy theory, the first seems to correspond better with the distribution of gravity than the second.

Since the average heights in the Caucasus and America are mainly between 0 and 2000 m, the thickness of the earth's crust is between 77 - 104 Km. on my first assumption for the Airy theory.

From the result of my discussion it follows that:-

1. In order to explain the course of gravity in the Caucasus, we must consider isostatic compensation in some form or other.

2. Of the Topo-isostatic reductions the Airy reduction on the assump-tion of the earth's crust having a thickness of 77 - 104 Km. agrees best with the observed facts.

3. If we try to explain the observed facts on the Hayford theory, in order to get an equally good agreement, we are compelled either to adopt a depth of compensation of 250 Km., or to assume that compensation in the Caucasus is regional.

4. The Apspheron peninsula on the Caspian sea and the surrounding country is an area of mass defect. Of the European stations the following have been reduced by me:-

9 stations in the Harz mountains, 6 in the Riesengebirge, 6 in Austria, 2 in Hungary, 2 in Galicia, 6 in Bavaria, 1 in Bohemia, 1 in Italy, 1 in Spain and 8 in different parts of Germany.

In addition, from the work of W. Bowie,[1] I had at my disposal the results of 21 topo-isostatically reduced stations in Switzerland, 2 in Arabia, 2 in the Harz mountains, 2 in the Riesen-

1) W. Bowie, Investigations ...p 59.

-gebirge, 1 in Norway. Also in a treatise by Reina and Cassini,[1] I found the results of topo-isostatically reduced stations in Italy and from A.N.[2] one station Lipari. I moreover availed myself of the results of a further 11 stations in Spitzbergen, topo-isostatically reduced by Bonsdorff.[3]

The first European group in table X comprises a table of altogether 11 stations in the Harz mountains. The Harz was very thoroughly investigated, because a common impression exists that it is not isostatically compensated, though no one had given yet a definite proof, whether this were really the case.[4]

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1) V. Reina and G. Cassini, Astronomical latitude and gravity determinations in Umbria and Tuscany 1913-15.

2) O. Meissner, Isostatic reduction of 34 stations carried out in the geodetic institute by Hübner and O. Meissner A.N.B. 207 No. 4967.

3) Ilmari Bonsdorff, Isostatic reductions of the direction of the vertical and intensity of gravity, measure of an arc at Spitzberg, Russian mission, 1 Part IV, B, 1916.

4) E.R. Helmert, gravity and distribution of mass on the earth.Enc. of Math. Wissensch; Vol. VI I B Part 2 p. 152, 1910.

These 11 stations are regularly distributed over the whole Harz.

The Bouguer reduction gives a mean anomaly of + 0.021 cm/sec^2, whilst the Hayford reduction, for a depth of compensation of 113.7 Km. and 85.3 Km., gives values of + 0.046 and + 0.048 cm/se respectively.

Reductions according to Airy reductions on my first, second and fourth assumptions gave values + 0.043, + 0.045 and + 0.048 cm/sec^2 respectively. These figures do not indicate much, because we do not know how great the normal value of gravity is, in this region. Also the Bouguer reduction cannot be used, if we wish to investigate whether the Harz is isostatically compensated or not, because the Bouguer reduction does not take the compensation of the more distant zones into account (e.g. the Alps, which lie in compensated regions).

In order to show whether the Harz is compensated or not, it is necessary to apply the Hayford or the Airy reduction and treat the Harz region as uncompensated, and compare the latter anomalies with those on the Hayford or Airy theories. This was done, and the last column (8) derived the average value of which gives + 0.030 cm/sec^2.

The average variation of the 11 anomalies from their mean values on the Hayford reduction is 0.009, on all the Airy reductions 0.008, and in the case, where the Harz is treated as uncompensated, also 0.008 cm/sec^2.

Whether the Harz is treated as compensated or uncompensated, the anomalies follow a course, which depends on the height of the station of observation. The anomalies A on the Hayford theory (depth of compensation 113.7 Km.) can be represented by the formula:-

$$A = +\underset{\pm 6}{0.036} + \underset{\pm 12}{0.000025} \times H \text{ cm/sec}^2$$

The anomalies in the case where Harz is taken as uncompensated, by the formula:-

$$A = +\underset{\pm 4}{0.021} + \underset{\pm 9}{0.000019} \times H \text{ cm/sec}^2$$

and the anomalies on the fourth assumption for the Airy theory, by the formula:-

$$A = +\underset{\pm 5}{0.040} + \underset{\pm 9}{0.000019} \times H \text{ cm/sec}^2$$

where H is the height of observation in metres.

I have only taken into account one Hayford reduction and one Airy reduction for the deduction of the above formulae as Table X shows that the Hayford and all three of the assumptions for the Airy theory give almost the same results.

In order to investigate the distribution of gravity in a wider area around the Harz, I reduced the stations Leipzig, Ballstädt, Harsewinkel, Lüdenhausen and Hohendodeleben. The anomalies at these stations, in order, according to the first reduction on the Hayford theory, are +0.038, +0.032, +0.027, +0.046 and +0.060 cm/sec^2 and on the 4th assumption on the Airy theory, they are +0.041, +0.037, +0.030, +0.046 and +0.062 cm/sec^2. The mean value of these anomalies is +0.040 and +0.043 cm/sec^2. The corresponding mean anomaly at the stations in the Harz is, on the first Hayford reduction, +0.046, and on the fourth Airy reduction +0.048, and on the Isostatic reduction, in which the Harz is treated as uncompensated, +0.030 cm/sec^2. The average anomalies in the Harz and the surrounding area show as good agreement, whether we regard it as having subterranean compensation, or treat it as uncompensated. The variation of the anomalies from the mean anomaly is somewhat less on the assumption that the Harz is uncompensated than on the Hayford reduction. But the difference is so small, that it is impossible to maintain that gravity observations <u>compel</u> us to assume that the Harz is uncompensated, and the Airy assumption agrees just as well with the observed values as the assumption that the Harz is uncompensated. <u>We thus arrive at the result that the distribution of gravity in the Harz is in regular agreement with isostatic reduction and that the Harz forms no exception to the universal principles of isostasy</u>.

It is quite another matter if, from other data such as geological results, a definite conclusion is arrived at, that the Harz is an uncompensated area. The gravity results in no way support such an assumption.

The 8 stations in the Riesegebirge which form the second European group show unconditionally, that these mountains are fully compensated. Hence the statement that the Reisengebirge are only partly compensated[1] is beside the point.

The anomalies on the Hayford reductions are + 0.020, + 0.023 and those on the Airy reductions + 0.014, + 0.017, + 0.023 cm/sec^2. If we remember that as near as in Leipzig, the Hayford anomaly is + 0.038, and in Sadska in Bohemia, the anomaly is + 0.055 cm/sec^2, it is clear that the value of gravity in the Riesengebrige is rather too small than too large, and that, in this area, overcompensation, rather than undercompensation holds sway. Then come the stations in the marginal depression[2] of the Alps. Geologists maintain that mountain chains are not compensated in themselves but are compensated, if their marginal depressions also are included.

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1) F.R.Helmert, Gravity ... p. 152.

2) Vide B.F.Kosmatt I.c. p. 21.

This would mean that the marginal depressions are over-compensated and the mountain chains under-compensated, or, in other words, that the gravity anomalies in the marginal depressions would be negative, and those in the mountains, positive, in comparison with anomalies in surrounding areas. In support of their assumptions, the values of gravity in the marginal depressions of the Alps, the Carpathians the Caucasus have been quoted.

The 10 stations I have reduced are along the marginal depression of the Alps from Vienna ($= 16^{\circ} 21'.5$) to Freiburg ($= 7^{\circ} 50'.9$). The mean anomalies at the stations on the Hayford reductions are $+0.025$, $+0.026$ and on the Airy reductions $+0.030$, $+0.031$, and $+0.032$ cm/sec^2.

If these anomalies are carefully considered, it will be seen that they require a correction. In computing the Topo-isos -tatic reduction, a mean density of 2.67 is assumed for the earth. Now the Topographic reduction falls mostly in zones A-K and within a circle of 18.8 Km. radius, whilst the Isostatic reduction falls mostly in zones L-13, at a distance of from 19-480 Km. from the station. Therefore it must be clear that the density of the immediate surroundings of these stations affects the Topographic reduction, while the density of the farther zones (mostly of the density of the Alps) ....(contd.)

affects the Isostatic reduction.[1] In the works of Borras the average density of the 10 stations in the neighbourhood is given as from 2.15 to 2.50, and we must compute the Topographic reduction with these values instead of with 2.67. On the other hand the density of the Alps is between 2.6 and 2.8, so that the value 2.67 is approximately correct for the Isostatic reduction. This procedure was accordingly adopted, and the anomalies on the first Hayford reduction corrected. The corrected values are given in column 8, which shows the mean value of +0.031 cm/sec^2 with the correction. The remaining mean anomalies become +0.032, +0.036, +0.037 and +0.038 cm/sec^2.

If the station Freiburg, with its large anomaly, is omitted, the mean anomalies are +0.026, +0.027, +0.031, +0.032 and +0.033 cm/sec^2.

The justification for omission of this station lies in the fact that Freiburg borders on the Black Forest, and is not actually in the marginal depression of the Alps.

These anomalies in the marginal depression of the Alps have to be compared with the anomalies of the Alpine stations.

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1) The influence of the isostatic compensation in zones A-K and that of the topography in zones L-13 is almost meaningless, and in any case only plays a subordinate part.

The anomalies according to the first Hayford reduction at the stations vary between + 0.057 and − 0.014 and the mean value is + 0.017 cm/sec^2.

Adopting a depth of compensation of 85.3 Km., and on the Airy hypothesis, I have only been able to reduce Bowie's stations Nos. 1 - 10 and 22 - 23, in addition to the stations Nos. 24 - 27, which I have computed myself, as the mean heights of only a few zones for these stations were at my disposal. The table shows that, on the first and second assumptions, the Airy theory decreases the anomalies, the third makes ~~them~~ as great, and the second Hayford assumption greater, than those of the first Hayford assump -tion.

The gravity observations in the marginal depression of the Alps and in the Alps also clearly show that the Hayford and Airy anomalies in the marginal depression of the Alps have rather larger than smaller positive values than those in the Alps themselves, so that the statement of the geologists, already mentioned, is not substantiated by the gravity measuremants in the environs of the Alps. On the contrary, under- rather than over-compensation holds sway in the marginal depression of the Alps as compared with the Alps themselves. Other stations in the immediate neighbourhood of the Alps were also isostatically reduced in the exhaustive enquiry to be described later.

The isostatic reduction at Lyons, Marseilles and Turin gives the positive anomalies + 0.048, + 0.023 and + 0.035 cm/sec^2, so that these sides of the Alps confirm my statement.

In order to include a sketch of the distribution of gravity in the vicinity of the Carpathians, the stations Munkács (on the south), and Lemberg and Stryj (on the north), were reduced on the Hayford, as well as on the Airy hypothesis. The anomalies at these stations on the first Hayford assumption are + 0.065, -0.039 and -0.009 and on the fourth Airy assumption +0.069, -0.037 and -0.002 cm/sec^2.

The jump of about 0.100 cm/sec^2 from the south to the north side of the Carpathians is very striking. Other stations in the neighbourhood of the Carpathians show that the anomalies on the south side of the Carpathians (i.e. in Hungary), on the whole are strongly positive. On the other hand, those to the north of the Carpathians are negative in only a very limited area. Negative anomalies are only met with between latitudes $48°55'$ and $49°50'$ and longitudes $23°28'$ and $24°0'$ while even at Lawoczne (latitude $48°49'$; longitude $23°22'$) we get the positive anomaly + 0.050 and at Cracow (latitude $50°4'$; longitude $19°58$) + 0.053 cm/sec^2.

If only the stations near Lemberg were taken into account, we might conclude that in the marginal depression of the Carpathians over-compenation actually held sway.

But, if other portions of the northern side of the depression and the southern side be examined, we must admit that, on the whole, the gravity distribution agrees regularly with the theory of isostasy.

In order to see how the marginal depression of the Caucasus behaves in this respect, let us compare the stations actually on the Caucasus with those to the north, and also groups I and IV of Table X, one with another. The mean value of the anomalies in the first group is +0.074 and of the fourth group +0.028 cm/sec^2. Now, if the marginal depression were actually over-compensated in comparison with the flat country, the anomalies of gravity in the neighbourhood of the Caucasus should have smaller positive values gradually increasing up to normal values, as we leave the mountains. My 12 stations to the north of the Caucasus, with the exception of Stawropol, Armawir, Jekaterinodar and Tichoretzkaja, lie quite close to the mountains.

The mean value of the anomalies of the 8 stations close to the mountains is +0.038 and that of the other 4 stations +0.008 cm/sec. The anomalies near the mountains are also greater than those at a distance, so that it cannot be said that the marginal depression is over-compensated, but that it is but slightly compensated and the mountains themselves rather under-compensated, unless the depth of compensation is greater.

The country between the Caucasus and Armenia which has a mean anomaly of + 0.049 cm/sec^2 is similarly not overcompensated. If one wished to mention a case of over-compensation, one might take that of the shores of the Caspian sea. Strange to say, to the best of my knowledge, this country has never been quoted as an area of over-compensation.

As a result I may therefore state "In the marginal depression of mountain chains overcompensation does not hold sway, but the distribution of gravity in such areas is probably normal and confirms the theory of isostatic compensation".

The fact that geologists have held other opinions, is due to the fact that they only had the Bouguer anomalies ($g_0'' - \gamma_0$) to go upon. These anomalies in the marginal depression are strongly negative, but they cannot be otherwise. For if the isostatic compensation everywhere is complete, the anomalies can be no purely linear functions of the height of observation, but the negative anomalies in the marginal depression must be proportionately greater than high up in the mountains, according to the height of observation. The correctness of this statement is obvious.

Of the other reduced stations, the Italian stations form the first group.

These fourteen stations in the table show that gravity in Italy is in excess. Except Genoa, all the stations show greater anomalies than $+0.060$ cm/sec^2 and at Brindisi the anomaly is as great as $+0.110$ cm/sec^2.

All these stations fall in a small area. But other stations in the Mediterranean and on its islands (e.g. in Algeria, in Sardinia, Corsica and Dalmatia) show that the whole Mediterranean area between Spain and Dalmatia is an area of excess of gravity. This shows that, under the Mediterranean, there is a positive excess of compensation. It may have been mentioned that the defect of gravity in France, Spain and deeper inland in Algeria is probably somehow connected with the excess under the Mediterranean. The station Sörvaagen in Norway, reduced by Bowie, with its anomaly of $+0.134$ cm/sec^2 gives no real impression of the gravity distribution in Scandinavia, as at only 50 Km. distance we meet with anomalies of about -0.050 cm/sec^2, and in the whole of Scandinavia the anomalies are generally negative, which fact agrees well with the height of the country. The eleven stations in Spitzbergen show that gravity there is normally distributed, and they confirm the theory of isostatic compensation. These stations receive a large weight in the discussion on account of their high latitude.

Does the isostatic hypothesis of Hayford or that of Airy agree better with the gravity observations?

In the foregoing we have already seen that the Airy reduction agrees with the gravity observations better than the Hayford reduction in the case when the depth of compensation is taken as less than 185 Km. I will now treat this question more generally and investigate whether the observations, that I have used, enable us to reply to this extremely important question.

The Hayford hypothesis has explained the gravity observations in the U.S.A. satisfactorily. It is now my task to put to the test how Airy's hypothesis agrees with the American gravity observations.

The 56 mountain stations in the U.S.A., which Bowie has reduced, have been reduced under the first, second and fourth Airy assumptions and the results are given in Table XI. This table gives the numbers of the stations in Bowie's table; the names, co-ordinates and heights of stations; then the corrections by the Hayford reduction, and those by my first, second and fourth Airy reductions (columns 1-4); and lastly, tha anomalies in the same order (columns 5-8). The unit again is 0.001 cm/sec^2. The stations fall into two groups. The first group includes those sta -tions which are above the level of the surrounding country, the second group those which are below.

According to this table, the mean anomalies on the Hayford reduction (Depth of Compensation 113.7 Km.) and on the 3 Airy assumptions for the first group are +0.009, -0.010, -0.003 and + 0.011, and in the second group, +0.005, 0.000, +0.003 + 0.010 cm/sec^2, and the average variation of the anomalies, 0.017, 0.018, 0.017, 0.017 and 0.020, 0.022, 0.021, 0.021 cm/sec^2 respectively, so that the Hayford and the 2nd Airy reduction are equally good, while the other two Airy reductions show a slightly worse agreement.

The 56 anomalies "A" corresponding to these four methods of reduction can be represented by the following linear functions of the height of observation

$$1.\ A = \underset{\pm 5}{-0.001} + \underset{\pm 3}{0.000007} \times H \ (\text{cm/sec}^2)$$
$$2.\ A = \underset{\pm 6}{-0.003} + \underset{\pm 4}{0.000001} \times H$$
$$3.\ A = \underset{\pm 5}{+0.001} + \underset{\pm 3}{0.000001} \times H$$
$$4.\ A = \underset{\pm 5}{+0.005} + \underset{\pm 3}{0.000005} \times H$$

, where H denotes the height of observation in metres. The linear dependence of the anomalies on the height of observation is least on the 2 first Airy assumptions and hence these methods of reduction are the best. The linear terms by all of these meth -ods however are so small, that not much weight can be attached to this criterion.

The coastal stations can be reduced on the Airy assumptions by a simpler method. This is because the reduction in the nearest zones for these stations has but little influence on the result, and the value only becomes sensibly large in zones 18-1, so that the different Airy reductions can be easily taken direct from the Hayford reductions, by remembering that the Hayford theory, for a depth of compensation 2T, leads to practically the same result as the Airy theory, with a mean depth of compensation T. If we accept that the mean depth of these zones is 2000 m, the mean depth of compensation on our Airy assumptions amounts to 69, 58 and 37 Km. respectively, so that the Airy reductions correspond exactly with the Hayford reductions for depths of compensation 138, 116, and 74 Km.

In this manner the reduction at the coastal stations can be carried out according to the 3 Airy assumptions without getting an error of more than 0.002 cm/sec^2 in the mean anomalies at these stations. The mean anomalies for the plain stations were similarly determined. The mean anomalies of the first and second group of hill, coastal and plain stations on the Hayford reductions with the various depths of compensation, and on the Airy reductions, Nos. I, II and IV, are shown in Table XII.

follow Tables XI & XII.

Table XI.

The Mountain Stations in the U.S.A.

1. Group.

No.	Station	φ	λ	h	1	2	3	4	5	6	7	8
129	Lancaster, N. H.	44°29′	71°34′	261	− 7	− 15	− 7	0	−10	−18	−10	− 3
71	Las Vegas, N. Mex.	35 36	105 12	1960	− 17	− 44	− 38	− 20	+11	−16	−10	+ 8
116	Ely, Nev.	39 15	114 53	1962	− 20	− 47	− 38	− 18	−13	−40	−31	−11
101	Helenwood, Tenn.	36 26	84 33	422	− 15	− 21	− 17	− 12	+48	+42	+46	+51
52	Lower Geyser Basin, Wyo.	44 33	110 48	2200	− 28	− 49	− 41	− 23	+ 7	−14	− 6	+12
51	Norris Geyser Basin, Wyo.	44 44	110 42	2276	− 31	− 55	− 47	− 26	+29	+ 5	+13	+34
48	Pleasant Valley Junction, Utah.	39 51	111 1	2191	− 24	− 49	− 41	− 32	+12	−13	− 5	+ 4
152	Asheville, N. C.	35 36	82 33	670	− 26	− 42	− 33	− 30	+ 3	−13	− 4	− 1
50	Grand Canyon, Wyo.	44 43	110 30	2386	− 38	− 64	− 55	− 34	+ 6	−20	−11	0
98	Alpine, Tex.	30 22	103 40	1359	− 33	− 51	− 42	− 29	+29	+11	+20	+33
64	Nogales, Ariz.	31 21	110 57	1181	− 38	− 49	− 45	− 40	−42	−53	−49	−44
20	Deer Park, Md.	39 25	79 20	770	− 41	− 53	− 48	− 35	+18	+ 6	+11	+24
86	Lake Placid, N. Y.	44 18	73 59	571	− 32	− 44	− 40	− 30	+14	+ 2	+ 6	+16
103	Hughes, Tenn.	36 09	82 07	994	− 53	− 70	− 63	− 51	−21	−38	−31	−19
75	Lead, S. Dak.	44 21	103 46	1590	− 44	− 58	− 56	− 46	+60	+46	+48	+58
68	Yavapai, Ariz.	36 04	112 07	2179	− 34	− 53	− 46	− 30	+ 9	−10	− 3	+13
114	Truckee, Cal.	39 20	120 11	1805	− 57	− 90	− 79	− 41	−20	−53	−42	− 4
55	Mount Hamilton, Cal.	37 20	121 39	1282	−120	−135	−130	−116	+ 5	−10	− 5	+ 9
102	Cloudland, Tenn.	36 06	82 08	1890	−130	−149	−142	−130	+12	− 7	0	+12
43	Pikes Peak, Colo.	38 50	105 02	4293	−187	−225	−218	−197	+29	− 9	− 2	+19
	Mean Value								+ 9	−10	− 3	+11
	Average variation from Mean								17	18	17	17

II. Group.

No.	Station	φ	λ	h	1	2	3	4	5	6	7	8
70	Gallup, N. Mex.	35 32	108 44	1990	− 14	− 34	− 29	− 11	− 5	−25	−20	− 2
156	Bristol, Va.	36 35	82 12	514	− 12	− 22	− 14	− 5	− 7	−17	− 9	0
105	State College, Pa.	40 48	77 52	358	− 10	− 16	− 12	− 5	−13	−19	−15	− 8
202	Moorcroft, Wyo.	44 16	104 58	1295	− 5	− 10	− 7	+ 1	+29	+24	+27	+35
67	Goldfield, New.	37 42	117 15	1716	− 27	− 43	− 35	− 20	− 5	−21	−13	+ 2
153	Cleveland, Tenn.	35 09	84 53	263	− 2	− 7	− 4	0	−15	−20	−17	−13
210	Harrisburg, Pa.	40 16	76 53	104	− 2	− 7	+ 3	+ 3	−21	−26	−16	−16
175	Lexington, Va.	37 47	79 27	324	− 5	− 11	− 6	+ 2	−16	−22	−17	− 9
172	Clifton Forge, Va.	37 49	79 50	325	+ 3	− 5	− 1	+ 9	−26	−34	−30	−20
85	North Hero, Vt.	44 49	73 18	35	+ 9	+ 8	+ 8	+ 10	+ 9	+ 8	+ 8	+10
176	Prestonsburg, Ky.	37 41	82 46	193	+ 4	+ 1	+ 3	+ 6	−16	−19	−17	−14
131	Little Falls, N. Y.	43 03	74 51	137	+ 7	+ 2	+ 6	+ 13	−16	−21	−17	−10
155	Knoxvillo, Tenn.	35 58	83 55	280	+ 1	− 2	+ 1	+ 5	−13	−16	−13	− 9
201	Wasta, S. Dak.	44 04	102 25	706	+ 13	+ 15	+ 16	+ 14	+38	+40	+41	+39
63	El Paso, Tex.	31 46	106 29	1146	− 1	+ 6	+ 8	+ 13	+15	+22	+24	+29
198	Edgemont, S. Dak.	43 18	103 49	1066	+ 12	+ 9	+ 12	+ 14	+62	+59	+62	+64
113	Heppner, Oreg.	45 21	119 33	598	+ 7	+ 10	+ 10	+ 9	−19	−16	−16	−17
130	Whitehall, N. Y.	43 33	73 24	38	+ 12	+ 10	+ 13	+ 19	−31	−33	−30	−24
112	Olympia, Wash.	47 03	122 53	19	+ 12	+ 14	+ 15	+ 14	+41	+43	+44	+43
110	Boulder, Mont.	46 14	112 7	1493	+ 7	− 7	− 2	+ 9	− 7	−21	−16	− 5
111	Skykomish, Wash.	47 42	121 22	280	+ 47	+ 33	+ 39	+ 51	−20	−34	−28	−16
117	Guernsey, Wyo.	42 16	102 44	1322	+ 16	+ 11	+ 14	+ 19	+44	+39	+42	+47
115	Winnemucca, Nev.	40 58	117 44	1311	+ 4	− 2	+ 2	+ 7	− 1	− 7	− 3	+ 2
109	Sheridan, Wyo.	44 48	106 59	1150	+ 31	+ 23	+ 27	+ 37	+40	+32	+36	+46
82	Rock Springs, Wyo.	41 35	109 13	1910	+ 1	− 11	− 9	+ 4	+21	+ 9	+11	+24
45	Gunnison, Colo.	38 33	106 56	2340	+ 1	− 25	− 16	+ 7	+28	+ 2	+11	+34
194	Huntley, Mont.	45 54	108 20	919	+ 22	+ 26	+ 26	+ 25	+19	+23	+23	+22
42	Colorado Springs, Colo.	38 51	104 49	1841	+ 7	− 8	− 5	+ 14	+ 1	−14	−11	+ 8
195	Lander, Wyo.	42 50	108 43	1635	+ 28	+ 11	+ 20	+ 35	+27	+10	+19	+34
49	Salt Lake City, Utah	40 46	111 54	1322	+ 41	+ 41	+ 43	+ 49	+18	+18	+20	+26
44	Denver, Colo.	39 41	104 57	1638	+ 15	+ 11	+ 14	+ 12	− 8	−12	− 9	−11
79	Boise, Idaho	43 37	116 12	821	+ 42	+ 45	+ 49	+ 42	+16	+19	+23	+16
78	Sandpoint, Idaho	48 16	116 33	637	+ 44	+ 45	+ 47	+ 48	+10	+11	+13	+14
69	Grand Canyon, Ariz.	36 05	112 7	849	+ 96	+ 82	+ 89	+103	− 2	−16	− 9	+ 5
46	Grand Junction, Colo.	39 04	108 34	1398	+ 51	+ 49	+ 52	+ 64	+32	+30	+33	+45
47	Green River, Utah	38 59	110 10	1243	+ 43	+ 49	+ 49	+ 52	−13	− 7	− 7	− 4
	Mean Value								+ 5	0	+ 3	+10
	Average variation from Mean								20	22	21	21

Table XII.

Hayford theory

	Compn. depth Km.							Airy theory		
	42.6	56.9	85.3	113.7	127.9	156.3	184.6	1	II	IV
Mt. Stns.	+33	+27	+18	+9	+6	−1	−7	−10	−3	+11
Group 1.	26	23	19	17	17	18	18	18	17	17
Mt. Stns.	+12	+11	+9	+5	+4	0	−4	0	+3	+11
Group II	18	18	19	20	21	21	22	22	21	21
Coastal	+10	+8	+3	−1	−3	−7	−8	−4	−1	+4
Stns.	17	17	17	18	18	18	18	—	—	—
Plain	+11	+10	+8	+7	+5	+4	+3	+3	+5	+8
Stns.	19	19	19	20	20	20	21	—	—	—

The figures marked with the signs before them denote the mean anomalies of the groups, and the numbers without signs the average variations of the anomalies from the mean. The numbers I, II and IV, under the heading Airy theory, refer to our first, second and fourth Airy assumptions.

As the individual coastal and plain stations on the Airy theory were not reduced by me, I have been unable to determine the average variations of the anomalies for these stations from the mean.

The mean anomalies of the mountain stations according to my three assumptions, in the first group, are -0.010, -0.003 and + 0.011 cm/sec^2, and in the second group, 0.000, + 0.003 and + 0.010 cm/sec^2, while the corresponding mean anomalies of the coastal and plain stations are -0.004, -0.001, + 0.004 and + 0.003, + 0.005, + 0.008 cm/sec^2 respectively.

The thickness of the earth's crust corresponding to sea level according to my first, second and fourth assumptions is 77.2, 63.8 and 40 Km. Graphic interpolation, between these types of thickness of the earth's crust and the mean anomalies corresponding shows that the mean anomalies in the four groups of stations agree better for a thickness of the earth's crust of 50 Km. indeed better than on any Hayford assumption. The average group values then becomes +0.004, +0.007, +0.002 and +0.006 cm/sec^2.

<u>As a result, it follows that the Airy hypothesis, for a thickness of the earth's crust of about 50 Km., explains the distribution of gravity in the U.S.A. somewhat better than any assumption based on Pratt's theory.</u>

The 16 Alpine stations in Europe, which I was able to reduce on the Airy assumption form a standing proof of this, as also the ten stations in the marginal depression of the Alps. As the anomalies at the stations Franzenhöhe, Stilfserjoch, Telfs, Steinach, Spittal and Hohenmauthen in the Austrian Alps have a different character to the anomalies for the 10 stations in Switzerland, those stations must be treated separately.

The mean anomalies of the remaining Alpine stations on the Hayford assumptions are +0.029 and + 0.042 cm/sec^2 and on the Airy assumptions are -0.003, +0.008 and +0.030 cm/sec^2. If we examine all the 21 stations of the Swiss Alps, the mean anomaly of the first Hayford reduction amounts to 0.022 cm/sec^2. Had I been able to reduce all these stations on the second Hayford reduction and each of the Airy reductions, the mean anomalies of the corresponding reductions would have amounted to about +0.035, -0.010, +0.001 and +0.023 cm/sec^2.

The mean anomalies in the marginal depression of the Alps, if we omit the station Freiburg with its large anomaly of +0.075 cm/sec^2, are +0.026, +0.027, +0.031, +0.032 and +0.032 cm/sec^2.

The mean anomalies of the stations in the Swiss Alps and marginal depression of the Alps therefore fit in the best with the first and second Hayford assumptions.

The average variation of the single anomalies from the mean for the 10 Alpine stations on the first and second Hayford assumptions and my first, third and fourth Airy assumptions amount to 0.016, 0.018, 0.018, 0.017 and 0.014 cm/sec^2, so that the fourth Airy reduction shows the least variation in the anomalies.

If we interpolate and exterpolate by means of the mean anomalies on the 2 Hayford and 3 Airy reductions, so as to find out the correct depth of compensation or thickness of earth's crust corresponding to sea-level, by making the anomalies of the Alpine stations and those in the marginal depression equally great, we arrive approximately at the figures 107 Km. and 30 Km. respectively. Beneath the Alps the earth's crust therefore is 41 Km. thick.

The result may be stated as follows:-

A depth of compensation of about 107 Km. on the Hayford theory and a thickness of earth's crust of about 41 Km. on the Airy theory agree best with the distribution of gravity in the Swiss Alps and in the marginal depression of the Alps.

If we wish to explain the negative anomalies of the six stations in the Austrian Alps on the basis of isostatic compensation, we must compute with a smaller depth of compensation and a smaller thickness of earth's crust. The depth of compensation 85.3 Km. gives the anomalies +0.003, +0.007, +0.001, -0.002, +0.013, +0.037 and the fourth Airy assumption gives -0.017, -0.013, +0.007, -0.002, +0.022, +0.041 cm/sec^2.

It is quite possible that under the Austrian Alps between longitude 10° and 13°, there is a local area of defect of mass, extending for 2 degrees of latitude. My last two stations Spittal and Hohenmauthen (longitude 13°.5' and 15°.2'), with their positive anomalies, show that this area of defect gradually changes over to the area of excess of gravity in Hungary. In the Riesengebirge and in the Harz, the average variation of the anomalies from their mean seems somewhat smaller on the Airy than on the Hayford theory. These mountains however are too small to render it possible to decide which isostatic theory and depth of compensation or thickness of earth's crust corresponds best with the distribution of gravity.

The other stations reduced by me gave an equally indecisive result in this respect.

My discussion leads to the following conclusions:- <u>In all the areas I have investigated, in the Caucasus, in America, as well as in the Alps, the Airy theory shows just as good, if not better, agreement with distribution of gravity, in comparison</u>

<u>with the Hayford-Pratt theory; but the depth of compensation (on the Pratt theory), and the thickness of earth's crust (on the Airy theory) are not everywhere the same on the globe.</u>

The above is an important contradiction of the statement, which, to the best of my knowledge, was made first by Helmert,[1] that the Airy theory could never explain the distribution of gravity in high mountains.[2]

My Table IV shows that my second and third Airy assumptions, which only differ as regards the difference of density adopted for the earth's crust and lava layer, (viz. 0.3 and 0.6 respectively) lead almost to the same result, so that for the Airy theory the thickness of the earth's crust corresponding to sea-level is what really matters, while the difference between the density of earth's crust and lava-layer plays quite a subordinate part.

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1) W. Schweydar, Notes on Wegener's hypothesis of continental drift. Zeitschrift der Gesellschaft für Erdkünde zu Berlin p. 121. 1921.

2) The gravity stations on islands in the ocean are known to give too great positive anomalies to admit of explanation by Hayford's theory (depth of compensation 113.7 Km.). Thus Bowie in his investigations p.57 obtained the anomaly + 0.080 at the station St. George on the Bermudas, + 0.120 at Jamestown on St. Helena, and +0.075 cm/sec^2 at Honolulu in the Hawaii islands.

But, if we compute with a depth of compensation of 156.3 Km., we obtain approximately the anomalies + 0.008, + 0.060 and +0.022 cm/sec^2.

Similar results would be obtained according to the Airy theory, if the thickness of earth's crust and difference of densities between Sal and Sima-layers are suitably selected.

The above statement has been made in order to show that ocean islands need not necessarily be areas of excess of gravity, and is usually accepted, but that one can select a suitable assumption on the Hayford or Airy theory, which will account for the positive anomalies.

III. Derivation of the gravity formula and the flattening of the earth.

By means of the stations, which were isostatically reduced, I derived some new formulae for gravity, and from these I made an estimate of the flattening of the earth.

But, as the stations in Europe lay for the most part on high plateaux or mountains, I also carried out the isostatic reduction of a large number of plain and coastal stations by contracted methods, combining these results with those at the other stations which had been worked out by more rigid methods, so as to deduce the gravity formulae. Plain stations, such as those in N. Germany, Russia and Finland, where the country is nearly flat, can be easily reduced isostatically. The Orographical reduction is so small for these stations, that it can be neglected; and the Purely Isostatic reduction, that has to be added to the Bouguer reduction to obtain the Topo-isostatic reduction, is easy to estimate. It also changes so little from point to point, that it has only to be computed for a few stations, after which the majority of stations can be dealt with by interpolation. On the contrary, in the case of stations near hills or deep sea, e.g. the stations in Norway, France, England, (the peninsula of) the Pyrenees, the Mediterranean and the Red Sea, the purely isostatic reduction has to be computed for nearly every station. All these reductions were made on the Hayford theory with a depth of compensation of 113.7 Km.

Although errors of observation and reduction at the various stations are very unequal in amount; and, in consequence, the derived anomalies burdened with variable amounts of error; it is impossible to consider each station purely on its own merits, or allot unequal weights to the results at the various stations; because, in that case, Germany, Denmark and Hungary, with their numerous well determined stations, would entirely overwhelm the influence of other areas, where gravimetric investigations have not been carried out to the same extent. In order not to give small areas, where there are many gravity stations, an undue influence in the result, all stations situated within a one degree square have been considered as one station, with co-ordinates at the centre of the degree square, and of weight " 1 ".

Now if we had at least one station in each degree square throughout the whole world, it would be possible to derive a completely homogeneous gravity formula. As however this is not the case, it is impossible to prevent those countries, whose gravimetric conditions are more fully investigated, from having an undue preponderance of weight.

In table XIII the anomalies of the degree squares are given, which I utilised, the values of the stations being taken from the previously mentioned work of Borras.

The table gives firstly the geographical co-ordinate (φ_0, λ_0) of the middle point of the degree squares, then the number of the stations lying in each degree square and in columns 1 and 2 the anomalies according to the Bouguer reduction and the Hayford reduction (depth of compensation 113.7 Km.). Where the Bouguer reduction was not computed, the anomalies according to th Free Air reduction are shown in column 1 and these anomalies are marked with an asterisk. Column 3 shows the remaining anomalies according to my sixth gravity formula. For the American and Indian stations, which were previously reduced isostatically, I have not given the Bouguer anomalies, but in Columns 2 and 3 I have entered the remaining anomalies according to the Hayford theory and according to my gravity formula.

Table XIII follows.

Table XIII.

1. The Stations in Europe and the Caucasus.

φ_0	λ_0	n	1	2	3
80.5	20.5	1	+ 68	+ 31	+ 26
79.5	11.5	1	+ 57	+ 16	+ 11
"	16.5	1	+ 13	− 4	− 9
"	17.5	1	+ 14	+ 8	+ 3
"	20.5	1	+ 3	− 1	− 6
78.5	11.5	1	+ 34	+ 4	0
"	20.5	2	− 10	+ 6	+ 2
77.5	18.5	1	− 13	− 9	− 13
"	20.5	1	+ 19	+ 13	+ 9
76.5	15.5	1	− 7	− 26	− 30
72.5	52.5	1	+ 10	+ 2	− 3
71.5	25.5	1	+ 18	+ 14	+ 3
"	27.5	1	+ 26	+ 20	+ 11
70.5	23.5	1	− 12	− 15	− 24
"	29.5	1	− 2	− 4	− 13
69.5	15.5	1	+ 94	+ 80	+ 70
"	18.5	2	− 13	− 17	− 27
68.5	17.5	1	− 38	− 24	− 34
67.5	13.5	1	+148	+134	+123
"	14.5	1	− 59	− 45	− 56
"	32.5	1	− 40	− 38	− 49
66.5	12.5	1	− 1	− 13	− 24
"	14.5	1	− 65	− 43	− 54
65.5	24.5	2	− 10	− 5	− 17
"	25.5	1	− 22	− 17	− 29
"	35.5	1	+ 61	+ 63	+ 53
64.5	11.5	2	+ 28	+ 28	+ 15
"	27.5	1	+ 1	+ 11	− 2
"	40.5	1	+ 12	+ 14	+ 3
63.5	10.5	1	− 16	+ 6	− 7
"	21.5	1	− 37	− 34	− 47
62.5	17.5	1	− 27	− 20	− 34
"	26.5	1	+ 6	+ 18	+ 5
"	34.5	1	− 19*	− 16	− 29
61.5	23.5	1	− 15	− 5	− 19
"	30.5	1	+ 33	+ 34	+ 20
"	31.5	1	0*	− 2	− 16
"	34.5	1	+ 1*	− 1	− 15
"	35.5	1	− 6*	− 10	− 24
60.5	−0.5	1	+ 43	+ 30	+ 16
"	5.5	1	− 15	0	− 15
"	22.5	1	+ 21	+ 24	+ 9
"	24.5	1	− 9	− 6	− 20
"	26.5	1	− 31	− 29	− 43
60.5	28.5	1	−39	−37	−49
"	30.5	1	+11*	+10	− 5
"	46.5	1	+14	+18	+ 6
"	56.5	1	+ 6	+20	+ 9
59.5	10.5	1	+26	+40	+24
"	17.5	1	+11	+16	0
"	18.5	1	−10	− 7	−23
"	30.5	3	+24	+30	+15
"	39.5	1	− 5	+ 4	−10
58.5	−6.5	1	+55	+45	+31
"	−2.5	1	+47	+40	+26
"	26.5	1	+18	+22	+ 6
"	31.5	1	− 6	0	−16
"	33.5	1	+10	+19	+ 4
"	38.5	1	+ 5	+16	+ 1
"	49.5	1	+18	+28	+16
"	52.5	1	+ 5	+16	+ 4
"	56.5	1	+13	+33	+21
57.5	−2.5	1	+44	+40	+25
"	9.5	5	+23	+22	+ 5
"	10.5	2	+32	+30	+13
"	26.5	1	+12	+18	+ 1
"	28.5	1	+21	+26	+ 9
"	33.5	1	−27	−11	−20
"	39.5	1	− 3	+ 9	− 6
"	40.5	1	+17	+28	+14
"	43.5	1	+ 5	+17	+ 3
"	48.5	1	+19	+30	+17
"	53.5	1	−11	− 3	−15
56.5	9.5	6	+27	+25	+ 8
"	10.5	2	+34	+36	+19
"	25.5	1	−19	−10	−27
"	44.5	1	+17	+28	+13
"	46.5	1	+ 2	+11	− 4
55.5	−4.5	1	+42	+40	+24
"	−3.5	1	+30	+28	+12
"	9.5	8	+44	+44	+26
"	10.5	46	+40	+40	+22
"	11.5	7	+17	+19	+ 1
"	12.5	4	+13	+14	− 4
"	13.5	1	+ 8	+10	− 8
"	14.5	15	+48	+46	+28
"	37.5	1	+11	+20	+ 3
"	49.5	1	+ 5	+15	+ 1

φ_0	λ_0	n	1	2	3
55.5	52.5	1	+12	+23	+10
„	55.5	1	− 9	+12	+ 1
54.5	−1.5	1	+38	+35	+18
„	7.5	1	−12	−15	−34
„	10.5	10	+33	+33	+14
„	13.5	4	+16	+18	− 1
„	15.5	1	+20	+20	+ 1
„	20.5	1	+ 3	+ 5	−14
„	25.5	1	+13	+24	+ 5
„	39.5	1	−22	−11	−28
„	46.5	1	+22	+33	+17
„	48.5	1	+51	+63	+48
„	55.5	1	−19	+ 4	− 9
53.5	−1.5	1	+ 3	+ 9	− 8
„	8.5	8	+ 3	+ 3	−16
„	9.5	1	+ 1	+ 2	−17
„	10.5	3	+ 8	+11	− 8
„	13.5	6	+14	+17	− 3
„	15.5	3	+ 1	+ 8	−12
„	28.5	2	+19	+33	+14
„	29.5	1	0	+15	− 4
„	39.5	2	−23	−12	−30
„	45.5	1	+ 2	+14	− 2
„	50.5	1	+19	+23	+ 8
52.5	−1.5	1	+22	+26	+ 8
„	4.5	1	+28	+32	+13
„	7.5	1	+ 6	+16	− 4
„	8.5	11	+26	+34	+14
„	10.5	7	+11	+25	+ 5
„	11.5	1	+48	+60	+40
„	13.5	3	0	+ 8	−13
„	15.5	4	+ 5	+10	−11
„	21.5	1	−18	−11	−32
„	25.5	1	+ 1	+15	− 5
„	36.5	1	−42	−26	−45
„	39.5	1	− 7	+ 6	−12
„	47.5	1	+22	+39	+23
51.5	−0.5	3	+13	+ 9	−10
„	2.5	1	+16	+14	− 6
„	8.5	1	+17	+27	+ 6
„	9.5	3	+13	+24	+ 8
„	10.5	10	+18	+46	+25
„	11.5	2	+14	+36	+15
„	12.5	1	+20	+39	+18
„	35.5	1	− 2	+15	− 5
„	36.5	5	−13	+ 5	−15

φ_0	λ_0	n	1	2	3
51.5	37.5	5	+ 8	+24	+ 5
„	46.5	1	− 9	−10	−27
„	54.5	1	− 6*	− 3	−17
„	55.5	1	+ 1	+ 8	− 5
50.5	−4.5	1	+ 58	+50	+31
„	−1.5	1	+ 9	+ 8	−11
„	4.5	1	− 9	0	−21
„	7.5	1	+ 5	+26	+ 5
„	10.5	9	+ 10	+32	+10
„	11.5	2	+ 5	+37	+15
„	15.5	11	+ 14	+42	+20
„	19.5	1	+ 26	+49	+27
„	20.5	1	+ 14	+42	+20
„	25.5	1	+ 10	+30	+ 8
„	30.5	1	+ 5	+19	− 3
„	36.5	4	− 20	+ 6	−14
„	37.5	1	− 20	0	−20
49.5	2.5	1	+ 10	+16	− 5
„	8.5	1	+ 20	+47	+25
„	11.5	1	− 11	+34	+11
„	19.5	4	+ 22	+52	+29
„	20.5	2	− 26	+14	− 9
„	23.5	2	− 66	−23	−46
48.5	2.5	1	− 6	0	−22
„	7.5	1	+ 19	+72	+49
„	10.5	1	− 37	+26	+ 3
„	11.5	1	− 52	+23	− 1
„	14.5	1	− 40	+30	+ 6
„	16.5	1	− 9	+31	+ 7
„	22.5	1	+ 23	+64	+40
„	26.5	1	− 18	− 2	−25
„	44.5	1	+ 4	+10	− 9
47.5	6.5	2	− 42	+38	+15
„	8.5	1	− 14	+51	+27
„	9.5	2	− 62	+22	− 2
„	11.5	1	− 73	+17	− 7
„	12.5	1	− 82	+10	−14
„	17.5	19	+ 12	+35	+11
„	19.5	9	+ 27	+39	+14
„	20.5	1	+ 7	+23	− 2
„	28.5	1	− 5	+17	− 7
„	35.5	1	− 59	−57	−79
„	39.5	1	+ 48*	+43	+22
46.5	6.5	2	− 88	+22	− 2
„	7.5	7	−114	+20	− 4
„	8.5	5	−127	+ 6	−18

φ_0	λ_0	n	1	2	3
46.5	10.5	2	−128	−12	−37
"	11.5	2	−148	+12	−36
"	13.5	1	−104	+ 4	−21
"	15.5	1	− 35	+34	+ 9
"	17.5	30	+ 31	+51	+26
"	18.5	10	+ 17	+40	+15
"	30.5	1	+ 30	+33	+ 9
"	33.5	1	0*	− 2	−25
"	34.5	1	+ 5*	+ 6	−17
"	38.5	1	+ 8*	+ 9	−18
"	48.5	1	+ 42	+48	+29
"	53.5	1	+ 15'	+19	+ 2
45.5	−0.5	2	− 25	−24	−47
"	4.5	1	+ 11	+48	+25
"	7.5	4	−114	+40	+15
"	10.5	9	− 4	+30	+ 5
"	12.5	1	− 6	+13	−12
"	28.5	1	− 20	− 9	−34
"	35.5	1	+ 47*	+47	+23
"	36.5	1	− 52	−57	−81
"	38.5	1	− 42	−35	−58
"	40.5	1	+ 16	+26	+ 4
"	41.5	2	− 18	+19	− 3
44.5	−1.5	1	+ 6	+ 6	−18
"	−0.5	2	− 12	−11	−35
"	8.5	1	+ 10	+48	+22
"	13.5	1	+ 29	+42	+16
"	14.5	1	+ 34	+50	+23
"	15.5	1	+ 12	+32	+ 5
"	26.5	1	+ 8	+20	− 6
"	37.5	2	+ 84	+70	+46
"	39.5	1	+ 32	+31	+ 8
"	40.5	1	− 2	+30	+ 7
"	42.5	1	− 27	+52	+30
"	43.5	1	− 48	+33	+11
"	50.5	2	− 10	+16	− 3
43.5	−8.5	1	+ 50	+ 9	−11
"	−0.5	1	− 12	−12	−36
"	6.5	1	+ 38	+23	− 3
"	10.5	1	+ 53	+72	+45
"	11.5	3	+ 41	+74	+47
"	12.5	2	+ 43	+77	+50
"	15.5	1	+ 19	+39	+12
"	16.5	2	+ 42	+63	+36
"	41.5	1	− 34	+15	− 8
"	42.5	1	− 60	+43	+20

φ_0	λ_0	n	1	2	3
43.5	44.5	3	− 74	+ 40	+ 18
"	45.5	1	− 81	− 17	− 39
"	47.5	1	− 75	− 31	− 52
42.5	9.5	1	+121	+100	+ 73
"	12.5	4	+ 51	+ 77	+ 49
"	17.5	1	+ 33	+ 53	+ 25
"	18.5	1	− 5	+ 13	− 15
"	41.5	1	− 37	+ 12	− 12
"	42.5	4	− 58	+ 38	+ 14
"	43.5	5	− 79	+ 65	+ 41
"	44.5	10	− 84	+ 73	+ 50
"	48.5	1	− 73	− 25	− 46
41.5	2.5	1	+ 4	+ 25	− 2
"	8.5	1	+ 64	+ 45	+ 17
"	12.5	1	+ 43	+ 60	+ 31
"	41.5	2	− 10	+ 96	+ 72
"	42.5	2	−105	+ 50	+ 26
"	43.5	2	− 98	+ 69	+ 45
"	44.5	3	− 72	+ 56	+ 33
"	45.5	1	− 26	+ 87	+ 64
"	48.5	1	− 90	− 47	− 69
40.5	−3.5	1	− 90	− 23	− 48
"	17.5	1	+120	+110	+ 78
"	18.5	1	+ 89	+ 72	+ 42
"	42.5	1	−124	+ 78	+ 53
"	43.5	3	−114	+ 70	+ 46
"	44.5	3	−100	+ 74	+ 50
"	46.5	2	− 48	+ 57	+ 34
"	47.5	1	− 41	+ 28	+ 5
"	48.5	1	− 80	− 6	− 28
"	49.5	3	−122	−102	−124
"	50.5	1	−123	−121	−142
"	52.5	1	+ 41*	+ 51	+ 31
"	53.5	1	+ 12	+ 26	+ 6
39.5	−0.5	1	− 48	− 28	− 55
"	19.5	1	+ 8	+ 23	− 7
"	45.5	2	−104	+ 75	+ 46
"	46.5	1	+ 16	+139	+115
"	49.5	1	−102	− 77	− 99
"	52.5	1	+ 45*	+ 55	+ 35
"	53.5	3	0	+ 15	− 5
"	54.5	1	− 23*	− 3	− 22
38.5	14.5	1	+134	+ 91	+ 60
"	45.5	1	− 90	+ 73	+ 47
"	48.5	1	+ 34	+ 85	+ 62
37.5	−0.5	1	+ 82	+ 82	+ 54

φ_0	λ_0	n	1	2	3	φ_0	λ_0	n	1	2	3
37.5	53.5	1	−16*	+19	− 2	36.5	53.5	1	− 32	+41	+30
36.5	−6.5	2	+24	+14	−13	35.5	− 5.5	1	− 40	−51	−79
„	−5.5	1	−33	−25	−52	„	14.5	1	+101	+70	+37
„	−4.5	1	+56	+66	+38	33.5	2.5	1	− 73*	−45	−77
„	3.5	1	+71	+47	+16	34.5	5.5	1	−122	−23	−55
„	10.5	2	+38	+25	− 7						

II. The Stations in Africa.

29.5	32.5	2	−13	+ 3	−32	15.5	39.5	3	− 17	+47	+ 9
„	33.5	1	−17	+18	−17	„	42.5	2	+ 16	+42	+ 5
„	34.5	1	−73	−15	−49	14.5	−17.5	1	+116	+44	+15
28.5	33.5	2	−22	+17	−18	„	40.5	1	+ 31	+61	+20
„	34.5	3	−66	−12	−47	„	42.5	2	+ 21	+52	+12
27.5	33.5	1	+44	+60	+24	13.5	−16.5	1	+122	+86	+56
„	34.5	2	+35	+62	+26	„	41.5	1	+ 25	+55	+17
„	35.5	1	+15	+42	+ 7	„	42.5	1	+ 5	+43	+ 6
26.5	33.5	1	+14	+31	− 6	„	43.5	1	+ 16	+61	+24
„	34.5	2	+48	+65	+29	12.5	43.5	1	+ 39	+70	+33
„	36.5	1	+18	+33	− 2	„	44.5	1	+ 45	+84	+48
25.5	34.5	1	+33	+50	+14	8.5	−13.5	1	+ 85	+52	+20
24.5	35.5	2	+35	+46	+ 9	6.5	−10.5	1	+ 86	+31	− 4
„	37.5	1	+18	+25	−11	„	3.5	1	+ 59	+24	−20
„	38.5	1	+ 9	+30	− 5	− 0.5	8.5	1	+ 51	+ 8	−38
23.5	35.5	1	− 1	+25	−12	− 5.5	38.6	1	− 35	−25	−66
22.5	36.5	1	+ 6	+26	−13	− 6.5	12.5	1	+ 40	+24	−23
„	39.5	1	+34	+54	+18	„	39.5	1	+ 16	+ 3	−38
21.5	39.5	1	+22	+42	+ 6	− 8.5	13.5	1	+ 62	+36	−11
20.5	37.5	1	+ 2	+22	−16	−12.5	13.5	1	+ 59	+57	+11
„	40.5	1	+46	+68	+32	−15.5	38.5	1	+ 78	+27	−12
19.5	37.5	1	+29	+54	+12	−16.5	11.5	1	+ 49	+15	−19
„	41.5	1	+20	+40	+ 4	−22.5	14.5	1	+ 42	+48	+ 7
18.5	38.5	1	+ 8	+48	+10	−26.5	15.5	1	+ 36	+34	− 5
16.5	40.5	1	+21	+38	0	−29.5	16.5	1	+ 46	+50	+12
„	41.5	1	+13	+30	− 7	−33.5	18.5	1	+ 21	−15	−50

III. The Stations in America.

51.5	116.5	1		− 3	−12	49.5	99.5	1		+15	+10
„	115.5	1		+15	+ 5	„	97.5	1		− 1	− 6
„	114.5	1		+ 4	− 6	„	94.5	1		+ 9	+ 5
50.5	120.5	1		− 1	−14	„	81.5	1		−14	−15
„	118.5	1		−35	−46	48.5	116.5	1		+10	− 2
„	110.5	1		+ 2	− 7	„	107.5	1		+37	+29
„	105.5	1		+ 3	− 3	„	105.5	1		+27	+19
49.5	123.5	1		− 8	−22	„	103.5	1		+25	+18
„	121.5	1		0	−14	„	100.5	1		+40	+34

φ_0	λ_0	n	2	3
48.5	97.5	1	+27	+22
„	89.5	1	−37	−40
„	72.5	1	−20	−20
„	69.5	1	+ 9	+ 9
„	64.5	1	+16	+15
47.5	122.5	3	−25	−40
„	121.5	1	−20	−34
„	96.5	1	+19	+15
„	92.5	1	+31	+28
„	88.5	1	+39	+37
„	83.5	1	+18	+17
„	79.5	1	+ 6	+ 6
„	68.5	2	− 4	− 4
„	65.5	1	−18	−18
46.5	123.5	1	− 5	−21
„	112.5	1	− 7	−18
„	105.5	1	+38	+30
„	103.5	1	+43	+35
„	100.5	1	+10	+ 4
„	96.5	1	+ 2	− 2
„	94.5	1	+20	+16
„	92.5	1	+58	+56
„	88.3	1	+46	+44
„	85.5	1	+ 9	+ 8
„	84.5	1	−13	−14
„	78.5	1	−22	−22
„	76.5	1	− 2	− 2
„	71.5	1	+ 3	+ 3
„	67.5	1	−15	−15
„	64.5	1	+ 2	+ 2
„	63.5	1	− 8	− 9
„	60.5	1	− 1	− 2
45.5	119.5	1	−19	−33
„	108.5	1	+19	+10
„	102.5	1	+23	+16
„	98.5	1	+20	+15
„	94.5	1	+14	+10
„	93.5	1	−19	−23
„	92.5	1	−41	−44
„	90.5	1	+32	+29
„	83.5	1	−12	−13
„	80.5	1	+14	+14
„	76.5	1	−10	−10
„	74.5	1	+19	+19
„	73.5	1	+14	+14
„	66.5	2	+14	+14

φ_0	λ_0	n	2	3
45.5	63.5	1	+ 2	+ 2
44.5	110.5	3	+14	+ 4
„	106.5	1	+40	+32
„	103.5	1	+60	+53
„	100.5	1	+22	+16
„	96.5	1	+25	+21
„	93.5	2	+56	+53
„	92.5	1	−42	−45
„	91.5	1	+23	+21
„	89.5	1	−34	−36
„	87.5	1	−17	−16
„	85.5	1	+ 9	+ 8
„	76.5	1	− 4	− 4
„	74.5	1	+26	+26
„	73.5	2	+12	+12
„	71.5	1	−10	− 9
„	69.5	1	− 7	− 6
„	63.5	1	−21	−20
43.5	116.5	1	+16	+ 3
„	104.5	1	+29	+21
„	103.5	1	+62	+55
„	102.5	1	+38	+31
„	98.5	1	+ 9	+ 4
„	94.5	1	+14	+10
„	92.5	1	−18	−21
„	89.5	1	+ 3	+ 1
„	80.5	1	− 4	− 4
„	78.5	2	−14	−14
„	75.5	1	−17	−17
„	74.5	1	−16	−15
„	73.5	1	−31	−30
„	66.5	1	+19	+20
42.5	108.5	1	+22	+12
„	104.5	1	+44	+36
„	100.5	1	+26	+20
„	97.5	1	+10	+ 5
„	94.5	1	+23	+19
„	85.5	1	+10	+ 9
„	83.5	1	+20	+20
„	80.5	1	−19	−19
„	79.5	2	−19	−19
„	73.5	1	−35	−35
„	71.5	3	+ 1	+ 2
41.5	125.5	1	− 2	−19
„	109.5	1	+21	+11
„	101.5	1	+ 2	− 4

φ_0	λ_0	n	2	3	φ_0	λ_0	n	2	3
41.5	90.5	1	0	− 2	37.5	94.5	1	+24	+20
„	87.5	1	+ 1	0	„	92.5	1	+19	+16
„	85.5	1	+19	+18	„	84.5	1	−21	−21
„	81.5	1	+ 5	+ 5	„	82.5	1	−16	−16
„	74.5	1	−25	−24	„	79.5	2	−21	−20
„	69.5	1	− 6	− 5	„	77.5	1	+11	+12
40.5	117.5	1	− 1	−16	„	75.5	1	−21	−20
„	111.5	1	+18	+ 6	36.5	112.5	2	+ 4	− 9
„	93.5	1	0	− 3	„	101.5	1	− 9	−16
„	80.5	2	−18	−18	„	91.5	1	+21	+19
„	77.5	1	−13	−12	„	89.5	1	+ 9	+ 7
„	76.5	1	−21	−20	„	87.5	1	+14	+13
„	74.5	2	+11	+12	„	84.5	1	+48	+48
„	73.5	1	+30	+31	„	82.5	3	− 5	− 4
„	72.5	1	−14	−13	„	80.5	1	−30	−29
39.5	120.5	1	−20	−37	„	78.5	1	+44	+45
„	114.5	1	−13	−26	„	77.5	1	+21	+22
„	111.5	1	+12	0	„	75.5	1	−40	−38
„	108.5	1	+32	+22	35.5	108.5	1	− 5	−16
„	104.5	1	+ 8	−16	„	105.5	1	+11	+ 2
„	94.5	1	− 8	−12	„	100.5	1	+40	+34
„	89.5	1	− 8	−10	„	94.5	1	− 8	−12
„	87.5	1	− 1	− 2	„	90.5	1	+21	+19
„	86.5	1	+ 9	+ 8	„	87.5	1	+34	+33
„	84.5	1	−11	−11	„	84.5	1	−15	−15
„	82.5	1	− 4	− 4	„	83.5	1	−13	−13
„	81.5	1	−16	−16	„	82.5	1	+ 3	+ 3
„	79.5	1	+18	+18	„	80.5	1	+33	+34
„	77.5	2	+ 6	+ 6	„	77.5	1	−10	− 8
„	76.5	2	+20	+21	34.5	103.5	1	− 8	−16
„	75.5	2	+14	+15	„	95.5	1	−19	−23
„	74.5	1	−15	−13	„	94.5	1	−44	−48
38.5	110.5	1	−13	−25	„	93.5	1	+26	+23
„	106.5	1	+28	+19	„	92.5	1	+38	+35
„	105.5	1	+29	+20	„	86.5	1	−15	−15
„	104.5	1	+ 1	− 7	„	79.5	1	+10	+12
„	101.5	1	− 4	−11	„	77.5	1	−23	−21
„	98.5	1	+22	+16	„	76.5	1	−13	−11
„	90.5	1	+ 3	+ 1	33.5	118.5	1	−42	−59
„	81.5	1	−16	−16	„	96.5	1	+13	+ 9
„	78.5	1	− 5	− 4	„	94.5	1	+19	+15
„	77.5	1	+45	+46	„	91.5	1	− 4	− 6
„	76.5	1	+21	+22	„	88.5	1	− 9	−10
37.5	122.5	1	−15	−34	„	86.5	1	−25	−25
„	121.5	1	+ 5	−13	„	84.5	1	−15	−15
„	117.5	1	− 5	−21	„	82.5	1	+23	+24

φ_0	λ_0	n	2	3
32.5	114.5	1	+17	+ 2
„	100.5	1	−21	−30
„	91.5	1	+24	+22
„	85.5	1	−18	−18
„	83.5	1	+27	+28
„	79.5	1	−13	−11
31.5	110.5	1	−42	−55
„	106.5	1	+15	+ 5
„	94.5	1	− 4	− 7
„	92.5	1	+ 2	0
„	89.5	1	+22	+21
„	86.5	1	− 5	− 5
„	84.5	1	+10	+11
30.5	103.5	1	+29	+20
„	99.5	1	+39	+33
„	97.5	2	− 1	− 6

φ_0	λ_0	n	2	3
30.5	88.5	1	−36	−37
„	87.5	1	− 6	− 6
„	81.5	1	+18	+19
29.5	94.5	1	− 1	− 4
„	90.5	1	− 5	− 6
„	84.5	1	+ 8	+ 9
„	83.5	1	−13	−12
28.5	81.5	1	− 6	− 4
„	80.5	1	+ 7	+ 9
27.5	99.5	1	−12	−17
„	81.5	1	− 9	− 7
26.5	97.5	1	+35	+30
„	82.5	1	+18	+20
„	80.5	1	+26	+28
25.5	80.5	1	−28	−26
24.5	81.5	1	+13	+15

IV. The Stations in Asia.

φ_0	λ_0	n	1	2	3
69.5	60.5	1	0	+ 5	− 2
66.5	66.5	1	− 72	−62	−69
63.5	65.5	1	− 76	−68	−75
58.5	57.5	1	+ 9	+32	+21
„	59.5	3	+ 71	+96	+88
„	68.5	1	− 62	−54	−62
„	92.5	1	− 56	−26	−29
57.5	59.5	1	+ 75	+96	+86
„	60.5	1	+ 40	+60	+50
„	65.5	1	+ 15	+ 5	− 4
56.5	59.5	1	+ 25	+55	+44
„	60.5	1	+ 14	+36	+25
„	62.5	1	− 34	−20	−30
„	112.5	1	− 54*	−20	−22
55.5	59.5	1	+ 18	+65	+54
„	60.5	1	+ 27	+49	+38
„	61.5	1	− 7	+23	+13
„	109.5	1	−100*	−65	−67
52.5	104.5	1	− 27*	+ 5	+ 5
„	105.5	1	− 46*	−11	−11
„	106.5	1	− 88*	−51	−51
„	108.5	1	− 7*	+26	+26
51.5	104.5	1	− 37*	− 2	− 3
50.5	57.5	1	− 41*	−40	−54
48.5	58.5	1	+ 75*	+60	+46
47.5	59.5	1	− 2*	0	−14
46.5	61.5	1	+ 8*	+14	+ 1
44.5	65.5	1	− 4*	− 2	−14

φ_0	λ_0	n	1	2	3
42.5	59.5	1	0*	+ 4	−12
„	60.5	1	47*	+50	+35
41.5	59.5	1	− 10*	− 6	−22
„	60.5	3	− 3*	+ 1	−15
„	61.5	2	− 8*	− 5	−20
38.5	70.5	1	−152*	−66	−77
37.5	38.5	1	− 74	−21	−46
32.5	75.5	1		−75	−84
31.5	74.5	1		+41	+32
30.5	67.5	1		+ 9	− 5
„	73.5	1		+19	+ 9
„	78.5	3		+32	+25
29.5	67.5	1		−58	−72
„	77.5	2		−26	−34
28.5	68.5	1		+38	+24
„	77.5	2		− 7	−15
27.5	77.5	1		+15	+ 7
„	78.5	3		+ 7	0
„	88.5	1		+54	+52
26.5	77.5	1		− 5	−13
„	78.5	1		− 7	−14
„	83.5	2		−64	−69
„	85.5	1		−42	−45
„	88.5	2		−30	−32
25.5	77.5	1		+29	+21
„	78.5	1		+15	+ 8
„	81.5	1		+ 9	+ 3
„	83.5	2		−10	−14

φ_0	λ_0	n	2	3
25.5	84.5	1	−28	−32
"	86.5	1	−25	−28
"	88.5	1	+39	+37
24.5	77.5	2	+30	+21
"	78.5	2	+12	+ 4
"	80.5	1	− 3	− 9
"	83.5	1	+ 9	+ 5
"	84.5	2	+14	+10
"	85.5	1	+ 3	0
"	88.5	1	+ 5	+ 3
23.5	75.5	1	−10	−20
"	77.5	1	+22	+14
"	78.5	1	+11	+ 4
"	79.5	2	+18	+11
"	80.5	2	+19	+13
"	85.5	1	+31	+27

φ_0	λ_0	n	2	3
22.5	75.5	2	−16	−26
"	76.5	1	+ 5	− 4
"	77.5	3	+27	+19
"	82.5	2	+12	+ 7
21.5	75.5	1	+20	+10
"	76.5	2	+39	+30
"	77.5	2	+36	+28
"	80.5	1	− 3	− 9
"	81.5	1	− 2	− 8
20.5	77.5	1	+27	+19
"	85.5	1	+ 6	+ 3
18.5	72.5	1	+63	+50
13.5	80.5	1	−53	−60
11.5	76.5	1	+16	+ 6
"	78.5	2	−40	−48

I have deduced the following six gravity formulae :-
The first formula is derived from the stations in Europe, in the Caucasus and a few in Algeria. Total 283 degree squares.
The second formula is derived from all these stations together with the stations on the coast of Africa and in the Red Sea, reduced by Hübner and Meissner. (vide: A.N.B. 207 No 4967). Total 335 degree squares.
The third formula is derived from the stations in America. Total 234 degree squares.
The fourth formula is derived from the stations in Asia. Total 87 degree squares.
The fifth and sixth formulae are derived from the stations in Europe , Africa ,America and Asia . Total 656 degree squares.
In computing the sixth formula, I have assumed the earth is a tri-axial ellipsoid, while the first five formulae are based on the assumption that it is an ellipsoid with only two axes. The deduced formulae are as follows.

1. $\gamma_0 = 980.6416 - 2.5689 \cos 2\varphi + 0.00685 \cos^2 2\varphi$
   $\pm 24 \qquad \pm 65$
2. $\gamma_0 = 980.6401 - 2.5729$ " "
   $\pm 18 \qquad \pm 39$
3. $\gamma_0 = 980.6218 - 2.6027$ " "
   $\pm 17 \qquad \pm 65$

4. $\gamma_0 = 980.6221 - 2.5990 \cos 2\varphi + 0.00685 \cos^2 2\varphi$

$\quad\quad \pm 46 \quad\quad \pm 80$

5. $\gamma_0 = 980.6293 - 2.5883$ " "

$\quad\quad \pm 12 \quad\quad \pm 29$

6. $\gamma_0 = 980.6289 - 2.5842 \cos 2\varphi + 0.00685 \cos^2 2\varphi +$

$\quad\quad \pm 15 \quad\quad \pm 31$

$0.0266 \cos^2 \varphi \cos 2(\lambda - 18)$

$\pm 29 \quad\quad \pm 5$

or written otherwise:-

1. $\gamma_0 = 978.080\,(1 + 0.005253 \sin^2 \varphi - 0.000007 \sin^2 2\varphi)$

$\quad\quad \pm 7 \quad\quad \pm 13$

2. $\gamma_0 = 978.074\,(1 + 0.005260$ " ")

$\quad\quad \pm 4 \quad\quad \pm 8$

3. $\gamma_0 = 978.026\,(1 + 0.005322$ " ")

$\quad\quad \pm 7 \quad\quad \pm 13$

4. $\gamma_0 = 978.030\,(1 + 0.005315$ " ")

$\quad\quad \pm 10 \quad\quad \pm 16$

5. $\gamma_0 = 978.048\,(1 + 0.005293$ " ")

$\quad\quad \pm 3 \quad\quad \pm 6$

6. $\gamma_0 = 978.052\,[1 + 0.005285 \sin^2 \varphi - 0.000007 \sin^2 2\varphi +$

$\quad\quad \pm 3 \quad\quad \pm 6$

$0.000027 \cos^2 \varphi \cos 2(\lambda - 18)]$

$\pm 3 \quad\quad \pm 5$

In these formulae φ stands for geographical latitude and λ for longitude.

It may be seen that the gravity formulae deduced from the data of the European and African stations (Formulae 1 and 2) differ considerably from those deduced from stations in America and Asia. (Formulae 3 and 4)

This shows that the values of gravity at corresponding latitudes in Europe and Africa differ from those in America and Asia. It therefore appears that the force of gravity not only depends on latitude, but also on longitude. In order to determine the dependence of gravity on longitude, the last formula was computed with the data from all stations treating the earth as a triaxial ellipsoid.

The term depending on longitude is $+ \underset{\pm 6}{0.000027} \cos^2\varphi \cos 2(\lambda \underset{\pm 5}{-18})$. *)

The direction of the longer equatorial axis passes 18°E. of Greenwich, and the shorter equatorial axis, 72°W. of Greenwich.

The difference of these two axes is 690 ± 75 m.

Without the term involving longitude, our fifth gravity formula is derived from the data at all stations.

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*) The term $-0.000007 \sin^2 2\varphi$ has been deduced theoretically.

The sum of the squares of the whole 656 anomalies on the fifth formula amounts to 635,300, and in the sixth formula to 554,300, so our sixth formula makes the anomalies the smallest.

Corresponding to the five formulae the following inverse values of $\frac{1}{f}$ are obtained for the flattening of the earth;

$$\frac{1}{f} = \underset{\pm 1.1}{293.8}, \quad \underset{\pm 0.7}{294.5}, \quad \underset{\pm 1.1}{299.8}, \quad \underset{\pm 1.4}{299.2} \text{ and } \underset{\pm 0.5}{297.4}$$

and according to our sixth formula the average value is $\frac{1}{f} \; \underset{\pm 0.5}{296.7}$ and the smallest and largest values $\underset{\pm 0.6}{294.3}$ and $\underset{\pm 0.6}{299.0}$.

For comparison, a few of the earlier gravity formulae are given below:-

$$1. \; \gamma_0 = 978.030(1 + 0.005302 \sin^2\varphi - 0.000007 \sin^2 2\varphi)$$

$$2. \; \gamma_0 = \underset{\pm 3}{978.052}\left[1 + \underset{\pm 5}{0.005285} \sin^2\varphi - 0.000007 \sin^2 2\varphi + \underset{\pm 3}{0.000018} \cos^2\varphi \cos^2(\lambda + \underset{\pm 4}{17})\right]$$

$$3. \; \gamma_0 = \underset{\pm 4}{978.039}(1 + \underset{\pm 12}{0.005294} \sin^2\varphi - 0.000007 \sin^2 2\varphi).$$

Of these formulae, the first is Helmert's, which is used by Borras. In table X, the anomalies refer to this formula.

The second formula is also due to Helmert. He calculated this formula for a tri-axial ellipsoid by means of 410 gravity stations distributed all over the earth, but none of these were situated near mountains or coasfs of deep seas, and but few near the coasts at all.

the Free Air method was used for the reduction of these stations. The third formula was deduced by Bowie[1] from 252 stations or groups of stations isostatically reduced, which are mostly in America. These stations he has grouped together into zones, each covering 3 degrees of latitude.

Although Helmert has deduced his second formula from the results of plain stations, allowing for the Free Air reduction, it neverthless agrees with my sixth formula, which is deriv-ed from plain, mountain and coastal stations.

The first two terms, reduced on the Topo-isostatic method, are identical in both formulae, and only the third term differs. The numerical coefficient of this term is 18×10^{-6}, but according to my formula 27×10^{-6}; and according to Helmert, the longer equatorial axis passes 17°W. of Greenwich, whilst I find it passes 18°E. of Greenwich. The large difference in these terms is mainly due to the fact that Helmert has not taken into account the stations in the Caucasus, the Mediterranean, or the Red Sea. The formula for gravity deduced by Bowie is not so very accurate, as he only had at his disposal stations lying within a zone of 33° in latitude, consequently his determination of the $\sin^2\varphi$ term is more doubtful. It can be easily seen that his formula does not agree with the general distribution of gravity in Europe.

1) W. Bowie, Investigations ... p. 134.

The inverse value $\frac{1}{f}$, representing the flattening of the earth according to the first and second formulae of Helmert, is 298.2 ± 0.5 and 296.7 ± 0.4; and according to Bowie's formula 297.4 ± 1.0

It is difficult to judge how well my last gravity formula corresponds with the distribution of gravity all over the earth, as the areas investigated by me cover only a small fraction of the globe. It will not be possible to deduce a gravity formula, satisfactory in every respect, until isostatically reduced stations are spread all over South America, Africa, Asia and Australia, as well as over the oceans, but this ideal is not likely to be obtained in my life time.

I can however say now with confidence that the Earth is a tri-axial ellipsoid.

The anomalies according to my sixth formula are shown in the last column of table VIII.

I have prepared a Map of Europe and Adjacent Countries on which these anomalies are entered in units of 0.001 cm/sec^2.

It is remarkable that on this map the anomalies appear to be regularly distributed. On comparing this map with one prepared by Kossmat, which shows the anomalies according to the Bouguer reduction, it will be seen how much smaller and more regular the anomalies become on the assumption of isostasy than they are without this assumption. For instance, the strong negative anomalies, which are shown in Kosmatt's map, almost entirely disappear in the Alps and Carpathians and the positive anomalies on the Mediterranean show a great decrease. The larger areas, which exhibit a defect of gravity are Scandinavia, France, Spain, Algeria, Galicia and the area round the Caspian Sea. The areas, which exhibit an excess of gravity, are Germany, Bohemia, Hungary and the Mediterranean Sea. The strongly positive anomalies (+123 and +70), found in the Lofoden islands, adjacent to the negative anomalies in Scandinavia, appear very remarkable.

The negative anomalies in the Alps and the positive anomalies in the Caucasus become normal, if the stations in the Alps are reduced on the basis of a smaller depth of compensation, and those in the Caucasus, with a larger depth of compensation, as already stated.

IV CONCLUSION.

The outcome and most important results of my whole investigation are as follows:-

The results obtained at 71 gravity stations in the Caucasus, and 48 in Europe, have been investigated on various isostatic assumptions, and reduced on the basis of both Pratt's and Airy's theories. Different depths of compensation have been tested for the Hayford theory, and various thicknesses of the earth's crust and lava-layer have been tried for Airy's theory.

Moreover the Bouguer reduction, the Free Air reduction, the Purely Topographic reduction and the reduction on the basis of Regional Compensation have been carried out for the stations in the Caucasus. In order to carry out these reductions, it was necessary first to calculate some auxiliary tables. To simplify the calculation of these tables for the reduction on the Airy hypothesis, it was assumed that the earth's crust was homogeneous, and floating on a homogeneous layer of lava, of a density exceeding that of the earth's crust by 0.2, 0.3, and 0.6.

2. It has been found that the Purely Topographic reduction, which takes into account the more distant curvature of the earth and topography of the more distant zones, gives theoretical values of gravity in the Caucasus, exceeding those obtained on the Bouguer reduction (which neglects the distant zones), by about 0.100 cm/sec^2. Also that no reduction without isostatic compensation corresponds with, or can explain, the observed distribution of gravity.

3. It is shown that the Hayford theory, with a depth of compensation of about 250 Km., and regional compensation with a depth of 110 Km., shows the best accordance with the observed distribution of gravity in the Caucasus. The Airy hypothesis, assuming a thickness of 77 Km., for the crust of the earth at sea-level, shows a still better accordance with observed values of gravity in the Caucasus.

The Apsheron peninsula on the Caspian Sea, (and surrounding count -ry), forms an area where gravity is in defect.

4. The commonly accepted ideas that the Harz mountains have no subterranean compensation whatever, and that the Riesengebirge are but slightly compensated, have been shown to be incorrect. On the contrary, it appears rather that, in both areas, the gravity distribution corresponds with that which it should have been under isostasy.

5. The statement of the geologists that mountain chains are not compensated in themselves, but are so, when taken in combination with their marginal depressions and that accordingly the marginal depressions are actually over-compensated, whilst the mountains themselves under-compensated - has been proved to be incorrect; and it has been found that the distribution of gravity is just as normal in the marginal depressions of the Alps, Carpathians and Caucasus, as in mountain ranges.

6. An investigation of the American mountain and coastal stations, reduced by Bowie, shows that Airy's theory, on the assumption of a thickness for the earth's crust of 50 Km., explains the gravity conditions of the United States better even than the Hayford theory.

7. An examination of the earlier reductions of Alpine stations, as well as of those carried out by me in the Alpine marginal depression, shows that the Hayford theory,

with the depth of compensation of 107 Km., and the Airy theory, assuming the thickness of the earth's crust of 41 Km. under the Alps, best explain the observed facts. Under the Austrian Alps, the thickness of the earth's crust is less, or there may be, a local area of defect of gravity.

8. From the discussion of the anomalies in the Caucasus, the Alps and the U.S.A., it is evident that Airy's theory accords with the gravity observations at least as well as Pratt's theory, but the thickness of the earth's crust up to sea-level, varies, on the Airy theory, between 30 and 80 Km. in different parts of the world.

9. With the aid of the isostatic reduction of the gravity stations, six formulae for gravity are derived. Moreover in order to be able to utilise the data from as large an area as possible, a large number of stations in the plains, in the lower mountains and on the coasts were reduced by contracted methods. This simplified method of procedure produces sufficiently accurate data.

10. In order not to give too much weight to the areas which had been gravimetrically explored in detail, the procedure was adopted of treating all stations in the area of one degree square as a single station of weight "I".

The gravity formulae have been derived from results of the gravity stations in the following areas:-

The first formula was derived from the results in 283 (degree square) areas in Europe and the Caucasus.

The second formula from the results in 234 (degree square) areas in Europe and Africa.

The third formula from the results in 234 (degree square) areas in America.

The fourth formula from the results in 87 (degree square) areas in Asia.

The fifth and sixth formulae from the results in 656 (degree square) areas in Europe, Africa, America and Asia.

The fifth formula is based on the assumption that the equator is a circle.

The sixth formula on the assumption that the equator is an ellipse.

11. Our last gravity formula which is:-

$$\gamma_0 = \underset{\pm 3}{978.052}\left[1 + \underset{\pm 6}{0.005285}\sin^2\varphi - 0.000007\sin^2 2\varphi + \underset{\pm 5}{0.000027}\cos^2\varphi\cos 2(\lambda \underset{\pm 5}{-18})\right],$$

shows that the earth is a tri-axial through longitude 18°E. of Greenwich and the shorter axis through 72°W. of Greenwich.

The flattening of the earth along 18^{0} longitude amounts to $\frac{1}{294.3 \pm 0.6}$ and along 72^{0} longitude to $\frac{1}{299.0 \pm 0.6}$. The differen-ce in length between the longer and shorter equatorial axes is 690 ± 75 m.

12. The gravity anomalies have been corrected by means of this formula and the corrected values are shown in table XIII. The anomalies of the stations in Europe, the Caucasus and Algeria are shown in the map at the end of the book.

<u>End</u>

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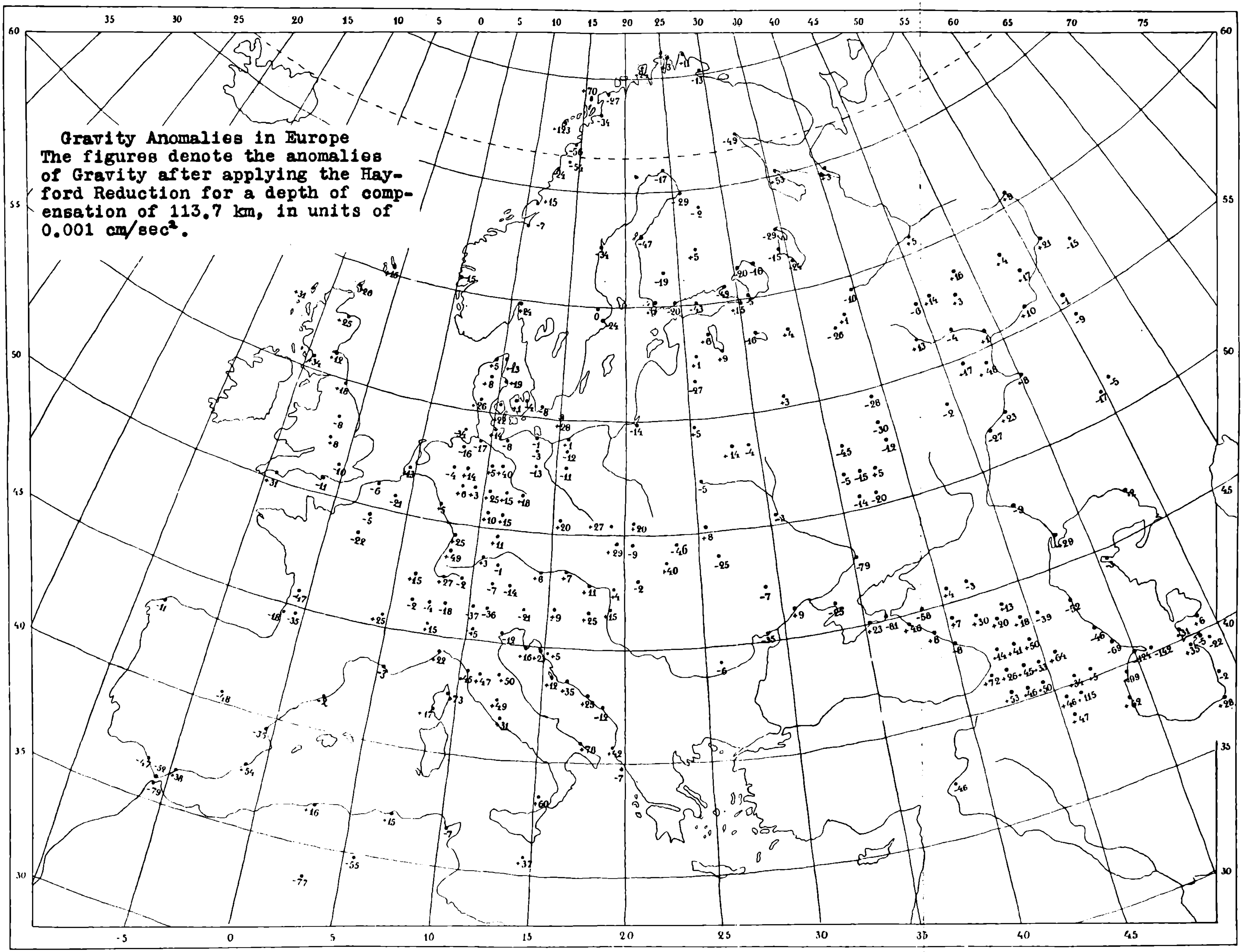
Gravity Anomalies in Europe
The figures denote the anomalies of Gravity after applying the Hayford Reduction for a depth of compensation of 113.7 km, in units of 0.001 cm/sec².