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Contact

Niedersächsische Staats- und Universitätsbibliothek Göttingen
Georg-August-Universität Göttingen
Platz der Göttinger Sieben 1
37073 Göttingen
Germany
Email: gdz@sub.uni-goettingen.de

Gravity Observations in the Solikamsk and Berezniaky Districts in the Northern Urals in 1926 and 1927.

By **B. Numerov.** — (With four Illustrations.)

The gravity survey north of Solikamsk City was first undertaken in 1926 to the purpose of securing the underground salt relief among the known bore-holes.

In 1926, a party under S. E. Alexandrov, with one variometer (large model Bamberg-Schweydar, No. 90) executed the survey of an area of about 6 sq. km, within the area of bore-holes Nos. 1, 2, 3, 4, 5 (s. fig. 1). From 25/VII to 11/X a total of 109 were secured, irregularly situated over the area, scattered along the roads and single meadows in wood, at some places very marshy. For this reason the estimation of the effect of topographical masses was hampered to a considerable degree.

In fig. 1 are given the vectors of gravity variations and isogams drawn (lines of equal gravity anomaly) from an arbitrary zero through every 0.0002 cm, obtained by means of numerical integrating of gradient values observed. Gravity is increasing from south to north. It would be natural to presume, with increasing gravityan increase of thickness of the overlying clays and sands; whereas the gravity minimum must correspond to maximal approach of salt to the day surface, the density of salt being lower than that of overlaying clays and sands.

In 1927, the survey began early in spring, when the snow cover in the wood was still over 1 m thick. An area has been surveyed of about 10 sq. km south of Solikamsk within the area of the bor-holes Nos. 6, 7, 8. A party under N. N. Samsonov secured with the variometer No. 90 from 5/IV to 6/IX, 253 points on a terrain strongly cut and at some places covered with thick wood. The estimation of topographical masses was performed according to new formulae*), worked out to the purpose of estimating the arbitrary relief. In fig. 2 are given the vectors of gravity variations and isogams drawn through 0.0001 cm, starting from arbitrary zero.

The second and third parties investigated in 1927 the region of Berezniaky near Ussolye City. The party under S. E. Alexandrov executed the survey

*) B. Numerov: Reduction of observations with gravity variometer for topography. Bull. Astr. Inst. 1927, No. 17 (Russian).

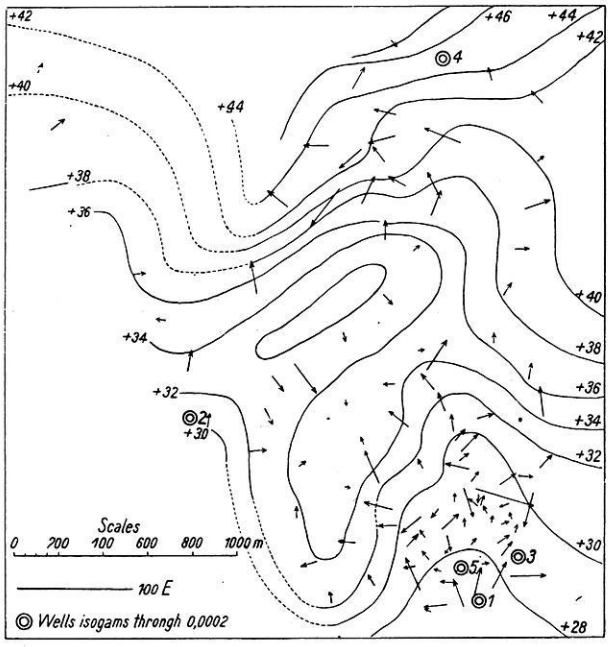

fig. 1. Results of gravity observations near Solikamsk in 1926.

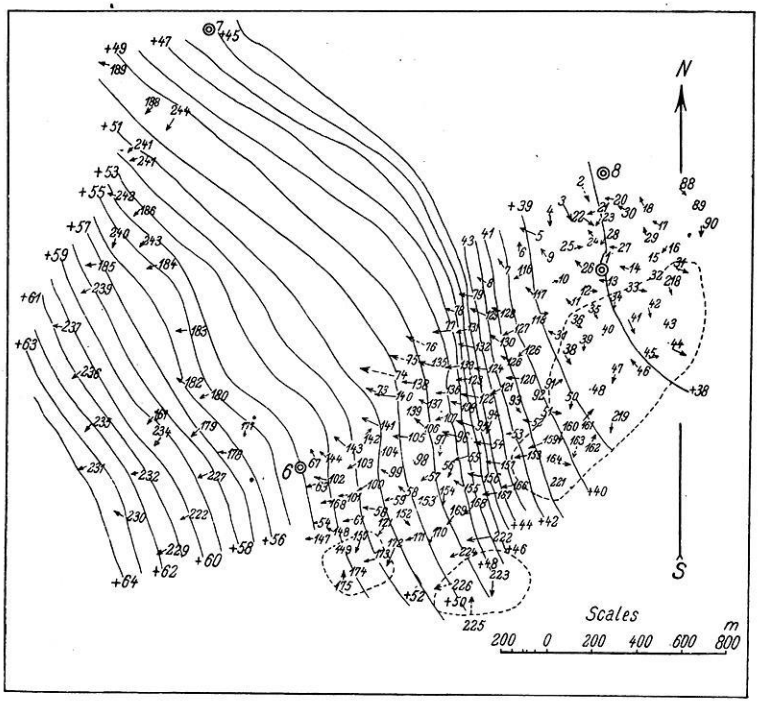

fig. 2. Results of gravity observations near Solikamsk in 1927.

of the northern portion of the area about 16 sq. km. From 4/VII to 16/X, 180 stations were secured with the little Bamberg variometer No. 533.

The party under S. P. Poletaiev worked on a more southern area of 15 sq. km and obtained 156 stations with variometer No. 45.

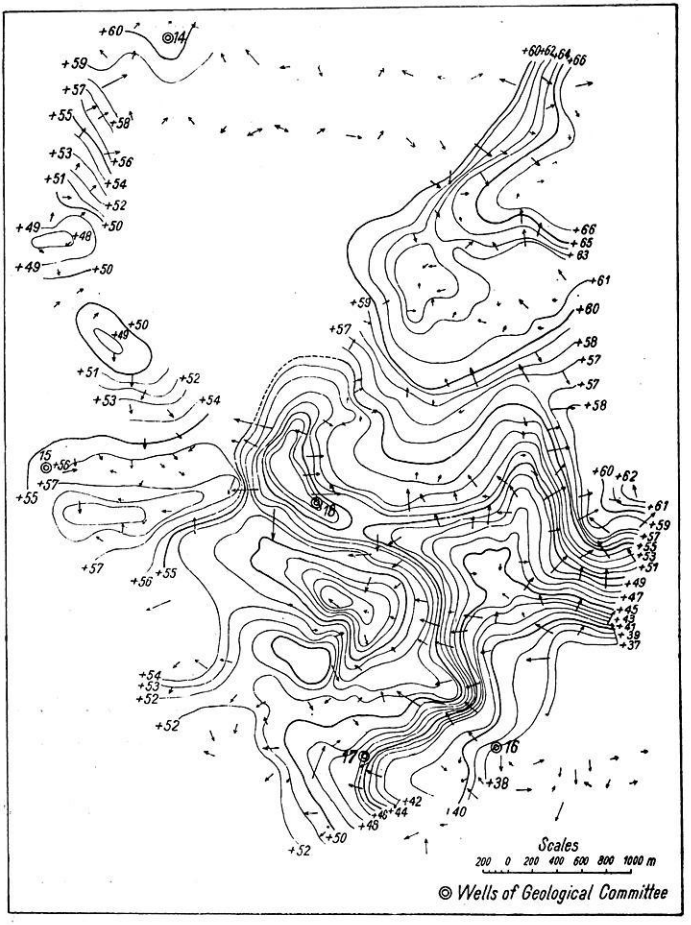

fig. 3. Results of gravity works near Solikamsk (Ussolye) in 1927.

Fig. 3 shows the combined results of the work of both parties. On this area borings Nos. 14, 15, 16, 17 and 18 are situated.

The gravity survey in the above three regions was executed by areas. Some modifications were introduced in 1927 by the party under S. E. Alexandrov which were due to wide marshes. The survey was carried out in single chains of triangles, like triangulation network. Each triangle was plotted separately,

*

thus the gravity transport was carried out under control along the whole chain, after which the entire chain of triangles was plotted.

To establish the connection between the depth of the salt-bearing mass and the gravity anomalies one has to confront the results of borings with anomalies Δg by single regions. In Table 1, are given the depths h of the salt-bearing mass and marks of Δg taken from the plans 1, 2 and 3.

Table 1.

No. of borings	Depth of salt h^m	$\Delta g . 10^4$	$h - h_0$	$\Delta g - \Delta g_0$	(h)	ε^m	
1	212	27	— 22	— 4.8	194	+ 18	$\Delta g . 10^4 = 0.139 h$
2	220	31	— 14	— 0.8	223	— 3	$h^m = 7.19\ 1g$
3	209	29	— 25	— 2.8	209	0	
4	329	45	+ 95	+ 13.2	324	+ 5	
5	200	27	— 34	— 4.8	194	+ 6	
6	368	54	70.5	10.25	375	— 7	$\Delta g . 10^4 = 0.144 h$
7	307	45	9.5	1.25	313	— 6	$h^m = 6.94 \Delta g$
8	271	38	— 26.5	— 5.75	264	+ 7	
11	244	38	— 53.5	— 5.75	264	— 20	
12	177	—	—	—	—	—	
14	386	61	84.6	11.2	384	+ 2	$\Delta g . 10^4 = 0.159 h$
15	320	55	18.6	5.2	346	— 26	$h^m = 6.29 \Delta g$
16	238	38	— 63.4	— 11.8	239	— 1	
17	281	47	— 20.4	— 2.8	296	— 15	
18	282	48	— 19.4	— 1.8	302	— 20	

The close connection between gravity anomalies and the depth of salt is directly appearing from the above Table. The maximal anomaly corresponds to sinking of salt and the minimal to rising. This dependency is graphically shown in fig. 4. We can state that the relation between Δg and h is of the simplest aspect:

$$\Delta g = a + bh \quad \ldots\ldots\ldots\ldots \quad (1)$$

or, that the gravity anomaly and the depth are linearly connected*), the coefficient a being dependent upon the accepted zero in the isogam marks and the coefficient b, on account of theoretical formula of attraction of an infinite layer, can be put as equal to

$$b = 2\pi K^2 \delta = 42 . 10^{-8} \delta (\text{C. G. S.}) \quad \ldots\ldots\ldots \quad (2)$$

where $K^2 = 667 . 10^{-10}$ (C. G. S.) is constant of attraction and δ the difference of density of two rocks, in the given case of clay and salt. Solving for each district a system of equations of the form (1) with two unknown quantities a and b, we find the searched numerical dependence between Δg and h, thus, by the gravity anomaly Δg in the given locality, we can compute the depth of salt h. In Table 1 are given computed depth values (h) by single districts, and finally discrepancies $\varepsilon = h - (h)$ which characterize the accuracy of

*) B. Numerov: Results of gravimetrie observations on Shuvalovo Lake in winter 1927 and 1928.

computation of the salt depth based upon the data of gravity survey. From confronting of single discrepancies we can compute the average quadratic error of determination of the salt depth, namely $\varepsilon = \pm 12$ m. None of the 14 borings is contrary to evidence furnished by gravity survey, which is the best argument in favour of application of gravitational method of prospecting in the Solikamsk District.

It is very important to point out, that the coefficient b connected on account of formula (2) with difference of densities δ, is almost equal for all the three districts and yields for density difference numbers $\delta = 0.33$; $\delta = 0.34$ and $\delta = 0.38$ or in average the density of salt is on 0.35 lower than that of overlaying rocks. The stability of the coefficient b throughout the whole area enables us to compute the salt depth but from the evidence or one single boring. However, we must bear in mind that the sphere of action of a given boring is limited, because the gravity variation at great distance will not only occur on account of variation of salt depth, but it depends upon "deep geology", which in exceptional cases only can be estimated by means of pendulum observations, the use of formula (1) being thus possible in limited areas only.

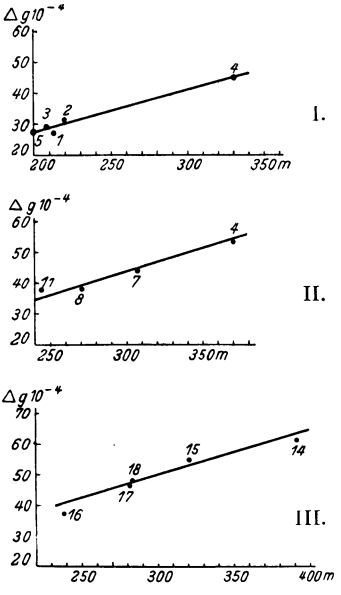

fig. 4.

Depence between the anomaly of gravity Δg (0.0001 cm sec^{-2}) and the depth of salt h (meters): Figurs at the points are numbers of the wells.

I. North of Solikamsk. II. South of Solikamsk. III. Near Berezniaky.

A natural continuation of the above works would be the gravity survey along the railway from Berezniaky to Solikamsk. The result of such survey would be a map in isogams, which, as is seen from experience, can be with certainty recognized as the underground salt relief.

Results of Gravity Observations of 1928 near Lake Baskunchak.

By **B. Numerov.** — (With one Illustration.)

With the developement in recent years of geophysical methods for the investigation of the inner structure of the nearest strata of the earth, special attention has been given to gravity observations: the determination of gravity by means of pendulums and the study of certain qualities of the potential of