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GRAVIMETRIC SURVEY AND GRAVIMETRIC DATABASE IN UKRAINE “Dniprogeofizika” during 2000–2011 carried out works on collection, analysis and formation of an electronic gravimetric data base (GDB) of the territory of Ukraine. Based on the results of the work car

***V. Svistun** (*Dnepropetrovsk Geophysical Expedition "Dniprogeofizika" State Geophysical Enterprise "Ukrgeofizika", Ukraine, Dnipro*), **P. Pigulevskiy** (*Dnepropetrovsk Geophysical Expedition "Dniprogeofizika" State Geophysical Enterprise "Ukrgeofizika", Ukraine, Dnipro*)

SUMMARY

Dnepropetrovsk Geophysical Expedition (DGE) “Dniprogeofizika” during 2000–2011 carried out works on collection, analysis and formation of an electronic gravimetric data base (GDB) of the territory of Ukraine. Based on the results of the work carried out, a systematization of the materials of all conditional gravimetric surveys in scales of 1:200000 – 1:1000 was carried out. The database was created for the purpose of systematization, reliable storage and operative application of digital attributes of gravimetric surveys of the last years with a possibility of construction of gravimetric maps of various territories and scales. Information from the database makes it possible to study both the general structure of individual tectonic structures, and to perform detailing to obtain additional information about the structural features of each element.

As an example, materials on the study of the engineering and geological conditions of the southern industrial zone of Kryvbas are given. The use of the GDB allows to correctly supplement the picture of the gravitational field obtained from individual profiles when constructing multi-scale spatial maps and to reflect more detail the structural features of the upper part of the earth's crust.

Introduction.

Dnepropetrovsk Geophysical Expedition (DGE) “Dniprogeofizika” is the base organization of the State Service of Geology and Mineral Resources of Ukraine for carrying out gravimetric works and has curatorial functions among geological enterprises. Specialists of expedition during 2000-2011 carried out work of collection, analysis and formation of the gravimetric data base (GDB). The purpose of the presented report is to familiarize the scientific community with information about the general state of coverage of the territory of Ukraine with different-scale gravity surveys, which are used in the construction of all-Ukrainian gravity map and for studying of the features of the geological structure of geological structures and massifs in the gravitational field according to scales of 1: 200 000 and 1: 50 000 – 1:10 000.

The state of gravimetric surveys in Ukraine. In the process of performing work on the creation of digital electronic maps of gravimetric fields of the territory of Ukraine, specialists of DGE “Dniprogeofizika” during 2000-2011 systematized the materials of gravimetric observations of all conditioned surveys in scales of 1:200000 – 1:10000, which were carried out on the territory of Ukraine, from the mid-40s of the last century to the present.

By the end of the 60s of the last century, the entire territory of Ukraine was covered with gravimetric surveys in scale of 1:200000 – 1:100000. Territories occupied by large reservoirs on the river Dnipro, estuaries and bays of the Black and Azov seas were not covered. The observation network ranged from 1 point per 8,0 km² to 1 point per 1,0 km², the root-mean-square error of the obtained values of Bouguer anomalies at ordinary points was from $\pm 0,8$ to 0,4 mGal, and the cross-section of isolines on the maps were 2,0 and 1,0 mGal, accordingly with the requirements of the normative documents depending on the scale of work. Subsequently (except for the “geological” application), the survey materials were used in the compilation of gravimetric maps of the USSR in scale of 1: 200000 and explanatory notes to them.

Gravimetric survey in scale of 1:50000 and larger, the territory of Ukraine is covered extremely unevenly. In total, such surveys cover about 72% of the area. Their coverage for individual geological geostructures of Ukraine is given in table 1.

Table 1 Study of the territory of Ukraine by gravimetric surveys (as of 01.01.2019 without taking into account detailed commercial surveys for oil and gas).

Name of geological regions	Area of the region km ²	A scale of 1:50 000-1: 10000 cross section of isolines 0,25-0,10 mGal			A scale of 1:50 000 cross section of isolines 0.50 mGal		
		Sheets to a scale of 1: 50000	km ²	% of coverage of the region	Sheets to a scale of 1: 50000	km ²	% of coverage of the region
1	2	3	4	5	6	7	8
1. Carpathian	41400	4,5	1553	3,8	113	38985	94,1
2. Volyn-Podolsk plate	91800	47,4	16114	17,6	127	43180	47
3. Ukrainian shield	190543	316,9	105583	57,2	164	56449	29,6
4. Dnipro-Donetsk depression (DDD)	120184	121	40156	33,4	93,5	31042	25,8
5. Donbass	51984	79,3	27129	52,2	59	20178	38,8
6. Black Sea aria	55885	13,3	4700	8,4	21	7428	13,3
7. Pre-Dobrudzha	8489	3	1061	12,5	21	7428	87,5
8. Crimea	24495	6	2130	8,7	63	22365	91,3
9. Voronezh-crystalline massif (VKM)	18920	10	3320	17,5	15	4980	26,3
Total on the territory of Ukraine	603700	601,4	201746	33,4	676,5	232035	38,5

The main volumes of gravimetric survey in scale of 1:50000 were carried out during 1960-1990. At the initial stage, observations were carried out over a network of 500-400m x 500-400m with an error

in determining the gravity potential (GP) no more than $\pm 0,15$ mGal, and the determination of the horizontal-height position did not exceed ± 40 m and $\pm 0,7$ m, accordingly, which ensured the determination of Bouguer anomalies with an error up to $\pm 0,20$ mGal (Instructions of gravity prospecting, 1980).

If this accuracy is observed, the cross-section of isolines on the maps is 0,5 mGal. Such surveys were mainly used at the stage of exploratory regional studies, as well as at the part of advanced geophysical surveys for medium-scale geological mapping.

From the mid-70s of the last century, the accuracy of gravimetric observations in scale of 1:50000 increased due to using of gravimeters GNU-KV and GNU-KS. Accordingly, the survey parameters also changed: the observation grid was condensed to 400-200m x 250-200m, the mean square error in determining the GP decreased to $\pm 0,07$ mGal, the horizontal-height position up to ± 40 m and 0,35 m, anomalies in the Bouguer reduction to $\pm 0,10$ mGal. Subject to these conditions, the cross-section of isolines on the maps was 0,25 mGal. Due to the more detail and accuracy, these surveys significantly increased the reliability of solving both purely geophysical and a wide range of geological problems.

Gravimetric survey in scale of 1:25000 has been carried out mainly from the beginning of the 70s of the last century to the present. It is characterized by the following parameters: observation network 250-200m x 250-100m, mean square error of GP determination not more than $\pm 0,06$ mGal, horizontal-height position, accordingly, ± 20 m and 0,25 m, anomalies in Bouguer reduction up to $\pm 0,08$ mGal. If such survey parameters are observed, the cross-section of isolines on the maps is 0,20 mGal (Instruction for gravity prospecting, 1980).

Detailed surveys in scale of 1:10000 are necessarily performed in conjunction with magnetic prospecting and are widely used in the preparation of geophysical foundations in scale of 1:10000 to provide geological exploration for the search for ferrous, non-ferrous, rare, precious and other metals and non-metals at the stage of prospecting and evaluation works, determination places of hydrocarbon deposits and engineering and geological surveys. Such surveys occupy very small areas and are not analyzed in this article.

Features of performing large-scale and detailed gravimetric surveys. Surveying is mainly carried out in conjunction with magnetic prospecting to solve three important tasks, namely:

1. Searching for promising structures for the presence of hydrocarbons in the sedimentary cover and crystalline basement, first on the territory of the DDD and its southern and northern slopes;
2. Preparing a geophysical base for geological study of areas in scale of 1:200000 – 1:50000 (GGM-200, GGM-50), deep geological mapping in scale of 1:200000 and 1:50,000 (GGM-200 and GGM-50), including the dissection of rocks of the crystalline basement with their geodensity (magnetic) properties, mapping of folded and ruptured tectonics of the sedimentary cover, searches for areas of development of reef limestones, and several others. Such works are mainly carried out on the Ukrainian Shield (US) and its slopes.
3. Detailing in scale of 1:10000 and 1:1000 in the localization and forecasting of traps of hydrocarbons, ferrous, non-ferrous, rare, noble and other metals and non-metals, in geoecological and engineering-geological studies. Correct interpretation of such objects requires more complete information about the structural features of various geological objects, depending on the depth of their occurrence.

The electronic database was developed for the purpose of systematization, reliable saving, operational use of digital data of gravimetric surveys of past years and for the construction of gravimetric maps of various territories and scales. The base of digital gravimetric data was created in the environment of DMS MS Access. In addition to the main geological electronic database, for surveys in scale of 1:200000 and sheet gravimetric maps of the USSR in scale of 1:200000, a separate subbase allows build digital electronic maps of gravitational fields of different scales and with different densities of the intermediate layer in the Bouguer reduction in any region of Ukraine.

For designing studies of regions and areas of particular interest, electronic schemes were developed for the study of the territory of Ukraine by gravimetric surveys in scale of 1:50000 – 10000.

The attributes of an electronic geophysical survey include the main parameters of gravity surveys (Instructions for gravity survey, 1980):

- the coordinates of gravimetric points (X, Y) in the Gauss-Kruger coordinate system, Pulkovo, 1942;
- the height of points (H) according to the Baltic system;
- the value of anomalies in the Bouguer reduction with an intermediate layer density of $2,67$ g / cm³.

An example of using a database of various scales. Since the end of the last century, one of the main priorities of geological surveying work by the state order in Ukraine has been the geological study of areas in scale of 1:200000 (GGM-200), the purpose of which is to compile, prepare and publish a multipurpose State Geological Map in sheets in scale of 1:200000 (Svistun et al., 2020). In addition to solving diverse problems with the GGM-200, the GDB is also used in the preparation of a geophysical basis for the geological study of areas under the GGM-50, deep geological mapping, prospecting for hydrocarbons, and geotechnical research. It allows you to build 2D and 3D geo-density models of the structure of the earth's crust and upper mantle (Pigulevskiy, 2011; Svistun et al., 2020).

Below is an example of the application of geological surveys when performing engineering and geological studies in the south of Kryvbas (Pihulevskiy et al., 2019).

Gravimetric studies in the southern part of Kryvbas were carried out by DGE “Dniprogeofizika” from a series of individual profiles in 2018 with a step of 10 m with an observation error of $\pm 0,38$ mGal. When constructing a spatial map of the anomalous gravitational field (in the Bouguer reduction) in the scale of 1:10000 with a grid of 50x50m, data from the electronic GDB were used (Fig. 1).

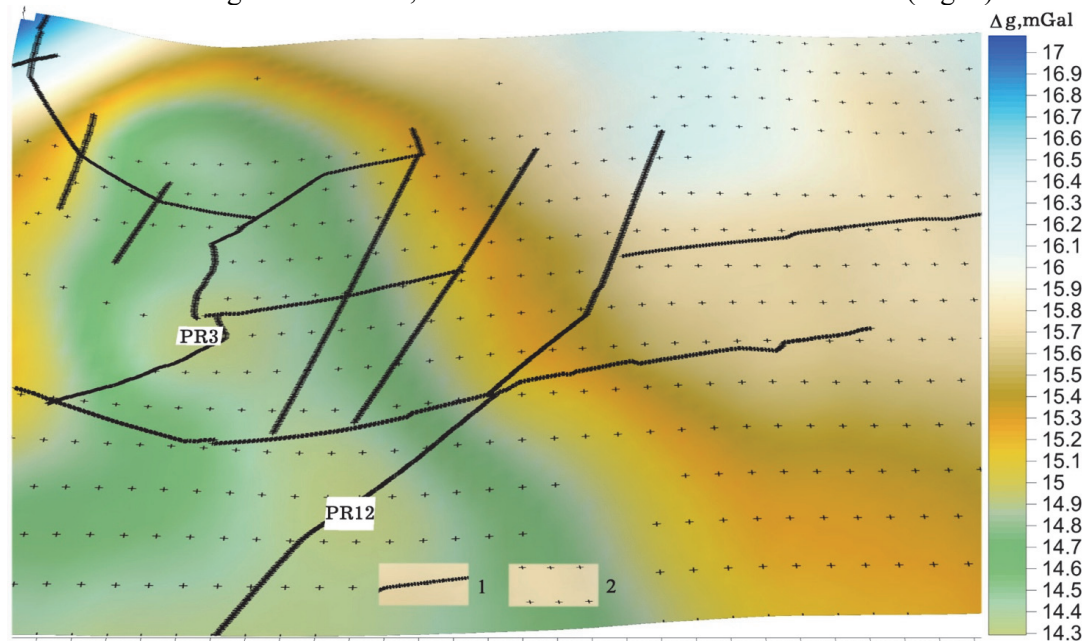


Figure 1 Light-shadow map of the anomalous gravitational field of the territory of southern Kryvbas based on survey materials the scale of 1:50000 – 10000. Symbols: 1 – observation points of the gravitational field in the scale of 1:50000 (1984); 2 – points of profile observations of the gravitational field with a step of 10 m (2018) and their number.

Analysis of materials from surveys of the territory in previous years showed that most of it is covered by a medium-scale gravimetric survey in the scale of 1:50000 with an observation grid of 200x400 m. The error in determining anomalous values of the gravitational field is $\pm 0,54$ mGal. Survey in the scale of 1:50000 was carried out to prepare the geophysical base for prospecting and exploration for ferruginous quartzites. Field observations were carried out in 1984 for the construction of the “Ob'yednane” sludge dump and with partial filling of the “Voikove” sludge dump, which made it possible to obtain additional information about the peculiarities of the tectonic structure under modern technogenic objects of engineering-geological zoning of the study area. Considering these data, a more correct map of the gravitational field was obtained by reducing the error during inter-profile interpolation (Fig. 1). In this case, the error in determining the anomalous values of the gravitational field is equal to the error of the Bouguer anomalies, which for such a scale is $\pm 0,05$ mGal.

The constructed map of the gravity field for engineering-geological studies of the area of the southern industrial zone of Kryvbas (Svistun et al., 2020; Menshov et al., 2012; Menshov, 2018; Pihulevskiy et al., 2019; Tiapkin et al., 2019) indicates a multi-level structure of the upper part of the earth's crust. In the next geo-density modeling of this area, it is necessary to consider the value of the gravitational field outside the area, which depend on the features of the deep geological structure and allow to calculate their contribution to the anomalous gravitational field.

Perspective of using. Characterizing the created electronic GDB of the gravimetric field of the territory of Ukraine, it should be noted that this is only the first stage. Second (final) stage of this large and important work needs to be completed. The urgent need to complete this stage is associated with the directive document SOU 73.1-41-04.02.04:2004 “Digital gravimetric map of Ukraine” the requirements of the from 01.01.2007. According to this document (clause 4.6), in order to adapt to European and world standards, a digital gravimetric map in the IGSN-71 system should be created using the coordinates and heights of the world geodetic system WGS-84 (SOU73.1-41-04.02.04:2006). Using the indicated geodetic system, not only the coordinates and heights of the gravimetric points changed, but the formula for calculating the anomalies in the Fai and Bouguer reductions also changed. This is due to several factors, namely: a change in the formula for calculating the normal gravitational field of the Earth due to a change in the ellipsoid and taking into account the sphericity of the Earth's figure and refinement of the Fai correction.

Conclusion. Based on the results of collection, analysis and generalization of the results of gravimetric surveys of different years, the materials were systematized and an electronic GDB (digital model) of the gravitational field of Ukraine was created, which includes information on all conditioned gravimetric surveys in the scale 1:200000 – 1:10000. The base allows to reliably store and efficiently use the digital attributes of gravimetric surveys of past years and build gravimetric maps of various territories at variable scales.

The materials presented by authors on the southern part of Kryvbas show that the gravitational field reflects not only the structural features of the sedimentary cover, but also the crystalline basement.

The implementation of the second stage of this important work will make it possible to adapt the digital model of the gravitational field of Ukraine to European and world standards using the coordinates and heights of the world geodetic system WGS-84.

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