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Bouguer anomaly map of Hungary

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The Bouguer anomaly map of Hungary on a scale of 1:500,000 is given as Encloure 2. The main stages in construction and some geophysical–geological viewpoints are given.

Keywords: gravity surveys, Bouguer anomalies, Hungary

Gravity measurements have been carried out in Hungary since 1901. At the beginning one used the Eötvös torsion balance; later, from the 1940s — regarded as modern — gravimeters were used. In the meantime, although the methods of measurement and preprocessing have not changed, the accuracy of field measurements has increased. This was due to the more up-to-date and precise gravimeters as well as to the more strict altitude-determination because of the increased accuracy (exact determination and consideration of the measuring mass and of the altitude of the instrument stage).

During the period of the cold war, gravity data were top secret, which caused a great many problems concerning the processing and interpretation of the measured data. The unified gravity network of Hungary was completed in the 1950s, and since that time gravity processing for geological purposes uses this so called MGH–50 basic network.

Because of the uniform data system and because of the pre-processing of gravity data (various corrections) the demand for computer based data processing arose very early. Doubtless this is why gravity survey data became the basis of ELGI's first digital database. The preliminaries of database handling started in the 'big-computer' period, in 1968, but the standardized form of stored gravity data became final and general in database processing only in 1984 [KOVÁCSVÖLGYI 1993]. Data were stored first in data files organized according to map sheets on a scale of

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1:25,000; later, in order to speed up database operations, on a scale of 1:100,000.

There are more than 380,000 gravity points in Hungary [KOVÁCSVÖLGYI 1994a, KISS 2001] and there are only a few places where one cannot get useful geological information of gravity data because of lack of data. In that most data originate from state-supported measurements the database is qualified as open access. The territory of Hungary is totally covered with measurements in a quasi-network, with sparse but uniform density along roads. The dense gravity field measurements in a regular network are connected with industrial raw-material prospecting, mainly with oil, gas, coal and bauxite prospecting, and some of these measurements are no longer open access.

The survey density for the whole country is, on average, 4 point/km^2; but there are parts where the density does not reach 1 point/km^2. Such places were for example, W Mecsek and its surroundings, where there was practically no measured point on an area of 240 km^2 up till 2002 [KISS 2002]. The efforts of the last years tried to terminate this situation. As geophysical preparation for geological prospecting with a view to the deposition of radioactive waste deposits we hope to rectify this.

A countrywide gravity map on a scale of 1:500,000 was first prepared in 1978. Later, in 1984, Szabó and Sárhidai [SZABÓ 1989], and in 1996 Kovácsvölgyi and Stickel prepared subsequent variations — the latter only for internal application. Thanks to the readiness of the database as well as the development of the processing and printing representation capacities [VÉRTESY 2002], and to the financial support by OTKA of 'Hungary's gravity lineament map' topic the latest printed version of the Bouguer anomaly map could be finished on a scale of 1:500,000 (Enclosure 2).

Because of the inequality of the measurement density and the need to prepare a gravity map of Hungary we made use of interpolated data to obtain grids with a size of 500 or 1000 m. The choice of a smaller grid could result in pseudo-anomalies in interpolation; e.g. one might show during the processing the measuring tracks instead of geological effects. We filtered out false and double points as well as testing by multiple interpolations which grid size and blanking distance should be applied for a given measurement density [KISS 2002]. While constructing the Bouguer anomaly map we interpolated the data in a 1000 m grid, and carried out further interpolation only so that we could achieve a better presentation by making the original grid more dense.

When constructing a Bouguer anomaly map reduction-density is a very important parameter, being 2000 kg/m^3 on basin-areas, and in outcrop regions about 2670 kg/m^3. Since in the framework of the OTKA project we basically examined the structural relationships of the basin areas covered with young loose sediments — faults and formation borders appear with good identifiability in the areas of outcrops — we applied as a basic map the Bouguer anomaly map calculated with a 2000 kg/m^3 reduction-density (Enclosure 2).

During processing we applied the MGH–50 gravity system — this is the gravity database system, on the Potsdam base-level, applying the Cassinis-like (1930) normal field formulae, and calculating with the Adrian-altitude. This has been used in Hungary since the 1950s for geology-oriented geophysical prospecting.

Bouguer anomaly maps — achieved as a result of gravity measurements and serving as the basis for interpretation — can be used in practice for the following purposes:

tracking the relief of high-density basin-basement;

proving the lateral density variations in the basement;

examining density inhomogeneities of the sedimentary sequences filling the basin;

delineating high-density magmatic formations settled in between the basin filling sedimentary sequences.

Almost all geological problems can be linked with one of the listed items. During raw-material prospecting (oil, gas, coal or bauxite), thermal water prospecting, geothermic surveys, as well as geological mapping, a Bouguer anomaly map is used as a kind of initial map. With the help of new digital processing programs, gravity interpretation based only on Bouguer or residual gravity maps is already outdated. When processing the map data we have at our disposal: iterative depth estimations by two-layers model; various possibilities of space and frequency domain filtering, depth slicing, and the delineation of below-surface bodies are also available — given that the geological model of the area makes such a resolution possible.

Based on the experience gained in interpreting Bouguer anomaly maps and from comparing the Hungarian Bouguer anomaly map and borehole and well-logging data it can be stated that the territory of Hungary is characterized by a number of different gravity models — though the main-structure is well reflected. In most parts of the country normal or basic mountain (roughly two-layers) models can be applied. Here the relief of the Tertiary basement defines the main characteristics of the Bouguer anomaly map; there are low density, loose basin sediments above the basement. The other type is the Plain-model where, against deep basin depths, we observed local maxima; this means that there is a contradiction between the relatively large basement depth and the Bouguer anomalies. A number of factors may play a role in this. These are worthwhile analysing:

1. The density-depth relationships of the debris sediments [SZABÓ, PÁNCSICS 1999, MÉSZÁROS, ZILAHI-SEBESS 2001] show that at a 2–3 km depth the density of these sediments relates to the basement; in other words, the deeper basins have no gravity effect or only a very small one. This is confirmed by automatic gravity processing and modelling along profiles [KISS 2000, BODROGI, KISS 2000, VÉRTESY et al. 2000].

2. From examining different sites other authors [such as KOVÁCS-VÖLGYI 1994b, 1995, 2005] see the lower crust-mantle density inhomogeneities reflected in the Bouguer anomaly values — since in the upper layers there are no sequences with anomalously high density.

3. The starting point of this explanation based on considerations similar to point 2 above, is a huge regional gravity maximum in the Carpathian Basin [WYBRANIEC et al. 2005, HORVÁTH 2004], and as an effect of this there are increased anomaly values in the Great Hungarian Plain. This regional effect can be determined on the basis of a European or Central-European Bouguer anomaly map and can be filtered out from the national data system. Thanks to the OTKA project and the CELEBRATION programme this can be done in the near future. As a result of the filtering one obtains a gravity anomaly map for the Hungarian Great Plain, which corresponds more to a normal basic mountain model. Despite the relevance of the previous two points perhaps one can increase the accuracy of the gravity anomaly map by crossing the border.

Bearing in mind the last three remarks a new perspective is given to apply the old data system on a modern European level, thereby giving a new impetus to gravity prospecting.

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Magyarország Bouguer-anomália térképe

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Magyarország Bouguer-anomália térképét a 2. sz. mellékletben közöljük. Rövid összefoglalást adunk a térkép szerkesztés geofizikai-geológiai szempontjairól és a történelmi előzményekről.

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