GEOLOGICAL AND GEOPHYSICAL STUDY FOR ELABORATION OF GEOTHERMAL MODEL IN ORADEA-BAILE FELIX AREA

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ABSTRACT

Thermal methods consist of measuring thermal gradient and satellite data, which can be used to determine the Earth's surface temperature and thermal inertia of surficial materials, of thermal infrared radiation emitted at the Earth's surface.

Thermal gradient measuring, with a knowledge of the thermal conductivity provides a measure of heat flow. Conditions that may increase or decrease and heat flow are influenced by hydrologic, topographic factors and anomalous thermal conductivity.

Also, oxidation of sulphide bodies in-place or on waste deposits, if sufficiently rapid, can generate thermal anomalies, which can provide a measure of the amount of metal being released to the environment.

The geothermal gradient on the territory of Romania, the increase of the temperature with the depth, has an average value of 2.5°-3°C/100m, which corresponds to a temperature of 100° C at 3000 m deep. There are many areas where the value of the geothermal gradient differs considerably from this average.

For example, in areas where the rock plate suffered rapid dips and the basin was filled with sediment "very young "from a geological point of view, the geothermal gradient may be less than 1° C/100m. On the other hand, in other geothermal areas the gradient exceeds much this average.

These areas are true underground thermal reservoirs of potentially high geothermal energy which under certain favourable conditions can be exploited to serve heating installations and domestic hot water systems.

The geothermal prospecting for the entire territory of Romania, carried out by temperature measurements allowed the development of geothermal maps, highlighting the temperature distribution at different depths.

Geophysical data obtained through various methods and geophysical modelling provide generalized and non-unique solutions to the geometry of underground geological relations as well as to the physical characteristics of different formations.

The non-uniqueness of these models (solutions to the direct problem) arises from the impossibility of knowing the boundary conditions between different strata, which together with the propagation equations of the different fields (depending on the geophysical method used for the investigation of the basement) form the systems that offer the solutions of the model.

The Oradea geothermal reservoir is located in the Triassic limestones and dolomites at depths of 2,200-3,200 m, on an area of about 75 km2 , and it is exploited by 14 wells with a total maximum flow rate of 140 l/s geothermal water with well head temperatures of 70-105°C. There are no dissolved gases, the mineralisation is 0.9-1.2 g/l, the water being of calcium-sulphate-bicarbonate type.

The Oradea Triassic aquifer is hydrodynamically connected to the Felix Spa Cretaceous aquifer, and together are part of the active natural flow of water. The water is about 20,000 years old and the recharge area is in the northern edge of the Padurea Craiului Mountains and the Borod Basin.

Keywords: *geological and geophysical model, geothermal water, thermal conductivity, flow rate*

INTRODUCTION

Geothermal energy is an unconventional renewable energy source with enormous potential for exploitation, of which only a very small part is currently used today.

Worldwide, countries with a high geothermal potential are Iceland, New Zealand and in Europe are Hungary, Romania, Serbia. In these countries, as well as in many others, there are geological conditions that allow to geothermal phenomena to manifest on the surface of the Earth. The limited exploitation of this energy resource is still limited by existing technologies and by the high cost of deep-water equipment.

For the future, geothermal energy is considered to be Earth's most important energy resource, given the estimate that the temperature in the centre of the Earth is equal to the temperature at the surface of the Sun. The problem lies in finding the most suitable technologies for exploitation both in areas with geothermal phenomena on surface and in areas with these manifestation in underground [12].

The main geothermal systems discovered on the Romanian territory are found in porous permeable formations such as sandstones interbedded with clay and shales or carbonate formations of Triassic age in the basement of the Pannonian Basin and Aptian age in the Moesian Platform.

Geothermal reservoir Oradea is located in the Triassic limestone and dolomites at the depths between 2200m to 3200m on an area of about 75Km^2 with a total flow rate of 140 l/s geothermal water with temperatures at the head of 70-105 degrees Celsius. Recharge area is in the Northern edge of the Padurea Craiului Mountains and the Borod Basin. Although there is a significant recharge of the geothermal system, the exploitation with a total flow rate of 300 l/s generates pressure draw down in the system [4].

The Bors geothermal reservoir is a tectonic closed aquifer with a surface area of 12km^2, situated at about 6 km Norh-West to Oradea with geological framework is completely different from the Oradea geothermal reservoir although the reservoirs in the same fissured carbonate formations.

In relation to geothermal resources and, especially, to their exploitation for geothermal energy utilization, sustainability means the ability of the production system applied to sustain the production level over long times. Sustainable production of geothermal energy therefore secures the longevity of the resource, at a lower production level [9].

GEOLOGICAL AND GEOPHYSICAL FEATURES, MAPS WITH GEOPHYSICAL PARAMETERS AND RESULTS.

In the North-West part of Romania, we can see as major units the Transylvanian basin with its Neozoic sediments covers a former Cretaceous mountain chain that closed the branch of Tethys, joining the Tisa and Dacia continental blocks, that represent fragments of the European Plate that were detached from it with the opening of Tethys. Their likeness to the European Plate took place during the Alpine orogenesis, especially the tectonic phases in the Middle and Upper Cretaceous.

The Dacia unit, located south and east, consisted of metamorphic rocks with lower Palaeozoic sedimentary affected by an early metamorphism. The non-metamorphosed sediments consist of discontinuous Carboniferous-Permian-Mesozoic sediments.

The Tisza Bloc, of which the Apuseni Mountains also belong, consist of a succession of nappes placed in the middle Cretacic, consisting of a meso- and epi-crystalline foundation and a Permian Mesozoic blanket.

The sedimentary succession, subdivided into 7 layers have with a total thickness of up to 22 km. It is composed of the Carpathian nappe pile and the post-collisional (post-Early Cretaceous) Paleo to Neogene Transylvanian Basin, which covers the local Late Cretaceous to Paleogene Tarnava Basin [4].

Different crustal blocks characterized by clearly distinct geometries and velocity structures were identified: the Tisza-Dacia crustal block, which underlies the Transylvanian Basin and most of the Eastern Carpathian Orogen.

The sedimentary sequence is composed of the East Carpathian flysch nappes and the Neogene infill of the Transylvanian Basin.

A regional geological interpretation for the elucidation of deep structures must be made on the maps of the anomalies mediated to eliminate the effects of surface geological structures. In this way we must to combine the results of filtering methods with previous knowledge.

For a good image of the geothermal potential in the West part of Romania, we present, the geophysical maps with main zones of geothermal potential. These maps we made with the Surfer program, based on the data presented on geophysical portal on the WEB page of the Geological Institute of Romania [1], [2], [5], [7], [8].

These maps indicate temperature of 3000m depth (fig.1), geothermal flow (fig.2), Bouguer anomaly, after filtering and smoothing of gravity data (fig.3) and

Free Air anomaly (fig.4), after filtering of gravity data with Fourier analyses 2D, on the Romanian territory.

By overlaying this geophysical information, corroborated with other geological, geophysical, geodetic, laboratory and drilling data, conclusions can be drawn regarding the geothermal systems on the territory of Romania.

Gravity measurements define anomalous density within the Earth. Ground-based gravimeters are used to precisely measure variations in the gravity field at different points. Gravity anomalies are computed by subtracting a regional field from the measured field, which result in gravitational anomalies that correlate with source body density variations. Positive gravity anomalies are associated with shallow high-density bodies, whereas gravity lows are associated with shallow low-density bodies.

Physical parameter measured in gravity method is total attraction of Earth's gravity field (the vertical attraction of anomalous masses) for calculating the rock density contrast. In gravity are important other parameter such as gradient of gravity, analytical continuation of gravity field, filtering's and smoothing of gravity data.

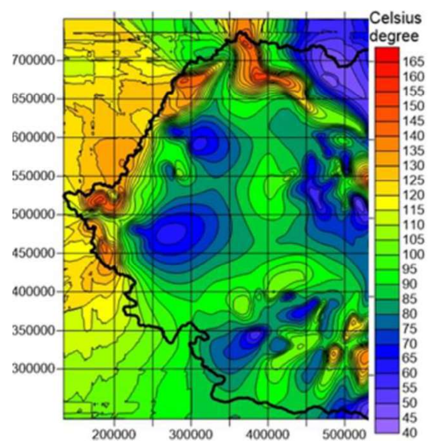

Fig.1 – Temperature of 3000m depth on the West part of Romanian territory, after data from the geophysical portal of Geological Institute of Romania.

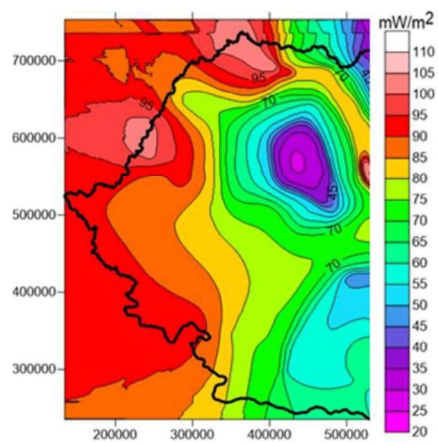

Fig.2 - Geothermal flow on the West part of Romanian territory, after data from the geophysical portal of Geological Institute of Romania.

In fig. 3 is residual map of the Bouguer anomaly, after the trend surface of order 6 has been extracted:

Z=A+BX+CX2+DX3+EY+FXY+GX2Y+HX3Y+IY2+JXY2+KX2Y2+LX3Y2+ MY3+NXY3+OX2Y3+PX3Y3, where coefficients A,…,P are:

A=	-896.5115703326 ,	B=	5.3598654924 ,	C=	-0.0044335874 ,	D=	-0.0000008798 ,	E=	6.9021045916
F=	-0.0437772562 ,	G=	0.0000483387 ,	H=	-0.0000000063 ,	I=	-0.0154970146 ,	J=	0.0001026575
K=	-0.0000001351 ,	L=	0.0000000000 ,	M=	0.0000107958 ,	N=	-0.0000000738 ,	O=	0.0000000001
P=	0.0000000001								

X is longitude, Y is latitude and Z is trend surface of order 6 (mgal).

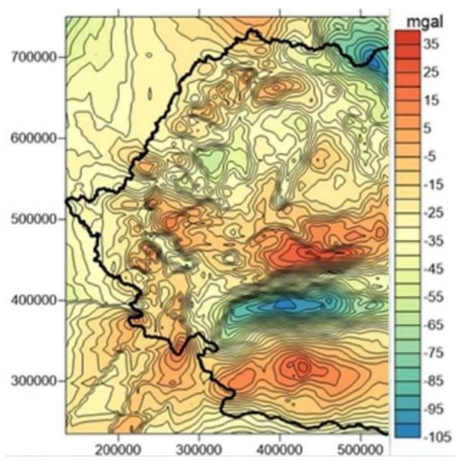

Fig.3 – Bouguer anomaly, after filtering and smoothing of gravity data, on the West part of Romanian territory (data from the geophysical portal of Geological Institute of Romania and [13]).

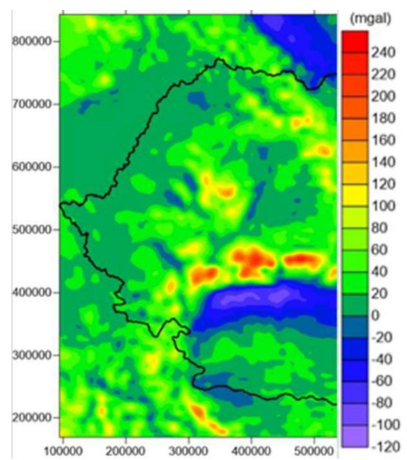

Fig.4 – Free Air anomaly, after filtering of gravity data with Fourier analyses 2D, on the West part of Romanian territory (data from the geophysical portal of Geological Institute of Romania and [13]).

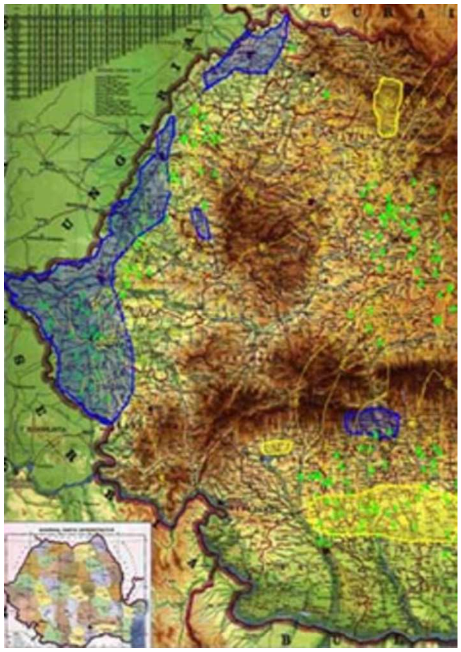

Fig.5 – Geothermal map, on the West part of Romanian territory (after Geological Institute of Romania, 2006)

In fig. 4 is the map with Free Air anomaly, after filtering of gravity data with Fourier analyses 2D, on the West part of Romanian territory, with [14] and [15].

The map from fig.5 indicate (with blue color) that geothermal resources concentrate the 60 to 120 °C (for the exploitation of geothermal water for the production of thermal energy) and possible areas for exploiting geothermal energy in order to generate electric power (with yellow color).

Applying the theoretical results to the geodetic and gravity data at the level of the Romanian territory over which we superimposed the neotectonics structural elements, we obtained the results presented in the images from figures 6 and 7.

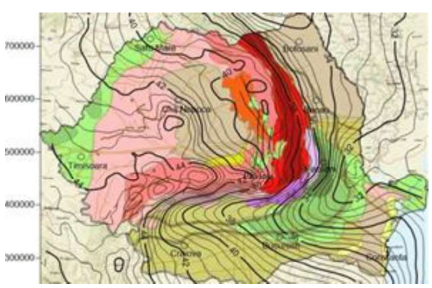

Fig.6 – Geoid of Romania

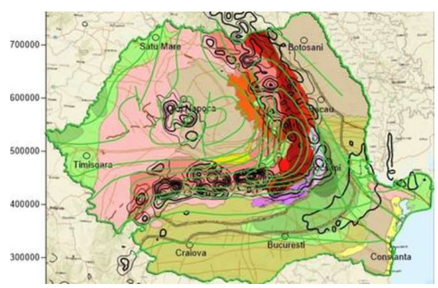

Fig. 7 – Differences between geoid and quasigeoid

Due to the fact that in determining the geoid the actual gravity is taken into account at each point, and in determining the quasi-geoid we use normal gravity, the quasigeoid-geoid separation is a particularly eloquent indicator for determining the difficulty or excess mass in the basement [3], [6], [10], [11].

Although this separation is only of the order of centimetres or at most of tens of centimetres on the territory of our country, it still follows rigorously, even bringing new details of the isobaths to Moho, determined by seismic methods. Thus, the quasi-geoid is located above the geoid in the sinking area of the Moho surface.

CONCLUSION

By overlapping the information obtained from the processing, corroborated with geological and geophysical data of knowledge, we can conclude that the complex image of Bouguer anomalies and outdoor anomaly, indicates the juxtaposition of effects produced by density contrasts (mass) located at different depths.

This is due to the deep structures of the subsurface platforms. By the presence of major lithospheric fracture systems, areas of inhomogeneity are created at their intersection that are manifested in the response functions of the subsoil through a multitude of geophysical parameters (density, seismic wave velocity differences, electrical resistivity differences) and large gradients. of them.

Assuming that the observed gravity anomalies were accurately estimated, there are still other sources of error related to the accuracy of the digital terrain model, the error in estimating topographic effects and the effect of terrain correction errors on geoid height determinations.

There are also differences between the methods for determining terrain corrections. Especially in mountainous regions, these corrections can have a significant impact on gravity anomalies.

All the knowledges about geological-geophysical-structural data, rock’s and hydrogeological features are essential to characterize the geothermal resources.

The main geothermal resources in the country are found in porous and permeable sandstones and siltstones (such as in the western plains), or in the fractured carbonate formations (such as at Oradea and Bors in the western part of the country).

On the territory of Romania, more than 200 drillings for hydrocarbons met at depths between 800 and 3500 m of geothermal resources. The use of extracted geothermal energy is used in the proportion of 37% for heating, 30% for agriculture (greenhouses), 23% for industrial processes, 7% for other purposes.

Geothermal waters represent an inexhaustible and non-polluting energy resource, of great importance, which will have to be used in the future and for the production of electricity.

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