Journal of Georgian Geophysical Society,
Issue (A), Physics of Solid Earth, v.15a, 2011-2012, pp. 142-147

The anomalous magnetic field and its relation to the deep structure of the territory of Georgia

Mindeli P.Sh., Ghonghadze S.A., Ghlonti N.I., Kiria J.K

Abstract

One of the important properties of the Earth is that it is characterized with its intrinsic magnetism – magnetic field. The observed magnetic field reflects summarized effects of anomalous masses. Analyses of geophysical fields, whatever purpose they have, require to be divided into main components. It is one of the important conditions for revealing physical-geological nature of an observed field. Besides, the anomaly parameters are in direct correlative dependence with the attitude positions of anomalous bodies.

Multi-aspect self-descriptiveness of the magnetic filed has stipulated multiple and multibranch mapping of the magnetic field of the Earth by the aeromagnetic method.

It is very difficult and labour-consuming to map the territory of Georgia with the aeromagnetic method in appropriate scale and precision. The bulk of the territory is occupied with high mountain chains being an obstacle for flying around the area in necessary direction and at required height. It influences on the quality of surveys and accuracy of cartographic images of the anomalous magnetic field. However, certain studies of the geomagnetic field of Georgia may be considered completed and before passing to the following phase, higher in quality, its materials are undergoing detailed analyses, construction of unified summarized maps, reinterpretation and generalization.

This work involves a survey of works for mapping the anomalous magnetic field ΔTa in 1:200000 scale.

The study of the territory of Georgia by aeromagnetic method began with surveying by *West Geophysical Trust* (Leningrad) in 1960 in the North Caucasus. The survey involved the southern slope of the Greater Caucasus and the part of the Black Sea to the north from the Poti latitude in the 1:20000 scale. However, those surveys do not meet nowadays requirements due to the low quality of techniques and methods of that time.

Modern technical progress in absolute measurement of the magnetic field module ΔTa by means of nuclear precession and nuclear quantum equipments, also by technically and methodically improved aeromagnetic surveys begun in 1960ies have stipulated for resurvey of the territory of Georgia by aeromagnetic method in 1:50000 and 1:200000 scales.

In 1973 the second phase of the investigation of the territory of Georgia by the higher standard aeromagnetic methods began. Besides, in geological-geophysical investigations the most prioritized were the prospect trends in order to discover new deposit minerals by means of equipment АЯМП-7 in ore areas of different genetic type and formation structure.

In 1973-74, after aeromagnetic surveys in Bolnisi Region, aeromagnetic investigations of the whole territory of Georgia in the 1:50000 and 1:200000 were carried out.

The main goal of the investigations was to study constant constituents of the magnetic field of the region at different heights in detail and accurately and in appropriate specified scales. More precisely they involved constructing of maps and schemes describing the anomalous magnetic filed ΔTa with optimal precision that would favour the solution of the following geological tasks:

a) Mapping of magnetoactive, magmatogene and volcanogenic-sedimentary formations and determining boundaries between them;

b) Studying deep geologic structure as a whole and determining the structural elements and material constitution to the extent of possibility.
c) Determining magnetic distinctions of different mineral deposits with assessment of their prospects.

Nevertheless, according to the authors of the report [G.Sekhniaidze, N.Sagharadze] precision of the survey by control observations is m_T=±5nTl, and in high gradient fields it is m_T=±10nTl.

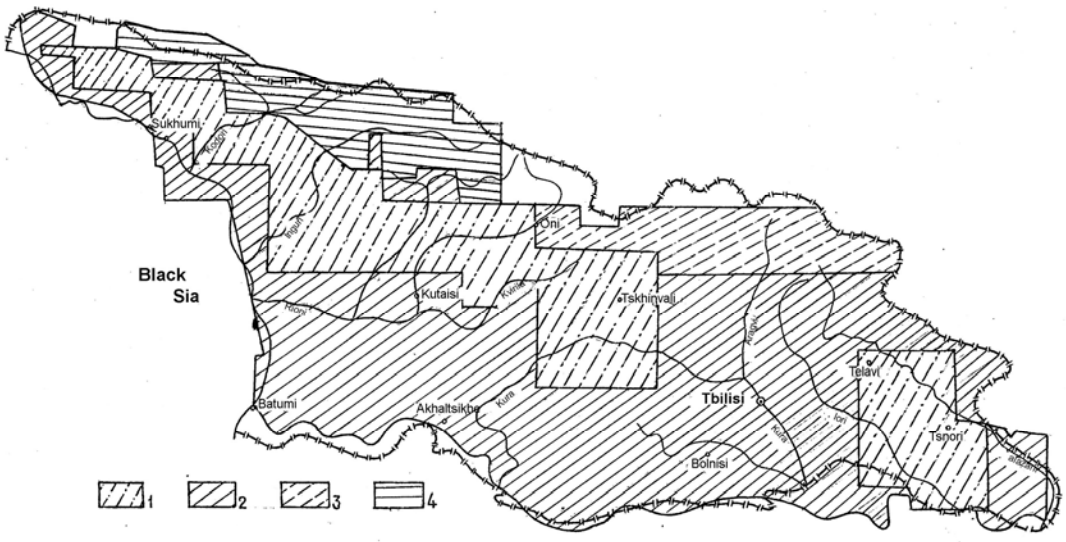


Figure 1. Scheme of aeromagnetic study of the territory of Georgia, scale: 1:2500000

Areas of aeromagnetic surveys

1 –scale: 1:50000, equipment KAM-28, photo connection.
2 - scale:1:50000, equipment АМП-7 photo and visual connection.
3 - scale: 1:50000, equipment АСГ-45.
4 - scale: 1:50000, horizontal survey, equipment M-13, visual connection.

The materials of aeromagnetic surveys are different in quality and information value due to complicated geologic-geophysical conditions of the region and different technical-methodological standards of works. Nevertheless, the level of study of the territory on the basis of scale taxonomy is assessed and presented as a cartogram (*Figure 1*). As shown by the cartogram the territory is not completely covered in any scale of aeromagnetic survey. Besides, there are some areas left without surveying: the high mountainous (ridge) part of the Greater Caucasus, the water area of the Black Sea in the scales 1:200000 and 1:50000, the southern part of the Lesser Caucasus (Adjara, Trialeti) in the scale 1:2500000 and other small, border areas.

Complete description of the structure of the magnetic field and its effective interpretation for solving the tasks of the deep structure and substantive composition of the Earth's deep heterogeneity requires mapping of the anomalous magnetic field at different heights. Such maps are also important for carrying out exploratory-prospecting works. Heights and scales of such maps are determined by taking into account geological tasks and geological -geophysical condition of an investigated area. In this respect there is too limited choice as the scales and heights of surveys of the magnetic field of the territory of Georgia are conditioned and

determined mainly in accordance to abilities of air transport (airplanes, helicopters) in difficult relief conditions. Consequently, the aeromagnetic surveys carried out on the whole territory of Georgia are done in three different scales: 1:2500000, 1:200000 and 1:50000.

As a result of revision of the primary aeromagnetic materials a map (on 14 sheets) of the anomalous magnetic field of Georgia in the scale 1:200000 with the section in 0.5 mega-erg was constructed. The map is constructed on the bases of normal field in 1975 by Institute of Terrestrial Magnetism Ionosphere and Radio Wave Propagation. Precision of the cartographic image of the anomalous magnetic field taking into account precision of measurements is $m(_{\Delta T})=\pm 15\text{-}20$nTl.

As the bulk of the archives materials of the aeromagnetic investigations of the past century are in paper form and the modern methods of analysis and interpretation of geophysical data require computer technologies, it is necessary to digitize those data that will be acceptable for up-to-date digital geophysical cartography.

As a whole, processing of the archives materials is to be divided in three phases: digitization of paper data, conversion of the digitized results into the required data format and mathematical procession of data in order to eliminate probable errors. Magnetic data of different surveys were converted into 2*2 grid by the *Kriging* method, a geostatic method for grid constructing, by which a map in the scale 1:200000 was constructed by means of the *Surfer* software.

In addition, in order to verify the accuracy of the constructed map and determine spatial regulations of the anomalous magnetic field of the region of the Caucasus isthmus similar magnetic maps of the adjoining countries have been digitized. The data on the Black Sea water area obtained from the available maps in the 1:000000 were digitized in order to be involved in the map construction.

By means of the GIS technology (*MapInfo, Surfer, Vextractor*) the obtained data were included into a unite system and the task of construction of the magnetic map was newly solved (*Figure 2*). On the basis of the drawn maps some digital maps of isolines were constructed by the method of linear interpolation. The length of the calculated isodynamic line is 20 nTl.

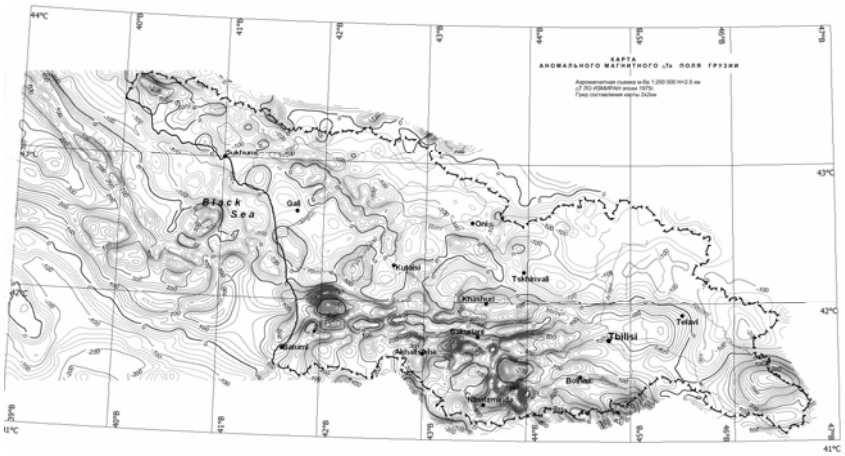


Figure 2.

Usually, a qualitative analysis of potential geophysical fields considers only solution of direct and reverse tasks. However, on the basis of the quantitative analysis, it is also possible to carry out the study of field structure and substance-formation interpretation of anomalies supposed for obtaining more geological information from them, formerly named as “Qualitative interpretation”.

One of the primary phases in the analysis of the geophysical field in respect of solution geological, partially regional tasks is their zoning that has been used so far. At the stage of so called qualitative interpretation the method of visual zoning of fields is a source for different subjective conclusions. Formalized zoning by means of corresponding programmed-

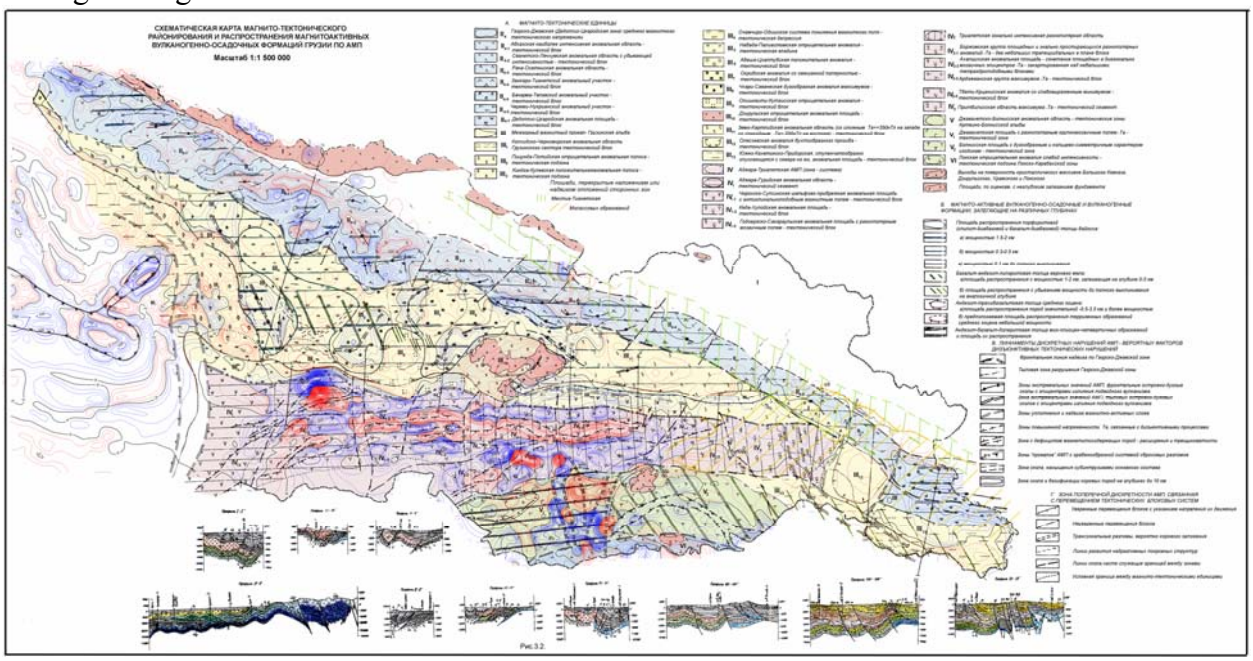
mathematical equipment with the consequent geological interpretation and connection to the real geological situation of the received formal result is able to use the information obtained from geological fields more completely.

For magnetic-tectonic zoning of a studied territory a transformed magnetic field is used. Transformation is the most wide-spread method for transformation and formal division of fields and filtration of the observed fields in order to distinguish useful information and suppress interference.

The theoretical basis for transformation of potentially useful fields is the Poisson integral, which is a solution for the outer Dirichlet problem for plane.

The transformation of the magnetic field was carried out by *Oasis Montaj* software.

For the zoning of the magnetic field we used two methods: the method of smoothing of fields and the method of analytic continuation in the upper direction. The method of smoothing is used to suppress interference connected with random errors. The method of analytic continuation in the upper direction makes it possible to smooth interference, suppress local anomalies and distinguish regional ones.



We recalculated the magnetic field of Georgia in the upper semi-space at heights of 6, 9 and 12 km. The optimal height for recalculation in order to receive maximal effect in the summarized field is determined in a practiced way – gradual increase in the height of recalculation.

At less height the intensity of the residual field rapidly decreases and mainly reflects local anomalies. As we have observed the interval of slow variation of the anomalous field takes place after 10 km and the configuration of anomalous areas is conserved in smoothed form. Magnetic anomaly of any sign is stipulated by surplus or shortage of rock magnetization. This is the consequence of mineral accumulation of deposits.

A map of magnetic-tectonic zoning of the territory of Georgia was constructed (*Figure 3*) on the basis of the geological-formational map.

As a whole, magnetic-tectonic zoning is adaptation of the same action carried out with geological background. However, when considering this process from the viewpoint of deep structure received by magnetic prospecting the former substantially specifies the latter. Besides, the interzonal tectonic boundaries and zone structures inside the blocks are specified, their continuation in immersion under young and molasse sediments is determined.

The schematic map of magnetic-tectonic zoning and distribution of magnetoactive volcanogenic formations in the depth is interesting for paleogeotectonic (geodynamic) study of the territory. Substantive properties distinguished during zoning of different areas of the

magnetic field may be geologically considered in further works on interpretation of the anomalous magnetic field of Georgia.

References

[1]Aleksidze M.A., Kartvelishvili K.M., etc. – Investigation of several problems of transformation of potential fields. Tbilisi, publishing house *Metsniereba*, 1972, p-282.
[2] Bloch Y.I., Interpretation of gravitational and magnetic anomalies, 2009.
[3] Computational mathematics and tectonics in prospecting Geophysics, Moscow, publishing house *Nedra*, 1990, p.437.
[4] The geological-formational map of the Caucasus in 1:500000, eddited by Gogishvili T.Sh.
[5] Davis D.J., Statistics and analysis of geological data, Moscow, Publishing house *Mir*, 1977.
[6] Sander V.N. Method of connection of anomalous field with rectilinear profiles and horizontal relieves. Prospecting and preservation of soil, №110, 1975.
[7] 50-th anniversary of Institute of Geophysics (a booklet), 1983.
[8] Litvinova G.P., Characteristic properties of cartographic image of the complex differentiated field, in the book The Principles of magnetic cartography and methodology for constructing maps, Works, VCEGEI.
[9] Nodia M.Z., The magnetic field of the Caucasian isthmus, The works of Institute of Geophysics of Academy of Sciences of GSSR,. V, 1939.
[10] Sekhniaidze G.A., The magnetic field of Georgia and its geological interpretation, Author's abstract on dissertation, Tbilisi, Publishing house *Metsniereba*, 1976, p.20.
[11] Logachev A.A., Zakharov V.P., Magnetic exploration, Publishing house *Nedra*, Leningrad, 1973.
[12] Cheishvili M., Anomaly of the vertical stress components of the magnetic field of the Transcaucasia.

Archives Materials

[1] Gamkrelidze N.P. etc., Study of physical occupancy of the territory of Georgia for 1*1 in 1980. Georgian Fund for Department of Geology, 1982.
[2] Gamkrelidze N.P., Basiladze G.S., Report on "Study, generalization of physical properties of rocks and ores for regional geophysical works in 1974-78.

(Received in final form 20 December 2012)

Аномальное магнитное поле территории Грузии и ее связь с глубинным строением

Миндели П.Ш., Гонгадзе С. А., Глонти Н.Я., Кирия Д. К

Резюме

В статье проанализированы данные аеромагнитной съемки территории Грузии и представлена схема его распределения.

На основе полученного материала составлена карта аномального магнитного поля территории Грузии. Карта пересечина в верхнее полупространство на высотах 6, 9 и 12 км. и приведен анализ полученного материала.

Составлена схематическая карта магнитно-тектонического районирования территории Грузии.

საქართველოს ტერიტორიის ანომალური მაგნიტური ველი და მისი კავშირი სიღრმულ აგებულებასთან

მინდელი პ., ღონღაძე ს., ღლონტი ნ., ქირია ჯ.

რეზიუმე

სტატიაში გაანალიზებულია საქართველოს ტერიტორიის აერომაგნიტური აგეგმვის მასალები და წარმოდგენილია მისი განაწილების სქემა.

არსებული მასალა მოყვანილია ერთიან სისტემაში. შედგენილია საქართველოს ტერიტორიის ანომალური მაგნიტური რუქა, რომელიც გადათვლილია ზედა ნახევარსივრცეში 6, 9 და 12 კმ. სიმაღლეებზე და ჩატარებულია მიღებული შედეგების ანალიზი.

შედგენილია საქართველოს ტერიტორიის მაგნიტო-ტექტონიკური დარაიონების სქემატური რუქა.