MORPHOLOGY OF THE EAST EUROPE DEEP STRUCTURE BY RESULTS OF MAGNETIC FIELD MEASUREMENTS FROM THE CHAMP SATELLITE

D. Yu. Abramova [1], *L. M. Abramova* [2]

[1]Pushkov Institute of the Terrestrial Magnetism and Radio Wave Propagation, 142190 Troitsk, Moscow reg., Russia, e-mail: abramova@izmiran.ru
[2]Geoelectromagnetic Research Centre of Shmidt Inst. of Physics of the Earth, 142190 Troitsk, Moscow reg., PO box 30, Russia, e-mail: labramova@igemi.troitsk.ru

Abstract. Data from the CHAMP satellite have allowed study of the constant magnetic field caused by sources in lithosphere. Interpretation of satellite anomalies maps had shown, that large-scale features such as shields, cratons and subduction zones are connected to positive anomalies (as caused enhanced magnetic susceptibility) while basins and abyssal plains are marked by negative anomalies. Authors of the present work analyse the regional lithosphere anomalies distribution revealed by results of satellite measurements above the East European craton territory and adjoining to it Alpine folded zone. Parameters of the satellite CHAMP orbit enable to receive measurements of a geomagnetic field in the practically uniform grid units above all surface of the Earth every day. It allows constructing daily average spherical harmonious model (DSHM) of the main magnetic field for each separate day. Using specified technologies of experimental data processing have been constructed maps of the anomaly magnetic field distribution at the satellite altitude for territory East European craton, the Black Sea depression and adjacent regions.

Key words: satellite magnetic observations, lithosphere field, crustal field, magnetisation.

Introduction

The data of satellite magnetic field measurements find wide application for the solution of fundamental and applied problems of geophysics, including evaluation of a part of the constant magnetic field caused by sources in lithosphere. The maps of anomaly magnetic field (AMF) received from airborne and shipborne measurements are usually used at studying geological and tectonic properties of the crust. These surveys discriminate, as a rule, geological features about 50 km on lateral dimension.

However in last decades there has been increasing interest to studying large-scale anomalies, extent in hundreds kilometres which are shown at regional generalisations of data aeromagnetic surveys. Spatial changes of these long-wave anomaly parameters reflect characteristics of magnetic properties and thickness of the magnetised layers.

Magnetic minerals in a crust (and it is possible also in the top mantle) produce magnetic fields, which are strong enough to construct magnetic anomaly maps on the data low - orbital satellites.

New insights on the long wavelength anomalies (wavelength exceeds 400-500 km) have come with the first magnetic anomaly maps received from satellites Pogo (Regan et al., 1975*)*, Magsat (Langel et al., 1982; Cain et al., 1989; Pashkevich et al., 1990; Arkani-Hamed et al., 1994; Ravat et al., 1995; Sabaka et al., 2000) and Ørsted (Olsen et al., 2000). Interpretation of satellite anomalies maps had shown, that large-scale features such as shields, cratons and subduction zones are connected to positive anomalies (as caused enhanced magnetic susceptibility) while basins and abyssal plains are marked by negative anomalies. Negative anomalies associated with a crust thinning and raising of Curie isotherm. However some researches speak that sources of observable anomalies can probably to reach also in the top part of an oceanic mantle (Arkani-*Hamed* and *Strangway*, 1986; *Arkani-Hamed*, 1991).

Last years there is a unique opportunity to analyse results of the geomagnetic field parameters on satellites Magsat, Ørsted and CHAMP and simultaneously measured data of ground survey. This information can be used at geological, tectonic and geophysical interpretation, providing a long-wave part lithospheric field as a basis for shipborne and aeromagnetic measurements.

The CHAMP satellite mission, which proceeds already 7 years, provides reliable measurements of scalar and vector parameters of a magnetic field. In this case planetary lithospheric field can be determined with high resolution and accuracy. The opportunity to use for the analysis the actual data opens wide prospect of studying of an anomaly magnetic field at satellite heights, to specify of regional anomalies position and to carry out of geological and tectonic interpretation.

Authors of the present work put a task to analyse the regional lithospheric anomalies distribution revealed by results of satellite measurements above the East European craton territory and adjoining to it Alpine folded zone. An approach is presented to detect deep-seated regional conductivity anomalies by analysis of magnetic observations taken by **low-Earth – orbiting satellites**.

For its decision it was necessary to make the following:

- To collect, generalise and lead to the convenient for the further processing form measured by the satellite parameters of the geomagnetic field.

- To develop technologies and approaches to processing these huge data sets with the purpose of extraction of the component, most adequately describing an anomaly lithospheric magnetic field.

- To carry out an interpretation of the magnetic anomalies to compare the received results to geological and geophysical data available for these regions.

Choice of experimental data

Experimental data of satellites POGO (1965-1971), Magsat (1979-1980), Ørsted (1999 - 2002) and CHAMP (2000 - on present time) are actively used at studying properties and spatial distribution of a geomagnetic field (Cohen & Achache, 1990; Ravat et al., 1995; Porohova et al., 1996; Maus et al., 2002; Reigber et al., 2002; Taylor et al., 2002; Hemant et al., 2005; Rotanova et al., 2005).

The data of satellite Ørsted are of little avail for an anomaly magnetic field research because its orbit is too high (about 700 km). At this height numerical values of an anomaly field even so strong magnetic anomaly as Kursk do not exceed 3-5 nT while on a surface of the Earth it has the order of two tens thousand nT; for the majority of regions satellite anomaly values are shares nT.

The first global lithospheric magnetic field maps were compiled according to scalar measurements of satellite POGO. After a recognition of the fact, that the magnetic field of the lithosphere is insufficiently well described by extremely scalar data (Backus, 1970), the following satellite, Magsat, has been equipped with the vector magnetometer, and also the special block for exact definition of a point of measurements coordinates.

The data of satellites Magsat and CHAMP are now used the most productive, because both scalar and vector measurements of a geomagnetic field are made on them with high accuracy. Except for that both satellites have a circumpolar orbit and provide series of the high-quality data in regular intervals covering a surface of globe.

However, the analyses of the field, which has been carried out by different researchers using different data sets, selection criteria and processing technique are significantly differ, particularly over areas with weak magnetisation and over the polar areas.

The satellite CHAMP started in July 2000 and is working until now. It is orbiting the Earth at an inclination of 87.3◦ and measures a magnetic field at low heights with high accuracy (Reigber et al., 2002). From its initial altitude it has decayed to 360 km after 5 yr., then two orbital manoeuvres were carried out to increase the altitude and prolong the mission. Scalar and vector CHAMP data are accessible since August 8, 2000, 3 weeks after launch.

If tracks of satellite Magsat shared on ascending and descending and always fell to 6 and 18 hours of local time CHAMP tracks cover a whole hour’s day. For one day the satellite does about 14 tracks.

The data utilized here are from the magnetometer package. Most important for this study are the readings of the absolute scalar Overhauser magnetometer (OVM). Another instrument considered here is the triaxial vector fluxgate magnetometer (FGM). The data for this study are calibrated with respect to the scalar OVM. A dual-head star camera system, mounted together with the magnetometer on an optical bench, provides the orientation of the measured field vectors with arc second precision. Vector data are only considered when readings from both camera heads are available. This provides a reduction in attitude noise.

On the satellite, except magnetic field, are measured also a gravitation field and atmospheric and ionosphere electric fields.

The choice of the initial data for constructing of the geomagnetic field space models depends on the solved problem. For our purpose we had used the CHAMP vector data obtained with a 5-second resolution during the time interval September - November 2003 (ISDC, Potsdam, level 2) (http://isdc.gfz-potsdam.de/champ/).

A technique of the satellite data selection and pre-processing.

In our investigation we use the initial data of the geomagnetic field recorded by the CHAMP satellite. The new original approach to the CHAMP geomagnetic data processing is proposed for the more correct extraction of the magnetic anomaly field. It includes a complex of modern mathematical methods and is based on the using of one-day reference field models constructed also from the CHAMP mission data.

To reduce the influence of the external part of the geomagnetic field of the Earth on the results of our study we used only the data for the quite days as defined by the following criteria. First, at all latitudes was required that the D st - index had not changed by more than 2 nT / hr. At non-polar latitudes (equatorward of 60^o dipole latitude) $Kp \leq 2^o$ had to be fulfilled. Only data from dark regions (sun 10˚ below horizon) were taken into account to reduce contributions from ionospheric currents. During the geomagnetic quiet periods considered here, these currents do not occur at latitude equatorward of 60^o (Feldstein and Starkov, 1970). Non-polar CHAMP data for local time past midnight were only used, to avoid the influence of the diamagnetic effect of dense plasmas (Lühr et al., 2003).

For CHAMP data processing we used classical so-called physical approach, consisting in consecutive exclusion from the geomagnetic field values, measured in an orbit, those parts, which were connected with the various external and internal sources different from the magnetic anomalies. After that the maps of anomaly magnetic fields were constructed.

- The geomagnetic field measured by satellite is a superposition of the following components:

- The main magnetic field, created by the sources of the magnetohydrodynamic nature located in a liquid part of the Earth’s core;

- The anomaly field connected to magnetisation of the rocks composing terrestrial lithosphere;

- The induction fields originated as a result of the various conductivity of the different structures in the Earth's crust and the upper mantle;

- The external fields made by magnetosphere - ionosphere current systems.

Anomaly magnetic fields remain after consecutive exception of all above field components from the CHAMP geomagnetic measurements. Reliability of this estimation depends on the choice of data processing technique.

At the first stage of the satellite data processing we eliminated from each orbit the model of the main geomagnetic field which was described using the spherical harmonic expansion. Our improvement consisted in producing daily mean models of the main field as SH expansion using CHAMP vector data available for each individual day. This method is briefly described below.

For subtraction of the main magnetic field part from the measured satellite values the international analytical model (IGRF) is commonly used. IGRF model is based on the spherical harmonic analysis of mid-annual values of geomagnetic field. We have improved this approach regarding to the main geomagnetic field model calculation. We have proposed a new method for subtraction of the main field part from the geomagnetic data received on the CHAMP.

For the good of the main field model construction it is very important that the obtained models are uniform. If the distribution of measurements over the Earth surface is non-uniform this may cause an additional error in calculation of the model coefficients. The ground observatories which data were used for IGRF are located unevenly. Parameters of an orbit of CHAMP satellite enable to receive measurements of geomagnetic field values in the near uniform grid units above all surface of the Earth every day (Golovkov et al., 2007). It allows to construct daily average spherical harmonic model (DSHM) of the main magnetic field for each individual day. Such procedure is carried out with the help of spherical harmonic expansion of the CHAMP geomagnetic field data received within every day of measurements. The global CHAMP satellite 1-second vector data (without averaging) were used. Every day consisted of about 85000 values.

$$\mathrm{U}(\mathrm{r},\theta,\lambda)=\mathrm{a}\cdot\sum_{n=1}^{N}\sum_{m=0}^{n}\left(\frac{a}{r}\right)^{n+1}(g_n^m\cos m\lambda+h_n^m\sin m\lambda)\times P_n^m(\cos\theta)$$

$$\mathrm{X}=-\frac{1}{\mathrm{r}}\frac{\mathrm{dU}}{\mathrm{d}\theta};\qquad \mathrm{Y}=\frac{-1}{\mathrm{r}\sin\theta}\frac{\mathrm{dU}}{\mathrm{d}\lambda};\qquad \mathrm{Z}=-\frac{\mathrm{dU}}{\mathrm{dr}},$$

where U is the geomagnetic potential in the point with geographic coordinates r, θ, λ; X, Y and Z are the northern, eastern and vertical components of the field, **a** is the mean radius of the Earth; $\mathrm{P}_\mathrm{n}^\mathrm{m}(\cos\theta)$ are the associated Legendre functions of degree n and order m, normalised according to the convention of Schmidt $\mathrm{g}_\mathrm{n}^\mathrm{m}$ and $\mathrm{h}_\mathrm{n}^\mathrm{m}$ - are the constant coefficients of the main field model.

As a result the main geomagnetic field calculated for the given individual day instead of the averaged for a long time interval one was subtracted from the measured values of each used pass. Thus we obtained the difference fields for each of the selected orbits which are related to the magnetosphere and ionosphere current system and to the Earth's crust magnetisation.

On the second step of the data processing the magnetosphere current system was approximated also using a spherical harmonic analysis (SHA) when only the first zonal spherical harmonic (m=0, n=1) was determined. Linear or parabolic trends were used to separate the field part created by ionosphere current systems. Anomalous magnetic field we needed was constructed upon eliminating all above approximated fields from experimental satellite data.

So the base of experimental data was created helping with the specially developed code for geomagnetic data extracting from the CHAMP records for any region of globe and for any index of geomagnetic activity. Thus, within the limits of studied region it has been selected and processed about 100 passes covering the sector 25˚-60 ˚ N on a latitude and 10˚-50 ˚ E on a longitude. It is necessary to note, that tracks had the 5-second discretization on time, i.e. there was about approximately 35-km discretization in space.

Discussion of the results

An anomaly magnetic field spatial distribution

Using specified technologies of experimental data processing the maps of the AMF distribution have been constructed at the satellite altitude for territory East European craton, the Black Sea depression and adjacent regions.

For research of reliability of extraction of the magnetic anomalies, lithospheric field maps of researched area have been constructed on several independent sets of the satellite data. Comparison has shown that the structure of anomaly fields is reproduced stable enough.

Maps of AMF have been compared to the similar maps of region published earlier according to satellite Magsat (Cohen and Achache, 1990; Pashkevich et al., 1990; Ravat et al., 1995; Taylor et al., 2002). The analysis has shown that the basic large-scale anomalies are precisely shown according to both satellites. Existing difference distinctions concern, mainly, to areas where the values of an anomaly field are close to the noise level.

The analysis of the lithospheric magnetic field shows, that at satellite altitudes the anomaly field disappear practically completely: high-frequency anomalies smooth out, they are observed only low-frequency regional anomalies with the sizes of the spatial periods 400 - 450 km and intensity about first tens nT.

From modeling calculations it is shown, that at altitude of 350 km and higher individual anomalies having even very high intensity (about thousand nT) fade practically completely (Pashkevich et al., 1990). In the same place is made the conclusion about existence at satellite altitude the total effect from strongly magnetized surface sources in case of the big saturation by them of the top part of a crust and the increased magnetization of the rock. Satellite measurements are insensitive to small-scale structures that allow selecting on them regional lithospheric anomalies that have been not complicated of the local component.

The lithospheric anomaly nature

The AMF of the continental lithosphere is characterized by the big variety. Sources of anomalies are concentrated in some lithospheric part, named as magnetoactive layer. The top boundary of this layer can coincide with a terrestrial surface or can be on depth more than 10 km in the closed and folded areas.

The bottom confining bed of the magnetoactive layer is or depth up to the magnetite Curie isotherm, or Moho border (Arkani-Hamed and Strangway, 1986; Pashkevich et al., 1994; Tanaka et al., 1999). There is open a question on, whether layer there is completely in a crust or penetrate also into the top mantle.

The basic opportunity of magnetization of tops of a mantle of some regions proved to be true geothermal calculations: Curie Isotherm (580 ˚) appeared in some cases on depths up to 100 km. (Buryanov et al., 1983). However the detailed analysis of a magnetic field of some regions of Europe has shown that the mantle component contribution in regional anomalies at correct selection of values of magnetization mantle rocks is insignificant.

Most likely, a source of the majority of the revealed anomalies, joint action of both above-named factors is change of temperature, and, accordingly, both thickness a

magnetoactive layer and change of structure of magnetic minerals.
Unfortunately, the global distribution temperature- depth variation is still not available in the required spatial resolution and accuracy (Artemieva & Mooney, 2001).

The received on the satellite AMF data can be considered as some regional characteristic of large tectonic units only. The magnetic segments extensions are close to the extension of tectonic structures, but not always coincide spatially. Magnetic segments specify more likely mechanism of distribution of various magnetic heterogeneity types in an earth's crust; testify about «translucence" ancient structures. Zones of a coupling of magnetic segments, apparently, are deep and long-living faults on which developed avlakogenes and depressions.

Kursk magnetic anomaly (KMA)

At the first stage for debugging and testing of the CHAMP experimental data processing technique have been constructed maps of spatial distribution of an AMF for well investigated territory of Kursk magnetic anomaly and adjoining regions.
The data file including about 100 tracks has been processed in frameworks of the "physical" approach. Spatial distribution of an anomaly magnetic field, which has made a basis for magnetoactive layer studying of an earth’s crust, is constructed. The vertical component lithospheric AMF Za at altitude of the satellite of 400 km is shown on fig. 1a. In the middle of a map’s fragment a positive anomaly is visible. Its intensity makes more than 25 nT.
Its comparison to geological and tectonic structure of this region shows that it is not looked through unequivocal connection of satellite anomaly with the morphostructure an earth's crust of different age of consolidation.

However, in a context told in item 4.2, we with confidence can connect this positive anomaly with total effect from the blocks of an earth's crust composing the Ukrainian craton, Mazur-Belarus and Voronezh anticlines, that is connect with "translucence" of the Archaean Sarmatia craton.

The constructed map has been compared to similar results of other authors (Taylor and Frawley, 1987; Pashkevich, etc., 1990; Taylor et al., 2002). Such comparison has shown that the basic features of anomaly are selected reliably enough. Available differences are dated for areas of a map where values of the selected AMF are close to noise level (2-4 nT). Additional comparison of spatial distribution of an anomaly field with the land magnetic and gravitational data, seismic sounding and of a heat flow results has shown, that actually all complex of geophysical observations is determined by the same tectonic structures within the limits of investigated territory.

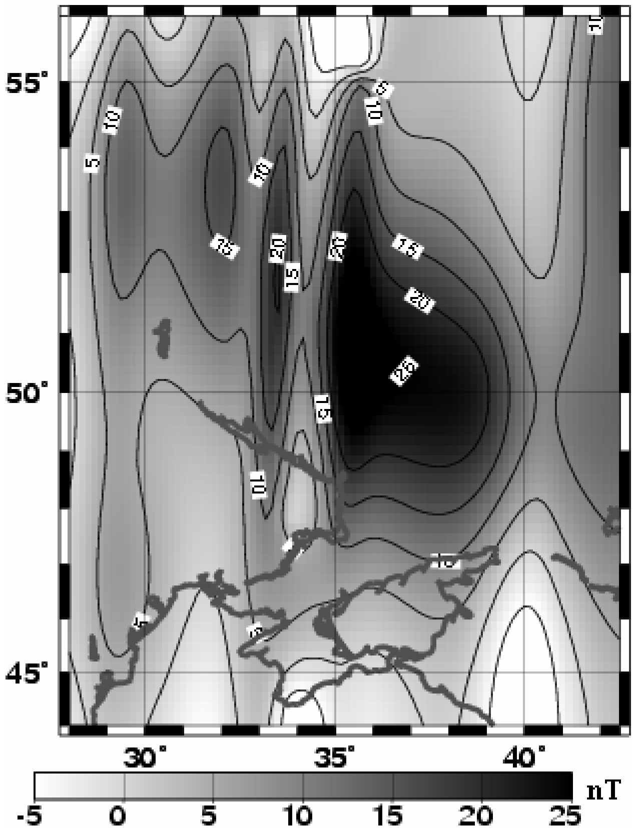

Fig. 1a. Distribution of the vertical component lithospheric anomaly magnetic field Za for Kursk magnetic anomaly region at height of satellite CHAMP.

Europe

By the technique used for territory Kursk magnetic anomaly scalar and vector maps of magnetic anomalies of Europe territory have been constructed.

A vertical component Za of AMF at altitude of the satellite of 400 km is submitted on fig. 1b.

It is interesting to compare the received result to the location of regional magnetic anomalies received on ground surveys (Buryanov et al., 1987).

It is obvious enough, that positive satellite anomalies are answered with the maximal concentration of regional "ground" anomalies. In minima of satellite anomaly fields "ground" anomalies meet much less often and concern to their flank parts.

The central part of the East Europe platform form, a so-called, "Leningrad" segment (3), covering Baltic monocline (2) and Moscow syneclise (7). In the anomaly fields received at satellite CHAMP, this segment is characterized by negative anomaly.

Magnetoactive layer thickness in a segment is reduced from below, as in its central

part intensive positive anomaly of a heat flow is observed. This fact allows the basis to believe, that average magnetization of the magnetoactive parts of a crust is insignificant.
Around of this segment various intensity positive anomalies of settle down.
Positive anomalies of CHAMP answer areas of the maximal saturation the regional magnetic anomalies received according to ground magnetic surveys.

Segment KMA has maximal for a platform the crust thickness and a "basalt" layer. In Northeast of region is allocated narrow (between 30 ˚ and 32 ˚ E) submeridional zone. It is traced further within the limits of Russian plate and the Ukrainian craton up to southern border of East European platform, down to East African rift.

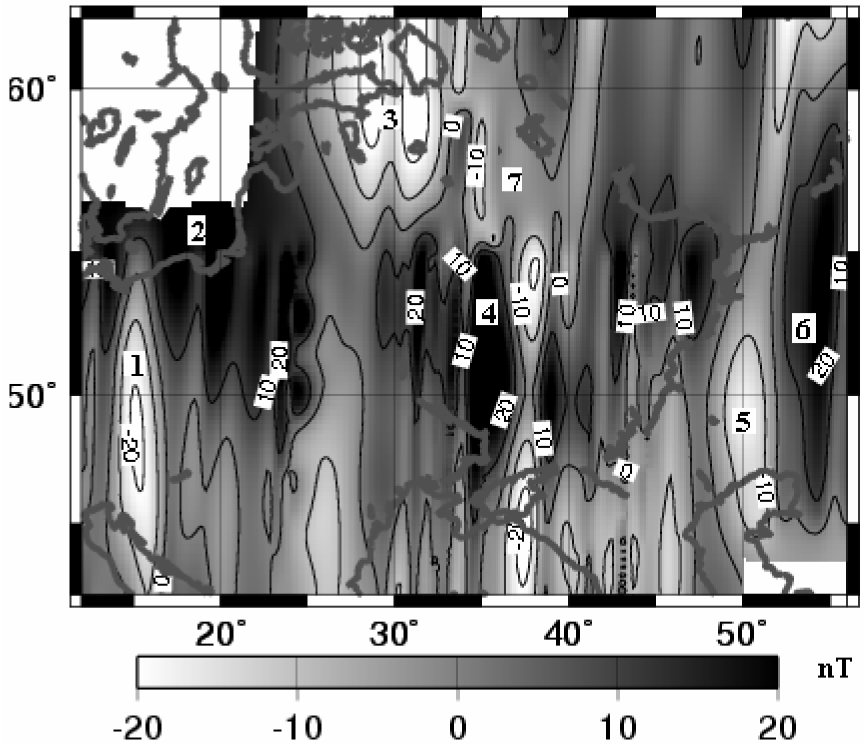

Fig. 1b. Magnetic anomalies (MA) of the satellite vertical component magnetic field Za for Europe territory. Positive: 2 – Baltic MA, 4 – Kursk MA, 6 - Kama - Emba MA. Negative: 1 - Central European MA, 3 -Leningrad MA, 5 - Near-Caspian MA.

Submeridional extension of this zone proves to be true materials of the satellite photographic pictures interpretation of a high level of generalization as Lapland- Nile transcontinental lineament.

Along east border of the East Europe platform is traced the significant positive segment: Kama - Emba (6) magnetic anomaly. Satellite anomaly above this segment has several maxima. The region consists of uneven-age structures. The regime of the temperature, density and structure of an earth's crust are extremely various here.

According to satellite CHAMP data negative anomaly of a magnetic field (5) in the central part of the Near-Caspian depression is observed. On the seismic data sediments lay here directly on a "basalt" layer, which has thickness of 6-9 km, and Moho is on depth of 26 - 30 km.

At the same time on borderland of the Near-Caspian depression there is a "granite" layer, thickness of the "basalt" layer reach 15 km, and thickness of a crust increases up to 40 km. Near-Caspian negative anomaly coincides with positive anomaly of a heat flow.
The Near-Caspian depression is within the limits of the Mediterranean Alpine belt zone - a wide band concerning young geological formations occupying all south part of Europe.

Ural

By results of measurements of satellite CHAMP scalar and vector maps of magnetic anomalies for Ural territory are constructed. The vertical component anomaly magnetic lithosphere field Za at satellite altitude is resulted on figs. 1b and 2a.

Presence Proterozoic areas in the Ural territory insignificantly, however positive satellite magnetic anomalies occupy enough big area, which is apparently the indication on existence of the extensive magnetized layers in deep parts of the crust. Some of this assumption confirmation is results of the seismic researches which have been carried out on a profile "Uralseis-95" (Berzin et al., 2000). The profile in the extent of 500 km passes through Southern Ural and crosses from the West on the East the Pre Ural regional depression, Western Ural fault zone, Central Ural anticlinorium, Tagil - Magnitogorsk depression, the East Ural rise, the East Ural depression (fig. 2b).
Position of this profile is demonstrated on the anomaly satellite field map as AA′ (fig.2 a). Constructed as a result of these researches hypothetical geological - geophysical model of an earth's crust structure is shown on fig. 2 b (Berzin et al., 2000). The structure of its deep part can explain the lithospheric magnetic field increased values at the satellite altitude.
In authors of model opinion: « the earth's crust represents system of the tectonic dislocation, plunging symmetrically to the south on which as a result of working compressing stress there are failures of the whole blocks and layers and their immersing in a "soft" mantle. Apparently from fig. 2 b, last, bottom, most thick stratum of a crust (presumably Archaean) is at a level of 22-40 km and deeper in the traverse central part.
« The central part of a section looks like "bowl" … from the west and from the east "bowl" is limited large submeridional dislocation with a break of continuity » (Berzin et al., 2000). Moho, according to model, is on depth about 40 km.
Resulted on fig 2 b the curve of a satellite AMF qualitatively corresponds to this model: the increase in values of an anomaly field above area of immersing of Moho and weakling of a field in places where present submeridional dislocations are observed.

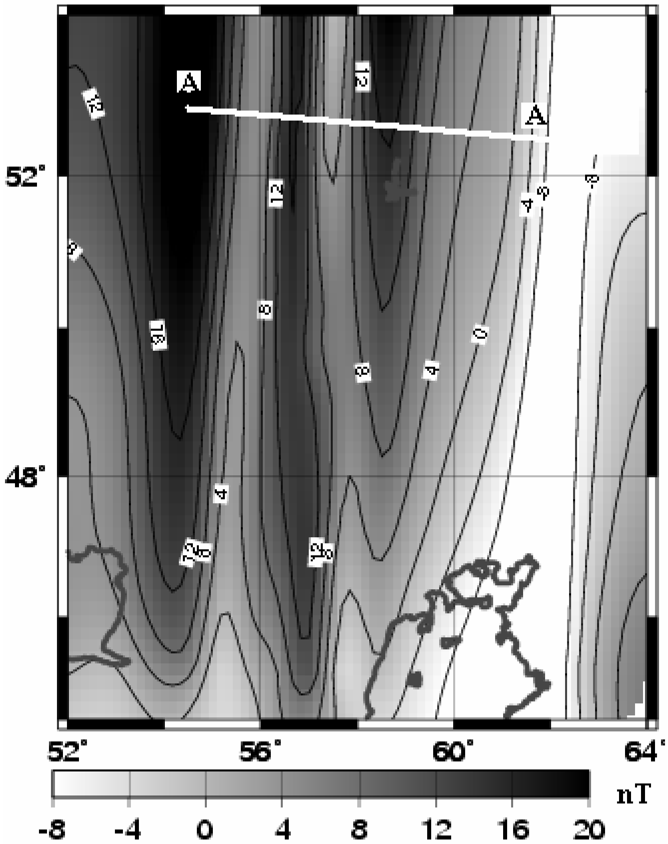

Fig. 2a. The map of the vertical component lithospheric anomaly magnetic field Za at height of satellite CHAMP for South Ural. AA´ - Position of a structure on fig. 2b.

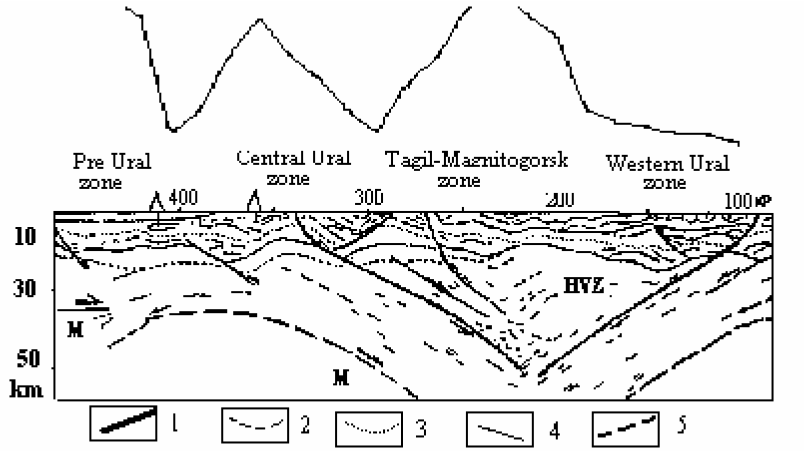

Fig. 2b. Hypothetical geology-geophysical model of the earth's crust structure at the “Uralseis-95" profile (Berzin et al., 2000).

North part of the Black Sea Coast

We make attempt of interpretation of magnetic field anomaly maps in more details by the example of a southern part of the East European platform.

The vertical component AMF map is shown on fig. 3 a. The major tectonic areas of region are a southern part East European platform Ukrainian craton and a north-east part of the Mediterranean geosynclinal's belts (Baidoff et al., 1974). The important role here belongs to the faults, which determine a configuration of the basic structural elements.
It is gently plunging monocline, in a southern direction. Depth of the crystal base bedding from 1,5 - 2 km in the south, from border with the Scythian platform, up to 3-4 km in north-west sector of Black sea.

It is established, that the southern border of the East Europe platform is an edge zone that is a deep fault along which Precambrian basement is coupling with a Palaeozoic complex.

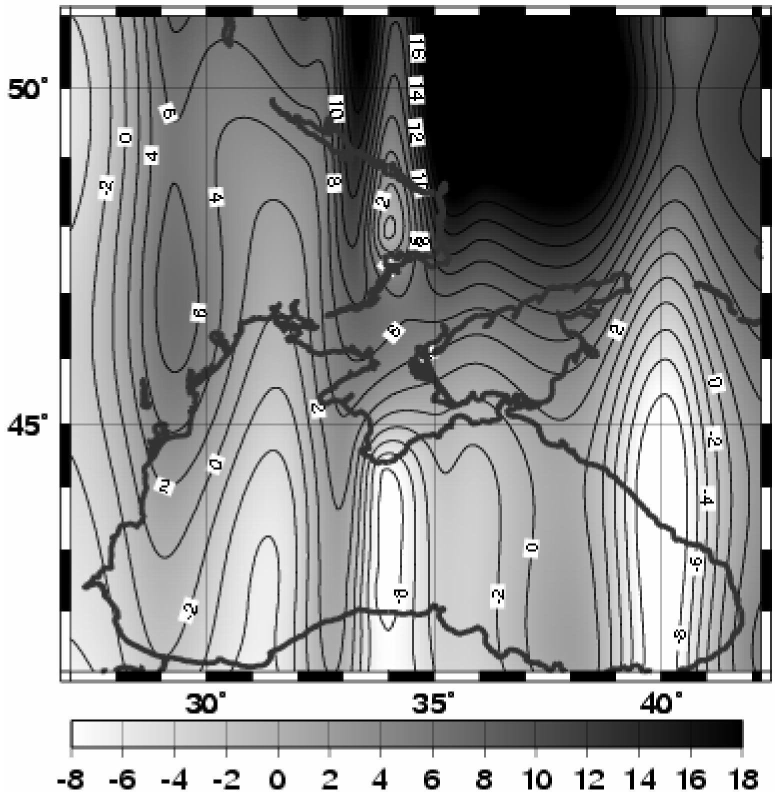

Fig. 3. **T**he map of the vertical component lithospheric anomaly magnetic field Za at height of satellite CHAMP for Prichernomorsky margin and the Black Sea depression.

The part of border of these uneven-age platforms is traced by results of geophysical researches. Character of gravitational and magnetic fields sharply here changes. The data of seismic measurements testify to presence a ledge along considered border on which the basement of an ancient platform is sharply buried in aside the Scythian platform; it is covered here by a powerful complex Palaeozoic and early Mesozoic formations.

Sinking of the basement of an ancient platform is characterized by smooth change regional AMF from 16 up to 2 nT from the north on the south on a map lithospheric field of satellite CHAMP, fig.3a. The southern border of a platform (branch to negative values) is distinctly traced on a map.

This border is traced on the tectonic decoding of satellite photographic pictures of the Alpine Mediterranean zone. To it fit Atlas - Azov and Caucasus- Kopet Dagh transcontinental lineaments.

Lithospheric AMF sources in the light of geological -tectonic insight

From the point of view of tectonics the European continent is rather complex region, therefore it is difficult to make unequivocally geological -tectonic interpretation of observable magnetic anomalies.

Precambrian platforms include as superficial boards, named cratons, and the buried under later deposition areas, so-called Precambrian basements. More younger Phanerozoic crust (<570 million years) includes Cenozoic, Mesozoic and Palaeozoic belts.

Different European platforms correspond with the different nature of anomaly magnetic fields. The most complex on structure and differentiation are anomaly fields of the East Europe Precambrian platform. For example, Moscow syneclise, form the most part of the centre of the East Europe platform, overlap almost completely 23 small and big Archaean blocks with sharing them folded belts (Goodwin, 1991). Hence, the basement under Moscow syneclise should be considered as Archaean.

The partial fit of observation magnetic maps and geological provinces shows that the nature of magnetic anomalies sources is really by origin geological and is in the Earth crust.

However discrepancies between the predicted and observable anomalies in some areas of the world cause questions. It gives the basis for the further researches, is especial in a context subsurface Precambrian areas, composition of lower parts of a crust and its thickness. It is considered, that on a surface of the Earth exposed Precambrian rocks constitute only 29 % of the full Precambrian crusts (Goodwin, 1996). It specifies that a significant part of the Precambrian crust on the continents is overlain by younger Phanerozoic cover.

Conclusions

Our improvement consisting in producing daily mean models of the main geomagnetic field as SH expansion using CHAMP vector data for each individual day and subtraction of them from experimental values has shown its efficiency. In addition, this lithospheric field exhibits significantly less noise than previous as a result of improved data selection.

Using this technique on the experimental values received by satellite CHAMP at altitude about 400 km several maps of the anomaly lithospheric magnetic field for the European platform and Ural were constructed. The analysis has shown the following:

i. The dimensions of magnetic areas are close to the dimensions of tectonic segments, however not always they coincide spatially. Magnetic segments specify the common mechanism of distribution of various magnetic heterogeneity types in the Earth's crust testify about "translucence" of ancient structures.

ii. Zones of a magnetic segments coupling, apparently, are deep and long-living structures.

iii. Areas deep magnetic heterogeneity, seen as magnetic segments, frequently does not represent uniform tectonic formations in modern structure lithosphere.

iv. Direct correlation between satellite anomalies and geological structures is not observed. At the same time, their site does not contradict to the tectonic decoding of satellite photographic pictures and correlates with the seismic and heat flow data.

The following research steps could become the incorporated modelling of satellite measurement data and sea and aeromagnetic surveys data that can considerably improve accuracy of representation of an AMF on a surface of the Earth.

Other than our space magnetic investigation shows the barest necessity to use transformation of space photos for location of the large tectonic units and their joint analysis with lithospheric magnetic field.

Acknowledgements. Authors thank colleagues Frunze A.H. and Volkova N.I. for the help in carrying out of calculation. Maps of a magnetic anomaly field are prepared using GMT (*Wessel & Smith*, 1998). This work is supported by the Russian Foundation of Basic Researches (RFBR) (04-05-64890).

References

Arkani-Hamed, J. 1991. Thermoremanent magnetization of the oceanic lithosphere inferred from a thermal evolution model: Implications for the source of marine magnetic anomalies. *Tectonophysics*. **192**, 81–96.

Arkani-Hamed, J., and D. W. Strangway. 1986. Effective magnetic susceptibility anomalies of the oceanic upper mantle derived from Magsat data. *Geophys. Res. Lett*. **13**, 999 – 1002.

Arkani-Hamed, J., R. A. Langel, and M. E. Purucker. 1994**.** Magnetic anomaly maps of Earth derived from POGO and Magsat data. *J. Geophys. Res*. **99**. 24 075 – 24 090.

Artemieva, I. M., and W. D. Mooney. 2001.Thermal thickness and evolution of Precambrian lithosphere: A global study. *J. Geophys. Res.*, **106**, 16, 387–16, 414.

Backus, G.E. 1970. Non-uniqueness of the external geomagnetic field determined by surface intensity measurements. *J. Geophys. Res.* **75.** 6339–6341.

Baydov F., I. Garkalenko, Goncharov et al. 1974 (in Russian) About deep structure of the Black sea depression, *in Tectonic and seismology of the Black sea depression*, pp. 3-50. Kishinev, Shtinitsa.

Berzin R.G., Akkuratova L., & Kerimova I.K. 2000. Preliminary results of the geology-geophysical data analysis along the International traverse «Uralseis-95» strike. *Geofizika*. № 6. 25-29. (in Russian).

Buryanov V.B., Gordienko V.V., Kulik S.N., et al. 1983. *Complex geophysical study of the continental tectonosphere.* 176 pp. Kiev: Naukova Dumka (in Russian).

Buryanov V.B., Gordienko V.V., Zavgorodniaya O.V. et al. 1987. *The Europe tectonosphere geophysical model*. 184 pp. Kiev: Naukova Dumka (in Russian).

Cain, J. C., Z. Wang, C. Kluth, and D. R. Schmitz. 1989. Derivation of a geomagnetic model to n = 63. *Geophys. J.* 97. 431 – 441.

Cohen, Y. & Achache, J. 1990. New global vector magnetic anomaly maps derived from Magsat data. *J. Geophys. Res*. **95.** 10. 783 –10 800.

Feldstein, Y. I., & G. V. Starkov, 1970. The auroral oval and the boundary of closed field lines of geomagnetic field, *Planet. Space Science*, **18**, 501-508.

Golovkov V.P., Zvereva T. I., Chernova T. A. 2007. Method of main geomagnetic field space-time model constructing on the base of both a spherical harmonic analysis and natural orthogonal components. *Geomagnetism and Aeronomiya*. **47**. №2. 272 - 278 (in Russian).

Goodwin, A. M. 1991. *Precambrian Geology*, Elsevier, New York.

Goodwin, A. M. 1996. *Principles of Precambrian Geology,* Elsevier, New York.

Hemant, K., Maus, S. & Haak, V. 2005. Interpretation of CHAMP crustal field anomaly maps using a geographical information system (GIS) technique. *Earth Observation with CHAMP: Results from Three Years in Orbit*. 249–254.

Lühr, H., M. Rother, S. Maus, W. Mai, and D. Cooke, The diamagnetic effect of the equatorial appleton anomaly: Its characteristics and impact on geomagnetic field modelling, *Geophys. Res. Lett.*, 30, 2003.

Langel, R. A., G. Ousley, and J. Berbert. 1982. The Magsat Mission. *Geophys. Res. Lett.* **9**. 243–245.

Maus, S., Rother, M., Holme, R., L.uhr, H., Olsen, N. & Haak, V. 2002. First scalar magnetic anomaly map from CHAMP satellite data indicates weak lithospheric field. *Geophys. Res. Lett.* **29** (14), doi: 10.1029/2001GL013, 685 pp.

Olsen, N., et al. 2000. Orsted initial field model. *Geophys. Res. Lett*. **27**. 3607– 3610.

Pashkevich I.K., Markovski V.C., Orlyuk M.I. et al. 1990. *Magnetic model of the lithosphere.* 168 pp. Kiev: Naukova Dumka, (in Russian).

Pashkevich I.K , Pecherski D.M. 1994. *Petrology-magnetic lithosphere model*. 175 pp. Kiev: Naukova Dumka. 175 p (in Russian).

Porohova L.N., D.Yu. Abramova, D.A. Porohov. 1996**.** . Mantle electrical conductivity models constructed by efficient linearization method using global observatory and satellite data. *Geomagnetizm & Aeronomiya. **34**. № 5. 137-146, (in Russian).*

Ravat, D., Langel, R.A., Purucker, M., Arkani-Hamed, J. & Alsdorf, D.E. 1995. Global vector and scalar Magsat magnetic anomaly maps. *J. Geophys. Res.* **100.** 20 111–20 136.

Regan, R. D., J. C. Cain, and W. M. Davis. 1975. A global magnetic anomaly map. *J. Geophys. Res.* **80**. P. 794 – 802.

Reigber, C., Luhr, H. & Schwintzer, P. 2002. CHAMP mission status. *Adv. Space Res*. **30.** 129–134.

Rotanova N.M., Kharitonov A.L., Frunze A.H., Filippov S.V., D. Yu. Abramova. 2005. Kursk magnetic anomaly field from CHAMP measurements. *Geomagnetism i Aeronomiya*. **45**. № 5. 712-719 (in Russian).

Sabaka, T. J., N. Olsen, and R. A. Langel. 2000. A comprehensive model of the near-Earth magnetic field: Phase 3 // NASA Tech. Memo. TM- 2000-20, 9894.

Tanaka A., Okubo Y., Matsubayashi. 1999. Curie point depth based on spectrum analysis of the magnetic anomaly data in East and Southeast Asia. *Tectonophysics*. **306**, 461-470.

Taylor P.T., Frawley J.J. 1987**.** Magsat anomaly data over the Kursk region, USSR. *Physics of the Earth and Planetary Interiors*. **45**. 5-15.

Taylor, P.T., Frawley, J.J., Kim, H.R., Frese, R., and Kim, J.W. 2002. Comparing Magsat, Orsted and CHAMP crustal magnetic anomaly data over the Kursk Magnetic Anomaly, Russia. *Proc. of the 1- st. CHAMP International Science Team Meeting*. Potsdam-Springer.

Wessel, P . & W. H. F Smith. 1998. *New, improved version of the Generic Mapping Tools Released*. EOS Trans. AGU. **79.** 579 pp.

Морфология на дълбочинната структура на Източна Европа по резултати от измервания на магнитното поле от спътника CHAMP

Д. Ю. Абрамова, Л. М. Абрамова

Резюме: Данните от сателита CHAMP дават възможност за проучване на постоянното магнитно поле, причинено от източници в литосферата. Интерпретацията на сателитните карти на аномалиите показва че, крупномащабни особености като щитове и зони на субдукция, са свързани с положителни аномалии (причинени от засилена магнитна възприемчивост), докато басейни и дълбочинни полета са с негативни аномалии. Авторите анализират разпределението на регионалните литосферни аномалии установено от сателитните измервания над Източна Европа и прилежащите Алпийски нагънати зони. Параметрите на орбитата на сателита CHAMP дават възможност за измервания на геомагнитното поле в унифицирана мрежа над цялата земя за всеки ден. Това позволява създаването на средноденонощен сферично-хармоничен модел (DSHM) на главното магнитно поле за всеки ден. Чрез специфични технологии за обработка на експерименталните данни са изработени карти на разпределението на магнитните аномалии на височината на сателита за територията на Източна Европа, Черноморската депресия и съседните региони.