BALLOON GRADIENT GEOMAGNETIC SURVEYS AT STRATOSPHERIC ALTITUDES

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ABSTRACT

Magnetic fields and their vertical gradients on a stratospheric balloon on the base of 6 km length are measured. Magnetic anomalies and their gradients are extracted with the use of global magnetic models of the normal field. Magnetic gradients allow to determine places in which there are no significant magnetic anomalies. Ordinates of a profile of the extracted magnetic anomalies in these places are the error of applied global magnetic model of the normal geomagnetic field set at the moment of measurement, and serve as the amendment to magnetic anomalies. It is shown, that only magnetic anomalies at the altitudes numerically equal to thickness of the Earth's crust, are formed of all sources, and its local component is filtered naturally. With the use of the offered technique of extracted of magnetic anomalies it is possible to create strict model of anomaly magnetic field for cosmic circumterrestrial space.

I. Introduction

Studying of the anomaly magnetic field of the Earth (MFE) at the altitudes numerically equal to thickness of the magnetoactive layer of lithosphere (20-40 km), is important that at these altitudes it is formed as equivalent from all sources of this layer, and local component is filtered naturally. Hence, anomaly MFE (crustal magnetic anomalies) at these altitudes most full reflects all complex of the processes happening on all depths of the Earth's crust and allows to study at essentially new scientific level a phenomenon anomaly MFE. But directly anomaly MFE it is not measured - it is necessary to extract it from measured induction of MFE by subtraction from it normal MFE and noise elimination of external sources. It is expedient to use modern global analytical models of the normal MFE for an extraction of normal MFE For allocation abnormal МПЗ it is expedient to use modern global analytical models normal МПЗ. However such models possess appreciable errors of representation of the normal (main) МПЗ and its century variation that does not allow with the sufficient accuracy with their help to extract magnetic anomalies from surveys. The problem of extraction reliably is solved, if during extraction to use the vertical magnetic gradients obtained in the stratosphere on measuring base in length of some kilometers [1]. For this purpose can be used gradient magnetic surveys which are carried out on a stratospheric balloon, drifting at altitudes of 20-40 km in zone air currents [2]. Only last decades preconditions for carrying out qualitative stratospheric balloon surveys have been created. These preconditions are caused by last achievements in the science and technology :

- First is a creation of global navigating system (GPS);
- Secondly is a creation of stratospheric balloon gradiometer with the measuring base estimated in kilometers;
- Thirdly is a creation of global analytical model of the main magnetic field of the Earth by satellite data.

II. The Basic part

Any estimation of result of extraction of the anomaly MRE is based on the analysis of an error of representation of the normal MFE. Since second half of XX century regular satellite magnetic surveys by which analytical models of the normal MFE and its century variations are built. For creation of such models usually use the mathematical device of decomposition of a field by spherical harmonics. The normal MFE is described basically by harmonics up to a degree and the order 13 (n=m=13). The use of such models for extraction of regional and long-wavelengths (till lengths of the waves equal of 3000 km) of magnetic anomalies also imposes a condition of necessity of restriction of some harmonics of a spectrum of the normal field by first 13-th harmonics, that leads to appreciable errors of representation of the normal MFE. There are also errors of prognostic models of the century variation, reaching to 150 nT/year, errors due to influence of the external field and due to course of geophysical processes of global character. To study errors of these models it is possible by comparison modeling and measured MFE, in places in which there are no significant magnetic

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anomalies. To find places, not containing significant magnetic anomalies, by available materials, for example, maps of the anomaly MFE, are highly problematic. It speaks that these maps are constructed basically by aeromagnetic data in whom because of specificity of low-level surveys the regional component of the anomaly MFE is noticeably distorted, and it plays an essential role in formation of magnetic anomalies (average they make 200 nT for all surface of the Earth). We shall consider the solution of a problem according to, received at altitudes numerically equal to vertical capacity of the Earth's crust where the anomaly MFE is formed practically equivalent from its all sources. Geomagnetic surveys at altitudes of 20-40 km are carried out onboard the stratospheric balloons capable in zone air currents to make round-the-world flights, and such surveys are practiced widely enough [3]. We shall notice, that stratospheric balloons of "super-pressure" capable to be in continuous flight at altitudes of 20-40 km over 100 days are already created. It is supposed to start with the view of geophysical researches of hundred such stratospheric balloons (www.gaeospace.com) K.T.Nock, M.K.Heum, K.M.Aaron. Global constellations of stratospheric satellites).

Magnetic surveys aboard a stratospheric balloons were carried out also by authors of present article, but an extraction from them anomaly MFE with the use of modern analytical models of normal MFE have not led to success. In the number of the flights of stratospheric balloons executed by us with gradiometers onboard it has been shown, that in the extracted anomaly MFE there is a trend of the order 200 nT even in short (600 km) a site of the route. The found trend exceeds size of the majority of the magnetic anomalies existing at altitudes of 30 km, and is explained by errors of the analytical model of normal MFE and its century variation [4]. In the paper [1] it is shown, that the problem of extraction of magnetic anomalies reliably is solved for vertical magnetic gradients if their measurement to carry out in the stratosphere. The practice of such measurements by authors of paper is mastered. They were carried out on measuring base in length of 6 km. The effect of strict extraction of magnetic anomalies by gradients speaks that gradients of the normal MFE, received by analytical models for the points carried on 6 km, do not contain a regular error of models including models of century variation of MFE. At such rather small distance these errors are practically identical and are destroyed at calculation of gradients. Thus other gradients of fields of far external and internal sources are destroyed also all. Not less than 100 km on which the deviation of parameter from an axis abscissa does not exceed 10 % from average value of a gradient (2,2 nT/km) [5], it is necessary to consider sites of a profile of anomaly magnetic gradients in length not anomaly. In Fig. 1 the profile of a vertical gradient of anomaly MFE, received at the altitude of h = 30 km is resulted.

In Fig. 1 it is visible, what not anomaly sites in which it is possible to make correction of the anomaly MFE, alternate on the average through 1000 km. Considering it, together with that the length of a wave of 13-th harmonic of normal MFE makes 3000 km, the offered way of correction is suitable for any lengths of harmonics of a spectrum of the normal MFE on territory of all globe. Transferring abscissa these sites on found by exception of measured induction of MFE of analytical normal MFE, a profile of magnetic anomalies, we shall receive on these sites of ordinate of the profile, corresponding errors of analytical model. Then the found places it is connected by direct pieces and all profile is developed so that connecting pieces coincided with an axis abscissa. Values of the developed profile in deviations from an axis abscissa show values of magnetic anomalies at the altitude of flight of a stratospheric balloon along a line of magnetic survey. Let's consider the concrete example showing extracted anomaly MFE as with the use of directly analytical model of a normal MFE, and the anomaly MFE with the use of the corrected model.

In 2007 and 2008 are executed stratospheric balloon flights with magnetic gradiometer onboard through the territory borrowed Kama-Emba magnetic anomaly. Routes of flights missed approximately to 100 km. In Fig. 2 the magnetic anomalies received in these flights are resulted. The curve 1 represents the profile received by subtraction from a magnetic induction measured aboard a stratospheric balloon of values of normal MFE, synthesized by analytical model. The curve 2 represents a piece of a direct line, the united of a place in which there are no significant magnetic anomalies, and a curve 3 represents magnetic anomalies at the altitude of 30 km received by coincidence of received piece 2 with axis abscissa together with a curve imposed on it a curve 1. Here ground magnetic anomaly (a curve 4), taken off with a map of anomaly MFE [6] is resulted.

In Fig. 2 the correlation of average values of positive and negative anomalies in presented two Figures makes 1,35 for ground realization (curve 4) and 7 for stratospheric realizations (curve 3). This result received experimental by, explains many questions arising at studying of a phenomenon of anomaly MFE. As at any high-altitude level anomaly MFE is superposition of fields of sources, averaging of ground data is acted with a field approximately the same as recalculation at the altitude, and for ground data averaging gives the underestimated result in comparison with actual. Apparently, maps of anomaly MFE constructed at low-level surveys, do not carry the full information on the sources located in all capacity of the Earth's crust. Hence, they reflect the processes occuring in near-surface layer of the Earth's crust, and in a smaller measure deep processes. In our opinion mainly for this reason it is not possible to count anomaly MFE, taught of low-level surveys, in top half-space (instead of owing to limitation of the sizes of territory of representation of initial data as it is considered to be though also it in any measure takes place). Other result gives averaging stratospheric balloon data where the field is generated natural by from fields of all sources of the Earth's crust. This result shows, that only anomaly MFE, extracted by the new method offered by authors from gradient magnetic surveys at altitudes of 20-40 km, added by satellite magnetic data, is suitable for creation of strict analytical model of anomaly MFE for a circumterraneous space. Such model will be the basic source of data in studying deep structure of an earth's crust and will allow to study on principle new scientific level a phenomenon of the anomaly MFE.

III. The Conclusion.

1. The new method of allocation of the anomaly magnetic field of the Earth from measurements aboard a stratospheric balloon and a new independent method of an estimation of errors of global analytical models of the normal magnetic field of the Earth Is offered.
2. It is shown by Experimental methods, that maps of the anomaly magnetic field of the Earth reflect the processes occuring in the near-surface layer of the Earth's crust and in a smaller measure deep processes.
3. Only the use of data received at altitudes, in numerical expression equal to thickness of the Earth's crust where the annomaly magnetic field is formed naturally from all its all , allows to create strict model of magnetic anomalies for circumterrestrial space.
4. The stratospheric balloon gradient magnetic surveys in the stratosphere in due course by virtue of their advantages will take the same place in the theory and practice of geomagnetism, which is occupiedh aeromagnetic and satellite magnetic surveys.

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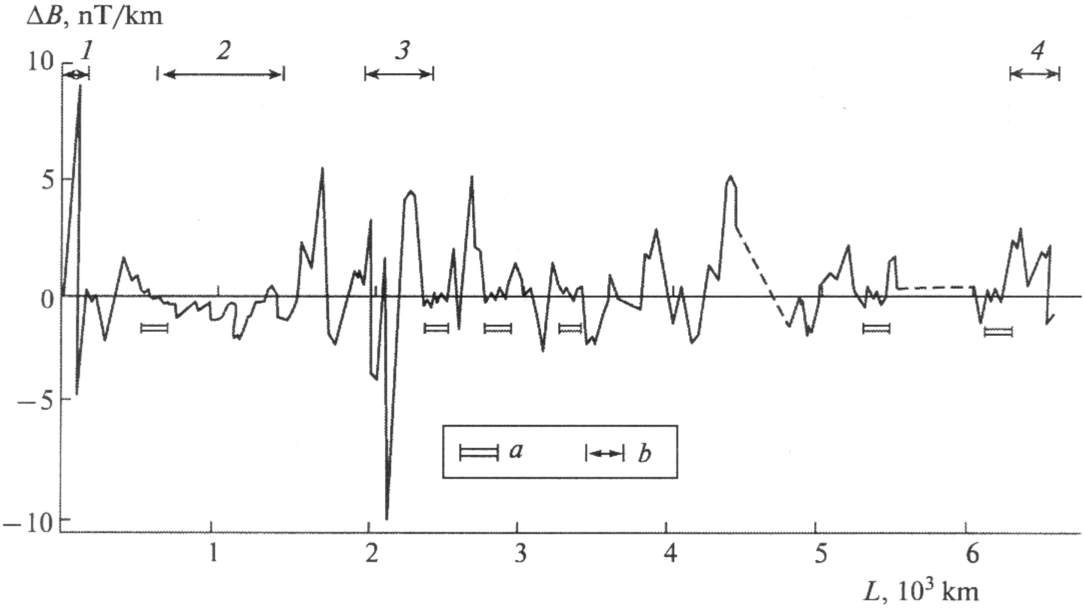

Figure 1. Vertical gradient of the anomaly EMF derived at the altitude h = 30 km. (a) Profile portions where magnetic anomalies are absent; (b) profile portions that divide the territories with the following objects: (1) Klyuchevskaya volcanic group, (2) Sea of Okhotsk. (3) Aldan shield, (4) Kama-Emba magnetic anomaly.

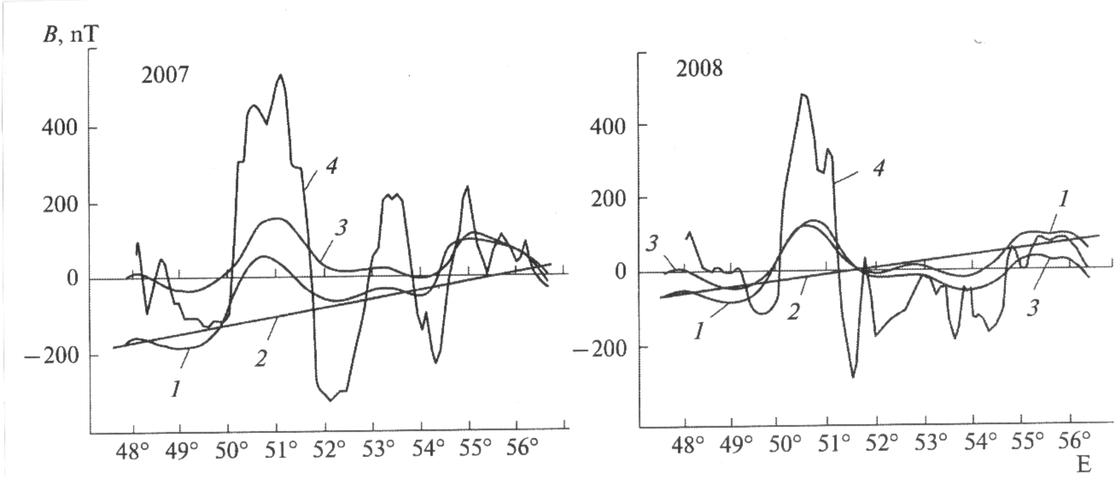

Figure 2. Magnetic anomalies along the stratospheric balloon drift route; (1) distinguished by the IGRF model (h = 30 km); (2) trend connecting portions where magnetic anomalies have no significant values; (3) with the excluded trend (h = 30 km); (4) derived from the map [6] (h = 0).