The experiences with anisotropic averaging transformation of gravity and magnetic fields (on the example of the southeast part of Ukrainian Carpathians)

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Introduction

Anomalous gravitational and magnetic fields are extremely informative for solving problems of detecting and tracing tectonic zones, faults, and individual structural forms within the Ukrainian Carpathians [V.G. Kuznetsova and V.Yu. Maksymchuk; V.Ja. Bilichenko].

The transformations allow selecting and tracing local anomalies. The positive results in the use of transformations of gravity and magnetic fields have been achieved in studies of the Ukrainian Shield basement fault systems and in the creation of a rotational hypothesis of structure formation [K.F. Tyapkin theory], in the study of tectonics of the western regions of Ukraine etc.

Therefore, V. M. Strakhov's opinion on the relevance of the development of the theory and practice of transformations of potential fields is valid.

As our experience shows, for geological interpretation is important the physic-geological content of the results of transformations, which depends not only on the type of transformations and their frequency characteristics, but, we emphasize, also on the determination and analysis of their depth characteristics. *The depth characteristics of isotropic and combined anisotropic averaging transformations are discussed in our previous work [S.G. Anikeyev et al, 2019].*

Anisotropic transformations are effective for highlighting linear anomalies and gradient bands hidden by a regional background and complicated by other forms. They allow to trace confidently the long zones of maximums, minimums and gradients caused by deep faults, tectonic thrusts fronts, and long forms of sedimentary cover.

This work is a continuation of studies of anisotropic transformations. In particular, a method to pick out local isometric anomalies, whose sources lie in certain bands of depth, by means of combined isotropic-anisotropic transformation against the background of regional anomalies and substantially attenuated long linear anomalies is described.

Methods.

The transformation of averaging is a well-known method of dividing potential fields into regional and local components.

A regional component (background) is a group of low-frequency anomalies whose sources are located deeper than a certain depth h. Result of averaging is considered to be a regional background if the degree of attenuation of local anomalies is at least 60% (according to the practice of applying transformation). This is achieved if the radius of the averaging window *R* approximately corresponds to the greatest depths of isometric sources of anomalies *h* (*h/R≈1*- according to the depth characteristic of transformation - B.A.Andreev, I.G.Klushin). If remove the background from the observation field, local anomalies will prevail in the remainder. For example, local anomalies obtained at averaging with a radius of 2500 m are highly likely to be caused by geological objects at depths up to 2500 m. Obviously, the difference between two local fields, defined by different radii of the averaging window *R2* i *R1* (*R2>R1*), is a group of difference local anomalies caused by sources, mainly located in the depths band *R1÷R2*. To obtain the field of difference anomalies, it is easier to take the difference: averaging from R1 minus averaging from R2. It is a combined Saxov-Nigard type transformation (S. Saxov and K. Nygaard, 1953), but has a higher resolution (S.G. Anikeyev, 2009).

Anisotropic transformations (the transformation window is an ellipse, a rectangle and the direction of the window is additional parameter) are proposed to identify and trace substantially elongated anomalies in the field caused by faults or linear structures [Andreev and Klushin, 1962]. Frequency and depth characteristics of isotropic averaging, combined isotropic or anisotropic averaging, which depend on the ratio of window sizes, are given in [S.G. Anikeyev et al, 2019].

Short description of gravity and magnetic fields transformations on the example of the southeast of the Ukrainian Carpathians.

The geological-tectonic nature of the gravity anomalies (Figs. 1B, 1C) is investigate taking into account the structural-tectonic maps (Fig. 1 A).

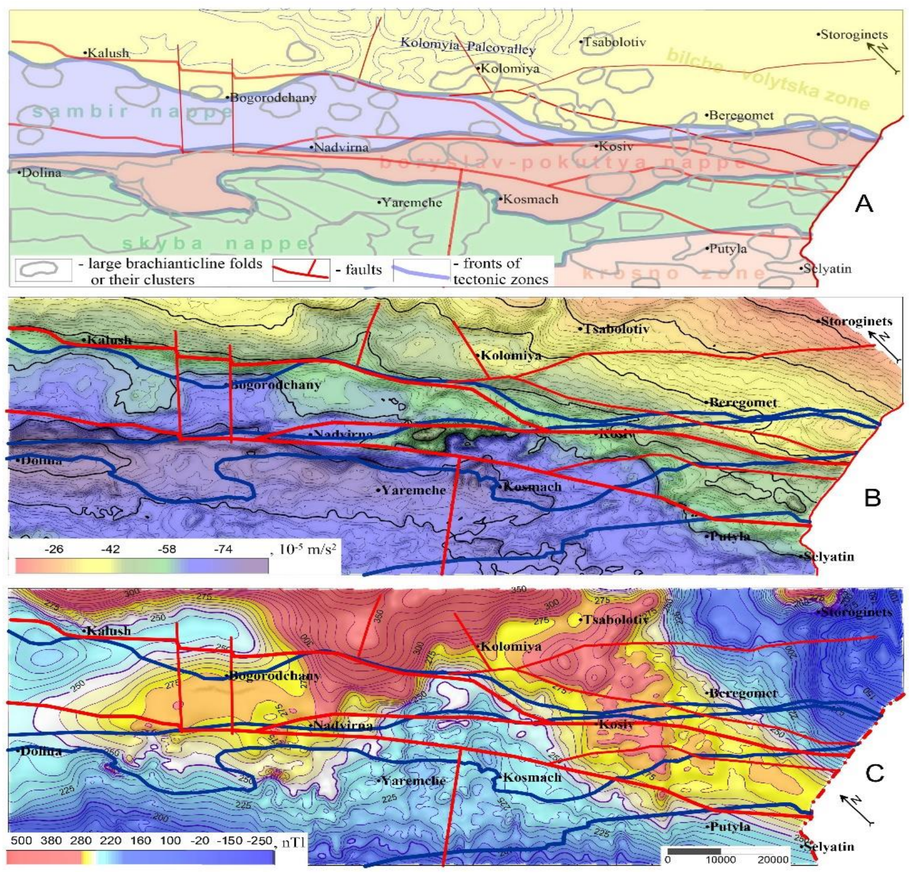

Figure 1 Fragment of the Ukrainian Carpathians tectonics and the forecasted brachy-anticlinal folds (V.V. Glushko, S. S. Kruglov and etc) (A), Bouguer gravity anomalies (B) and magnetic field anomalies (C) of the southeast of Ukrainian Carpathians.

The first example is maps of local anomalies obtained by an isotropic transformation of the gravity field averaging (Fig. 2A) and an anisotropic averaging transformation of gravity and magnetic fields (Fig. 2, 3).

Extended, mainly in the northwest direction, and small isometric anomalies are obtained by removing from the observed fields anisotropic averaging with orthogonal direction of window-ellipse (Figs. 2B, 3B), and anomalies of the northeast direction and small isometric anomalies are obtained using of window-ellipse of the northwest direction (Figs. 2C, 3C).

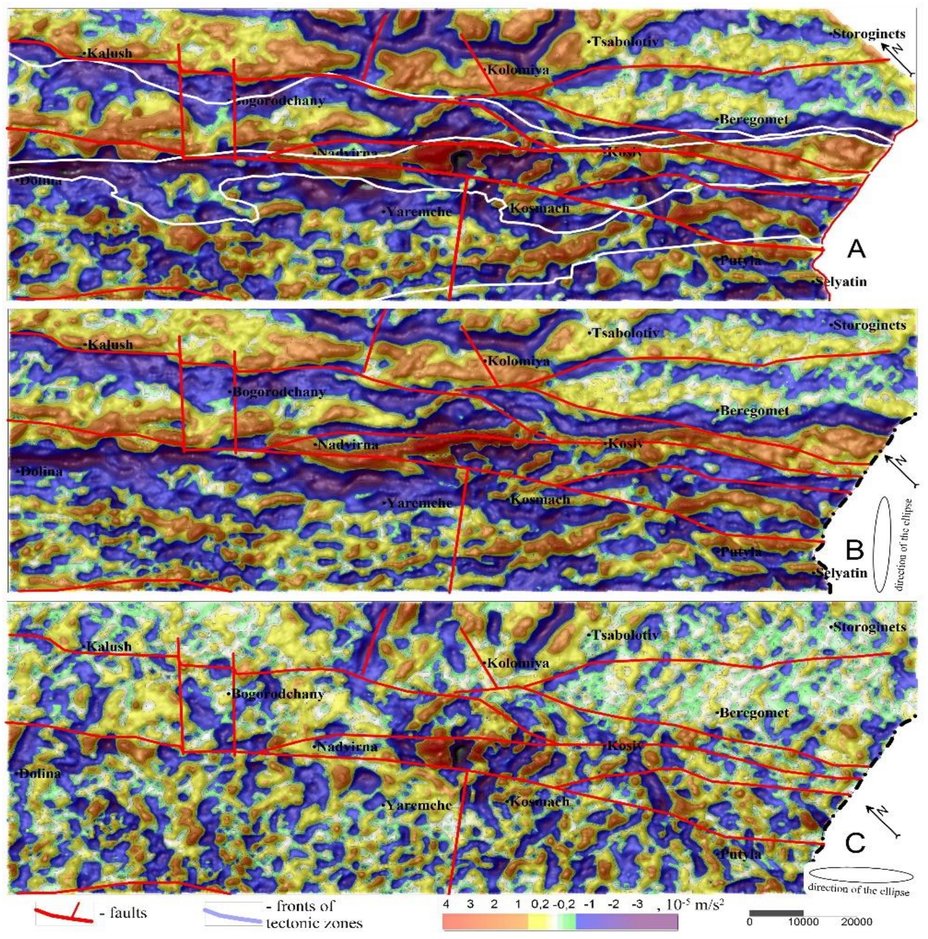

Figure 2 Local anomalies (averaging radius - 5000 m) (A) and anisotropic transformants (half axis of window-ellipse of 500 and 5000 m): small local anomalies of size <5000 m and elongated anomalies of northwestern extend (B) or northeastern extend (C) (sources to depths of 5000 m) of gravity field.

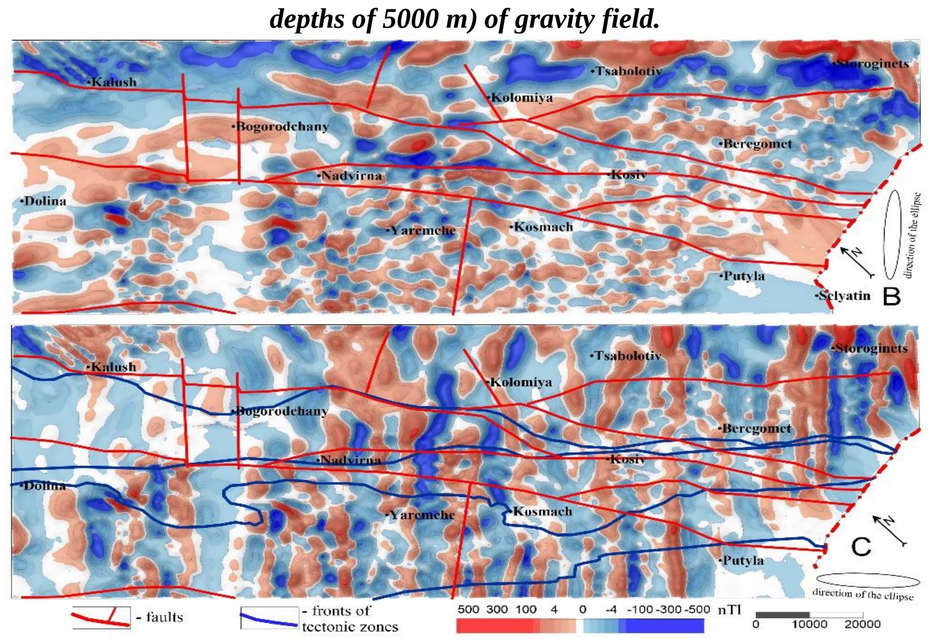

Figure 3 Anisotropic transformants (half axis of window-ellipse of 500-5000 m): small local anomalies of size <5000 m and elongated anomalies of north-west extend (B) or north-east extend (C) (sources to depths of 7000 m) of magnetic field.

In Fig. 4 shows *the results of the combined isotropic-anisotropic transformation by the empirical formula* $\mathbf{2\cdot\underline{U}_R - \underline{U}_E - \underline{U}_W}$; *where* $\mathbf{2\cdot\underline{U}_R}$ *– is a double isotropic averaging with radius R that equal to the small half axis of the ellipses;* $\mathbf{\underline{U}_E}$ *– anisotropic averaging in the northeast direction of the window-ellipse (500 м × 5000 м);* $\mathbf{\underline{U}_W}$ *– is also anisotropic averaging, but in the northwestern direction of the window-ellipse. The result of this transformation is local anomalies, the sources of which are located in a band of depths* ***from the first kilometers to 5,000 m (from magnetic anomalies - up to 7,000 m)***.

Anomalies of significant extend, except for chains of positive or negative anomalies, are practically absent. Regional isometric anomalies and anomalies smaller than 2000 m are also significantly attenuated. Most of the brachy-anticlinal structures (Figs. 4A, 4B) tend to contours positive anomalies. The folds (Fig. 1A), which are located within the positive anomalies of the gravitational field, and which coincide with the magnetic anomalies, formed above the projections of the basement. In the case when the anomalies in the plan do not coincide, the folds are formed as a result of the slide near of the projections of the basement. Concerning the faults, let us pay attention only to the following results: the double fault near Bohorodchany has a linear continuation in the Folding Carpathians (Figs. 3, 4B).

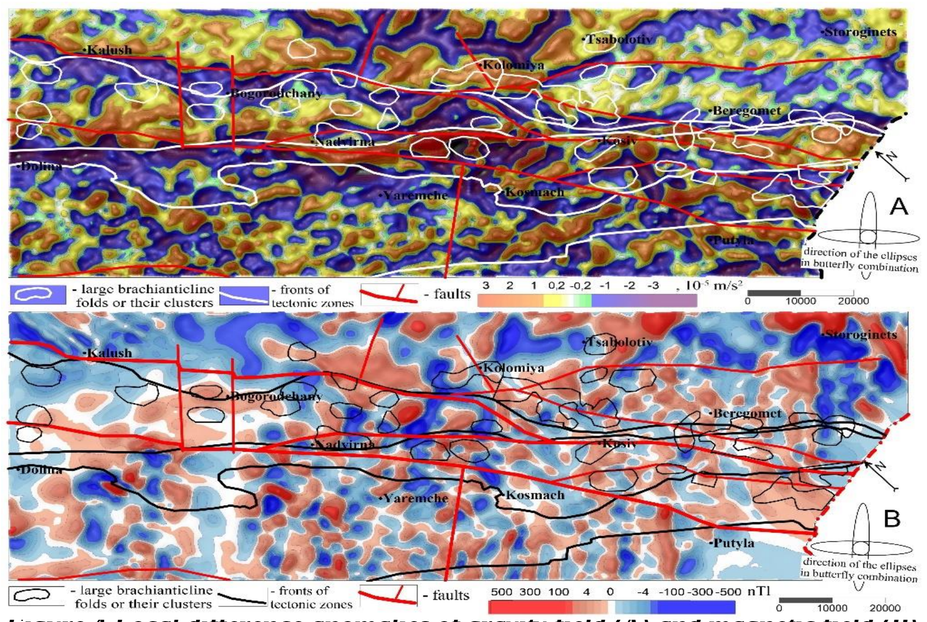

Figure 4 Local difference anomalies of gravity field (A) and magnetic field (B).