



Automated software system for interpretation of the potential fields (GMT-Auto)

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Keywords: automated software system, potential field, automated interpretation, forward problem

Резюме

Изложены принципы работы автоматизированного программного комплекса интерпретации потенциальных полей (GMT-Auto), предназначенного для: 1) автоматизации ввода в компьютер изображений геолого-геофизических карт с последующим преобразованием введенных данных в цифровой вид; 2) решения прямых задач гравиметрии, магнитометрии и геотермии для трехмерных неоднородных слоев; 3) визуализация трехмерных геофизических моделей и их полей.

Abstract

The principles of automated software system for Earth potential fields' interpretation (GMT-auto) are briefly outlined. They are designed: 1) to automate the input process of scanned geological-geophysical maps in the computer with subsequent transformation of the introduced data into digital form; 2) to solve the forward gravimetric, geomagnetic and thermal problems for three-dimensional inhomogeneous layers; 3) to visualize the three-dimensional geophysical models and Earth's fields.

1. INTRODUCTION

A new automated complex software system for data interpretation of gravity, geomagnetic and geothermal fields (GMT-Auto) of the Earth is developed at the Institute of Geophysics, National Academy of Sciences of Ukraine (Starostenko et al., 2015). It allows building a three-dimensional model of the Earth's fields with continuous distribution of the physical parameters. This makes possible to explore the Earth's field in more detail and fully, because the approximation of the calculated geophysical field towards the model depends on the degree of approximation of the Earth's interior in the model.

Complex GMT-Auto system consists of three main blocks:

- 1) An automated input of scanned images of the geological and geophysical maps (top and bottom surface of the layer, the distribution of the geophysical parameters on it) and building the digital geophysical models, which serve as initial data for solving a direct problem;
- 2) Resolving the forward gravimetric, geomagnetic and thermal problems for three-dimensional inhomogeneous layers, which are approximated by the set of heterogeneous vertical prisms with the arbitrarily placed upper and lower base;
- 3) The output of automated complex system is graphical presentation of the final results.

2. AN AUTOMATED INPUT OF THE IMAGES OF GEOLOGICAL AND GEOPHYSICAL MAPS

A large amount of the available geological-geophysical information exists in the form of cartographic maps. For that purpose, special programs that perform automated input of these data in the computer and their representation in digital form were developed.

2.1 Complex Geophys0 software

This software package is dedicated to automated interactive processing of the black and white images of geological and geophysical data. These images contain mainly information about the different isolines and faults (Starostenko et al., 2004). Building a grid network is performed by the software program *Gridlinear* (Savchenko et al., 2008).

2.2 Software package Isohypse

It is used to digitize the geological and geophysical objects, represented by isolines and faults in rectangular or geographic coordinate system. The main advantage of this package is the ability to handle monochrome and color maps.



The software package provides various methods for determining the value of $Z(x, y)$ (the calculated value of function in the grid node), depending on its location on the map. Also for the first time the concept of a planar representation of closed isolines surface and the special type isolines is introduced, that allows to more fully approximating the Earth's interior in the model. The **Isohypse** package enables from existing digital image description to cut and save the data in any rectangular area, as well as to get information along the selected line or a sequence of straight lines for further use in constructing the two-dimensional cross-section.

2.3 SpaceMap program

This program package is specifically designed for use when modeling the crystalline shields, because in this case, the map's images is needed to be input in the computer, which main content are structure bodies in the Earth's interior or areas not isolines (Starostenko et al., 2011). The building of network is carried out directly in the work of the program *SpaceMap* and does not require the use of additional programs.

The result of the each program is the file in *.dat format. It contains information about the number of points along X and Y axis, grid cell, coordinates and the calculated geophysical parameter of each node.

3. SOLUTION OF THE FORWARD GRAVIMETRIC, GEOMAGNETIC AND GEOTHERMIC PROBLEMS

To solve the forward problems of the gravity (Starostenko and Legostaeva, 1998) and the geothermal (Starostenko et al., 2003) fields' modeling the software package *Profil*, and respectively for the geomagnetic problem the program *Magnitca* are developed (Starostenko et al., 2009).

For solving these forward problems the horizontally layered geological structures are approximated by arbitrarily truncated set of inhomogeneous vertical rectangular prisms (Starostenko, 1978).

Each program allows solving the forward problem for multilayer models (from 1 to 9 layers). The input information is entered per each layer separately depending on the selected forward problem. It represents a description of the top and bottom surface of each layer; as well it contains information about the distribution of physical parameters in it, which are inputted in the complex software system as maps or concrete values.

In the software package *Profile* a possibility to change the physical parameters (density σ for gravity and heat flow density Q in geothermal problems respectively) within the prism linearly along the horizontal coordinate on the upper and lower bases and linearly or exponentially along any vertical line is provided, so that at the tops of prisms the geophysical parameter has a specified value.

An algorithm for calculating the geomagnetic field for anisotropic homogeneous bodies is included in the program *Magnitca*, which is implemented on the basis of contour's integration along the edges of walls limiting the body surface. To calculate the magnetic effect (anisotropic case) it needs to enter the normal field components T_o and the three main values χ_{ij} of the magnetic susceptibility tensor. A modification of the program is also developed that allows performing calculations of the magnetic layer effect for the isotropic case. For that purpose it is necessary to enter information about the normal field components T_o and magnetization I .

The work of each program runs into three stages:

1. Entering the initial information;
2. Entering the parameters of resulting model, within which the calculations are being done, i.e. the initial point' coordinates, size and step of the output model are entered;
3. Solving the three-dimensional forward problem.

The result of the automated complex software system is a file that contains information about the coordinates of each point along the X and Y axes and calculated field values in it. In case of the magnetic problem solution, the output file also contains information about the components of magnetic field intensity and its full value at each point.

4. PRESENTATION OF RESULTS IN GRAPHICAL FORM

The results of the above motioned complex software programs can be represented by the powerful mapping service *Golden Surfer* to build graphical representations of functions of two variables. Also the vector graphics editor *CorelDraw* can be used for the graphic layout of the obtained results and the geographic information system ArcGIS for transformation the received data into the required map projection, building the isosurfaces, etc.



5. CONCLUSION

Automated complex software platform GMT-Auto has found wide applications in solving many practical problems, which are related to studying the structure of various geological objects with complex sub-surface geological structures, using the geophysical data. In particular, this software platform had been used to built the new three-dimensional density model of sedimentary basins like the Dnieper-Donets depression and Donbass (Kuprienko et al., 2010); the Pripyat trough (Buryanov et al., 2000); the Carpathian-Pannonian region (Szalaiová et al., 2008, Bielik et al., 2013; Krajnak et al., 2012); the Black Sea basin (Starostenko et al., 2005; 2010; 2011), the Netherlands coastal zone (Dirkzwager, et al., 2000); and Ukrainian (Kuprienko et al., 2007), Voronezh (Starostenko et al., 2013), and the Baltic (Pashkevich et al., 2014) shields.

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