EVALUATION OF ORE-CONTROLLING GEOLOGICAL STRUCTURES USING REMOTE SENSING

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ABSTRACT

As a result of this work, remote sensing bases were obtained based on Landsat and Aster materials, a cosmostructural scheme in the East Balkhash site (Kazakhstan), and the main ore-controlling factors were identified, on the basis of which promising sites for the detection of endogenous mineralization were identified. The selected digital satellite images provide a given scale of research and have the maximum spectral completeness, that is, they cover the area of research in all possible spectral ranges. On cosmostructural schemes, objects of linear morphology show faults, areas of increased fracturing, geological boundaries, bedding elements, dyke bodies, and other elements that have a geological nature. To identify the linear structures, the whole complex of source and derivative space materials was used. In conditions of poorly dissected relief, methods for multi-oriented gradients and various filtering methods turned out to be especially effective for emphasizing linear structures. In identifying the ring and arc structures in the area of work, the following features were used: arc and ring borders between blocks with different textures of space materials; borders of landscape inhomogeneities, arc and ring morpholog. Radially ring structures are conventionally divided into structures of the second-order and small. Structures with radii from 4 to 48 km are assigned to ring structures of the second-order, and small structures with radii less than 4 km are assigned to small structures. Stratified complexes in the studied areas are clearly divided into loose and lithified ones. Neogen-Quaternary proluvial, alluvial-proluvial, alluvial, aeolian and undifferentiated sediments are classified as loose. The lithified stratified complexes are creased in folds with a predominant northwestern strike of the axes. In identifying the bodies of intrusive rocks, spectral libraries, textural features of satellite images and the authors' experience were used.

Keywords: *Remote sensing, Ore controlling factors, Cosmogeological scheme, Prospective blocs*

INTRODUCTION

At present, Applied Remote Sensing plays an important role in solving geological, terrestrial problems and observing coastal and ocean ecosystems [1], [2], [3], [4], [5], [7], [8], [9]. In addition, Remote Sensing provides building new knowledge about the Universe through observation of the Planetary and Solar systems, as well as beyond [7].

The initial data for the work was provided by the archival data of the Landsat ETM +, Aster satellite imagery and data processing materials, as well as data from

the digital terrain models SRTM and AsterGDEM. To provide the work with the materials of the survey scale level, mosaics from the Landsat ETM + archival space images were used. For the preparation of mosaics, the photographs of 1999-2002 were used. These data are obtained from the library of satellite images and materials processed by the Maryland University (USA) (http://glcfapp.glcf.umd.edu:8080/esdi/index.jsp).

Space images of the average spatial resolution of two systems - Landsat ETM + and Aster, as well as mosaics of space images based on Landsat ETM + images were selected. Radar data SRTM (Shuttle Radar Topography Mission, 2000) and Aster GDEM (Aster Global Digital Elevation Model, 2011) were used to build a digital terrain model and calculate three-dimensional models.

Selected data provide a comprehensive spectral characteristic of the investigated area in the visible, infrared and thermal regions of the spectrum. All cosmic materials were selected taking into account local climatic features, depressed vegetation and lack of snow cover, which corresponds to the requirements for carrying out such work. The accuracy of the location, spatial and spectral characteristics of the selected remote survey data fully correspond to the scale of the work [3], [4], [5], [6], [8], [9], [10], [11], [12].

An original technological scheme for the preparation and processing of the space materials Landsat ETM +, Aster, SRTM and Aster GDEM was developed. It includes the following main blocks [1], [2], [6]:

- extraction of cosmic materials from archives and mapping into a single cartographic projection (Landsat maps only, Landsat mosaics are disseminated without map projection, and Aster data is in a geographic coordinate system);

- primary processing of source raster materials using channel classification algorithms, various enhancement procedures, a complex of methods for filtering and resampling images;

- decoding of mono-channel raster images;

- creation and processing of synthesized images of Landsat ETM+, Aster (Figure 1) multispectral imagery, as well as image mosaics with subsequent statistical filtering for all studied areas;

- creation of representative composites on the basis of the received materials;

- creation of derivative raster images with the use of "algebra of maps" and calculation of spectral indices based on Landsat and Aster materials;

- correlation analysis of mosaics of synthesized images Landsat ETM + and Aster by the method of main components;

- creation, processing and analysis of digital terrain models based on SRTM and AsterGDEM data;

- joint analysis of raster images and digital terrain models, construction of three-dimensional images, interpretation with the use of 3D visualization, creation

and interpretation of anaglyphic (stereo) images; preparation of space-structured schemes (Figure 1).

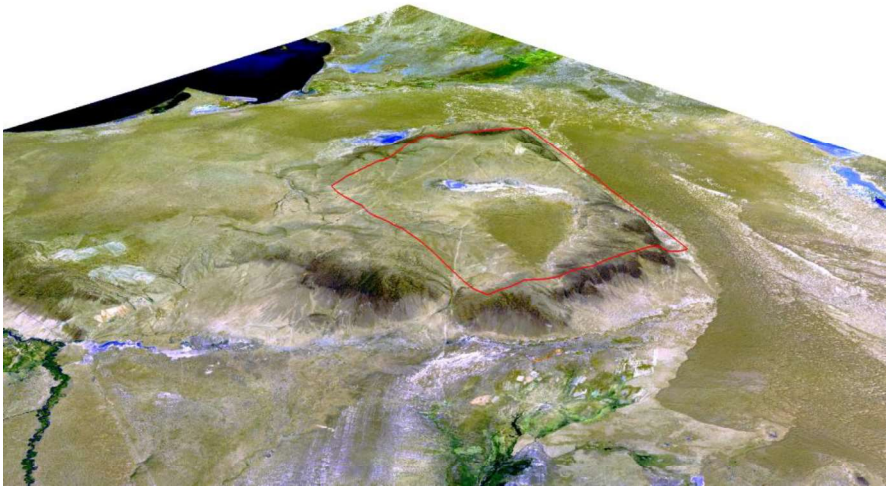

Figure 1 Perspective 3D image of the East Balkhash site based on Landsat ETM + and SRTM materials. View from the south. Vertical factor 10.

THE RESULTS OF INVESTIGATIONS

Cosmological structures of the East Balkhash site. On the area of the East Balkhash site, linear, ring and area, cosmogeological structures are distinguished.

More than 900 linear structures have been identified, among which about 640 received a geological interpretation. These structures include faults, geological boundaries and layered elements of lithified stratified complexes.

Disruptive disturbances in the Eastern Balkhash segment have a predominantly northwestern and sublatitudinal strike.

The main discontinuous disturbance is the right shift displacement located at the northeast border of the area. It has a northeast strike, and it is not possible to determine the displacement amplitude, due to the wide development of modern sediments and the flattened relief near the site.

Secondary discontinuous faults are related to sublatitudinal discontinuities associated with the main structure. The amplitudes of the right-shift displacements in such structures reach 860 m.

Other faults are mainly of the northeast trend.

Elements of stratification of stratified complexes are manifested over the entire area with the exception of areas with developed non-lithic Neogene-Quaternary sediments. In some cases, folded forms of their occurrence are established.

On the Eastern Balkhash section and in its immediate vicinity, ring structures with a radius from 0.13 to 48 km are mapped. It should be immediately noted that

the site is located in the central part of a second-order magmatogenic telescopic ring structure with a radius of 48 km. Ring rings with smaller radii are “embedded” in this ring structure. The presence of such a complex of ring structures usually indicates a multi-layered position of intermediate magmatic foci.

According to possible formation mechanisms, all ring sections are conventionally divided into magmatogenic and hydrothermal-metasomatic. The reasons for this separation were the spatial alignment of ring structures with single manifestations of intrusive magmatism, signs of thermal effects on host rocks in the north-eastern part of the site and with traces of metasomatic changes. All these facts suggest the presence of a not deeply lying blind magmatic body of considerable size, with which the manifestations of minerals are possibly associated.

As areal bodies on the site, eolian and undifferentiated Neogene-Quaternary sediments, lithified complexes, an intrusive body exposed to erosion, presumably of medium composition, and a blind intrusive body of presumably acid composition, areas with traces of thermal effects and hydrothermal metasomatic changes of enclosing rocks were identified.

Stratified formations occupy almost the entire area of the site. Modern eolian deposits occupy a depression in the central part of the area, and undifferentiated Neogene-Quaternary formations are located in the northeast, central and southern parts of the site. The lithified complexes of presumably Middle Paleozoic age are exposed on elevations in the eastern, northern and western parts of the area.

In the eastern part of the site, a single stock of intrusion is presumably of medium composition. Its size is 1.8 by 0.67 km. In his exocontact, traces of thermal exposure are found - contact hornfels are assumed here. The same hornfelses are recorded in the northern and eastern parts of the area.

A blind intrusive body, presumably acidic, is mapped in the central part of the area. Signs of its release were traces of weak thermal effects on host rocks and the system of telescoped ring structures. Such systems of ring structures not only indicate the position of the magma chamber but may also indicate its conditions of formation and occurrence. Thus, for the Kalgutinsky rare metal deposit located in the Gornyi Altai, the authors of the report showed that the systems of telescoped magmatogenic ring structures indicate the pulsating nature of the development of the magmatic system as a whole, and the eccentricity of the telescoped ring structures indicates a declination of the leg of the intrusive body. Based on the experience obtained, it can be argued that the blind, acidic intrusive body in the central part of the site has a southeast declination.

Of particular interest are traces of hydrothermal-metasomatic changes. Spectral analysis of Aster materials of these areas indicates the presence of newly formed muscovite, chlorite, carbonate, epidote. All these areas of hydrothermally altered rocks are exposed to rupture faults of the northwestern and sublatitudinal orientations [9].

PROSPECTS FOR THE EAST BALKHASH SITE

The prospects of the East Balkhash site are associated with the manifestation of endogenous mineralization and the possible detection of groundwater.

Endogenous mineralization can be associated with the manifestation of intrusive magmatism, signs of which (single rod, areas of thermal impact on host rocks, and magmatogenic ring structures) are found within the area. Here you can expect a wide range of minerals - gold, copper, molybdenum, lead, zinc, tin, tungsten.

As remote factors of mineralization within the area it is proposed to consider: ring structures, or rather their arc segments and especially the junction areas of such arc segments with multidirectional faults; multidirectional faults; intrusive body; blind intrusive body; sites with traces of thermal effects on host rocks; areas with signs of hydrothermal-metasomatic changes.

Based on the remote factors of mineralization within the Eastern Balkhash site, as well as in its immediate vicinity, five promising areas were identified for the detection of endogenous mineralization (Figure 2). According to the degree of "perspective" plots are divided into queues.

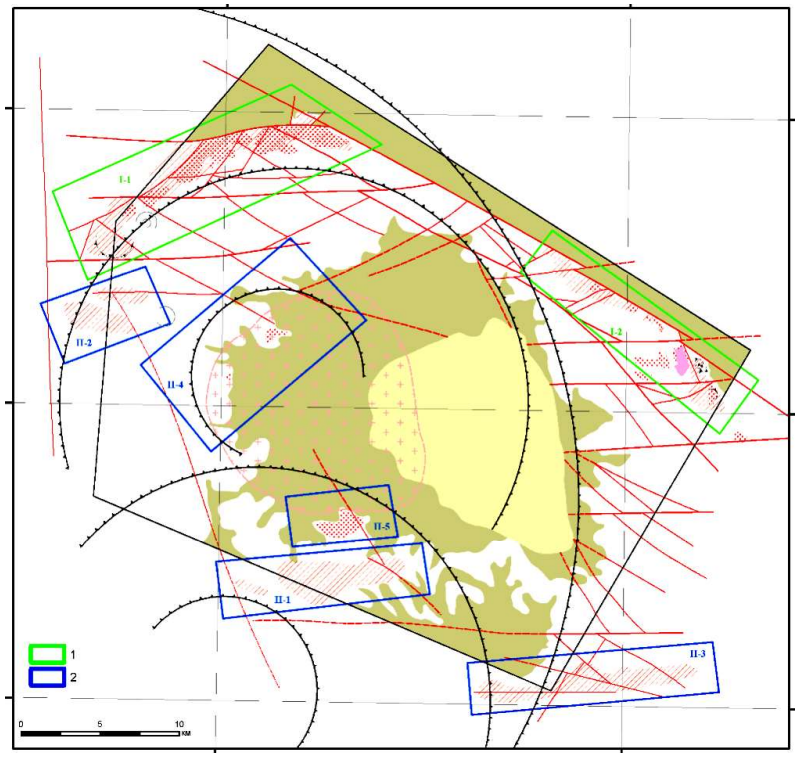

Figure 2 Perspective areas of Arganaty sites (Eastern Balkhash) for detection of endogenous mineralization: 1 – area of the first stage; 2 – area of the second stage.

Detection of underground artesian water is possible in the central part of the site.

For the formulation of prospecting works, a traditional minimal complex is proposed - deciphering materials of high-resolution space satellite surveys, ground-based search routes, lithochemical surveys using secondary diffuse halos, areal geophysical surveys, magnetometric, electrometric (EP and VP methods) and gamma spectrometric surveys. For the verification of the identified direct signs of minerals, a complex of surface mine workings is proposed. For the search of sections II-4 and II-5, it is proposed to include mapping and exploratory drilling in the work package.

CONCLUSION

As a result of the work, cosmostructural schemes of scale 1: 100000 were obtained. The main cosmogeological factors of mineralization have been identified, and perspective areas have been identified for the setting up of exploratory works for the first and second stages. Recommendations on a set of search methods are developed.

Geological and geophysical studies were carried out using various modifications of magnetic survey and electrical exploration methods. Deep-lying endogenous mineralization and buried geological structures are reliably distinguished by the results of the interpretation of satellite images. Perspective areas identified by cosmological and geological technology can be objects for further exploration and evaluation work. Ground-based geophysical studies, in our case magnetic and electrical exploration, provide for the selection of specific anomalies and the choice of locations for exploratory drilling wells.

Prospects of blocks can be associated with the manifestation of endogenous mineralization, placer gold content and tininess. With regard to endogenous mineralization, gold, molybdenum, tin, and copper deposits can be predicted at the site in connection with granitoid magmatism.

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