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Satbayev University

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ИЗВЕСТИЯ

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CLASSIFICATION OF GEOPHYSICAL FIELDS IN THE STUDY OF GEOLOGICAL AND STRUCTURAL FEATURES OF THE ZHEZKAZGAN ORE DISTRICT

Abstract. As a result of generalization and analysis of complex geological and geophysical data, the geophysical studies were shown in application to structural mapping of ore-prospective areas and detailed study of ore-controlling complexes of cupreous sandstones in the Zhezkazgan ore district of Central Kazakhstan. Basing on modern means of registration, processing and interpretation of magnetic, gravity and seismic exploration, the ore geophysics proved its efficacy in studies of tectonic structure of ore areas, localisation and identification of the morphology of differentiated intrusive massifs at depth, detection and deep mapping of tectonic faults, defining the ore-controlling structures of sedimentary and effusive-sedimentary folded complexes as well as in determination of the spatial position of ore-bearing zones.The deep structure of the Zhezkazgan syncline on sides of the Sary-Oba rise differs sharply, fixing the simple structure of the eastern part and the complex folded one of the western part. The deposits of the Zhezkazgan and overlying zhidelisai and kingir suites represent a conforming continuous section, in places, there are local disconformities over faults with repeated tectonic displacements, lying on sediments of the taskuduk suite. Taking into account the rather complex geological structure of the given ore district and the significant differentiation of the composing rocks, ores and near-ore hosting strata, further identification of additional criteria for localization of copper mineralization is possible with the integration of detailed geological and geophysical methods, geochemical and physical-chemical studies of rocks and ores.

Key words: cupreous sandstones, geophysical fields, interpretation, ore-bearing zones.

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ЖЕЗҚАЗҒАН КЕНДІ АЙМАҒЫНЫҢ ГЕОЛОГИЯЛЫҚ ҚҰРЫЛЫС ЕРЕКШЕЛІКТЕРІН ЗЕРТТЕУ БАРЫСЫНДАҒЫ ГЕОФИЗИКАЛЫҚ ӨРІСТЕРІН КЛАССИФИКАЦИЯЛАУ

Аннотация. Кешенді геологиялық-геофизикалық мәліметтерді қорыту және талдау нәтижесінде Орталық Қазақстанның Жезқазған кен аймағындағы кен перспективалы жабық аумақтардың құрылымдық картасын жасау және мыс құмтастарының рудалық бақылау кешендерін егжей-тегжейлі зерделеу үшін геофизикалық зерттеулер жүргізу мүмкіндігі пайда болды. Магниттік, гравитациялық, сейсмикалық барлауды тіркеудің, өңдеудің және интерпретациялаудың заманауи құралдарын пайдалану негізінде кенді аймақтардың құрылымдық-тектоникалық құрылымын зерттеуде кен геофизикасының тиімділігі көрсетілді; тереңдікте дифференциалды интрузивті массивтердің морфологиясын локализациялау және анықтау; тектоникалық бұзылуларды анықтау және терең картаға түсіру, шөгінді және эффузивті-шөгінді қатпарлы кешендердегі кенді реттейтін құрылымдарды анықтау; кенді аймақтардың кеңістіктегі орнын анықтау. Жезқазған синклиналының терең құрылымы Сарыоба жыртылысының әр бетінде күрт ерекшеленеді. Зерттелетін кенді аймақтың айтарлықтай дифференциациясын ескере отырып, мыс минерализациясының одан әрі анықтау егжей-тегжейлі геологиялық, геофизикалық әдістерді геохимиялық және физика-химиялық зерттеулермен біріктіру арқылы мүмкін болады.

Түйін сөздер: мыс құмтастар, геофизикалық өрістер, интерпретация, кенді аймақтар.

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РАЙОНИРОВАНИЕ ГЕОФИЗИЧЕСКИХ ПОЛЕЙ ПРИ ИЗУЧЕНИИ ГЕОЛОГО-СТРУКТУРНЫХ ОСОБЕННОСТЕЙ ЖЕЗКАЗГАНСКОГО РУДНОГО РАЙОНА

Аннотация. В результате обобщения и анализа комплексных геолого-геофизических данных показана возможность геофизических исследований для структурного картирования рудоперспективных закрытых площадей и детального изучения рудоконтролирующих комплексов медистых песчаников в Жезказганском рудном районе Центрального Казахстана. На основе применения современных средств регистрации, обработки и интерпретации магнито-, грави- и сейсморазведки показана эффективность рудной геофизики при изучении структурно-тектонического строения рудных районов; локализации и выявлениии морфологии дифференцированных интрузивных массивов на глубине; обнаружения и глубинного картирования тектонических разломов, выделения рудоконтролирующих структур в осадочных и эффузивно-осадочных складчатых комплексах; определении пространственного положения рудоносных зон. Глубинное строение Жезказганской синклинали резко различается по разные стороны Сарыобинского взброса, при этом фиксируется простое строение восточной части и сложное складчатое для западной половины. Отложения жезказганской и вышележащих жиделисайской и кингирской свит представляют собой согласный непрерывный разрез, местами отмечаются местные несогласия над разломами с неоднократно повторявшимися тектоническими смещениями, залегающий на отложениях таскудукской свиты. Учитывая достаточно сложное геологическое строение исследуемого рудного района и значительную дифференциацию слагающих их пород, руд и околорудных вмещающих толщ, дальнейшее выявление дополнительных критериев локализации медного оруденения представляется возможным при комплексировании детальных геологических и геофизических методов, геохимических и физико-химическим исследований пород и руд.

Ключевые слова: медистые песчаники, геофизические поля, интерпретация, рудоносные зоны.

Introduction. Deposits of cupreous sandstones are one of the leading types in terms of reserves and copper mining in Kazakhstan. The Zhezkazgan ore district includes the unique Zhezkazgan deposit and a number of small copper deposits of the Zhilandy group (It-Aauz, Sary-Oba, Kipshakpai, Karash-Oshak and Zhartas), ore occurrences of the Northern and Southern Akchii, Spassky, Taskuduk, etc. The copper mineralization is associated with deposits of the Taskuduk and Zhezkazgan suites of the Middle and Upper Carboniferous and is confined to layers of their gray-colored sandstones. By formation conditions, the copper mineralization belongs to the stratiform type (Baibatsha A. et.al, 2017).

Until recently, direct search for Zhezkazgan type of ores were confidently carried out only by methods of litho-chemical surveys and the method of induced polarization (IP), mainly, in open areas. Other geophysical methods of prospecting, including electrical resistance, gravity, magnetic and seismic methods of exploration did not solve this problem, but in search for favourable structures of locked areas they could assist to targeted exploratory drilling (Istekova S.A. 2006) (Uzhkenov B.S. 2011).

In general, the Zhezkazgan ore region was well studied by detailed geological surveys, prospecting and geophysical studies, including a wide range of methods. In different years, magnetic exploration, gravity exploration, electrical exploration, and seismic exploration were implemented in separate sections of the area. The surveys defined the area as a promising one for copper mineralization. For its search at depth, few deep boreholes were drilled (the deepest was 1587.7 meters down), however none of the them have managed to cross the ore-bearing horizons of Zhezkazgan and Tastykuduk suites, while part of the wells have not been tested (Uzhkenov B.S. 2011).

Contemporary means of physical field registration, processing and interpretation allowed to produce high-quality materials and increase efficiency of geophysical methods when solving geological problems at ore deposits.

The high-precision geophysics was applied for both structural mapping of ore-promising areas and detailed study of deep-lying ore-bearing complexes. Generalization and comprehensive analysis of accumulated geophysical information on the Zhezkazgan ore region, with help of modern processing and interpretive geo-information systems, allowed to study in detail the deep-lying ore-bearing complexes and identify additional deep search criteria for stratiform copper mineralization. The territory of the southern immersion of the Western Sary-Oba deposit, covered by loose and Upper Paleozoic sediments, is currently unexplored and remains one of the most promising for replenishing the mineral resource base of the Zhezkazgan region.

Materials and basic methods. The studies were carried out in order to develop search criteria for copper mineralization and to prepare recommendations for exploratory drilling based on geophysical data at the sites of the southern immersion of the Western Sary-Oba deposit within the Zhezkazgan ore district (figure 1).

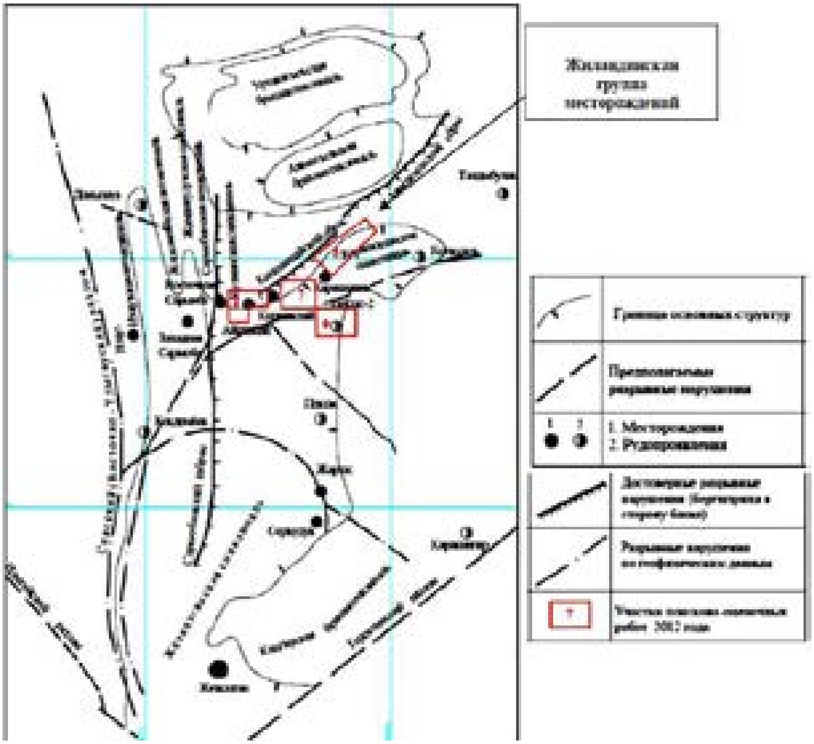

Figure 1. Layout of deposits and ore occurrences of the Zhezkazgan district (Uzhva V.I. 2011).

Regionally, the study area is located within the Zhezkazgan ore district and covers fragments of the Sarysu-Teniz, Zhezkazgan structural-fomation zone (SFZ), and small volumes of the Konsky and Shagyrly SFZ. The study area is composed of carbonate-terrigenous deposits of the Carboniferous and Permian systems; in the west part of the district there are terrigenous formations of the Ordovician and Devonian systems along the Eskuly block framing (Zientek M.L. et.al, 2014).

Legend to the layout of the tectonic structure of the Zhilandy ore district:

- boundaries of main structures
- anticipated faults
- 1. deposits
- 2. ore deposits
- reliable faults (berg beames towards the block)
- faults as per geophysical data
- areas of 2012 search and appraisal works

Most of the Zhezkazgan ore district is occupied by the Zhezkazgan syncline, which is a symmetrical structure with the axis dipping to the south in the meridional direction at an angle of 3-5°. Its western side is steep (at an angle of 70-90°), from the Kokdombak occurrence and to the north has reverse dipping (to the west). The eastern side is flat, dipping at 10-15° to the west. Along the northern side of the syncline, the steepest angles are located to the south of the Eastern Sary-Oba deposit (up to 70-80°); the rock flattens down to 20-12° in the west of the deposit and to 45-30° in its east.

In the northern part of the Zhezkazgan syncline, there is the Northern (Zhilandy) group of copper ore objects, including the deposits of It-Auz, Western and Eastern Sary-Oba, Kipshakpai, Karashoshak and the ore occurrences of Airambai, Pektas, Kokdombak, and oth.

The area of the southern immersion of the Western Sary-Oba deposit within the Zhezkazgan syncline has a meridional strike between the Zhilandy and Zhezkazgan ore fields; is almost by 80% covered by loose formations with a total thickness of up to 30-120m. The indigenous outcrops of Paleozoic rocks are concentrated mainly in the northeastern part of the site and in a small amount are present in the central, southwestern and southeastern parts of the site, where the area of local indigenous outcrops of Late Paleozoic formations does not exceed 1 sq.km. Paleozoic formations are presented by the Zhezkazgan suite of the Middle Upper Carboniferous period, the Zhidelisai suite of the Lower Permian and the Kingir suite of the Lower-Upper Permian period (Cossete P.M et.al, 2014).

The structure of the Zhilandy group of deposits is characterized by complex tectonics, especially within the fields of Western and Eastern Sary-Oba and It-Auz. Sites of the deposits are the zones of maximal stress causing folds and large disjunctive ruptures (Hitzman M.W. et.al, 2010).

Prospects of the planned exploration works in the area of the Zhezkazgan syncline are determined, first of all, by the presence of productive horizons predicted by results of the areal geophysical works and confirmed by exploratory drilling in the past periods. Productive horizons of the Taskuduk suite in the northern part of the Zhezkazgan syncline were revealed during the search and evaluation work carried out by the Zhezkazgan GEE in 1981-1986 (Khailovsky V.N. et al, 1987). The authors established that due to steep rock dipping at the syncline wings, the productive horizons depths of the Taskuduk and Beleuty suites grow sharply down to 1800-1900 m.

In the southeastern part of the Zhezkazgan syncline, in the area of its junction with the Kingir and Uitas brachyanticlines, there are a small deposit Zhartas and an ore occurrence Sorkuduk, both of which are close to the Zhezkazgan type, but are much smaller in scale and with a narrower stratigraphic interval of mineralization (Lyubetskaya L.D. et.al, 2009).

The seismic surveys of 1975-1977 and 1980-1981 performed by the Sarysu and West Teniz seismic parties by the method of reflected waves and CDP indicated to the spread of productive horizons within the Zhezkazgan syncline. The works resulted in delivery of seismogeological sections and a map of the isodepths for the sole of the productive strata in the central and western parts of the Zhezkazgan syncline.

Research methodology. Additional search criteria for localization of a copper mineralization within the study area were identified using a complex of geophysical methods, including gravity and magnetic exploration, performed in the last decade by geophysical companies applying modern hardware and methodological complexes. The interpretation results obtained by geophysical methods of potential fields were linked to the 2D areal seismic survey data carried out in the area in different periods of time. The main methodological principle was to identify additional search criteria for the localization of copper deposits, from the standpoint of the deep structure: structural-tectonic, stratigraphic and lithological heterogeneity of geological complexes with extensive use of geophysical data (Lyubetskaya L.D. et.al, 2009; Togizov K.S. et.al, 2019).

The following basic localization conditions of Zhezkazgan type copper mineralization contribute to the successful application of structural geophysical methods:

- stratigraphic and lithological control of mineralization, i.e., occurrence of copper mineralization to sandy rocks of the Carboniferous system, namely, to gray medium-coarse-grained sandstones;
- attribution of deposits to peripheral areas of large structures of the first order, having planar dimensions of about 20-30 km; relatively higher copper enrichment of sites, complicated by local folds and ruptures and located along the lines of extended, repeatedly renewed tectonic seams (Balk P.I. et.al, 2016).

Gravity exploration is the main geophysical method applied to studies of deep ore-controlling structure geology. The main parameter affecting the intensity of the gravitational field is the density of rocks which clearly varies in dependence of composition and substances of the geological complexes (Balk P.I et.al, 2017; Cossette P.M. et.al, 2014).

In studies of deep structures, gravimetric maps of observed field of various scales serve as a basis since they contain the most complete information about the whole region and individual target objects. The Zhezkazgan ore region was intensely studied by gravimetric methods. Therefore, deep structures at the target Middle and Lower Paleozoic horizons are provided with sufficient gravimetric data. The territory is fully covered by the 1:200,000 conditional gravimetric survey, and ore areas are covered by surveys scaled 1: 50,000 and larger. The constructed gravimetric maps are of high quality. Maps of the observed field are accompanied by gravitational field transformation maps: regional and local components (filtering by high-frequency bandpass, narrow bandpass and medium-width filtering), and vertical and horizontal derivative of the Bugey anomaly. Iso-anomal cross-sections were made by 1 and 0.5 mGal.

The gravitational field of the research area is quite differentiated (figure 2).

In the map of the gravitational field, conjunction parts are highlighted for zones with the field's different levels and character. In the western part, the gravitational field is characterized by a submeridional strike of isoanomalos Vzz, corresponding to the position of the of the Ulytau-Arganaty structural-formation zone structures. In the southeastern part, the elongated positive and negative anomalies of the northeastern direction are distinguished, spatially coinciding with the Sarysu-Teniz riftogenic structure and the eastern subzone of the Konsky SFZ.

In the central part of the district, there is a band of extensive decrease in intensity of the gravitational field with two separate epicenters caused by large granitoid massifs. Difference in the values of the field Δg is -50 mGal in marginal parts and is up to -68-76 mGal in epicenters. Both massifs are the marginal eastern part of a vast zone of magmatism, stretching in a submeridional direction far to the north beyond the studied area. Individual granitoid protrusions are clearly outlined on transformed maps Δg (H_{down}=500 m) and isolines Vzz in the form of local anomalies of a negative sign.

A negative gravitational anomaly is confined to the nuclear part of the Zhezkazgan syncline, within which two large local minimums (Northern and Southern) are fixed, the geological nature of which, despite the close parameters (area and intensity), is rather different. According to density selection of the Δg curves along the interpretation profiles, the northern minimum is apparently associated with the presence here of a thick layer of low-density deposits of the Zhidelisai suite, and the southern one, according to the interpretation, outlines the granitoids of the Terekty intrusive complex of the Middle Devonian, not exposed by erosion, at a depth of about 2900 meters and deeper. In addition, in the western marginal part of the southern minimum, a well has uncovered loose deposits of the Zhidelisai suite with deposits of rock salt, which can explain its nature. However, it is possible that both minimums are conditioned by the combined influence of the factors.

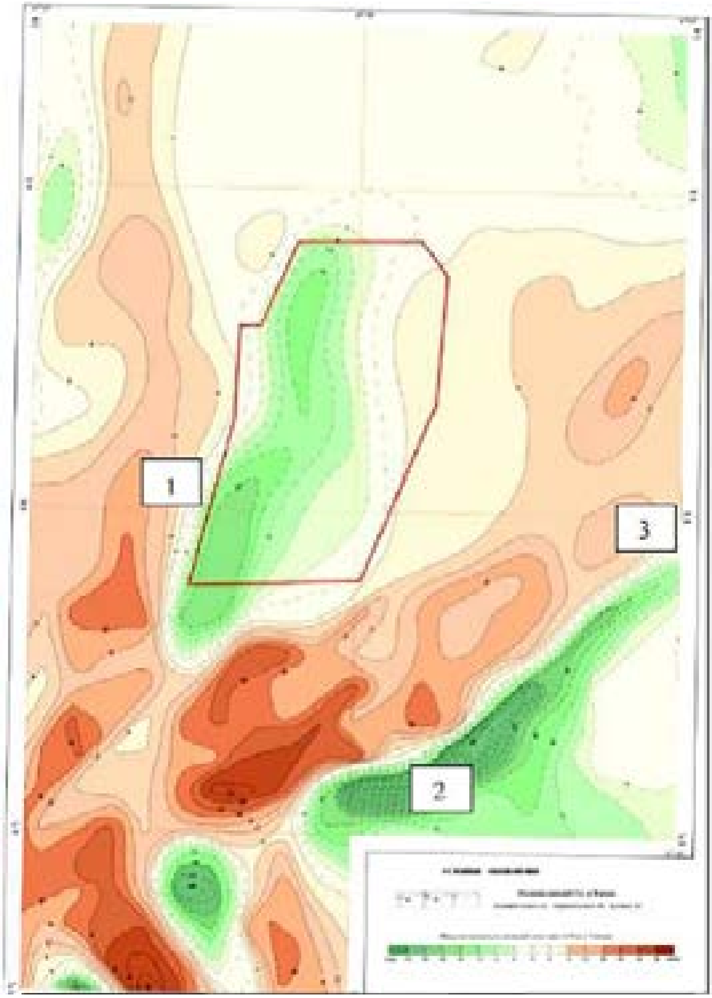

Figure 2. Transformations of the gravitational field. The isoline map Vzz:
1 - Ulytau-Arganaty SFZ; 2 - Sarysu-Teniz SFZ; 3 - Konsky SFZ.

In the south of the site, south of the South-Terekty fault, the northern end of a large negative gravitational anomaly, according to the interpretation, also fixes the granitoids of the Terekty intrusive complex, not exposed by erosion, at a depth of about 3000 meters, composing a large massif of Talap.

To the west of the Zhezkazgan syncline, within the Zhanai and It-Auz brachyanticlines, a submeridionally elongated zone of a positive gravitational field was traced. This zone is associated with the approach to daylight surface of anticlinal structures anticipated at the depth of dense amphibolite-shale rocks of the Lower Proterozoic.

A number of local positive gravitational anomalies were distinguished in the side parts of the Zhezkazgan syncline, the largest of which are the Spassky and South Sary-Oba maximums, within which respectively the Zhezkazgan deposit and the southern immersion of the Sary-Oba deposit are located. Their nature is presumably conditioned by an increase in density of ore horizons, mainly, epigenetically altered sedimentary host rocks.

The southern side of the Zhezkazgan syncline in the gravitational field has a clear band of positive gravi-maximums with a change in the strike from the sublatitudinal (Spassky maximum) to the northeast. A group of deposits and manifestations are confined to the gradient zones of this band: Spassky, Zhezkazgan, Ak-Chii, Dalny, Karashoshak, Sorkuduk, Zhartas, Pektas and Mezhdurechnoye. It should be noted that the nature of the most extensive and intensive Spassky gravi-maximum is presumably associated with the processes of intensive ore formation.

The Zhezkazgan copper deposit is structurally located on the western submerged lock part of the Kingir brachyanticline, at the junction of the Zhezkazgan-Terekty and the East Zhilandy deep faults. In this area, a fragment of the latter, according to regional works, is called East Ulytau.

The northern side of the Zhezkazgan syncline is accompanied by the Sary-Oba gravimaximum, to the gradient part of which confined are deposits of It-Auz and both Eastern and Western Sary-Oba. The entire northern group of deposits and manifestations, together with the above-mentioned Kipshakpai and Karashoshak, is confined to the junction of faults zones of the sublatitudinal strike (Kipshakpai throw) and a series of faults of the submeridional direction (Spassky, Eastern Zhilandy, Sary-Oba and a number of unnamed faults parallel to them), which are identified by gravimetric and, to a greater extent, seismic data.

In the studies of the geological structure of the Zhezkazgan ore region, utilised were maps of anomalous magnetic fields scaled 1: 100,000-1: 50,000, obtained by production companies upon high-precision aeromagnetic and ground surveys. Survey materials of different years were harmonised and interlinked. The measured magnetic field reflects various deep sources on the Earth's surface. Maps of the observed magnetic field provided the information about material composition of hidden Paleozoic structures and were utilized in specifying the outlining boundaries.

Most of existing methods of solving the inverse problem of magnetic exploration were developed for local anomalies. Therefore, in magnetometers, as in the analysis of the gravitational field, for practical purposes, the whole of geomagnetic field is divided into a normal field and an anomalous one. For this purpose, magnetic field transformations are calculated in order to emphasize certain features of a field and to weaken its side effects. As a rule, the anomalous part is associated with the nonhomogeneous magnetization of Upper Paleozoic structures, and the normal part is associated with the effects of currents flowing in the Lower Paleozoic complexes and the Proterozoic crystalline basement (Istekova S.A. 2006).

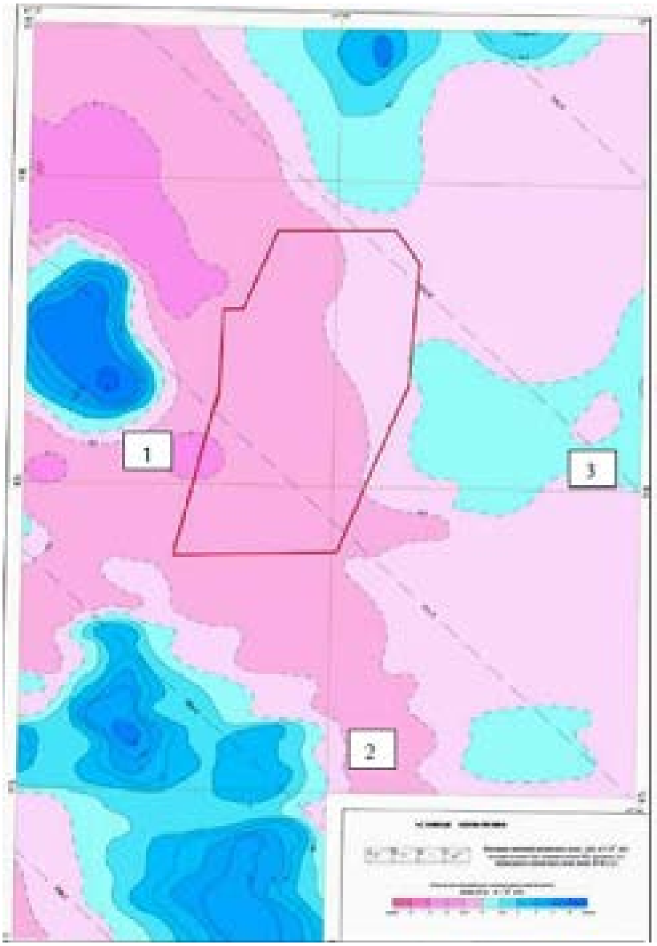

Figure 3. The isoline map of the anomalous magnetic field ΔTa
1 - Ulytau-Arganaty SFZ; 2 - Sarysu-Teniz SFZ; 3 - Konsky SFZ.

The magnetic field of the work area (figure 3) has a quiet character of intensity (ΔT)a, varying from 100 to 50nTl, reflecting, in general, a non-magnetic carbonate-terrigenous-sedimentary thickness starting from the Middle Ordovician to the Upper Devonian-Permian ($\chi_{sr.=.}$=4-23$\cdot 10^{-5}$units SI). Only a chain of positive magnetic anomalies (ΔT)a, which in the north outside the reporting area ends with an intense magnetic anomaly (ΔT)a associated with the manifestation of ultrabasites of the Esculy dome and accompanies the East

Ulytau fault, traced by fragments of Δg gradient zones of the northwest strike.

Small anomalies (ΔT)a (over 300nTl) outline fragments of melanged mafic-ultramafic tectonic covers at depth. This increase in the magnetic field is associated with the juncture of two systems of discontinuous disturbances of the submeridional and sublatitudinal directions. In addition, positive magnetic field anomalies (ΔT)a with a strength of over 50nTl are registered by deep, undiscovered, granodiorites of the Karamendy intrusive complex of the Early Devonian (χsr.= 636·10-5 SI units).

The 1975-1977 Zhezkazgan geological exploration team carried out the seismic exploration work by reflection method within the Zhezkazgan ore region (Kotlyarov A.M., Smirnova N.N., etc.). The works clarified the structure of individual parts of the Zhezkazgan syncline, primarily the previously identified Sary-Oba anticline and the Kokdombak uplift. The reference seismic horizons were traced, and depths of productive deposits in the eastern and central parts of the Zhezkazgan syncline were determined (figure 4).

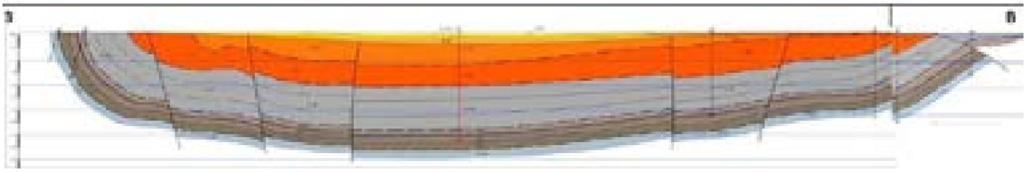

Figure 4. The geological and geophysical section along the III-III profile.

In 1980-84, experimental and methodological work was carried out on the site of the Northern Group of the Zhezkazgan type copper deposits, in order to evaluate the possibility of seismic exploration when searching directly for copper deposits by a number of anomalous signs (Smirnova N.N. et al., Zhezkazgan GEE). The authors analyzed the data, obtained by the past reflection method and the correlation refraction method works, in light of new velocity parameters for the Zhezkazgan syncline, and linked them with new data, obtained in the 1980-1981 MOGT survey.

In 1996-1997, the JSC “Zhezkazgan Geologiya” led by N.N. Smirnova conducted the MOGT seismic exploration by 24-fold profiling with exploratory drilling in the northeastern part of the Zhezkazgan Depression. The aim of the work was to identify the structures promising for cupreous sandstones, study the geological section of Upper Paleozoic deposits, trace tectonic disturbances and check the copper content of the identified structures. As a result, the team traced the reference reflecting horizons R_{III} (the sole of sediments C_1), R_{II} (the sole of sediments C_2 ts), R_{II} (the bottoms of the sole C_1v_2), the Terekty fault zone and other tectonic disturbances, and estimated the depth of the sole of the productive Taskuduk suite.

The research outcome. As a result of geological interpretation of the obtained geophysical materials, the geological structure of the Zhezkazgan ore district was clarified.

The gravitational and magnetic fields allowed us to study the heterogeneity of the deep geological structure (tectonics, intrusive magmatism). The qualitative analysis and results of the quantitative interpretation performed by both previous and present researchers allowed to identify the supposed contours of intrusions at depth: granitoids (according to gravity exploration), granodiorites and ultramafites (according to magnetic exploration), and to build a generalized structural and tectonic model of the district. According to the data of large-scale geophysical surveys, identified were the areas of development of presumably Zhidelisai deposits of considerable thickness (with lowered values of density σ_{sr} =2.60g/cm^3 and of resistances 15-20 Ohm·m), as well as the areas of development of rocks of presumably Zhezkazgan and Kingir suites of considerable thickness (local gravimaximums, σ_{sr}=2.66-2.67g/cm^3).

Tectonic disturbances were traced in space and at depth. Deep faults are usually accompanied by extended linearly elongated zones of high gradients of physical fields, regions of flank junction of anomalous zones of various strikes, clear-cut local anomalies of gravitational and magnetic fields - the local gravity minimums above the rock crush zones and the chains of positive anomalies (ΔT)a, resulted from small intrusions of hyperbasites into weakened zones. The lithological-stratigraphic model of the district does not manifest itself in gravitational and magnetic fields, since sedimentary complexes of various formations do not differentiate by physical properties.

The gravitational and magnetic fields of the Zhezkazgan syncline district, in general, are differentiated ones. Apart from the geological structures mapped on daylight surface, the deep structure of the district and their features influence on the gravitational and magnetic fields. Within the territory under consideration, the southern locking of the Zhezkazgan syncline is accompanied by a quiet negative magnetic field (ΔT)a, and is fixed by a local negative anomaly Δg, emphasizing the submeridional extension of the structure. The structure of the gravimetric field of the southern part of the Zhezkazgan SFZ is overwhelmingly influenced by the spread of a huge mass of Middle Paleozoic granitoids at depth, which cause the presence of local gravi-minimums.

In the southern part of the Zhezkazgan syncline, complicating folds of the second order, or the so-called structural "noses", are located at the pass to the western periclinal locking of the Kingir brachyanticline: the Pokrovskaya and Krestovskaya anticlines and separating them the Zlatoust syncline, to which the Spassky gravi-maximum of sub-isometric shape (10×17 km) is confined with intensity of up to 3 mGal, coinciding with the Zhezkazgan deposit. This gravi-maximum is conditioned by the denser composition of the underlying foundation as well as the higher density of epigenetically altered rocks of the host ore horizons (Strutynsky, 1988).

The Zhilandy syncline branches off from the northwestern end of the Zhezkazgan syncline and stretches in a meridional direction for almost 20 km. This narrow (3 to 5-6 km) continuous fold has the features of a typical linear fold with a rather complex internal structure. It splits into a number of synclinal pits, the southernmost of which is composed of deposits of the Taskuduk, Zhezkazgan and Zhidelisai suites. The undulating hinge of the syncline plunges in the direction of the Zhezkazgan syncline. The generalized lithological and stratigraphic horizons were identified as a result of the geological interpretation of the reflection method seismic data. According to the seismic data, fault zones are confidently identified by the shift of amplitudes of varying significance and the change in nature of the wave field (Martyshko P.S. et.al, 2016). The internal structure of the Zhezkazgan syncline is complicated by fault zones with different displacement amplitudes, and the sole depths isolines of the Famennian layer sediments emphasize the mosaic structure and the submeridional strike of the structure (figure 5).

Discussion. The deep structure of the Zhezkazgan syncline on sides of the Sary-Oba rise differs sharply, fixing the simple structure of the eastern part and the complex folded one of the western part. The deposits of the Zhezkazgan (C_{2-3}dž) and overlying Zhidelisai (P_1žd) and Kingir (P_{1-2}kn) suites represent a conforming continuous section (in places, there are local disconformities over faults with repeated tectonic displacements), lying on sediments of the Taskuduk suite. Their accumulation coincides with the Middle Carboniferous tectonic activity, which led to formation of the Sarysu-Teniz uplift and division of the Zhezkazgan-Teniz coal basin into three independent depressions, Zhezkazgan, Shubarkul and Teniz (Boris S. 2010).

Application of modern means of registration, processing and interpretation of geological and geophysical data led to increased effectiveness of ore geophysics in studies of tectonic structure of ore areas, localization and morphology of differentiated intrusive massifs at depth, detection and deep mapping of ore-controlling faults, isolation of ore-controlling structures in sedimentary and effusive-sedimentary folded complexes, and determination of the spatial position of ore-bearing zones.

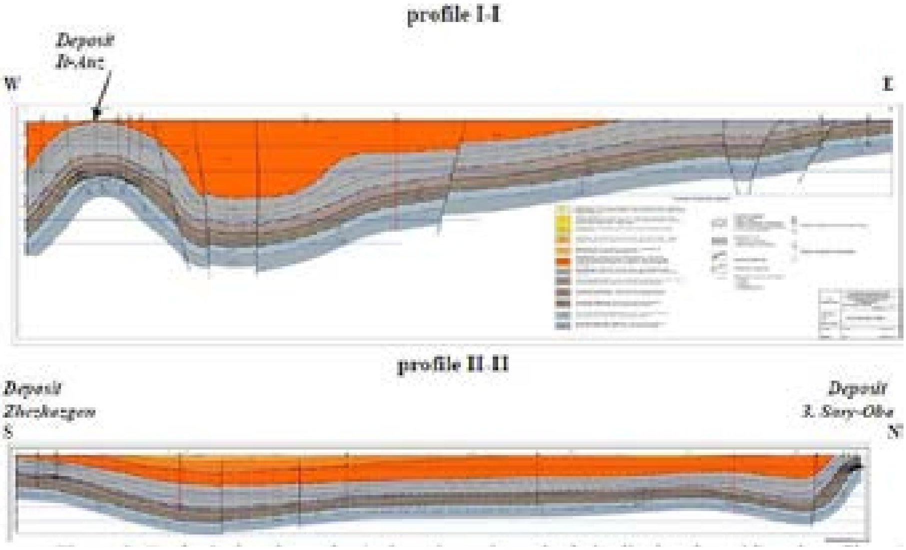

Figure 5. Geological and geophysical sections along the latitudinal and meridional profiles of the Zhezkazgan ore field.

Conclusion. Taking into account the rather complex geological structure of the given ore district and the significant differentiation of the composing rocks, ores and near-ore hosting strata, further identification of additional criteria for localization of copper mineralization is possible with the integration of detailed geological and geophysical methods, geochemical and physical-chemical studies of rocks and ores.

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