Ore-magmatic concentres in Uzbekistan

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Abstract. This paper presents a study of ore-magmatic concentres in Uzbekistan. New data of integrated geological and geophysical investigations of Central-Kyzylkum, Nurata, Chatkal-Kurama, Baisun, Sultanuvais ore-magmatic concentres are presented.

1 Introduction

Currently, metallogenists believe, that at least four factors determine the concentration of ore minerals in a specific place in the Earth's crust. These are structural, lithologic, stratigraphic and magmatic factors.

Meanwhile among geologists increased the interest for metallogeny and factors stipulated large and superlarge (giant) mineral deposits formation. This interest was manifested especially distinct in the Program of the XXX-th session of the International Geological Congress (China, Beijing, 1996). But before this on the initiative of the IAGOD (International Association on Genesis of Ore Deposits) leaders: professor Pei Rongfu (Institute of Mineral Deposits of Geological Sciences, Beijing, China) and professor Jan Kutina (American University, Washington, USA) in 1994 worked out the International Program (Project) titled "Interrelations between Deep Lithospheric Structure and Metals Concentrations". It was approved by UNESCO department under the number IGCP- 354 and from 1998 was renamed as "The Role of the Deep Lithospheric Structures in the Genesis of Large and Superlarge Ore Deposits". In Uzbekistan this work had began in 1997 in frame of the theme "Study of the Earth Crust Upper Stage of the Ore Districts (on examples Almalyk-Angren (Chatkal-Kurama) and Central Kyzylkum regions) using geophysical methods". The investigations have been financed by the State Committee on Science and Technique of Uzbekistan. As a result of study by the IGCP-354 the authors came to the following conclusions [1]:

- The upper part of the Earth crust within this region on the depth from surface up to 500-1000m is composed of the Mesozoic-Cenozoic sedimentary cover, from 0 up to 10-15 km – of the Paleozoic and Upper Proterozoic metamorphosed sedimentary and volcanic series and intrusive bodies of granitoid and to the less degree, ultramafite-mafite composition.
- Paleozoic – Late Proterozoic stage (basement) in vertical and lateral sections is heterogeneous, that is stipulated with tectonic displacements and facies-formation changes of sedimentary-metamorphic as well as magmatic rocks. Especially heterogeneity as well as plastic deformations are conditioned by region in field of

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virgations of regional Kyzylkum-North-Nuratau deep-seated fault, separated the Middle Tien Shan from the southern province. At present this region as well as Chatkal-Kurama one is related to contemporaneous uplift which raise at a speed of 2-8 mm/year with producing of certain tectonic energy.

- The next characteristic peculiarity of region is multiple manifestation of magmatism from the Precambrian up to the Late Paleozoic – the Permian. Moreover form the Middle Carboniferous up to the Permian magmatic processes took place continuously during 45 million years (e.g. without sedimentation) and resulted in forming mafite bodies and large granitoid plutons with their dikes and postmagmatic ore manifestations.
- Observed peculiarities of geophysical field and geophysical parameters of separate sections (blocks) have been stipulated with the geological setting features of this stage of the earth crust. Thus, the most part of region is characterized with weak-anomalous positive gravity and magnetic fields and local negative gravity and positive magnetic anomalies as well as local areas of high electroconductivity. The intense positive magnetic anomalies trace in line within zone of Kyzylkum-Northern Nurata fault and arise from mafite and ultramafite bodies of ophiolite formation.
- Concentration of majority of magmatism manifestations and ore deposits within limited area between the Middle and the Southern Tien Shan permits to consider this province as a single ore-magmatic concentre. Such limited sections of the earth crust , where diverse deposits of different age are localized and spatial conjugated with products of multiple and different magmatism, have been named ore-magmatic concentres (OMC) – in other words, there are sections of the earth crust where polychromous and polygenic magmatic and ore-forming processes are conjugated closely with forming of complicated ore-magmatic systems. Within Uzbekistan territory five OMC are distinguished with certainty – (I) Central-Kyzylkum, (II) Nurata, Chatkal-Kurama (III), (IY) – Baisun; (Y) – Sultanuvais (Figure 1).

In the last years, an integrated study of the lithosphere of Uzbekistan within the frames of the fundamental and applied scientific grants were continued. New data were obtained in the laboratory “Structure of Lithosphere” about the deep structure of isolated ore-magmatic concentres.

2 Materials and methods

The methodology of establishment of integrated dynamic interactive models on ore-magmatic concentres consists of two consecutive stages including: 1) the methodology of integrated geological-geophysical processing and interpretation of potential fields and seismic profiles cross-cutting ore-magmatic concentres; 2) the methodology of creation of a united interactive 3-D model in ArcGIS in combination with materials of remote sensing. Each of these stages is divided into more detailed sub-stages. During the study of the deep structure of ore-magmatic concentres, the first step is the integrated methodology of the processing and interpretation of potential fields. It is mainly orientated at the identification of positions of geometric borders of the division of mediums determined by the data of seismic exploration of preferably deep seismic sounding. Our experiences shows [2] that the use of these potential fields for the area zoning of the territory, identification of the depth of manifestation of isolated blocks and their density may significantly affect the interpretation of seismic exploration data. Therefore, the implementation of the method-based interpretation of data of gravitational and magnetic fields preceding, the stage of the construction of the integrated model enables a more complete use of opportunities of these methods.

Anomalous objects are isolated in the Earth crust on the basis of the interpretation of potential fields using the methods of the solution of direct and inverse tasks. An integrated interpretation of potential fields enablers the maximal use of information available in this field for the analysis of the deep structure. The processing of data, at the first stage, is an important integrated part of the whole process of development of the 3-D model of the ore-magmatic concentre within the frames of the GIS project.

The following blocks interact at the second stage: the management system of the basis of geological-geophysical vector data of the concentre, which include: 1) electronic maps of different scales; 2) data on the materials of the remote sensing; 3) integrated analysis of data and solution of prognosis-diagnostic problems. In the main block of GIS-project, the software of the packet ArcView (version 10.1), which is a component of ArcGIS, is a point of entering to Desktop ArcGIS, providing a high-quality visualization, requests, analysis, integration and basic functions of the entering of digital data. The ArcGIS represents a scaled system of programs for development of interactive management, analysis of geodata basis at any level. The geodata basis is and management system (DBMS) is based on two main concepts: 1) it is a physical storage of geographic information; 2) geodata basis includes processes of interactive modeling of data – management, settings, editing and interactions of spatial objects.

Fig. 1. The Landsat space image of Uzbekistan (yellow contour) with location of Ore-Magmatic Concentres: I – Central Kyzylkum; II- Nurata; III – Chatkal-Kurama; IV – Baisun; V- Sultanuvais.

3 Results and Discussion

3.1 Central- Kyzylkum Ore-Magmatic Concentre (CKOMC)

The Central Kyzylkum OMC covers an area of 100*125 km. It is located on the both sides of the Northern Nuratau-Kyzylkum deep-seated fault within the spot of its virgation and intersection by submeridional and the north-eastern faults. 10 endogenous commercial gold, gold-silver, gold-rare-metals deposits are concentrated here. This concentre includes Muruntau, Balpantau (Djeroy-Tamdybulak), Amantaitau-Daughyztau and Kokpatas ore magmatic systems. Figure 2 illustrates the 3-D relief contour of the concentre with three DSS (Deep Seismic Sounding) profiles [2]: Muruntau, Kokpatas, Tamdy, which are traced up to Mohorovičič boundary (the earth crust thickness is 40-42 km). This OMC is provided 80% of gold output in the state. Here there are some giant gold deposits - Muruntau,

Amantaitau, Daughyz and others not great deposits of gold, tungsten, chrysotile-asbestos, pyrite and chromite ores.

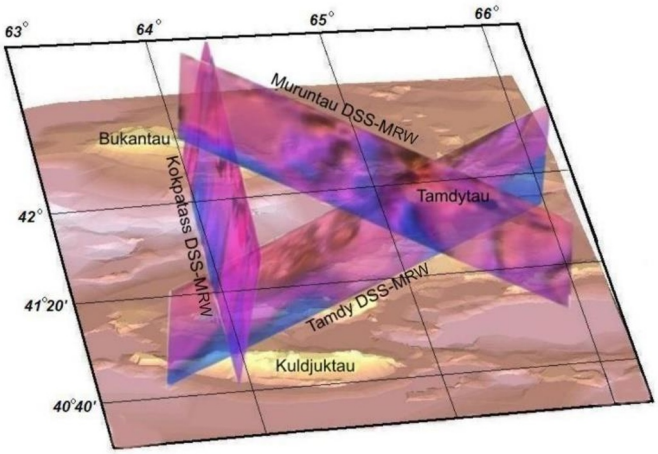

Fig. 2. Perspective view of the location of deep seismic profiles, crossing Central Kyzylkum Ore-Magmatic Concentre (CKOMC).

Muruntau ore field, with the area of 60 sq. km, is situated in the south-eastern slope of the mountains Tamdytau. The slope in the North is fringed by the ridge of carbonate rocks; in the South it turns into a gently sloping-hilly plain land made up of metaterrigenous formations. The western border of the ore fields lies along the north-eastern Kumishsai fault, which divides the blocks of rocks with mainly gold or silver mineralization. The northern and eastern border is the foot of screening carbonate thickness, complicated by a slightly sloping overthrust. The southern border is suggested to pass along the Sardarya sub-latitudinal fault established under the cover of loose Mesozoic-Cenozoic deposits. The major ore-gold objects of the ore field are within the strip of the north-western direction stretching for about 15 km. Deposit Besapantau is situated in its NW side, while Myutenbai and Triada in its SE side. A number of small gold-ore sites are situated separately in the northern (Boylik), eastern (Vostochny, Solnechny) and western (Tashkumir, Vostochny Besapan) sides of the ore field. All these deposits and ore manifestations belong to the gold-quartz geological-industrial type coupled with the rocks of three structural-substance complexes Jurgantau (PR), Taskazgan (R-O) and Kosmanchi ($€_3$ –O_{1-2}), which were formed in different parts of paleo-oceanic area and joined in one ore field as a result of subduction and overthrust-nappe processes of the Caledonian period of the regional development.

As we were developing the 3-D model of the geological structure of the concentre, we joined all available geophysical (seismic, gravimagnetic and geothermal) data with revealed peculiarities of the geological structure. As a result, the picture of the deep structure of the edge parts of continental lithosphere of two paleo-continents, that had collided, was obtained. A mélange, which consists of different-sized blocks of shale, flint, granitoids and dioritoids emerged as a result of the collision in the upper crust. The latter, as a rule, grew in volume and form an isolated layer of a significant thickness (up to 20 km), which consists of dioritoids and their metamorphic equivalents. The presence of this layer is accompanied by the lowering of the thickness of the lower crust and "intermediate" layer up to complete disappearance of the latter. Such a "typical" cross-section of the crust is

complicated by the presence of cup-shaped and cone-shaped structures, fringed by deep faults and consisting of an increased thickness of the mélange and diorite layer, reduced to the minimum of the thickness of the lower crust and partial absence of the "intermediate" layer.

Jointing of rocks, a heavy block structure and significant depth in the density of characteristics of joining blocks enables an intensive permeability of the upper crust at the formation of exocontact deposits in sedimentary-metamorphic layer. The presence of magmatic focuses of mainly acid and mid composition, their lighter link with the mantle through the zones of seismic "transparency" lead these structures to the rank of prognosis to the endogenic types of deposits, which is practically observed in the form of Muruntau mega-stockwork closer to the surface. This mega-stockwork represents a complicated combination of quartz veins, ore poles, streak-impregnated and impregnated mineralized zones. The total area of the stockwork on the surface reaches ca. 3 sq. km, and it traced in the form of a cone to the depth of 1200 m. The well SG-10 exposed some intervals of the gold mineralization (2-15 g/ton) to the depth of almost 4 km. Deeper is the cup-shaped depression as deep as 10-15 km, which is filled with mélange, i.e., the mixture of different-sized angled blocks and "fragments" of shale, granite and diorites. The latter in the form of roots descend to the lower crust and interrupted Mohorovičič discontinuity, coupling into the zones of the seismic transparency, which are, in essence, uncoupled canals of the supply of the mantle substance and energy into the upper crust (Figure 3).

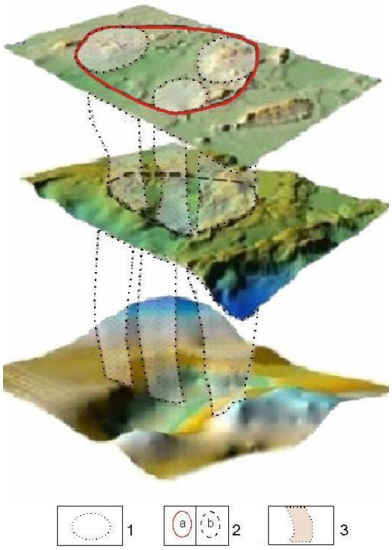

Fig. 3. The zones of seismic "transparency" in CKOMC. The legend:1- contours of ring structures in 3D surface of relief; 2-(a) the contour of the CKOMC on the surface, indicated by the academician Khamrabaev I.Kh. (1999) b) the projection of the concentre's contour on 3D surface of the fundament 3 – zones of seismic "transparency" from 3D Mohorovičić's surface.

3.2 Nurata Ore-Magmatic Concentre (NOMC)

The Nurata Ore-Magmatic Concentre is situated to the east of Central-Kyzylkum ore-magmatic concentre in the range of Transasian lineament [3], where it is represented by a gold deposit Charmitan in the center and gold deposits Sarmich and Mardjanbulak, surrounding it in the south (Figure 4).

The northern border of the concentre is connected with quartz-gold veins and linear quartz stockworks developed in the southern parts of North Nurata ridge. Quartz-microcline-albite-sericite- chlorite metasomatises, in which manifestation of gold, silver, copper and iron are noted, are widely developed there.

The concentre is crossed by two regional profiles of the deep seismic sounding (DSS) in the west – Romitan-Darbazatau and Karabekaul-Koitash in the east. The profile Karabekaul-Koitash carried out in 1959 and, first interpreted under the supervision of I.S. and B.S.Volvovsky, showed the borders of the division at the depth of 500 m, which corresponds the surface of the Paleozoic fundament, the thickness of the granite and basalt layers reached 15-17 и 10-20 km, respectively.

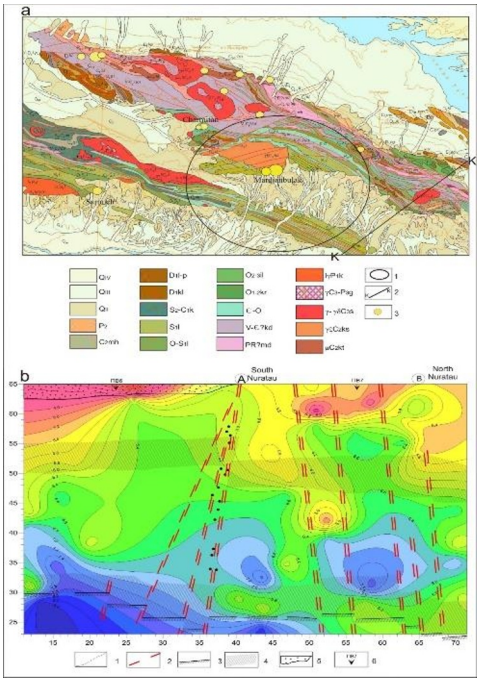

Fig. 4. The contour of Nurata Ore-Magmatic Concentre (NOMC) with NE part of DSS profile Karabekaul-Koitash. The legend: a) geological map with main deposits; 1- the contour of NOMC; 2- the line of profile DSS Karabekaul-Koitash; 3- the main ore deposits b) velocity section of NE part of DSS profile Karabekaul-Koitash 1- isolines of equal velocities, km/s; 2- the faults; 3- the Moho boundary; 4- the zones of low velocity – “wave guides”; 5- Mz-Kz sediments; 6- the source point.

In future, the profile was re-interpretated by B.B.Tal-Virsky (1971) and relieves of the surfaces of three upper borders in principle correspond to data cited by Yu.N.Godin et al. (1960). Based on the previous interpretations of the above-mentioned authors, velocity cross-sections were vectorized and high-low velocity areas on the part of the profile Karambekaul-Koytash, passing through the Nuratau mountains, were elucidated.

An integrated model of the Nurata region includes: 1) the 3-D surface of the relief create on the basis of Landsat and SRTM images; 2) the 3-D surface of the fundament; 3) the 3-D Mohorovičić's surface.

The most typical features of the geological-structural structure are as follows: a wide development of sub-parallel rupture violations, which, at inspissation, produce thick zones of crushing with an increased carbonaceous content, the presence of tectonic plates and blocks stretching in parallel to rupture zones, absence of normal stratigraphic interrelations between layered thicknesses. Of importance are the so-called "node zones", i.e. intersection

of differently directed rupture structures, from which the most important are north-western faults – ore supplying and ore-localizing, which are crossed by the faults of NE direction. Intrusive formations are represented by small stocks of dioritoids and dykes of subalkaline and alkaline lamprophyres.

The deposit Charmitan is located in southern slopes of the central part of north Nurata ridge, where it is confined to the exo- and endo-contact part of Koshrabad polyphase massif (C_2m) in the southern wing of north-Nurata anticlinorium.

Ore-inclosing rocks in the deposit are volcanogenic-terrigenous formations in the Jazbulak suite (S_1) and granosyenite of Koshrabad intrusive. The Jazbulak suite is made up of clayey shale, siltstone, sandstone with lenses of limestone, tuff sandstone, tuff siltstone and interlayer silliform bodies of diabases and gabbrodiabases. The rocks of the suite are crushed in isoclinal folds in WNW stretching; they were subject to the green shale regional metamorphism and thermal effect of the penetrating Koshrabadsky intrusive, which has the absolute age of 306 + 4 million years according to the Rb-Sr isochrone. The ultimate role in the formation of the deposit structure is played by Karaulkhona-Charmitan zone of faults – ore-controlling structure, while the cleavage of the WNW orientation is ore-inclosing. Ruptures in the form of a "horse-tail" are widespread; they separate the area of the deposit into separate blocks, owing to the faults of NE stretching. They, as well as submeridional faults, are post-ore ones. Commercial ore bodies by their morphology are divided into three types: significantly prevailing veins, linear stockworks and plate-like mineralized deposits.

Changes in ore-enclosing rocks near ores are represented by feldspar-quartz metasomatises, in the exterior zones of which beresitization with sites of argillizite changes is developed, which follow veins with increased content of polysulphide mineralization (sphalerite, galenite). The process of ore formation in the deposit begins with the pre-ore stage, into which the quartz-albite-chlorite paragenetic mineral association was deposited. The ore stage is characterized with scheelite-gold-quartz, pyrite-arsenopyrite, polysulphide and antimonite mineral associations. Non-ore minerals, namely, quartz, feldspar, chlorite, carbonates prevail in the scheelite-gold-quartz mineral association. Of ores, there is wolframite, scheelite, maldonite, khedleite and native gold. Pyrite-arsenopyrite mineral association is made up of non-ore minerals: quartz, carbonates, sericite; ore – pyrite, arsenopyrite, pyrrhotite, chalcopyrite, sphalerite. The polysulphide mineral association is fixed mainly in upper parts of ore bodies of the bonanza type, where it is represented by non-ore minerals, namely, quartz, sericite, carbonatites, fluorites; ore – sphalerite, galenite, gray copper ore, pyrite, arsenopyrite, bismuthine, gold and silver tellurides, sulphobismuthines, native gold and bismuth. Quartz, calcite, antimonite and pyrite were recorded in the antimonite mineral association. As a rule, it is found in peripheral parts of the deposit beyond the contours of ore bodies. The process of ore genesis is finished by the post-ore stage, into which quartz-calcite-chlorite mineral association with pyrite was formed.

Thus, within the Charmitan ore field the main geological factors determining localization of mineralization are tectonic, magmatic and lithologic ones.

Tectonic factors affecting the location of mineralization include: the zone of Karaulkhona-Charmitan sub-altitudinal long-term fault (southern part of Transasian lineament), manifested as a series of sub-parallel faults and accompanied by an intensive schist formation, carbonization, brecciation and mylonitization of inclosing rocks and being the major magma efferent and ore-controlling canal in the ore field; fragment faults in WNW stretching with a steep northern fall, which are the major ore-inclosing structures in the deposit.

The magmatic factor is determined by the ore gold geochemical specialization of Koshrabad intrusive gabbro (essexite)-syenite-granosyenite complex, which was confirmed (Khamrabaev I.Kh., 1958, 1969; Kushmuratov, 1971; Yudalevich, Sandomirsky, 1873;

Tillaev, 1974; Dautov, 1974) by the presence of accessory minerals of native gold, as well as enrichment of the rocks of this complex and in particular, aplite-granite dykes, by gold, silver, tin, tungsten, lead, lithium, fluorine, etc. The absolute age of the intrusive and related gold mineralization does not contradict radiological data (potassium-argon method; amphiboles, biotite) and is determined as 229 to 444 million years.

Thermometric data (Proskuryakov et al., 1979; Bertman, 1990) suggest an average temperature regime of ore formation in Charmitan's ore field. The interval of sedimentation of the productive scheelite-gold-quartz paragenetic association reached 360-280ºC (according to decrepitation data), by determining the temperature range of the border of temperature-controlled hydrothermal system.

The deposit Marjanbulak is situated on the height bearing the same name – the eastern continuation of South Nuratau mountains. Geological-structural position of Marjanbulak ore field is determined by its confinement to the zone Karakchatau-Marjanbulak deep fault expressed within the borders of the ore field of northern and southern stem branches. The entire ore field within the 2.5 km in the west to 6.5-7 km in the east is represented by a fan-like lens-strip giant tectonic zone – the mosaic of lens-like blocks divided by the strips of abundant carbonaceous tectonites of varying thicknesses. The deposit Marjanbulak is confined to the southern stem virgation of the deep fault in the flank of Marjanbulak syncline fold, expressed in the series of sub-latitudinal steeply falling zones of faults with a complex branching. They are accompanied by an intensive crushing, silicification of inclosing rocks and dykes of different compositions in Malguzar's complex. The terrigenous-shale thickness of nonsegmented Vendian-Lower Cambrian age (Marjanbulak suite) made up of siltstone, sandstone of different composition, gravelites, more rarely with interlayers and lenses of conglomerates. This thickness was crushed into the linear folds with axial planes oriented by the azimuth 270-300º and, as a rule tilted to the south. The visible thickness of the suite reaches 800 m.

Intrusive formations in the forms of dykes and dyke-shaped bodies in the north-western stretching are represented by diabases and alkaline basaltoids of Malguzar diabase-diorite-granitoid complex. They are mainly developed within the zone of South stem virgation of Karakchatau-Marjanbulak deep fault. This zone is the main ore-controlling structure of the deposit and ore field. The zone is expressed in the series of sub-latitude steeply falling ore-distributing faults with a complex branching and is made up of carbonaceous mylonites and cataclasites, less frequently of breccia and dense microshale. Changes near ores include beresitization and argillization. The process of ore formation in the deposits passed in three stages: pre-ore with quartz-chlorite with biotite, tourmaline, scheelite, pyrrhotite, pyrite and gold mineral association; gold-silver ore, in which pyrite-arsenopyrite and later gold-polysulfide mineral associations were formed. In pyrite-arsenopyrite associations, of non-ore minerals there are quartz, chlorite, carbonates, sericite; of ore minerals, there is pyrite, arsenopyrite, seldom marcasite, pyrrhotite, chalcopyrite, sphalerite and native gold. In gold-polysulphide mineral association two microparagenesises are noted: 1) gold-gray copper ore-galenite-sphalerite and 2) silver-sulphoantimonite-galenite.

The post-ore stage is represented by the quartz-calcite mineral association, in which of ore minerals only pyrite is noted. Based on the geological and mineral-geochemical data the deposit Marjanbulak is referred to as silver-gold-sulphosaltmineral type. The vertical range of mineralization is more than 500; the ore bodies in drilled depths are traced as deep as 300-500 m and are no more delineated; its upper horizons are eroded. Main geological factors determining the location of mineralization are the structural, magmatic and lithologic.

3.3 Chatkal-Kurama (Almalyk-Angren) Ore-Magmatic Concentre (AAOMC)

Chatkal-Kurama or Almalyk-Angren Ore-Magmatic Concentre (AAOMC) is the third described concentre connected with Transasian lineament, in the form of south-eastern branches to the block with consolidated, in the process of caledonides, continental crust in opposition to two previously described concentres developing on the crust of the subcontinental type.

AAOMC occupies area measuring 50*90 km (Figure 5).

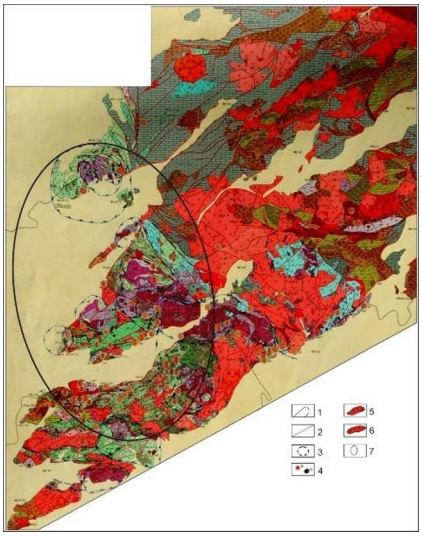

Fig. 5. The contour of Chatkal-Kurama Ore-Magmatic Concentre (the geological legend on the figure 4): the outcrops of Pz rocks; 2- faults; 3- the main ring structure; 4-(a) ore deposits; 4-(b) the necks of volcano of different ages; 5-granodiorite-porphyres; 6- diorites; 7- the contour of ore-magmatic concentre.

About 20% of this area is covered and about 60% is composed of magmatites. This OMC is located within the Middle Tien-Shan, in the south-eastern margin of the Kurama-Fergana median massif. There are 18 commercial deposits of porphyry-copper with molybdenum, gold-silver, base metal, lithium, fluorite other ores are concentrated here. Among them giant Cu-Mo deposit of the Almalyk group, as well as unique Li-deposit Shavaz are known (Voronich, 2008). This concentre produces 100% of cooper, molybdenum, fluorite, bismuth, 70% of lead, zinc, 10-12% of gold producing in Uzbekistan. In this region deep lithospheric structures is characterized with moderate thickness of the crust (38-40km), availability of mutually intersected sublatitudinal and submeridional deep faults dissected Mohorovičič discontinuity and the upper mantle.

According to Chernovsky (1991), structure of the Earth crust within the Almalyk-Angren OMC is concentric zonal: in the ctntral part granulitic basic layer (the lower crust) forms large swells. Their thickness is 20-22 km, but in flange parts it decreases up to 8-14km. The thickness of gneissose-granitic layer is 6-8 km in the centre,in the periphery it is 10-13 km. Those anomalous concentric zonal structure coincides with arched uplift contour, which was marked out by Tomson et al. [4-5] within the Kurama subzone, and with area of the middle-and upper Carboniferous volcanism development. According Islamov data (1997), volcanism products and geochemical types of gold-silver mineralization have been zpnal distributed within the arched uplift. In particular, zonality in distribution of mineralization within this concentre is notable for rough concentric character. Most of them are the parts of above named concentre and within some areas have

been characterized with zonality, which is correctly associated with concentric structures of volcanic systems, connected with the certain ore formations. Finally, the results of generalization of magnetic survey data, which are outlined concentre area as a single whole weak-positive magnetic field, are indicated of this concentre real being. The Central Kurama, the Western Chatkal, the Eastern Kurama fields of hightened magnetic density of the ore formations have been distinguished by computer analysis of ore manifestations distribution, which was carried out by Usmanov et al.(1998). Among them the Central Kurama and the western fields with barren interstitial of Angren river valley are coinsided with the Almalyk-Angren concentre contour. However, under this "barren" interstitial, which is composed of Jurassic, Palaeogene and Quaternary series, may be localized concealed ore manifestations.

The major factors in the formation of the concentre are the tectonic and magmatic ones. The geological-structural specifics of the central part of the concentre is determined by the development of two systems of faults of the north-western striking, with which the location of small intrusives of granodiorite-porphyries and fields of ore-bearing metasomatites [6]. The second system is represented by sub-latitudinal faults – Karabulak, Kalmakyr and Burgundin. These are old faults, which controlled the location of ore mineralization in the deposits Bolshoi Kalkamyr, and then were renovated up to the alpine orogenesis. The whole complex of those rupture structures formation were resulted in dividing up of rigid crustal block of Kurama-Ferghana median massif into a series of blocks in various erosion levels. Deep-seated faults and especially knots of their intersection were the active channels for flow of magmatic melts and ore-bearing fluids and were determined position of ore-bearing clusters (ore-magmatic systems) within OMC.

Almalyk ore field, which includes the deposits of copper-porphyry (Kalmakyr; Karabulak; Dalnee and North-Western Balykty), lead-zink (Kyurgashinkan) and gold ores (Akturpak, Sartabutkan), is situated in the northern block of Almalyk district.

Fragments of the anticline fold of north-western course, which enclosed the porphyry stocks of Almalyk gabbro-monzonite-syenite complex with the radiological age of 327+3 million years (uranium-lead method by zircon) have been preserved there. In general, the geological structure of the ore field is characterized by the abundance of magmatic rocks, diversity of their composition and age. Intrusive rocks occupy ca. 60% of its area; volcanogenic, ca. 35%, stratified terrigenous and carbonate deposits, less than 5%.

The forms of magmatic areals vary from linear and lens-shaped to elliptic, isometric or crescentic form, which are reflected the role of magmatites in forming of conctntric arch and caldera structures, occurred in intersection knots of deep faults. Generally, the role of concentric structures within these areals is very considerably and especially it is clearly in little eroded massifa, where intrusive bodies and elements of ring structures, pipes of eruptive magmatic breccia, concentric and radial dyke swarms are spatial conjugated. Series approached and intruded each other stock-shaped bodies, which form local magmatic structures of central type reminiscent of root parts of volcano, are to be marked out. As an example, the porphyry intrusives are of special ore-generating importance and the effect on the distribution of mineralization in the form of ring and ellipsoid structures around the contact of stocks and dykes of monzonite-porphyries with syenite-diorites.

The nucleus part of the considered concentre is expanded due to the Saujbulak ore field situated to the south-east from the Almalyk one, including deposits Sarycjeku, Kyzata and Sargalam. It main rupture structure is the Miskansky fault, which is traced for more than 40 km. The adjoining Sargalamsky fault forms a tectonic wedge with the deposit Sarycheku. A large number of feathering cracks, which promoted the formation of favorable conditions for ore deposition, is concentrated in a relatively narrow strip between these faults. For the deposits of Saukbulaksky type, sharply complanate ore stockworks confined to the eastern wing of the slightly sloping brachianticlinal fold made up of rhyolite broken by the stock of

porphyry rocks. Such a structural position envisaged the concentration of the copper-molybdenum mineralization only in the borders of the rhyolite horizon (D_1^2), underlain by andesites (D_1^1) and overlaid by a gently sloping dyke of Gushsai granodiorite-porphyries ($C_3 – P_1$).

The following types of primary ores are distinguished: scattered-impregnated, streak-disseminated and vein. The latter type of ores, in comparison with the former two, is of a later period (quartz-carbonate veins, quartz-barite veins with chalcopyrite and barite-hematite veins). Scattered-impregnated ores and streak-disseminated are distributed in K-feldspathized, silicificated and seritizied rhyolites and "pink" (owing to K-feldspathization) monzonite-porphyries. The main minerals of changed rocks near ores are chlorite, sericite, K-feldspath, quartz, ore minerals – molybdenite, pyrite. Of vein minerals, besides quartz, there is calcite, ankerite, barite, zeolite and frequently occurring anhydrite.

The main valuable components are the following: copper, molybdenum, gold, silver; incidental – selenium, tellurium, rhenium. The ores in Sarycheku are richer than those in Kalmakyr by the content of copper, but poorer by the content of gold.

The center of Almalyk-Angren concentre expands in the east with the Kochbulak ore field, which is situated in the borders of the caldera with the same name in the peripheral north-western part of the Lashkerek volcano-tectonic mould confined to the region of its coupling with sub-latitudinal Almalyk volcano-tectonic graben [5]. The caldera is situated in the zone of influence of Dukent-Gushsai lineament identifiable with the meridional deep fault, with which the deposits of gold Revashte, Kyzylalmasai, Kochbulak, Kairagach, as well as ore manifestations Changuzar, Uchkyz, Charbi, Madak and others, are correlated.

The Kochbulak caldera is oval reaching the size of 8.5-6.5 km. In north-west it is blocked by Mesosoic and Cenozoic deposits, while from the south, east and west it is limited by the semi-ring fault, the position of which is determined by the presence of subvolcanic and extrusive bodies, as well as the dykes of diabase porphyries. The location of the caldera took place in the Moscovian age of the mid-Carboniferous. Volcanogenic formations forming it show a centroclinal fall, while the bottom is broken by faults with the amplitude of relative movements for dozens and hundreds of meters. The process of formation of Kochbulak ores had many stages. Quartz-sericite-pyrite mineral association forming zones of metasomatically changed rocks: quartz-sericite-calcite-ankerite-chlorite-albite was formed in the first pre-ore state. Five paragenetic mineral associations were formed in the second silver-gold stage: 1 – gold-pyrite- quartz (week gold-bearing); 2 – gold-sulphide-telluride (gold producing); 3 – sphalerite-galenite (late gold and silver producing); 4 – barite-galenite; 5 – calcite- antimonite. Barite-galenite association forms veins, which cross ore bodies and are separated from the formation of ore-gold bodies by embedding diabase dykes. The earliest are the synvolcanic propylites and secondary quartzites related with the bolgansky volcanic complex.

Deposit Kyzylalmasai. Kyzylalmasai ore field is confined to the eastern flank of Shavaz-Dukent volcanic-tectonic graben restricted in the north by a series of faults of north-eastern stretching and Goshsaisky fault in the south. In the east, this structure is broken by the caldera made up of Permian rhyolites.

Within the ore field, volcanites of bolgachinxky, akchinsky and karabausky complexes lying on Caledonian and Hercynian granitoids were developing.

The maximal concentration of the gold mineralization is characteristic for the central part of Kyzylalmasai mineralized zone. There, the Caledonian granites were ruptured by dykes of sienito-diorites and petrosilex spatially close to ore bodies and accordingly characterize the high anomalous magnetic field (Figure 6). Both pre-ore and post-ore explosive breccia are developed there.

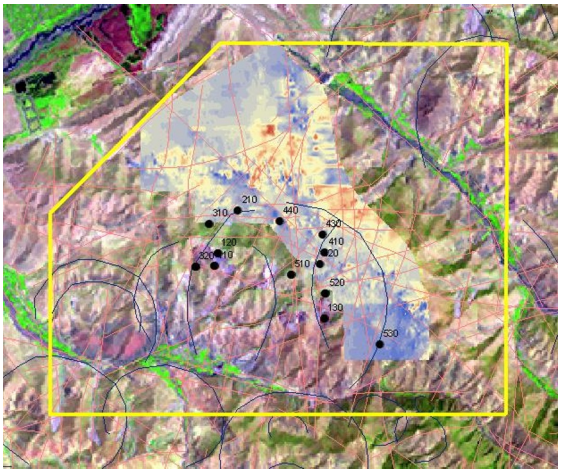

Fig. 6. The example of integrated interpretation - Kyzylalmasai deposit with some new reveal ore manifestations in field of positive magnetic anomalies on Landsat space image with indicated lineaments and ring structures.

Above-mentioned data on geological setting , age and specific character of reproductive magmatism composition and postmagmatic metasomatism, composition and zonality of the Chatkal-Kurama ore fields and deposits mineralization gave the opportunity to consider the whole complex of these objects as aforesaid ore-magmatic systems, which are the parts of the Almalyk-Angren ore-magmatic concentre.

3.4 Baisun ore-magmatic concentre (BOMC)

Baisun ore-magmatic concentre (BOMC) was detected by I.Kh.Khamrabaev, (1999) as a forecast one (Figure 7). This was based on a wide development of carbonate volcano-tectonic structures, the presence of pyrite-polymetallic deposit Handiza and a large number of endogenic ore manifestations of many metals, which were summarized as a result of intuition of this outstanding metallogenist of Uzbekistan.

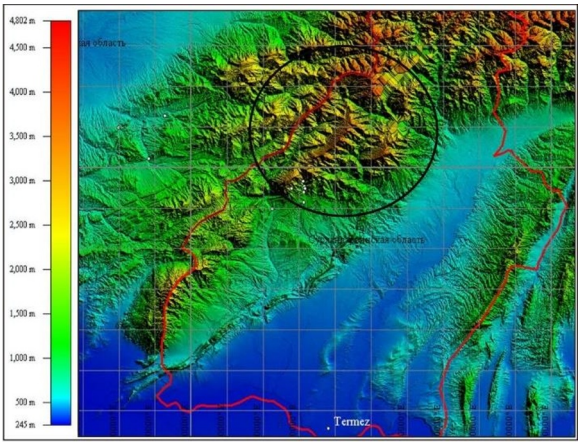

Fig. 7. The 3-D SRTM image of Baisun ore-magmatic concentre.

In the last years, the Baisun concentre, owing to the work of the units of State Committee of the Republic of Uzbekistan for geology and mineral resources, has been

outlined as the southern Uzbekistan mining district, in which specific areas and ore fields with targeted searches for precious, rare and nonferrous metals have been detected.

Thus, within the Chinarsai ore-bearing area situated with the deposit Handiza in a single volcano-tectonic structure, a gold mineralization of gold-polymetallic formation was revealed. In Kyzylturuk ore field, quartz-gold ore deposit Shirotnoe was found, which was situated in the carbonaceous shale. The deposit Akba is situated in the zone of a multijoint Madmon fault and belongs to quartz-carbonate-gold-silver formation. In ore manifestation Akata, the mineralization belongs to a new non-traditional for Uzbekistan commercial-genetic non-quartz gold-argillite-carbonate type.

3.5 Sultanuvais ore-magmatic concentre (SOMC)

Sultanuvais ore-magmatic concentre (SOMC) was detected by I.Kh.Khamrabaev (Figure 8), similarly to BOMC on the basis of a wide development of magmatic formations of different ages and composition in the, as well as one iron-ore deposit Tebinbulak and numerous ore manifestations of Fe, Au, Cu, Ni, Mn, etc.

Sultanuvais mountains lie in the junction of the Urals belt of deep faults with the western part of Mongol-Okhotsk belt. One of the branches of the Urals belt in the form of Urusaisky meridional course crosses Sultanuvais into two parts, the western one of which shows a meridional course of sedimentary-volcanogenic rocks of the Devonian ruptured by plagiogranite intrusives (C_1) and is quite similar to the same-age formations Mugodjar containing copper-pyrite, copper-pyrite, copper-magnetite and other copper-containing copper-pyrite mineralization.

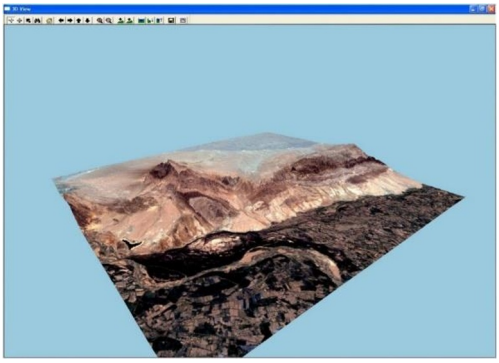

Fig. 8. The 3-D relief surface of Sultanuvais ore-magmatic concentre.

The eastern part of Sultanuvais is situated in the range of Transasian lineament, which predetermined as latitudinal stretch of rocks, except the Urusai near-fault plicated structures, in which Tebinbulak pyroxenite-gabbroid massif in the north and Aktau granitoid massif in the south are located.

Due to new notions on the geological structure of the Sultanuvais mountains, which were acquired while making a large scale (50000) map (V.K.Panasjuchenko, O.N.Nikitina, 2009), new data were obtained which enabled clarification of the metallogeny of this district.

It results in isolation of two major stages of ore-formation: the former was predetermined by the quasi-platform (D-C_1) sub-alkaline magmatism, in volcanic structures of which (Berkuttau) gold and silver are localized in connection with intrusives of shonkinit-syenite-diorites and granosyenites, in metosomatically transformed (beresite, listvenites) rocks gold-containing rocks, quartz and carbonate-quartz veins; gold was also found in carbonaceous phyllite-like shale of Urusai fault.

Tebinbulak titanium-magnetite deposit is preconditioned by the intrusion of the first intrusive phase of sub-alkaline gabbroids of the considered stage. The second stage of the ore genesis is connected with the intrusion of granitoid plutons and their vein derivates. Sultanuvais pegmatite-bearing zone stretching for more than 20 km is detected, into which coupled pegmatite and quartz-vein fields are joined, which trace the manifestation of Transasian lineament there. Sultanuvais pegmatite-bearing zone is complex by mineral raw material and its rare-metal and non-ore (quartz-feldspar) potential is evaluated at a commercially importance scale.

4 Conclusion

Integrated studies of mining areas of Uzbekistan, development of new forecast geological-geophysical models of ore-magmatic concentres, inclosing large mineral deposits wealth enable revealing new ore-bearing areas and cryptic ore bodies within the ore areas, fields, covering of the Mesozoic-Cenozoic sediments.

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