Anomalous geoobjects in the Lithosphere of Uzbekistan and their interrelations with ore deposits

I P Sidorova[1*], *R I* Saxobidinov[1], and *E A* Golovko[1]

[1]Institute of Geology and Geophysics named by Kh.M. Abdullaev, Tashkent, Uzbekistan

Abstract. One of the priority tasks of the Geological Service of the Republic of Uzbekistan is the study of the paleozoic foundation under the cover of Meso-Cenozoic sediments, mainly using deep seismic sounding profiles, in order to trace known ore fields and mineralized zones in the overlying part of the basement. In recent years, in the laboratory "Structure of the Lithosphere" of the Institute of Geology and Geophysics named after Kh.M. Abdullayev, new data have been obtained as a result of reinterpretation of a complex of geophysical data. In the present work examines the role of anomalous geoobjects with high and low seismic density parameters along deep seismic sounding (DSS) profiles in the Lithosphere of Uzbekistan from the point of view of their spatial correlation with explored deposits of ore minerals. New regional features of the interrelationships between the geological structure of the lithospheric deep structures of Uzbekistan and the spatial distribution of deposits have been identified.

1 Introduction

The Lithosphere includes the Earth's crust and, in general, some non-convecting part of the upper mantle called the lithospheric mantle. Knowledge of the structure, composition, and secular evolution of the lithosphere is crucial for the understanding of the geological evolution of the Earth since its accretion, including understanding the processes behind the formation of the early lithosphere, the processes behind plate tectonics, and lithosphere–mantle interaction. Human society is strongly dependent on knowledge of the geodynamic processes in the Lithosphere, which manifest themselves as variations in topography, deposition of minerals many of which occur only in specific lithospheric settings. Also, the understanding processes in the deep Earth is impossible without knowledge of lithosphere structures.

The Earth's crust deep geological structure analysis makes the majority of researchers conclude that the formation of mineral deposits is the result of general process of the Earth's evolution, including energy-mass exchanges between the upper mantle and the crust that occur along the most permeable zones of the Earth's crust. The main means of heat mass transfer are deep fluids that contain various chemical elements. Ore geology has a

* Corresponding author: irina_sid@mail.ru

great deal of worked out models and concepts to tie up the Earth's crust deep structure or some of its structural elements with the distribution of mineral deposits.

The most interesting conception to our mind is in the reviews carried out by Jan Kutina [1,2]. The authors suggested similar ideas -we were tied up with anomalous zones in the upper mantle, that have high Vp values (up to 8.3-8.5 km/sec). The existence of similar formations in the Lithosphere on the territory of Central Asia was first suggested by E.M.Butovskaya (1970), T.E.Ergeshev (1970), G.A. Ivanov (1977), I.P.Sidorova et all [3], who distinguished with in Central Kyzylkum Muruntau, Kokpatas and Djamankum bodies of high velocity and density values. Petrologically, according to data of Khamrabaev et al. [4] the similar bodies are interpreted as tectonic-magmatic formations similar to subalkalic basaltoids, gabbroides and dolerites. Recent fundamental investigations established the presence of the velocity heterogeneities in the upper mantle, both in horizontal and vertical directions. The most noticeable anomalous zones in the upper mantle are observed under Central Kyzylkum and Ferghana basin (Vp=8.5-8.6 km/sec). Amudarya basin is characterized the increased mean values Vp=8.2-8.4 km/sec, but at the same time it has the greatest change in the boundary velocity (Vp=8.0-8.3 km/sec) in Central Asia. However, the role of all these objects and anomalies in magma-and ore-genesis and formation, as well as their nature is not still clear nowadays.

Complex reinterpretation of geological-geophysical data on regional seismological and seismic prospecting profiles DSS (Deep Seismic Sounding), MRW (method reflected waves), DSS-MRW, CMRW (correlation method of refracted waves), deep, and potential field modeling, we had conducted during the last years [1] on the territory of Western and Central Uzbekistan (Figure 1), allowed us to make our data more precise, and in some cases to obtain new data on the structure of the region's Lithosphere and to accentuate its very pronounced layer-block character. The work helped reveal blocks with anomalous seismic-density parameters both increased and lowered. Regularities of their distribution were determined.

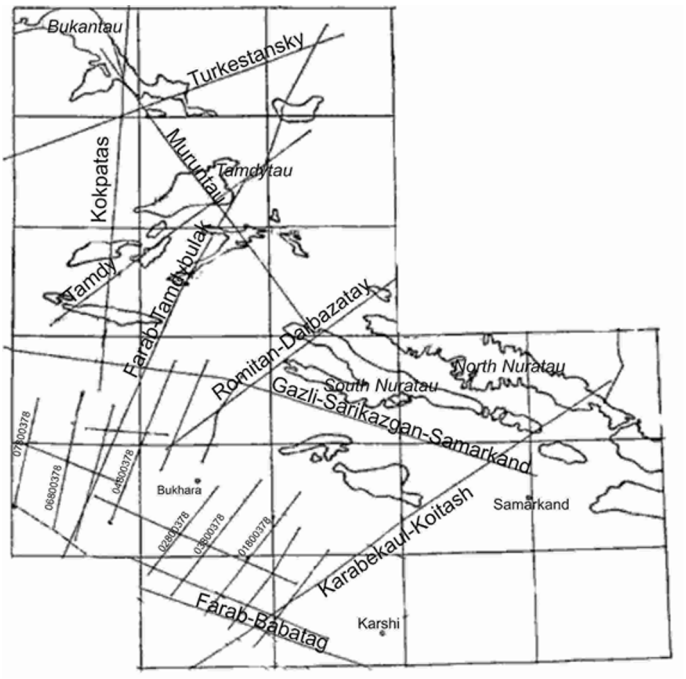


Fig. 1. The sketch map of distribution of regional seismic profiles in Uzbekistan.

2 Materials and methods

Materials of seismic and seismological studies were used for the identification of speed heterogeneities in deep horizons of the consolidated crust as the basis for further calculations of density parameters, hypsometrical position of the surface of the heterogenic fundament diagnostics of the pre-Jurassic formation composition and the gravitational effect of the Mesozoic-Cenozoic thicknesses.

The deep construction was based on the materials of studies conducted in 1980s of series of regional seismic profiles DSS-MRW (Figure 1): Farab-Tamdybulak, Romitan-Darbazatau, Tamdynsky, Muruntau, Kokpatas (M.S. Erenburg et al., 1989).

The system of observations provided the tracing of refracted waves in the Earth crust, reflections from the surface of Mohrovičič discontinuity and inner-core borders. The results of field observations in all profiles enabled obtaining temporary cross-sections, which subsequently formed the basis for the calculation of speed cross-sections. The program of calculation of the field of speeds along the profile provided smooth transitions of speed parameters from one geoblock to another. Therefore, sharp leaps of the speed of elastic wave spread are absent in obtained speed sections.

During the modeling along seismic profiles, three-dimensionality of crust objects was taken into account without fail. The study and inventory of distribution of rock density in the Mesozoic-Cenozoic mantle preceded the use of gravitation anomalies (in Bouguer reduction) for geological construction. A real distribution of density was taken into account, as well as its growth as the depth also grew.

The effect of the relief of the day surface is determined in the radius of 150 km. to record the impact on the observed gravitation field of deep factors (Mohrovičič discontinuity etc.) the gravitation effect was calculated on their basis, which then was subtracted from the observed field Dg. The basis for the anomalous effect from these borders included the materials of DSS, MRW (H.A.Atabaev, R.I. Abramson, B.S. Volvovskih, I.S. Volvovskih, E.M. Butovskaya, A.V. Egorkina, B.B. Tal-Virsky, T.E. Ergeshev), as well as the results of summary works of F.H. Zunnunov (1984), B.B. Tal-Virsky (1982), I.A. Fuzailov (1985), I.M.Golovanov [5] et al.

Gravitational modeling was carried out in two variants, in the first one the density was calculated according to its relation to the speed according to the formula σ=2.7+0.25 (Vp-6); in the second one, the density of the upper part of the geological section was obtained according to data of near-surface petrophysical studies, while for deep surfaces of the earth crust, through the speed. Both the variants of models were built taking into account the thermal thinning by the value of gravitation field of studied territories. Besides, it bears the character of more or less constant component and therefore practically does not affect the size and forms of local anomalies. At the same time the thermal factor is taken into account at regional modeling.

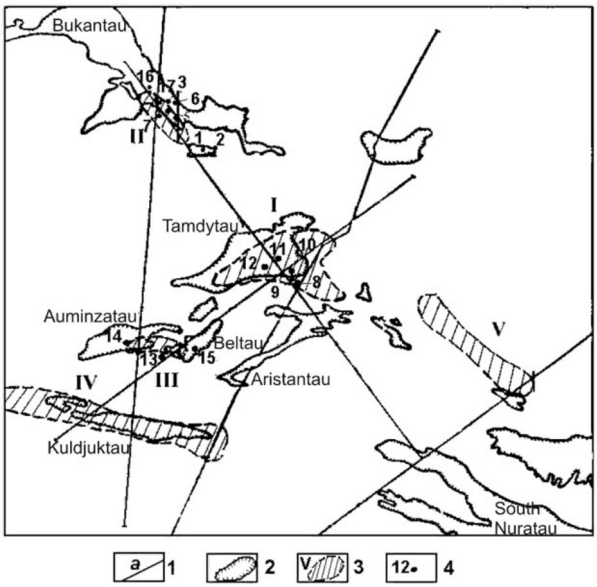
3 Results and Discussion

Anomalous geological objects in Central Kyzylkum

Objects having anomalous high velocity and density values have been mapped at different depths within Central Kyzylkum (Figure 2): Muruntau, Kokpatas, Auminza-Beltau, Kuldjuktau, Darbazatau. The largest - Muruntau has irregular shape and a little stretched in sublatitudinal direction, with lateral dimensions of about 70*40 km of them (according to the gravitational field analysis). Effective physical properties are σ_{ef}=2.90-2.85 g/sm^3, V_{pef}=6.8-7.4 km/sec. If viewed in the section it appears to be: on Muruntau profile - a mighty pillar - shaped vertical object originating in the lowest parts of the crust (Figure 3); on Tamdy one- a random section polygon with marks of roof and foot-3-14 km

(Figure 4). Then in the east and north-eastern directions the given body is observed at depths of 1.5-10.5 km on the DSS Farab-Tamdybulak profile. But the bodies density increases to 2.85 g/cm^3. On the north and south sides of the high velocity zone, on different hypsometric levels (4-15km), extensive weakened areas are observed. From the geological point of view most likely these bodies are large batholyths, that have acid granitoid compositions. Muruntau ore field corresponds to the spatially considered Muruntau anomalous area. The analysis of deposits distribution with in the ore field revealed that they (most of them) belong to contact zones of geoobjects with anomalously high and low values of physical properties. Gold deposits: Muruntau, Besapan, Myutenbai, Triada, Tamdybulak, Kosmanachi are situated within southern contact zone. The blocks of low and lowered seismic-density parameters, according to data I.Kh.Khamrabaev et al. [4] are interpreted as bodies of glimmerites and granite gneiss, enriched with fluids. In accordance with the data on complex interpretation and modeling, they correspond to acid granitoids or the rocks having similar physical properties.

The Kokpatas high-velocity body (Figure 5) is located to the south and south-east from the intrusive of the same name and gold ore deposit. It is stretched in the south-eastern direction; its observed size is 30*15 km; the depth of roof and foot is 1.5 -10.5 km. It's shape in the section: on the Kokpatas profile-vertical truncated prism that expands downwards and is enclosed between two faults, one of which is traced up to Mohorovičič boundary (according to seismic prospecting and geodensity modeling data) ; on the Muruntau profile- a block similar to the stratum-like one. Effective physical properties: σ_{ef}=2.9 g/cm^3 and V_{pef}=6.8 km/sec. Geoblocks adjacent to the considered body in the north and south have low petrophysical parameters: for southern areas – σ_{ef}=2.56 g/cm^3, V_{pef} =5.8-6.0 km/sec, for northern- σ_{ef}=2.64 g/cm^3, V_{pef}=6.0 km/sec. Most probably, they are granites and granitoids. The Kokpatas ore field deposits (Sulfidnoye, Zapadnoye, Yuzhnoye, Vastochnoye, Blizhneye- in the North, and Okjetpes and Barkhannoye- in the East), that correspond to the studied object are in the body's periphery zones, namely in the area of its contact with granitic massifs. Commercial concentrations of ore minerals in the areas, where intrusions of acid composition are absent haven't been revealed up to now [5].



Legend: 1-Regional seismic profiles DSS-MRW:a) Kokpatas; b) Muruntau; c) Tamdy; DSS: d) Farab-Tamdybulak; e) Romitan-Darbazatau; 2- Boundaries of the basement outcrop; 3- High velocity objects: I-Muruntau; II-Kokpatass; III-Auminza-Beltau; IV-Kuldjuktau; V -Darbazatau; 4- Revealed deposits: 1-Okjetpes; 2- Barkhannoye; 3-Sulfidnoye; 4- Zapadnoye; 5-Yuzhnoye; 6- Vostochnoye; 7-Blizhneye; 8- Triada; 9- Mjutenbai; 10- Muruntau; 11- Besapan; 12-Kosmanachi; 13- Adjibugut; 14-Kontaktovoye; 15- Sarybatyr; 16-Beltau.

Fig. 2. Distribution of the high velocity objects of Central Kyzylkum.

Auminza-Beltau high velocity zone is located within the uplands of the same name. It is an object of sub-latitudinal extent with lateral dimensions of 30*10 km. Among all the above mentioned bodies this one is the most deeply deposited (roof mark is 8 km), and the least dense one – σ_{ef}=2.82-2.87 g/cm^3. A notable thing is mapping of the anomalously weakened and low-velocity body (σ_{ef}=2.55 g/cm^3, V_{pef}=4.8 km/sec) right under it at a depth of of 12 to 21 km (along the Tamdy profile). At comparable depths in the Earth's crust of Uzbekistan, there are no geoblocks having similar seismic density parameters found at present. Daugyztau ore field corresponds to Auminza-Beltau zone. With in Daugyztau ore field, the following deposits have been revealed: Adjibugut, Beltau, Yuzhnoe and Sarybatyr. It is noted that they are also inclined to the complementary areas of objects having increased and lowered seismic-density characteristics. Deposits located for behind the contour of high-velocity zone allow us to suppose that the boundary of high-velocity object proper must lie immediately close to them (Figure 2).

Kuldjuktau anomalous block is crossed by three seismic profiles - Kokpatas, Tamdy and Farab-Tamdybulak. It is of sub-latitudinal extent, and in the West it spreads far exceeded the bounds of Kuldjuktau mountains (the object's boundaries are determined, according to the analysis of gravimetric data). Its lateral dimensions- 100*20km. In section it has a complicated structure. The Central area is a thick "column" of variable density. The column gets narrow as it goes downwards. The upper part between marks of H=3.0 to 24,0 km has σ_{ef}=2.90 g/cm^3 and V_{pef}=6.8 km/sec; the lower at H-24-36km – σ_{ef}=2.95 g/cm^3, V_{pef}=7,0 km/sec. The structure is limited by faults observed up to Mohorovičič surface. In western and eastern directions the body's density and velocity values decrease, its shape also changes: in the Tamdy profile it is a trapezium with σ_{ef}=2.87 g/cm^3, V_{pef}=6.4-6.6 km/sec roof and foot marks - 3 and 9 km accordingly; in the Farab-Tamdybulak profile the body represents a layer of 10 kilometers depth (roof-6km, foot-16km) with σ_{ef}=2.85g/cm^3, having horizontal sizes, (probably around 50 km). On southern and northern sides, in the immediate neighborhood of the studied object, there are bodies having low seismic-density parameters. Granites and granodiorites are rather definitely mapped in the Central part of the profile, with in the upper horizons of the Earth's crust (the peculiarity of the Kyngyrtau granodiorite intrusive is its anomalously high, for the rock of the given composition, magnetic susceptibility).

It is difficult to reveal any definite regularity in the distribution of commercial ore concentrations for the Kuldjuktau body, because of their small number. This fact can show that geology of the given area is not fully studied.

Darbazatau block is the last object that we consider within Central Kuzylkum. This is the least studied body, slightly crossed by only one profile – CMRW-IV Romitan-Darbazatau. However, its structure appears to be the most complicated. In section, it consist of 3 blocks that have different density: σ_{ef}=2.85-2.87-2.90 g/cm^3. Hypsometric levels of the roof and the foot are 4 and 19km accordingly. It is very much shattered (by faults). Total strike is north-eastern in the upper part (along the CMRW profile). It is in contact with granitoids - σ_{ef}=2.56 g/cm^3, and at a depth of 12 to 19 km with the unconsolidated area - σ_{ef}=2.68 g/cm^3. There are no deposits found with in its boundaries at present, but this region has big potential perspectives.

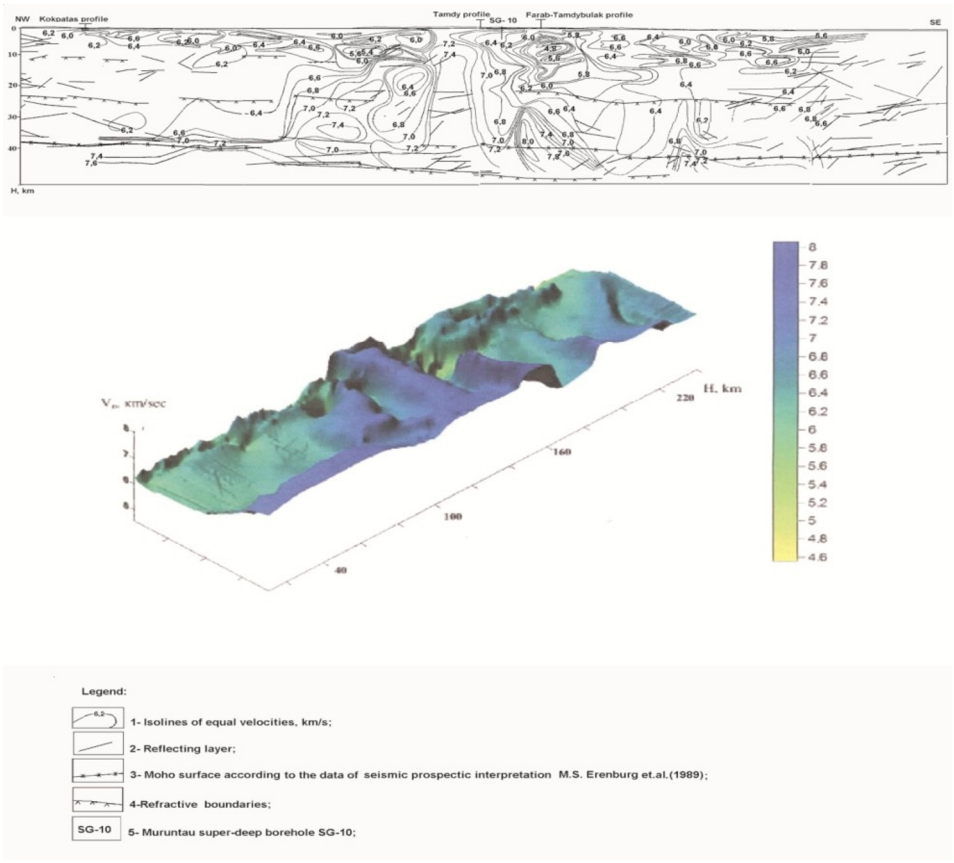


Fig. 3. Velocity section along the DSS-MRW Muruntau profile.

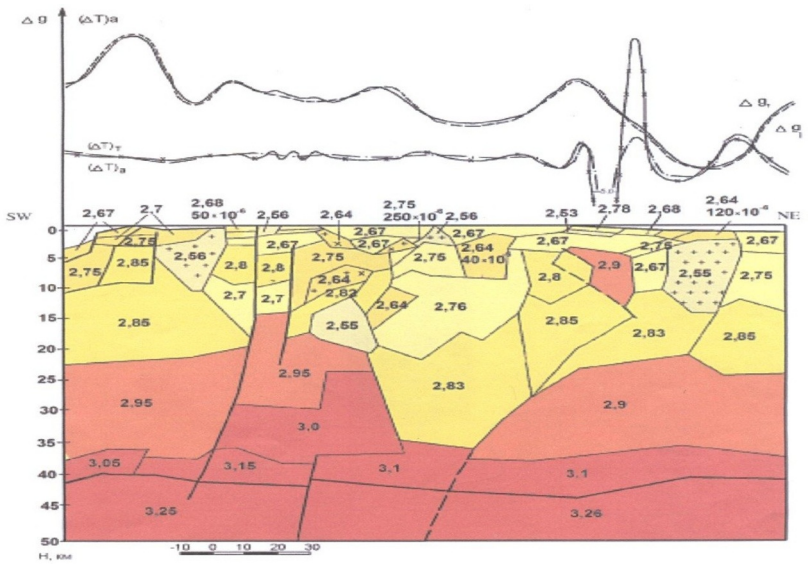


Fig. 4. Geologic-geophysical model along the DSS-MRW Tamdy.

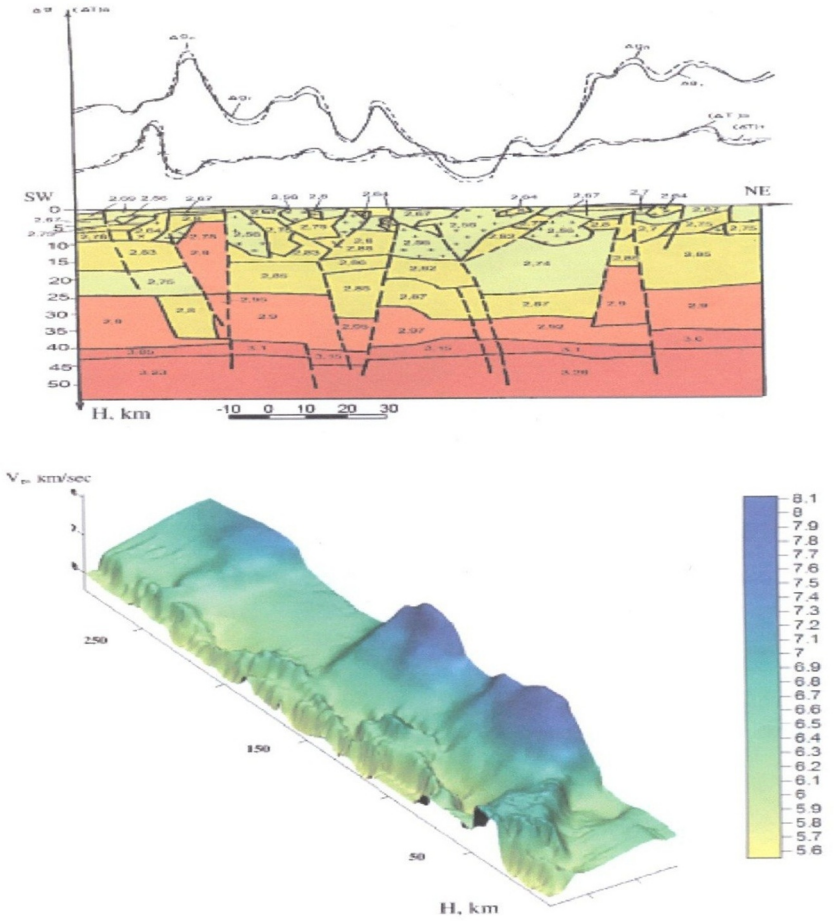


Fig. 5. Geologic-geophysical model along the DSS- MRW Kokpatas profile.

4 Conclusion

A wide development of geoobjects of high and increased seismic-density characteristics and their spatial connection between distribution of the explored deposits of ore minerals and anomalous blocks in the lithosphere of Western and Central Uzbekistan has been established. However, the nature of these blocks and their role in the process of ore-formation are not quite clear. Besides, the majority of anomalous bodies (revealed within the studied territory) are not magnetic or weak-magnetic anomalies neither in local nor in regional fields. In the immediate neighborhood of these objects, there are blocks of the Earth's crust with low or decreased values of density-velocity. The established accordance's point to a possible presence of commercial concentrations of minerals, but in deeper stratigraphic horizons. Thereby, new regional features have been revealed. They include peculiarities of the Earth's crust's deep geological structure and spatial distribution of deposits; they are contact areas of the Earth's crust geoblocks with anomalously high and low seismic-density parameters. Mapping of these zones helps select new ways in the search for mineral deposits.

Acknowledgement

The authors express thanks to World Bank project's experts for possibility to continue the study during the Grant REP-1/5.

References

1. J. Kutina, I.B. Campbell, Mineral deposits related to Australian continental ring and rift structures with some terrestrial and planetary analogies, Global Tect.&Metall., **6**, **2**, 83-101 (1997)
2. J. Kutina, The role of transregional mantle-rooted structural discontinuities in the concentration of metals, with examples from the United States, China, Uzbekistan, Burma and other countries, Global Tect.&Metall., **7**, **3-4**, 159-182 (2001)
3. I.P. Sidorova, R.I. Saxobidinov, E.A.Golovko, Ore-magmatic concenters in Uzbekistan, E3S Web of Conferences, **463**, 03001 (2023) https://doi.org/10.1051/e3sconf/202346303001
4. I.Kh. Khamrabaev, S.S. Seiduzova, A.A. Kustarnikova, A.V. Pokrovskiy, T.E. Ergheshev, A.A. Polikarpov, K.A. Rahmanov, F.G. Dolgopolov, V.A. Pak, G. Nasyrova, L.M. Matasova, N.N. Yankovskaya, The Nature of Layers and Boundaries of the Lithosphere of Central Asia [Priroda sloev i granitz litosfery Sredney Azii].- Tashkent, Publ.for the Acad.Sci. of the Uzbek Rep. by GFNTI, 212 (1998)
5. I.M. Golovanov, Ore deposits of Uzbekistan, Institute of mineral resources, Tashkent, 660 (2001)
6. P. Laznicka, Giant ore deposits: a quantitative approach, Global Tectonics and Metallogeny, 41-63 (1983)
7. B.H. Whiting, C.J. Hodgson, R. Mason, Giant Ore deposits, Society of Economic Geologists Special Publication, 21-163 (1993)
8. J.P. Richards, Giant ore deposits formed by optimal alignments and combinations of geological processes, Nature Geoscience, **6**, **11**, 911-916 (2013)
9. D.R. Cooke, J. Pongratz, Giant Ore deposits: Characteristics, genesis and exploration, CODES Special Publication, **4**, 1-269 (2002)