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Formation Features and Prediction Criteria for Gold-Sulphide deposits (East Kazakhstan)

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ABSTRACT

The region under consideration is part of the Central Asian mobile belt system, organized by a large geo structure of the Greater Altai (GA), which integrates geological structures of the Rudny Altai, Kalba, Zharma-Saur and adjacent districts of Russia and China. The regional gold-ore sites vary by ore formation types, age, geological formation conditions and mineralization scale. The largest among them are the Ridder-Sokolny gold-polymetallic deposit in the Rudny Altai and the Bakyrchik deposit of the gold-sulphide-carbonaceous type in West Kalba, comparable in many ways with the world sites of Sukhoi Log and MurynTau in the black shale strata. In recent years, much attention was paid to prediction and assessment of the unconventional (apocarbonate) gold-sulphide type of mineralization, associated with the island volcanic-carbonate-terrigenous formation C1v2-3 (the Suzdal deposit and others). The present paper considers new results acquired from the studies of the gold-ore sites of the Suzdal type.

Key words: gold, deposit, Greater Altai, West Kalba, mineralization

1. INTRODUCTION

When carrying out a research of gold-ore sites in this region, of principal importance is the identification of spatial-temporal connections of deposits with certain earth crust deep structures, roles of large mantle plumes (Siberian, Tarim and others) in the processes of tectogenesis, magmatism and ore formation, sources of magmatic melts and ore matter, the analysis of common issues of tectonics and metallurgy in Central Asia [3, 4]. In terms of metallogenic zoning, the GA combines four parallel ore belts in the northwest, limited by the following deep faults: the gold-copper-polymetallic Rudny Altai, the rare-metal Kalba-Narym, the gold-ore West-Kalba and the multi-metal Zharma-Saur [1].

The systemic material analysis indicates the maximal burst of mineralization in each ore belt (with formation of industrial deposits) happening under certain geodynamic mode and within certain age interval. In the Rudny Altai belt, main pyrite-polymetallic deposits (Cu, Pb, Zn, Au, oth.), representing the main raw material base of non-ferrous metallurgy in Kazakhstan, were formed in the riftogenic geodynamic environment (D_1e-D_3fr_1). In the West-Kalba belt, the main gold deposits were formed under the collision geodynamic mode of $C_{2\text{-}3}$-C_3 (Bakyrchik, Suzdal, Kuludjun, oth.). In the Kalba-Narym belt, productive are the rare-metal pegmatite deposits (Ta, Nb, Be, Li, Cs, Sn), associated with granites of the post-collision (orogenic) geodynamic situation (P_1). In the Cimmerian cycle, under conditions of the continental rift genesis, deposits of residual weathering crust were localized (Au, Ni-Co, Ti-Zr). Typical for the Alpine cycle are gold placer sites. The data show that in the self-developing ore-magmatic system the energy of ore formation is manifested in a certain geodynamic mode with an obvious tendency to a constant value. Therefore, a revealed mineralogenetic character of geodynamic settings is one of important clues for defining mineralization, especially in poorly studied and shut areas. Formation patterns and prediction criteria for the regional gold-ore deposits were specified from the stated positions. Actually, gold-bearing structures are localized in the central part of the GA, the most significant of which are West-Kalba and Zhanan-Boko-Zaisan ore zones.

The Suzdal deposit is a typical object of the gold mineralization of the apocarbonate type, located at the border of the West-Kalba and Char metallogenic zones, in the southeast exocontact of the SemeyTau volcanic-tectonic structure (Figure 1). Primary mineralization is represented by gold-sulphide mineralization zones, formed in tectonically disturbed volcanic-carbonate-terrigenous sediments of high carbon content (the Arkalyk suite ($C_1v_{2\text{-}3}$). The secondary mineralization has gold-bearing weathering crust of kaolinite hydro-micaseous type, exhausted by now. This deposit by a number of similar features is compared to the world famous Karlin trend of gold-sulphide objects formed in carbonate strata [5]. Such formations are titled “interformational metasomatites” (V.F. Fedorchuk, Yu.V. Kazitsyn, V.N. Sazonov, etc.), and considered as independent metasomatic formations and independent geological-industrial ore type (A.N. Ugryumov, E.P. Melnikov, G.P. Dvornik, V.D. Tsoi, and oth.). The leading factor determining development of gold-bearing jasperoids is their formation as a result of silicon-iron metasomatism of carbonate rocks in the zones of high tectonic activity and a sharp change in the acidity-alkalinity regime of the incoming ore-bearing solutions, which caused the mobility of elements (Si, Ca, Fe, Na, K, oth.), sedimentation and concentration of gold [6]. There are yet several poorly studied promising ore occurrences, but the search-assessment methods to study them are inadequate (Zhaima, Mirazh, Arkalyk, Baibura, etc). Genetic models and spatial-temporal positions of these sites are understood randomly, complicating the selection of a direction for prognostic and prospecting works, especially in shut and semi-shut areas.

Papers will be reproduced exactly as submitted and will not be edited in any way. Abbreviations should be kept to a minimum. Use of standard abbreviations is acceptable. Place special or unusual abbreviations in parentheses after the full term for the first time it appears. Linguistic accuracy is the responsibility of the authors.

2. REGIONAL GEOTECTONIC CRITERIA

The main ore-concentration structure is the Zaisan Sutural Zone formed at the jointing of the Kazakhstan and Siberian lithospheric plates, according to the mechanism of oblique collision, with elements of a turn [7]. There are over 450 deposits and ore manifestations of gold in the Zaisan suture, including the unique deposit of Bakyrchik, the large Suzdal deposit, and gold-ore sites of DolonoSai, SaryBulak in the adjacent Chinese area. According to the set of geological-geophysical data concerning the deep structure, the Zaisan suture is fixed by an elevated asthenospheric layer, oriented along the line “the Semipalatinsk city – the Zaisan lake” and the meta-basalt surface [1, 8]. Geophysical methods (gravimetric, magneto-exploration, IP, etc) are also effectively used to identify and trace hidden gold-bearing structures. The analysis of geological and geophysical data reveals the ore control value of the Char-Gornostai ophiolite belt, within the framing of which the main gold-bearing structures and deposits settled in the Zaisan suture. The Sentash-Baibura belt of hidden granitoid massifs is distinguished in the West Kalba zone, in the intrusive zone of which received their accommodation gold-ore nodes, ore fields and deposits (Kulujun, Jumba Sentash, etc). The geological and genetic modelling of the known ore fields and deposits based on geological-geophysical data predicts hidden granitoid massifs (Bakyrchik, Suzdal, Kulujun, Jumba, etc). With the results of detailed magneto-exploration works, the studied non-conventional apocarbonate gold-ore sites revealed high intensity magnetic anomalies (up to 2250 nTL) corresponding to the zones of gold-sulphide-magnetite mineralization, which is of applied significance [1].

The general pattern in the placement of gold deposits is that gold-ore zones (West-Kalba and Zhanan-Boko-Zaisan) cover the Char-Gornostaevsk uplift from the north-east and south-west and are traced along the ophiolite belt for a long distance. Therefore, the north-west flanks of these zones, thickly covered by loose deposits, seem to be the most promising for discovery of new gold deposits. Specifically, the Gornostaevsk area on the northwest flank of the Zhanan-Boko-Zaisan ore zone is expected to be potential with gold-ore objects of Suzdal and Bakyrchik types.

3. STRUCTURAL REGULATION

In the placement of gold-bearing structures and deposits, the leading importance is attached to the system of diagonal deep faults of the west-north-west direction (Char-Gornostaev, Baiguzin-Bulak, West-Kalba, Kalba-Narym, Terekty, and oth.). They functioned most actively in the Hercynian cycle and controlled the localization of linear island arcs and sedimentary strata of the early Hercynian stage of development (D_1-C_{1S}). In the collisional stage, under conditions of tangential compression, buckling zones were formed along them, thrust-melange structures with protrusions of hyperbasites, superimposed mulds and deflections (Bukon’, Tauba, MaiTobe suites C_2 and C_{2-3}). Especially important was the controlling role of deep faults in the placement of fault-line gold-bearing small intrusions and dikes of gabbro-diorite-granodiorite-plagiogranite series (C_{2-3}-C_2) and the main gold-ore zones associated with them: West Kalba, Zhanan-Boko-Zaisan, South Altai, and oth. (Figure 1).

The rhegmatic system of latitudinal faults of ancient placement and their fracture-discontinuous disturbances, actively manifested in many gold ore fields, deposits and fixed on satellite images (Bakyrchik, Suzdal, Kazan - Chunkur, Laila, Baibur, etc.) were also of the controlling role. An example is the Kyzylov latitudinal deep fault, confining large gold deposits (Bakyrchik, Bolshevik, Deep Log, etc.) (Figure 1) [2, 8].

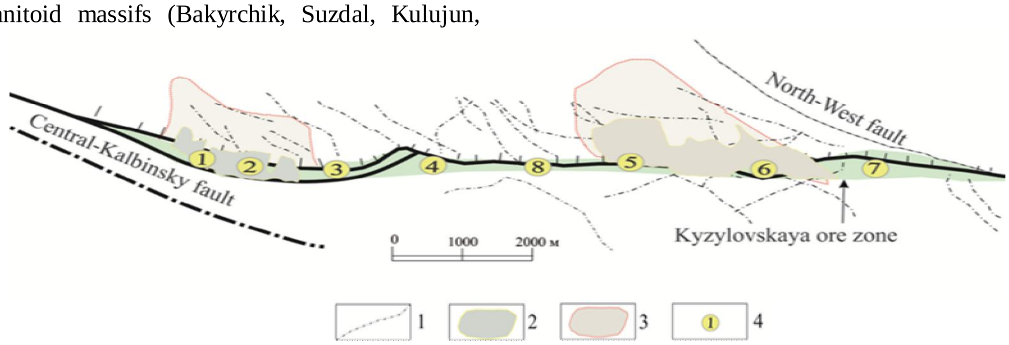

Figure 1: Faults zones and gold deposits of the West Kalba

a) deposits: 1-West Bolshevik, 2 Bolshevik, 3 - Chalobay, 4 - Cholodnyi Klyuch, 5 - Bakyrchik, 6 - Promeshutochnyi, 7 - Glubokii Log, 8 - ore occurrence Zagadka; b) 1-Semeitau volcanic complex; 2- deposits: Suzdal, Mukur, Zherek

The ore-controlling role of latitudinal faults is accurately manifested in rare-metal sites of the Kalba-Narym zone (the Asubulak ore field, others), and it also was noticed on the Smirnov gold-silver deposit in the South Ural Mountains [9]. The Suzdal deposit is controlled by Gornostaev overthrust of the north-west direction, and ore bodies are localized in the fledging north-east discontinuous disturbances. In general, discontinuous tectonics is the leading factor controlling the gold-sulphide mineralization.

4. LITHOLOGICAL - STRATIGRAPHIC CONTROL

When describing foreign gold-jasperoid deposits, attention is paid to their spatial distribution in carbon-containing carbonate and terrigenous (volcanogenic) carbonate strata [9]. Such deposits are formed as a result of substitution of carbonate-containing deposits with silicate hydrothermal solutions, which was accompanied by gold deposition on alkaline geochemical barriers. According to A.F. Korobeinikov, not only the chemical activity of carbonate rocks, but also their increased tectonic fracturing and porosity should be taken into account [10]. The studies in the West Kalba and Char zones, taking into account the data by A.M. Mysnik [1], resulted in determined spatial confinement of gold-ore objects to three lithologic-stratigraphic levels (figure 3a): *the early Hercynian island-arc* (D_3fm-C_1v_{2-3}), represented by derivatives of andesite-basalt island-arc volcanism, argillous-siliceous-calcareous and flushoid deposits (Suzdal, Mirage, Zhaima, Baibura and oth.); *the early Hercynian pre-collision* (C_1s), composed of marine poorly-carbonaceous graywackes (molasse-like) deposits of the Aganakty suite (Kuludjun, Djumba, Laila and oth.); *the middle Hercynian collision* (C_2-C_3), uniting the molasse limnic carbonaceous (black shale) strata of Tauba and Bukon' (C_{2-3}) suites (Bakyrchik, Bol'shevik, Gluboky Log).

As can be seen, the considered gold-ore sites of the Suzdal type are spatially confined to the basalt-andesite limestone-terrigenous formations (the Arkalyk suite C_{1V2-3}), enveloping the slopes of the Char-Gornostaev uplift (Figure 2a). At the ore manifestation *Baibur*, situated in the Kuludjun ore district, the gold-sulphide mineralization zones were directly formed along limestone of the Arkalyk suite. Pelitomorphic limestones of light grey and grey colour are predominant, containing inclusions of oxidized pyrite (up to 3-4 mm in size), micro-inclusions of galena, siderite, ilmenite, fluorapatite, sheelite and other minerals. According to ICP-MS analysis data, contents of the following elements are increased in limestones (g/t): Cu(80), Pb(100,1), Zn(109,9), Sr(372,5), Sn (16,14), and also noted are weight values: Sb(8,73), Au(0,43), Ag(2,1), Pt(1,86). These data indicate the primary scattered enrichment of limestones with antimony, tin, gold and other elements associated with their accumulation at the final stage of the island-arc basalt-andesite volcanism.

In the collision stage, obviously, the primary ore substance mobilization, introduction and concentration of juvenile gold took place, which is consistent with the materials of a number of researchers [11]. Taking into account the data on other sites of West Kalba and Zharma-Saur (Zhanan, Maibulak, Ak-Choko, Akzhal, etc), volcanogenic-siliceous-carbonate and flyschoid deposits (C_{1V2-3}) are the favourable environment for the formation and placement of gold-sulphide vein-embedded deposits (Figure 2).

a) b)

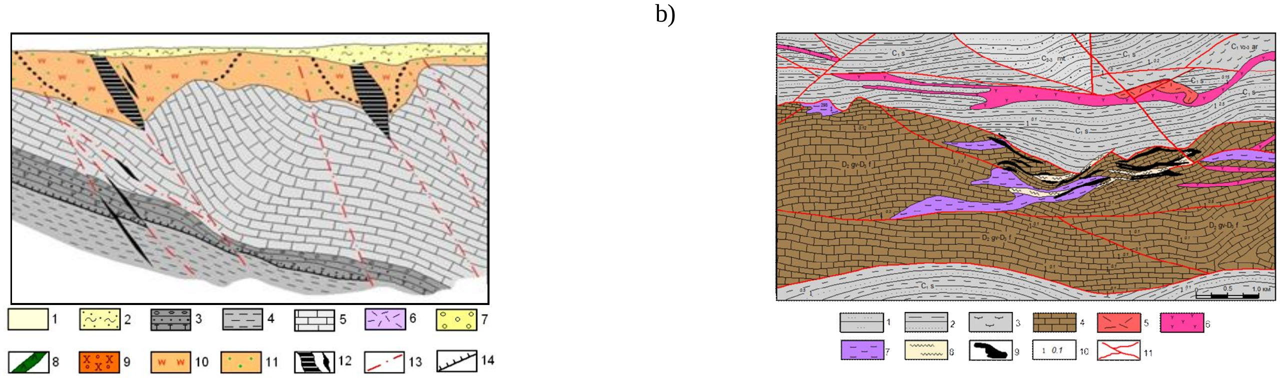

Figure 2: Lithological - stratigraphic control of structures of Suzdal (a) and Mirage (b) ore fields

a) 1, 2 – Q- N sediments; 3-5 - Arkalyk suite C_1v_{2-3}; 6 - Semeitau suite volcanites; 7 - gold-sulphide mineralization zones; 8 - diorite porphyrite dikes and 9 - granodiorite porphyries; 10 - quartzification zones; 11 - gold-bearing weathering crust; 12 - ore bodies; 13 - discontinuous disturbances; 14 – falts; b) 1 - Maitubin suite (C_{2-3})); 2 - Serpukhov suite (C_1s); 3 - Arkalyk formation (C_1v_{2-3ar}); 4 - limestones (D_2gv - D_3f); 5 - dikes of rhyolithoids (T_1); 6 - quartz syenites (T_1); 7 - serpentinites, birbirites (PR_1); 8 - secondary quartzites; 9 - gold ore zones; 10 - ore points with gold content (g/t); 11 - tectonic disturbances

5. MAGMATIC CONTROLS

As a result of many years of geological work in the Kalba region, the obligate spatial-genetic links of gold mineralization with small intrusions and porphyry-like dykes have been established (Bijian C2-3, Kunush C3 complexes and their analogues) [11]. The known ore fields of the region clearly show magmatic control of mineralization, which consists in the formation of gold-ore objects and intrusive-dike formations in a single collision ore-magmatic system (C2-3-C3) with a synchronous rhythmic-pulsation flow of magmatic melts and ore-bearing fluid flows from the deep crustal origins.

The Kunush complex unites small massifs of plagiogranites and granodiorites, as well as their dike derivates of few generations, which are typical representatives of pre-batolite small intrusions (massifs Zherek, Kedei, Bijan, Zelenov, ShieKol and others). The late Carboniferous age of the complex is reliably determined by geological data, intrusions and dikes of which break through the deposits of the Bukon' and Maitobe suites (C2-3), and themselves they are cut by Kalba granites (P1), and this was registered in satellite images. The age of the Kunush complex is confirmed by radio-geochronological data obtained by different methods: K/Ar (305 Myr), U/Pb (306,7 Мл), (299,2 Мл) [11, 21, 22]. Geochemical characteristics of Kunush complex granitoids are inclined to low-K calc alkaline series, which is also proved by low alkaline sum Na2O+K2O (6.06-6.38 mass % and 5.20-6.81 mass % respectively) and by high Na2O/K2O ratio (3.83-3.10 and 3.93-6.43). At a number of fields, plagiogranites of normal petrochemical series, sodium alkalinity (Na2O/K2O>4) and plumazite agpaity were shown (Ka=0,86). According to geochemical parameters (enrichment of Sr 686-815 g/t) and isotopic studies, plagiarites belong to a special adakite group of granitoids, derivatives of metabasites in the lower parts of the earth's crust. The ratio of magmatism and mineralization is manifested as a direct genetic bond in the beresitized granitoid domes and dykes (Balazhal, Zherek, Kedei, Manka, etc.), and also in a remote paragenetic bond in the thermogradient zones above hidden intrusions at a depth of 1.5-3 km (Bakyrchik, Kulujun, Laila, Sentash, Djumba and others). Thus, the close geological and structural conditions and age ratio of magmatites of the Kunush complex and gold mineralization allow us to consider the magmatic factor as one of the leading criteria for predicting and searching for gold-ore.

Primary mineralization is represented by the zones of gold-sulphide vein-embedded mineralization formed in tectonically disturbed crushed carbonaceous and calcareous siltstones, limestones, sandstones, extrusive and intrusive rocks saturated with sulphide minerals (pyrite and arsenopyrite) [1, 12]. They were formed as a result of glandular-siliceous and siliceous-carbonate-sulphide metasomatism, quartzization and argyllitization. Mineralization accumulated in the host carbonate-terrigenous rocks, in the filtration and metamorphism zones [13]. The main ore bodies were located in the central parts of the mineralized zones. The ores have embedded and veined-embedded textures, allotriomorphic and hypidiomorphic-grained structures. The main ore minerals are pyrite, goethite, arsenopyrite, and gold; antimonite, galena, sphalerite, magnetite, chalcopyrite, and others are also noted. The non-metallic minerals include quartz, calcite, barite and K-Al silicates. Gold is distributed extremely uneven, the average content in commercial ores is 9 g/t (the Suzdal deposit). In ores, it is free, as finely dispersed speckles in arsenopyrite and pyrite.

The implemented mineralogical and geochemical studies helped to determine a complex material composition of gold-sulphide (vein-embedded) ores, represented mainly by oxide and sulphide compounds of Si, Fe, Mn, Ni, Cr, Cu, Pb, Zn, As, Sb and other elements. The main typomorphic ore minerals are hematite, goethite, magnetite, pyrite, arsenopyrite, antimonite, galena, chalcopyrite, and sphalerite. Geochemical indicators of ore formation are native silver and fine and powdered gold, as well as admixtures in pyrite and arsenopyrite [14].

6. CONCLUSIONS

Specified were the regularities of formation and criteria of predicting of gold-ore sites of unconventional gold-sulphide vein-embedded type, represented by the industrial Suzdal deposit and promising small deposits and ore occurrences (Zhaima, Mirazh, Baibura and others) [16-20]. According to their genesis, these deposits are referred to the hydrothermal-metasomatic type, formed in the Hercynian cycle under collisional geodynamic environment (C2-3–C3), localized in the Zaisan sutural zone and of a significant material value [4, 8]. The deposits are characterized by spatial selective confinement to the island-arc volcanic-carbonate-terrigenous formation of inter-arc deflections (the Arkalyk suite C1V2-3), considered as a favourable ore-hosting medium (increased carbon and carbonic content) for the deposition and concentration of gold.

The most productive system for gold-sulphide mineralization is the collision ore-magmatic system, which reflects the leading ore-control role of the deep fracture system, which caused the rhythmic-tectonic pulsating inflow of ore-bearing fluids (under conditions of rhythmic tectonic compression-stretching motions) and the introduction of synchronous with them gipabissal small intrusions and dikes of gabbro-diorite-granodiorite-plagiogranite series (C2-3–C3) connected with deep magmatic sources of mantle-crust origin. Of special importance is the magmatic control of mineralization, determining the attribution of widely developed in ore fields plagiogranites and dykes of the Kunush complex (sodium alkalinity and high Sr-content) to adacite granitoids, the metabasite derivatives [8, 15].

The ore bodies are represented by gold-sulphide mineralization zones formed by tectonically disturbed host rocks of the Arkalyk suite (volcanics, carbonaceous-clay siltstones, sandstones and limestones) and intrusive formations, as well as gold-bearing weathering crust. According to the new results of mineralogical-geochemical studies, the gold-sulphide ores (except for typomorphic minerals (pyrite, magnetite, goethite, arsenopyrite, antimonite, gold, etc.) and geochemical elements-indicators of ore formation (Fe, Mn, As, Sb, Ag, Cu, Pb, Zn, etc.)) contain a group of transition siderophilic elements (Fe, Ni, Co, Mo, Ir, Pt), as well as heavy metals (W, Ta, U), which indicates the complex composition of the initial ore-forming solutions and mixed sources of ore matter.

The obtained results are the basis for the development of a technique for advanced assessment of gold deposits using modern methods of mineralogical-geochemical studies.

On the base of the developed regional and local prognostic and search criteria, the chances of detection of new deposits of the unconventional gold-sulphide (Suzdal) type, including hidden and buried under the cover of loose deposits, are expanding. Developed were scientific and practical recommendations on further geological exploration work, the positive implementation of which will contribute to the strengthening of the raw materials base of gold-noble metals of East Kazakhstan.

REFERENCES

1. G.N. Shcherba and X.A. Bespaev. **The Great Altai (Metallogeny).** Alma-Ata: RIOVAKRK, 2000.
2. D.I. Gorzhevsky, V.B. Chekvaidze and I.Z. Isakovich. **Types of polymetallic deposits in the Rudny Altai, their origin and methods of prospecting.** Moscow: Nauka, 1977.
3. Y. Liu, W. Li, Zh. Feng, Qu. Wen, F. Neubauer and Ch. Liang. **A review of the Paleozoic tectonics in the eastern part of Central Asian Orogenic Belt**. *Gondwana Res*, Vol. 43, pp. 123-148, 2017.
4. M. Mizernaya, B. Dyachkov, O. Kusmina, A. Mizerny and T. Oitseva. **Main types of gold deposits of the eastern Kazakhstan.** International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, Albena; Bulgaria, Vol. 17(11), pp. 299-306, 2017.
5. M.I. Kuzmin, V.V. Yarmolyuk and A.B. Kotov. **Early evolution of the Earth, beginning of its geological history: how and when granitoid magma appeared.** *Litosphera*, Vol. 5, pp. 653-371, 2018.
6. M.S. Rafailovich. **Geology of Central Asian gold: ore evolution, metasomatic formations, explosive breccia.** Almaty, 2013.
7. Yu.S. Parilov. **Genesis of the main types of non-ferrous metals deposits in Kazakhstan (based on the results of studying fluid inclusions).** Almaty, 2012.
8. M.A. Mizernaya, S.S. Aitbayeva, A.I. Mizerny, B.A. Dyachkov and A.P. Miroshnikova. **Geochemical characteristics and metalogeny of Herzin granitoid complexes (Eastern Kazakhstan).** *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, Vol. 1, pp. 5-10, 2020.
9. C. Han, W. Xiao, G. Zhao, B. Su, P.A. Sakyi, S. Ao, B. Wan, J. Zhang, Z. Zhang and Z Wang. **Mid-Late Paleozoic metallogenesis and evolution of the Chinese Altai and East Junggai Oiogenic Belt, NW China, Central Asia.** *Journal of Geosciences*, Vol. 59(3), pp. 255-274, 2014.
10. G.D. Ganzhenko, M.A. Yudovskaya and I.V. Vikenyev. **Gold-polymetallic mineralization of the Ridder-Sokolnoye deposit in the Rudny Altai (Eastern Kazakhstan)**. *Mineralogy*, Vol. 4(1), pp. 8-34, 2018.
11. N.L. Dobretsov. **Fundamentals of geotectonics and geodynamics.** Novosibirsk, Novosibirsk State University, 2011.
12. G.N. Shcherba and B.A. Djachkov. **The Great Altai (Geology and Metallogeny). Geological structure.** Alma-Ata, Gylym, 1998.
13. V.A. Narseev. **Bakyrchik (Geology, geochemistry and mineralization).** Moscow, CSRGI, 2001.
14. F.A. Letnikov**. Ultradeep Fluid Systems of the Earth and Problems of Ore Genesis.** *Geology of Ore Deposits*, Vol. 43(4), pp. 291-307, 2001.
15. V.V. Yarmolyuk, D.A. Lykhin and A.M. Kozlovsky. **Composition, sources, and mechanisms of rare metal granitoids formation of Late Paleozoic East-Sayan zone of alkaline magmatism (on the example of Ulan-Tologai massif).** *Petrology*, Vol. 24(5), pp. 515-536, 2016.
16. M.P. Afanas’ev and N.N. Shash. **Russian Investments in European Countries: Current State and Future Prospects.** *Studies on Russian Economic Development,* Vol. 31, pp. 327-334, 2020. https://doi.org/10.1134/S1075700720030028
17. M. P. Afanasyev and N. Shash. **Russian Federation Cross-Border Investments and Bank Expansion.** *Public Administration Issues*, 6, pp. 105-120, 2019.
18. V.A. Khomyakov, Y.M. Shokbarov, A.A. Bryantsev. **Experience in Handling Differential Settlements of Multi-Storey Buildings on Soft Soil.** *Soil Mechanics and Foundation Engineering*, Vol. 54(5), pp 330–335, 2017. https://doi.org/10.1007/s11204-017-9477-x
19. V.A. Khomyakov, E.E. Iskakov, E.T. Serdaliev. **Investigation of gravelly soil during underground construction in Almaty.** *Soil Mechanics and Foundation Engineering*, Vol. 50, pp. 171–177, 2013. https://doi.org/10.1007/s11204-013-9230-z
20. A. Zhussupbekov, R.E. Lukpanov, S.B. Yenkebayev, V.A. Khomyakov. **Analysis of Slope Stability and Landslide in Seismic Active Regions**. In: J. Chu, S.P.R. Wardani, A. Iizuka. Geotechnical Predictions and Practice in Dealing with Geohazards. Springer: Netherlands, 2013. https://doi.org/10.1007/978-94-007-5675-5
21. M. Chakouri, A. El Harti, R. Lhissou, J. El Hachimi, A. Jellouli. **Geological and Mineralogical mapping in Moroccan central Jebilet using multispectral and hyperspectral satellite data and Machine Learning.** *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 9(4), pp. 5772-5783, 2020. https://doi.org/10.30534/ijatcse/2020/234942020
22. S.M. Gomez, A.P. Guantero, J.A. Bulgao, J.C.T. Arroyo, A.J.P. Delima. **MUSICHUB: A Web and Android Based Rehearsal Studio Locator and Reservation System in Davao City Utilizing Geolocation API and Rabin-Karp Algorithm**. *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 9(3), pp. 3746-3751, 2019. https://doi.org/10.30534/ijatcse/2020/189932020