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Research Article

EVOLUTION OF VOLCANIC FORMATIONS AND THEIR ORE-FORMING POTENTIALS (UZBEKISTAN)

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ABSTRACT
Evolution of magmatism is the most important trend, visible during various periods of the geological history of the Earth. Two sides of magmatism evolution are marked: cyclic process, as well as irreversible cycle, the beginning of each is fixed during whole broader development of basic magmatism, and the end shows dominance of acid, subalcalic and alkaline magmatism.
The problem of the relationship of mineralization and magmatism with geological structures has always been in the spotlight of petrologists, and huge special literature is devoted to this issue. Analysis of link of mineralization with magmatism is usually considered in two aspects: 1) correlation of endogenous mineralization with magmatism in different stages of evolution of the orogen areas in the various geodynamic environments; 2) causes and nature of the relationship of mineralization with magmatism.

Keywords: *Evolution, Magmatism, Plate Tectonics, Ore, Deposits, Uzbekistan*

INTRODUCTION
According to the theory of plate tectonics, magmatism is divided into two large groups: 1) confined to the limits of the lithospheric plates; 2) intraplate. In terms of volume and intensity, magmatism of plates boundaries prevails. It is mainly divided into magmatism of constructive or divergent borders (plates separation) and destructive, or converged borders (plates movement), although sometimes magmatism of plates slipping is marked (transform). In turn, in geodynamics of plates constructive boundaries, oceanic and continental rift magmatism is marked. Among geodynamic environments of plates, destructive boundaries magmatism of oceanic island arcs is distinguished, magmatism of active continental margins (Andes and Californian types), of collisions of continents, as well as of continents and island arcs collisions. Each geodynamic setting is characterized by its magmatic formations, and vice versa, each magmatic formation is formed in a strictly defined geodynamic situation.
Evolution of magmatism is the most important trend, shown during various periods of the geological history of the Earth. Two sides of magmatism evolution are marked: cyclical process, as well as irreversibility and directionality. Evolving magmatism includes several tectonomagmatic consecutive cycles, the beginning of each is fixed in the whole broader development of basic magmatism, and the end shows dominance of acid, subalcalic and alkaline magmatism.
The problem of the relationship of mineralization and magmatism with geological structures has always been in the spotlight of petrologists, and huge special literature is devoted to this issue. Analysis of link of mineralization with magmatism is usually considered in two aspects: 1) correlation of endogenous mineralization with magmatism in different stages of evolution of the orogen areas in the various geodynamic environments; 2) causes and nature of the relationship of mineralization with magmatism. Usually, the concept of "potential ore existence in magmatic rocks," "metallogenic" or "geochemical" specialization of magmatic rocks is used. The meaning of these concepts is widely known from the works of V.S. Koptev-Dvornikov, L.V. Tauson, H. M. Abdullayev, etc. The concept of potential ore-bearing in magmatic rocks (or components of their arrays) implies the ability of magmas or rocks to generate ore deposits in enabling tectonic and geological conditions, associated with them.

Study area

Evolution of the volcanic formations of Uzbekistan complies with the above patterns of magmatic processes evolution, so the authors have tried to address the questions of volcanogenic formations evolution in conjunction with the geodynamic evolution of the Tian-Shan fold belt in the structure of Western part of the Tien Shan mountains on the territory of Uzbekistan. Three segments with different geology and history of development are usually distinguished: Middle, Southern and South-Western Tien-Shan, as well as the Ustyurt Plateau.

Median Tian-Shan on the territory of Uzbekistan covers Chatkalo-Kuramin region and Fergana Valley, which form the southern part of the Kyrgyz-Kazakhstan continent, which represents active north outskirts of the Turkestan paleo-ocean, on which the so-called Hercynian volcano-plutonic belt is formed, imposed on Baikal-Caledonian accretion complex.

Fold system of Southern Tian Shan is located to the south of the structures of median Tien-Shan and covers Nurata and Malguazar mountains and the mountains of Bukantau, Tamdytau, Auminzatau, and Sultanuvajs. It represents divergent fold-thrust belt, organized by formations of the Turkestan paleo-ocean, of overthrust-folding type, based on protruding Caledonian accretion complex in Kyzyl Kum desert, transgressively overlapped by Hercynian carbonate dust cover.

Fold system of Southwest Tien-Shan is separated from Southern Tien-Shan by Zeravshan split and stretches from the Kuljuctau mountains in the West through Zirabulak-Ziaedin Hills to Zeravshan and Hissar ridges, covering Baysun-Kugitang zone.

Eastern Ustyurt. Its pre-Jurassic base, according to modern views, has similarities with Southern Tian-Šhan belt. This fold-thrust complex is formed as a result of Caledono-Hercynian collision processes. The fold base forms the package of terrains, being formed in different geodynamic conditions of oceanic rifting, continental shelf and the foot, as well as island arcs.

Study of magmatic rocks and igneous processes (as one of the most important factors of ore formation) in Uzbekistan have always attracted considerable attention, as reflected in numerous publications of Uzbek geologists.

Geology of Uzbekistan

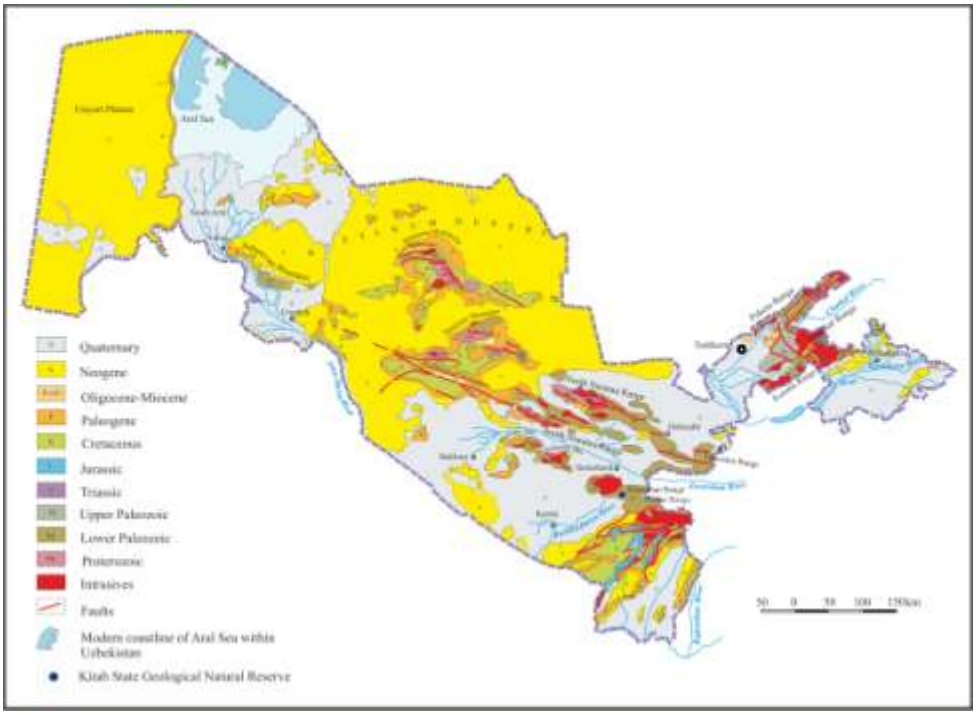

Figure 1: Geological map of Uzbekistan

MATERIALS AND METHODS

The materials for this article were collected during the thematic works on the topic "Study of the nature of evolution of volcanic formations and their ore forming potentials " in the period from 2008-2013 in the Goskomgeology. To collect materials, 20 outlets were set up in the field for sampling, exploring the area, and carrying out macro and micro petrographic sections. The routes passed through almost whole Uzbekistan including Usturt Plateau, Kizilkum desert and Tyan – Shein mountains. Also, when writing this article, reports were used that were compiled in the USSR (1966, 1985) for a complete understanding of the structure of the district. Silicate analyzes of 150 samples were carried out at the Central Laboratory of Goskomgeology (Republic of Uzbekistan). Separate elements such as gold, uranium and other rare elements were determined by the Plasma Atomic Emission Spectrometre ISPE-9000 Shimadzu in the laboratory of the State Institute of Geodesy of the State Committee of Geology (Republic of Uzbekistan). Also while writing this article, over 450 microscopic samples were produced and described to identify the results, which is presented in the article.

RESULTS AND DISCUSSION

Leading method of magmatic formations study is formation-environmental analysis, one of the founders of which, along with M.A. Usov, G.D. Afanasieff and Y.A. Kuznetsov was H.M. Abdullayev. According to the Petrographic code of the Republic of Uzbekistan, 2002, "igneous formation" or "formation type" is the term, corresponding to an abstract notion, summarizing the main features, inherent in a number of identical or similar compositions of concrete magmatic complexes, i. e.- standard for fitting specific complexes.

"Magmatic complex", which is a concrete manifestation of magmatic formations, is considered as a subject of corresponding information type.

"Volcanic complex", as a special case of the magmatic complex, is a concrete association (paragenez) of volcanic (effusive, volcaniclastic, hypabyssal) rocks, composing the geological body (epithelial, extrusive, subvolcanic, shallow and, hypabyssal) and their combination, located within a particular structural-formation zone. Therefore, rocks as cover and secant facies form volcanogenic-complexes, but often they are represented only with covering either section facies. The latest consolidated geological map of Uzbekistan, scale- 1:500000 (1998) shows volcanic rocks in the category of such volcanic complexes. This article will consider, in the evolutionary sequence, all reflected on this map volcanogenic complexes, supplemented with some new, recently received data.

Currently, on the territory of Uzbekistan, 68 volcanic complexes are allocated in the age interval from Upper Proterozoic to the Cretaceous period. In volcanic complexes correlation diagram (figure), they are arranged in chronological order (from oldest to youngest) from North to South in accordance with the geodynamic regime of their formation. Geological structure of these complexes, their petrographical and petrochemical characteristics are given in many published works, of which the most informative are: map of magmatic complexes of the Uzbek SSR, 1984; "Geology and mineral resources of the Republic of Uzbekistan", 1998; "Evolution and types of magmatism of Western Tien-Shan", 2010.

The Median Tien Shan, the most ancient volcanic formations are trachybasalts of Shorashuy complex of late-rift age. They are developed in the axial part of the Pskem mountain range where they compose lower parts of the opencast of namesake strata. Numerous dikes of basaltoid, breaking rocks of Beshor-Tunduk represent subvolcanic faces; intrusive significant manifestations of mineralization in this complex have not been discovered. Only in some cases, high concentrations of molybdenum and fluorine are marked.

In southern Tien Shan, metamorphosed volcanites are presented in the composition of Late-Riphean volcanogenic-sedimentary metabasalt complexes – Kokpatass (South Bukantau) and Taskazgan (Tamdytau, Nuratau). Copper occurrences, accompanied by a high content of gold and silver, are met in metavolcanits (amphibolite) of these complexes.

In South-Western Tien Shan in the Kugitang-Baysun crystalline Precambrian platform, there are highly-metamorphosed volcanic formations, comprising several Precambrian volcanogenic-sedimentary complexes. These are Zarautj metabasalt (Kuguitang), Hodjabuzbarak metabasalt-rhyolit (Baysuntau), Maland metabasalt-rhyolite (Surhantau), Ajlangar metabasalt-andesite (Baysuntau) and Handizin metabasalt-rhyolite (Surhantau) complexes. These complexes are presented by streaks of amphibolites (metabasalts) and gneissose granites (metarhyolites), lying among the gneisses and crystalline slates of relevant metamorphic strata. Any ore occurrences, associated with this complex, are not found. Among geochemical characteristics, high levels of arsenic, gold, silver, lead, and bismuth should be noted.

Lower Paleozoic volcanogenic formations in Median Tien Shan are presented by diabases, andesites and basalts in the composition of Sandalash ($Є$-O_2), Beshtor (O_{2-3}) and Autor (O_3) strata, with which some conventionality is grouped into basalt-andesite formation. The metallogenic significance of these volcanits is unclear.

In Southern Tien Shan this period is fixed with volcanogenic-sedimentary complexes of Ordovic-Silurian age: metabasalt Madjerum (Northern Nuratau) and metabasalt-plagiorhyolit Uchkuduktau (Tamdytau), representing the rocks of the upper layer of the oceanic crust of Paleoturkestan Ocean. In spatial relation to the Madjerum complex, minor exposures of copper and iron (jasperoids) are known.

In South-Western Tien-Shan mountains in Ordovician time, medium Upper-Ordovician volcanogenic-sedimentary Kazakasuy and Shuruc complexes (Kuldjuktau) and also Altyaul complex (Zirabulak) are formed, presented with andesites, dacites, rhyolites and their tuffs in the composition of the same name strata. Ore-bearing of these volcanits has not been studied enough.

In the mountains of Chakil-Kalyan (northern slopes of Zeravshan mountain chain) volcanogenic rocks are widespread of Shakhriomon Upper-Ordovician volcanogenic-sedimentary trachiandesite-trachidacitet-trachirhyolit complex. Ultra-potassic trahiriolites of this complex are new perspective type of feldspar raw material with industrial resources.

On the southern slopes of Gissar range at that time Mastavat medium-upper Ordovician sedimental - volcanogenic metabasalt-rhyolite complex and underlying Obizarang sedimental -volcanogenic metabasalt-rhyolite complex was formed, with the first of which gold-polymetallic exposures of Chairla were connected and with the second - gold ore exposures of Ojnamak lower and Chashma-Hajdaroz were connected.

In the Silurian time in Northern Tamdytau Kushkumbay (Kosbulak) lower Upper-Silurian volcanogenic-sedimentary andesite-basalt complex with which it was formed Balpantau and Tamdibulak ore grade gold deposits and synchronously to it in Nurata and Malgazar mountains Djazbulac Lower-Silurian volcanogenic-sedimentary metabasalt complexes were formed. Basaltoids of Djasbulac strata are present in the form of olistoliths and olistoplacs in the Katarmajsk olistostrome sequence

The Middle Paleozoic in Median Tien Shan was marked by the formation of Chimkurgan volcanogenic-sedimentary lower-middle Devonian basalt-andesite complex (Pistalitau mountains) that spatially and genetically linked deposit of iron Temirkan. At the same time, in the mountains of Hanbandytau (foothills of Northern Nuratau range) band volcanogenic trachidacit-trachyoliy complex is formed, with which polymetallic deposit Uchkulach is associated.

In Chatkal-Kuramin mountains at the same time, Katrangin lower-middle Devonian volcanogenic-sedimentary trachirhyolit-trachiandesite complex and Kalkanatin trachirhyolit-trachidiacite complexes were formed with geochemical high content of rubidium, copper, and gold.

In the mountains of Sultanuvajs, Silur- Devonian period is the time of the most volcanic processes activity. In Eastern Sultanuvajs volcanism begins with Sultanuizdag Upper-Silurian- lower Devonian volcanogenic-sedimentary metabasalt complex, it continues with Djamansay lower Devonian volcanogenic-sedimentary metabasalt and ends with Beshmazar lower Devonian volcanogenic-sedimentary andesite-dacite-rhyolite complex. Metallogenic specialization of these complexes is not found.

In Western Sultanuvajse in lower middle Devonian time, Sheikh-djeilin volcanogenic-sedimentary basalt-andesite-rhyolite complex is formed, which overlaps the middle upper Devonian Kuyanchic andesite-dacite complex. With these complexes, exposures of copper and gold are associated.
Upper Paleozoic stage of volcanism was the most intense and widely shown on the territory of Uzbekistan.
In Median Tien Shan, volcanism of this phase begins with Uin lower-middle coal volcanogenic-sedimentary trachibasalt-trachirhyolit-trachidiacite complex, continues with middle-coal volcanogenic-sedimentary Minbulak trachibasalt-trachirhyolit-trachidiacite complex, rocks of which are enriched in copper, molybdenum, lead and silver, and is associated with several points of copper mineralization.
Later volcanits of middle coal (S_2m) formed Bolgalin volcanogenic-sedimentary trachiadesite-trachidiacite complex, with which gold-silver mineralization was associated, and Akchinsk middle coal volcanogenic-sedimentary andesite dacite complex followed it.
Coal volcanism finishes in Chatkal-Kuramin region with formation of Nadak formation (Karabau) medium-upper coal volcanogenic-sedimentary trachiadesite- trachidiacite -rhyiolit complex, which is associated with gold-silver with telluridami deposit of Kochbulaq.
In southern Tien Shan oceanic phase of upper Paleozoic volcanism is fixed with Tubabergen (D_3-C_2) volcanogenic-sedimentary trachibasalt-trachiandesite complex in Northern Bukantau, Karashakh (D_2-C_2) complex of similar age and composition-in Northern Tamdytau, Elemesashinsk (S_2) trachibasalt-trachiandesite in South Tamdytau and Shavaz (D_1-C_2)-trachiabasalt complex in the North, in Nuratau, Djilandin (D_1) ankaramit-basalt complex in the mountains of Ziaetdin were fixed.
Island-arc phase continues with Berkuttau (Ashenyntau) middle coal volcanogenic-sedimentary basalt-andesite-rhyolite complex in West Sultanuvajs and Sangruntau (Balpantau) middle volcanogenic-sedimentary basalt-andesite-dacite complex in Northern Tamdytau.
In Gissar region oceanic phase of upper Paleozoic volcanism begins with lower coal basalt-plagiorhyolit Karatag and Chotnaushur complexes. In the watershed part of Gissar range, connected with copper-pyrites mineralization, Gawa is associated with the latter.
At the same time on southern slopes of Gissar range and Baysun-Kugitang mountains lower coal volcanogenic-sedimentary Ojnamak basalt-rhyolite and Vahshivar dacite-rhyolit complexes formed. Polymetallic deposit of Khandiza is associated with the latter.
In middle Carbone in the watershed part of Gissar Range, Kulmansur volcanogenic-sedimentary andesite-dacite-rhyolite complex formed, and on southern slopes synchronously It-Sagdor complex of the similar composition formed.
Over subduction volcanism ends in the watershed part of Gissar Range with Tamshush medium-upper coal volcanogenic-sedimentary trachiandesite-trachyte-trachirhyolit complex.
On southern slopes of Gissar range at the same time Hauz complex with the similar composition formed with which gold-silver mineralization is associated.
Post-collision stage of volcanism was also fairly widely evident in the territory of Uzbekistan. Median Tien Shan of that period was fixed by Oyasay (P1as) volcanogenic-sedimentary trachyte-trachirhiolit-rhiolit complex, associated with Shavaz deposits of lithium, as well as on adjacent Tajik territory- silver-polymetallic deposit Kanimansur. A little later, in sakmar time here Shurabsaj volcanogenic-sedimentary trachibasalt-trachyandesite complex formed, and here, this period ended with perm Kyzylnurin volcanogenic-sedimentary rhyolite-trachiriolit complex, metallogenically specialized in fluoride and rare metals.
In Eastern Sultanuvajse at the same time, Gaurkalin volcanogenic-sedimentary rhyolite complex was formed.
In southern Tien Shan perm period is characterized by an outbreak of basalt alkaline magmatism. In southern Bukantau Karashaho, diatreme formed, folded by lamproite rocks of the eponymous volcanic complex, associated with the manifestation of diamond mineralization.

In Northern Tamdytau at this time structurally complicated Kungurtepa volcanogenic-sedimentary picrite rhyolite complex formed, with which also manifestations of diamond mineralization are associated.
In South-Western Tien Shan post-collision stage is fixed with the formation of lower Permian volcanogenic Luchob dacite-rhyolite complex and the Permian Kajrak volcanogenic-sedimentary trachiandesite - trachiabasalt complex (South of the Baysuntau and Surhantau mountains).
This outbreak of volcanism completes with Hanakin conditionally Permo-Triassic volcanogenic-sedimentary rhyolite complex, locally developed in South-Western spurs of the Gissar Range.
Middle-Upper Triassic is characterized by the scattered rifting process with the formation of regionally widespread volcanic (dike-diatreme) Southern Tian-shan complex of alkaline basaltoid, associated with manifestations of diamond mineralization.
Volcanic activity on the territory of Uzbekistan in Cretaceous period completed with introducing alkali basaltoid of Angren-djigaristsan volcanic complex (Chatkalo-Kuramin), as well as the formation of structurally complicated volcanogenic (dike-diatreme) Chagatai trachyte-carbonatite complex, perspective with rare earth and magnetite mineralization. Melanocratic carbonatite Chagatai complex is associated with manifestations of diamond mineralization.

CONCLUSION

Each geodynamic environment is characterized by characteristic magmatic formations and, conversely, each magmatic formation is formed in a strictly defined geodynamic environment.
Evolution of magmatism is the most important regularity, manifested in all periods of geological history of the Earth. In this case, two aspects of the evolution of magmatism are noted: cyclicity on one side, and in other side irreversibility and direction. The stages of evolution of magmatism include a series of successive tectonomagmatic cycles, the beginning of each of which is fixed, on the whole, by the broader development of basite magmatism, and the end by the predominance of acidic, subalkaline and alkaline magmatism.
As can be seen from the above review, the most productive in terms of the formation of large mineral deposits is the post-collisional stage of volcanism (R-K), when the main deposits of gold, polymetals, diamonds, etc. were formed.

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