https://doi.org/10.33271/nvngu/2022-2/011

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ON THE POSSIBLE ROLE OF MAGMATISM IN THE ATASU TYPE STRATHIFORM MINERALIZATION (CENTRAL KAZAKHSTAN)

Purpose. Studying the geological features of large industrial "Atasu type" ore objects.

Methodology. Critical analysis of literature and stock materials, comparative analysis of geological factors characteristic of stratiform ores, stages and peculiarities of formation depending on the processes of volcanism, analysis of the results of isotope dating of rocks.

Findings. Participation of volcanism (magmatism) processes in forming deposits of ferromanganese and barite-polymetallic ores of the Atasu type was minimal. It was expressed only in the development of a dissected pre-Famennian paleorelief favorable for the accumulation of metal-bearing silts and in the development of local hydraulic seals, which made it possible for the metal-bearing waters to circulate. Magmatic formations are protrusions of more ancient pre-Famennian Givetian-Franian volcanic structures.

Originality. The pre-ore age of subvolcanic intrusions partially confirmed by the results of determining the absolute age, from the samples taken in the quarry of the Ushkatyn Ɨ deposit that amounted to 373 ± 4 million years, which corresponds to the middle of the Frasnian stage. The presence of three Atasu type ferromanganese deposits in the amagmatogenic Aidagarly graben-syncline also confirms this hypothesis. The genesis of deposits of the Atasu type is considered as sedimentary-hydrothermal one, associated with the processes of diagenesis and catagenesis.

Practical value. Predicting the possibility of finding deposits of the Atasu type in graben-synclines throughout the entire area of the Devonian volcano-plutonic belt.

Keywords: *Zhailma graben syncline, Atasu type, devonian volcanoplutonic belt, deposit genesis*

Introduction. In Central Kazakhstan, the discovery of new large industrial ore objects of the "Atasu type" in carbonate-terrigenous strata that fill superimposed depressions is primarily determined by reliability of geological and genetic metallogenic factors underlying the forecast. Based on the critical analysis of the published literature, this article attempts to clarify the role of magmatism (volcanism) in the processes of metasomatism and concentration of ores of the Atasu type deposits, which acts as the main predictor factor. The authors' (subjective) approach to the coverage of this issue is quite debatable however, in the current situation with reproduction of the mineral resource base in Kazakhstan, it seems not only possible but also extremely necessary.

The ideas of the stratiform iron-manganese and barite-lead-zinc mineralization of the Zhailma graben-syncline genesis were formulated in the period from the mid-1950s and have remained practically unchanged to the present day.

Within this period, the Soviet school dominated in metallogenic constructions, according to which each ore formation was associated with indusia determined by the age position, composition and formation depths. Subsequently, in Kazakhstan, the principle of metallogenic analysis of the Bilibino school was applied, which singled out its metallogenic specialization for each stage of the geosyncline development determined by the type of magmatism and its place in the geosynclinal process. At this, the allocation of promising areas did not differ much from that of M. A. Usov – K. I. Satpaev. Thus, Kazakh metallogeny of that time was mainly based on fixist positions, on ideas of the magmatogenic origin of endogenous ore deposits and the juvenile source of ore matter [1].

In this regard, the geologists who studied stratiform deposits of the Atasu type faced an urgent need to search for igneous (volcanic) formations with which it is possible to associate the formation of ore deposits and the accompanying hydrothermal-metasomatic processes that led to the accumulation of ferromanganese and barite-polymetallic ores.

So, N. S. Shatsky (1954) connected the hypothesis of the volcanic-sedimentary origin of ores with the supply of volcanic material from the Northern Balkhash region, where volcanic rocks in the Famennian-Carboniferous deposits has been known for a long time. N. S. Shatsky believed that the ore content of the formation was caused by a "remote" source or removal of ore material by local fumaroles that were far from the main centers of volcanism.

Noting the extremely insignificant scale of volcanic processes manifested in the Zhailma graben-syncline, compared with the deposits of Europe, N. A. Shtreis (1938) supposed that they were mainly expressed in fumarole activity, with which there was associated uneven, "spotted" silicification of limestones and ore formation.

Initially, only ferromanganese deposits were attributed to the Atasu type, of which genesis there were different points of view. So A. P. Russakov, K. I. Satpayev attributed them to the hydrothermal-epigenetic type; A. G. Betekhtin, G. S. Momdzhi to the primary sedimentary one, which arose as a result of lateritic weathering of the Frasnian effusives; N. A. Shtreis, N. L. Kheruvimova, N. S. Shatsky and others to volcanogenic-sedimentary one due to ore-bearing hydrotherms coming from magmatic sources.

Results. In connection with the discovery of barite-polymetallic ores at a number of ferromanganese deposits in the 60s of the last century, the association of ferromanganese with poor barite-polymetallic ores began to be considered as primary hydrothermal-sedimentary one, the accumulation of which took place in the Famennian sea basin due to volcanic activity. The main number of ore components was introduced into the subsequent hydrothermal-metasomatic stage of ore genesis. The combination of two stages of ore genesis in space led to the formation of industrial deposits. The third hydrothermal stage is manifested locally and led to the formation of small lenses, streaks of copper and copper-barite ores.

Thus, the term "Atasu type" began to be considered as a complex polygenic one including sedimentary hydrothermal-sedimentary ferromanganese and poor barite-polymetallic ores, as formations of the first stage of ore genesis. At the second stage, the richest post-sedimentary hydrothermal-metasomatic ore deposits of barite, lead and zinc were formed. The formation of ores of the second stage was accompanied by intense near-ore hydrothermal processes in the form of baritization, silicification, albitization that is not typical for the first stage associated with manifestation of Famennian volcanism. The genesis of the deposits was considered by various authors as volcanogenic-sedimentary one [2–8]. At the third, final stage manifested locally (hydrothermal, vein), poor copper-barite ores, quartz-barite and quartz-calcite veinlets with pyrite were formed.

Complex deposits are confined to siliceous-argillaceous-carbonate deposits of the Famennian stage. Ore bodies of lenticular-stratal form lie in accordance with the enclosing rocks or cut them at an acute angle to the bedding. On this basis, ores are classified as stratiform.

The total thickness of the Famennian carbonate-siliceous-terrigenous formations and the lower part of the Carboniferous system is about 2,500 meters.

For the first time, volcanic rocks synchronous with the deposition of sediments in the ore-bearing formation of the Zhailma depression were established by E. A. Sokolova (1958), who described six levels of volcanic rocks in the section of well 191 represented by dark greenish-gray spilite-type volcanic rocks with amygdaloidal texture, lava breccias, agglomerates, tuffs and ashes with intercalations of carbonaceous limestones. All volcanic rocks were strongly altered: albitized, chloritized, sericitized and calcitized.

Later, A. A. Rozhnov (1962) described two levels of diabase porphyrites and their tuffs, 125 and 40 m thick, established at the North Zhairem deposit. Above and below these levels, siliceous limestones contain less thick interbeds of andesitic spilites and tuffs, as well as an admixture of ash material in various types of siliceous-carbonate rocks [3].

In the central part of the Zhailma trough D. G. Sapozhnikov and A. A. Rozhnov (1963) found light gray felsite with the contents of SiO_2 – 70.68 %, Na_2O – 3.60 %, K_2O – 1.93 % interbedded with thin levels of liparitic tuffs [4].

Formozova L. N., comparing the intensity of volcanism at the deposits of Central Europe, Altai with its manifestations in the Zhailma graben-syncline, notes that one of the specific features of the Late Famennian volcanism of the Caledonian part of Central Kazakhstan is the insignificant development of volcanic rocks (lavas and tuffs) of basic and intermediate composition in comparison with sedimentary and volcanic-sedimentary rocks [5].

Within more than 70 years of study on the Zhailma trough, a significant number of works have been published on the issues of the ore genesis and their possible connections with igneous (volcanic) complexes. Further in the article, attention is focused only on some provisions that are important for general conclusions about the effect of magmatism on the formation of the Atasu type ores. Preference is given to the articles by the authors who carried out directly geological exploration work at the ore objects of the Zhailma graben-syncline, who studied volcanogenic and igneous rocks, their morphology, composition, and relationships with enclosing sediments, and who had a more balanced approach to assessing the role of volcanism in the processes of ore genesis.

Puchkov E. V. and Naydenov B. M. note that an insignificant admixture of tuffaceous material (no more than 1 %) of the total volume of rocks and their nature (tuffs, tuffites) indicate great remoteness of the source of pyroclastic material and its inertness in the transportation of ore matter. In this regard, for the Zhailma trough and other superimposed structures of the Famennian age in Central Kazakhstan, the presence of a volcanic source of ore matter is unlikely.

Then the authors point to the confinement of many deposits of the Atasu region to intrusive rocks of syenite composition occurring in the form of stocks and respectively occurring in enclosing rocks. At this, they conclude that the ***presence of intrusions is a necessary condition for the formation of deposits of the Atasu type.***

As a result of studying the isotopic lead contained in syenites, it was found that lead from igneous rocks almost did not participate, or did not participate at all in the ore process [6].

Shchibrik V. I., Mitryaeva N. M., and others [7] indicate the presence in some areas of the Zhailma graben-syncline of subalkaline lavas and much less often liparites, pyroclastic material, as well as the development in a small number of intrusive formations represented by dikes, sill-like and stock-shaped bodies of subalkaline diabases that are similar in composition to basalts that cut through the Famennian –Visean deposits. At Zhairem, subconsonant complexly built bodies conventionally referred to as K-feldspar or trachyte porphyries, at Bestyube isolated dikes of albitized granite-aplites and syenite-diorite porphyrites were found. The authors point out the absence of a direct connection, both ferromanganese and lead-zinc mineralization with basalts, noted earlier by Sapozhnikov, 1963 and Formozova, 1968.

In the process of geological exploration in the Ushkatyn ore field, 300 m northeast of the Ushkatyn II deposits, A. A. Rozhnov, N. M. Mitryaeva and others found a small massif of intrusive granite-porphyries (0.4 km^2) breaking through the volcanogenic-sedimentary formations of the Givetian-Franian stages. In the southwestern part of the ore field, boreholes uncovered gabbro-diabases among the Famennian carbonate deposits. By analogy, the age of the intrusions was taken as post-Lower Carboniferous, and at the Ushkatyn III deposit, as part of a member of red-colored limestones, bodies of green amygdaloidal cutites and felsite were found, the thickness of which does not exceed a few meters [8].

Fig. 1 shows the section of the Zhailma brachianticline that controls localization of the complex barite-polymetallicores, in association with the Zhayrem jelly-manganese deposits. At the base of the "ore-bearing" member, a "comb-like" body of trachytes, probably of subvolcanic facies, was identified and traced by drilling. Its top lies subconformably with the enclosing sedimentary formations. In its upper (ridge-like) part, the authors showed the presence of complexly branching dikes. In Fig. 1 the dikes are highlighted in bright red, and the subvolcanic trachyte body itself is marked in pink.

The section clearly shows a regular increase in thickness, sediments enclosing (enveloping) the body of trachytes of the subvolcanic facies. Such a "clothing", with an increase in the thickness of sediments at the foot of ledges, rocky ledges, is very characteristic of their accumulation in submarine conditions and is associated with the process of "slipping" under the action of gravitational forces, and is a forensic evidence of an earlier origin of the body of trachytes, compared with enclosing ore-bearing sediments that are actually the apical protrusion of a subvolcanic intrusion, the intrusion of which is associated with intense manifestations of shear-late Devonian volcanism.

According to A. A. Rozhnov, N. M. Mitryaeva, et al. (1982) at the deposits of the Karazhal group, the composition of the ore-bearing formation is quantitatively dominated by marine sedimentary rocks [9]. Volcanites are locally manifested and are known in the *underore deposits* of the Dalnezapadny and Yuzhny deposits. In the first section, they are represented by a deposit of paleobasalts (sometimes pillow-shaped), several tens of meters thick, interbedded with tuffs and limestones; in the second one, by lavas and tuffs of trachyparites and trachycytes, more than 100 m thick. Rare and thin layers of tuffs are found everywhere. Sills and dikes of diabase porphyrites are somewhat more widespread, cutting through the Famennian and Tournaisian deposits.

Fig. 2 shows a section of the Zapadny Karazhal deposit. Structurally, the deposit, as well as the Zhayrem deposits, is controlled by a "ridge-shaped" ledge of basalts, amygdaloidal trachybasalts with basic tuffs.

Subvolcanic bodies of rhyolites, trachytes, basalts, and trachybasalts form positive forms of underwater relief, dividing it

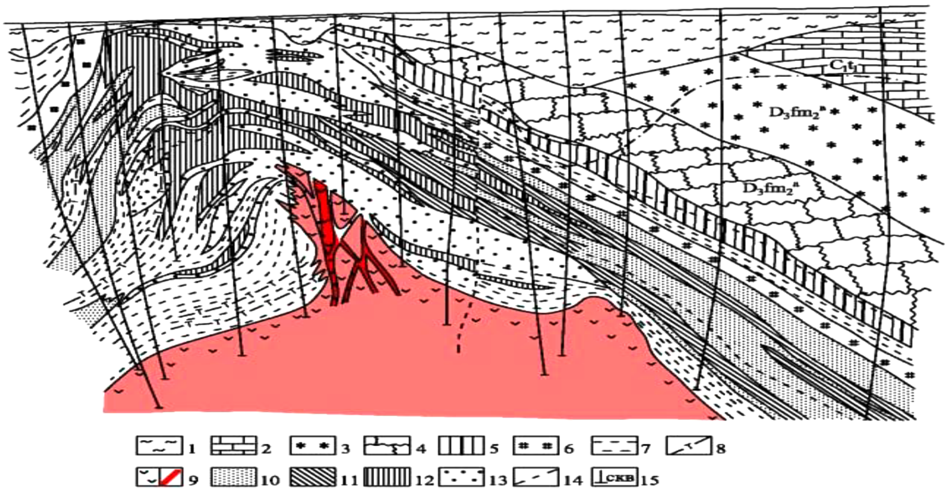

Fig. 1 . Geological and mineralogical section of the Zhairem deposit (*according to A. A. Rozhnov, N. M. Mitryaeva, D. N. Muratova*) [8]:

1 – cenozoic deposits: sands, loams, clays; 2 – black carbonaceous siliceous limestones; 3 – red-colored limestones; 4 – gray-colored siliceous-calcareous knotty-layered rocks; 5 – iron ore horizon; 6 – marking levels; 7 – barren rocks of the ore-bearing member; 8 – interlayers of tuffs; 9: (a) trachyte porphyries, (b) dikes; 10–13 – ores: 10 – lead-zinc (hydrothermal-sedimentary); 11 – lead-zinc, baritized; 12 – zinc-lead-barite (hydrothermal-metasomatic); 13 – copper-barite (hydrothermal); 14 – discontinuous violations; 15 – wells

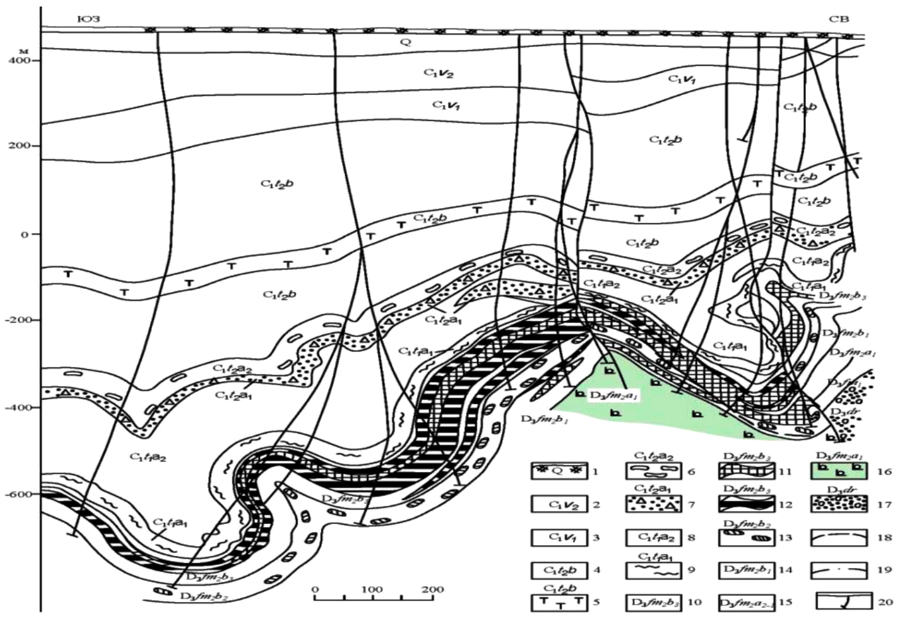

Fig. 2. Section of the Zapadny Karazhal deposit [10]:

1 – quaternary deposits, loam, sandy loam; 2 – polymictic sandstones with mudstone interbeds; 3 – siliceous and clay-carbonate-siliceous rocks; tuffites, tuffs; 4 – ash-gray limestone, sericite-siliceous-carbonate rocks; 5 – layer of pyroclastic siliceous-carbonate quartzite rocks; 6 – nodular limestone; 7 – subjaundice-sedimentary limestone breccias, siltstones level; 8 – clayey-siliceous-calcareous flyschoid rocks; 9 – siliceous and detrital limestones, sericitolites; 10 – siliceous-carbonate rocks and siliceous limestones; 14 – chlorite-clay-carbonate rocks with lenses of iron and manganese ores; 15 – clayey-carbonate-siliceous with interlayers of pyrite rhythmites, siliceous-carbonate rocks nodular and lenticular-layered, calcareous siltstones, lenticular-layered; 16 – almond-stony basalts and trachybasalts, basic tuffs; 17 – Daira Formation: conglomerates, sandstones, polymictic and volcanomictic siltstones, trachyrhyolites, tuffs and tuff-conglomerates of trachyrhyolitic composition; 18 – discontinuous violations; 19 – the boundary of the distribution of the weathering crust; 20 – hereinafter exploration wells

into a series of isolated silt depressions that are important for ore genesis.

In Fig. 3, in the section of the Bolshoi Ktai deposit, in the northeastern part, there is a dike-like intrusive body of "Early Carboniferous" gabbro-diabases and gabbro-diorites. Judging by the even, rectilinear boundaries of this "wedge-shaped" body, it most likely has tectonic thrust contact with the enclosing rock.

When considering the issue of the zonal distribution of various types of ores around the centers of volcanic eruptions, A. A. Rozhnov, et al. (1981) note that these issues have not been fully confirmed by detailed exploration work, not all deposits have signs of proximity to volcanic activity, so the connection with volcanism is paragenetic [3].

The latest monographic summary (Deep Structure and Mineral Resources of Kazakhstan, Volume 2 Metallogeny, 2002) notes that volcanism in the Famennian time was sporadic and on a very small scale. These are rapidly wedging out lenses of volcanic rocks located at different levels of the Famennian deposits. They are represented by derivatives of a contrasting basalt-rhyolite formation (V. M. Shuzhanov, 1984) that is characterized by increased and high alkalinity. Olivine basalts and trachybasalts are developed among the basic volcanic rocks, and trachyrhyolites are among the felsic ones. Among magmatites, subintrusive rocks (gabbro-monzonites, gabbro, gabbro-diabases, syenite-diorites, felsite-porphyry, forming stocks, sills and dikes) a special place is occupied by

Fig. 3. Geological section of the Bolshoy Ktai deposit [10]:

1 — quaternary loose deposits; 2 — contour quarry; 3 — hereinafter exploration pits; 4-–9 — upper famenn: ore-bearing member: 4 — variegated nodular-layered ferruginous-siliceous-carbonate rocks; 5 — ferruginous jaspers; 6 — hematite ores; 7 — mineralized wavy-layered red-colored limestones; 8 — manganese ores; 9 — dark gray and greenish gray thin-layered siliceous weakly ore limestones; 10–13 — lower and upper famenn: subore member: 10 — interbedded carbonate rocks, hornfelses, jaspers; 11 — interbedded dark gray layered and massive siliceous limestones, hornfelses and mudstones; 12 — limestone sedimentary breccia, dense dark gray and black siliceous limestones, mudstones, siltstones; 13 — dense dark gray and black siliceous limestones, mudstones, siltstones;14 — veins of barite; 15 — discontinuous violations; 16 — contour for counting iron, manganese and iron-manganese ores; 17 — well and its number; 18 — quarry contour

the rocks that have a small volume and insignificant distribution, high basicity (SiO_2 from 42 to 47 %), an abundance of olivine and increased potassium alkalinity (K_2O from 1.4 to 3.67 %) [3].

Thus, within the Zhailma graben-syncline, various researchers have established a wide range of volcanic-sedimentary (stratified) formations, which are a facies of long-range transport. They entered the sedimentary basin in a cooled form and, naturally, were neutral with respect to the processes of ore deposition.

"Igneous bodies" lie stratigraphically lower, either in the form of dikes devoid of roots participating in folding together with the enclosing sedimentary rocks, or in the form of ridges, tectonic wedges of gabbro-diabases and gabbro-diorites (Fig. 3). The latter were considered as Early Carboniferous.

In the authors' opinion, their presence in the Famennian-Carboniferous sedimentary basin is probably associated with both the collapse of the surrounding Early Upper Devonian volcanic positive structures associated with the high seismicity of volcanic areas, and with manifestations of local shaking associated with tectonic movements, especially in the basal layers of the trough. The largest bodies of trachytes, basalts, and trachybasalts probably represent local protrusions of "dike-shaped" bodies and extrusive domes, which protruded through erosional windows among the sediments of the Daira Formation and developed positive forms of underwater paleorelief. These formations divided the bottom of the Famennian sedimentary basin into a series of local depressions in which organic matter accumulated, as well as iron, manganese, lead, zinc and barite.

Determining the absolute age of rocks. The authors' ideas of the older age of the so-called intrusive formations underlying the carbonate-terrigenous deposits of the Zhailma trough are partially confirmed by the results of determining the absolute age of the trachyrhyolite selected in the Ushkatyn-1 quarry (S. I. Shkolnik, et al., 2021).

Trachyrhyolites are characterized by low contents of Sr (63 ppm) and Nb (25 ppm), high concentrations of Y (49 ppm) and distribution spectra indicating weak fractionation of rare earth elements (L_{an}/Y_{bn} = 3–4). These features that combine sharp minima in Sr and Ti and enrichment in a number of highly charged elements, are typical of A-type granites, whose formation is associated with within-plate settings. The zircon crystals isolated from trachyrhyolite are euhedral or subhedral with well-pronounced oscillation zoning and Th/U ratio varying from 0.65 to 0.90. This indicates the magmatic origin of zircon. U–Pb dating of zircon was carried out by the authors on a SHRIMP-II ion micro-analyzer at the A. P. Karpinsky Center of isotope research of VSEGEI. The analysis points obtained on the diagram form a concordant cluster with the age of 373 ± 4 Ma [11].

The dating of the absolute age obtained by the authors corresponds to the middle of the Frasnian stage of the Upper Devonian (Fig. 4), which corresponds to the lower boundary of the Darya Formation.

In the Ushkatyn ore field, these volcanics occur among the sediments of the Darya Formation, which is composed of continental red sandstones and mudstones, with basal conglomerates at the base. A characteristic feature of the suite is the presence in its composition of lenticular bodies of trachytes, trachyrhyolites, and less often trachybasalts. Its age is conditionally defined as the Middle Franco-Early Famenn. Stratigraphically higher are the deposits of the ore-bearing clay-siliceous-carbonate sequence of the Famennian age (D_{3fm}) containing volcanic rocks of the same composition as in the Darya Formation. This also confirms the authors' ideas of the older (pre-Famennian) age of the subvolcanic intrusions of the Zhailma graben-syncline.

Isotope studying argon, determining its air component, showed a significant content of air argon in gas-liquid inclusions of minerals and enclosing rocks and in newly formed hydrothermal stage. This is the evidence of vadose waters wide participation in the formation of the Atasu deposits.

Syromyatnikov N. G., et al. (1981) pointed to the deep origin of lead, zinc and a significant part of sulfur. In later hydrothermal solutions that led to the concentration of ore matter and the formation of industrial mineralization, sulfide and sulfate sulfur was borrowed from sedimentary rocks [12].

The results of isotopic studies allow drawing a conclusion about vadose and deep waters participation of in the processes of ore formation. In addition, for all the sedimentary basins, in the process of their formation, the accumulation in buried sediments of a large amount of free (marine) liquid, pore and crystalline waters is characteristic.

Patalakha G. N., Shuzhanov V. M., et al. (1991) considered the tectonic specificity of the ore-bearing strata of the Zhailma trough and drew attention to an important aspect when the dynamometamorphic cleaving process was superimposed on the strata that had not yet passed the stages of dehydration and dynamometamorphism (immature dynamometamorphism), in which there occurs not hard rock flow but that of water-saturated sediments (hydroplasticity) [13]. That is why the secondary tectonics at all the scale levels is so specific: the development of deep isoclinal clay formations along cleav-

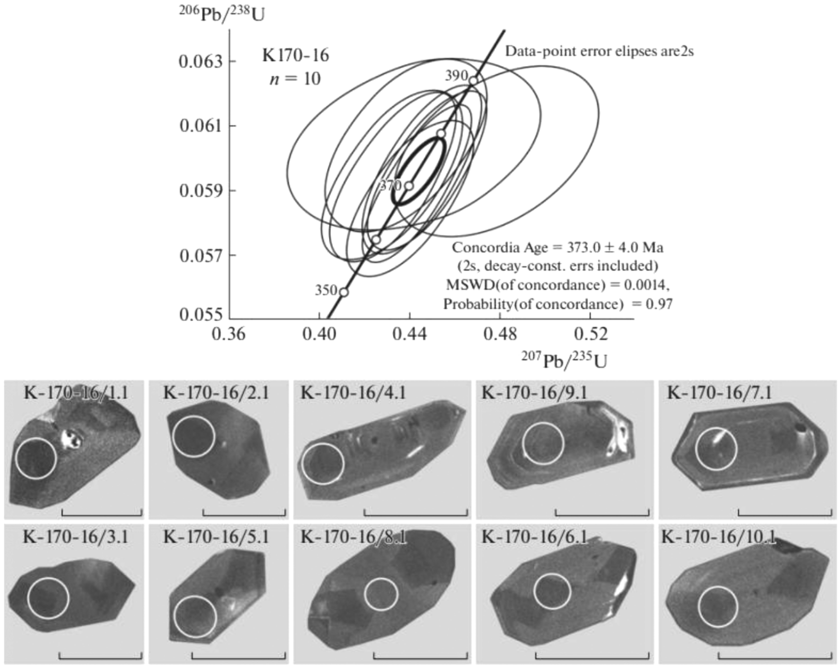

Fig. 4. Diagrams with concordia and examples of zircon crystals with oscillatory zoning (*cathodoluminescent photo, size scale in all the photos corresponds to 100* μ*m*) *from rhyolite* (*K-170*) *of the Ush-Katyn group of deposits* [12]

age slip planes, the almost complete absence of dynamo metamorphism zones (phyllites, green shales, etc.). The situation that can be qualified as a kind of metamorphism is not a solid body flow but a hydropathic one, devoid of commensurable metamorphic transformations. It is such a situation, according to observations of V. A. Lytkin that testifies to the discovery at Zhairem of siliceous nodules, whose cores turned out to be filled with a water-saturated plastic mass, obviously of sedimentary origin, captured in the process of centripetal growth of nodules and reflecting the prediagenetic stage of the initial sediment [14].

The hydrothermal-metasomatic stage of ore genesis is considered in detail by N. M. Mitryaeva (1979). The main ore stage (barite-polymetallic) is characterized by the temperature range of 120–195 °C, mineral associations of the late stage were formed with a sharp increase in temperature to 280–300 °C for coarse-grained barites, with decreasing the temperature to 100–200 °C for carbonate veinlets. In general, the balance ores of the Zapadny Zhairem deposits are outlined by the 200 °C isotherm with local elevations up to 250 °C in the form of a linear zone in the central part [15].

At the same time, as studies on the thermodynamics of sedimentary basins show, such temperature conditions arise in the process of diagenesis and catagenesis of sedimentary rocks and without participation of magmatism.

In the upper parts of the section of the emerging sedimentary basins, down to depths of 1–1.5 km (in the zones of diagenesis, proto-catagenesis), the rocks experience compaction due to the action of rock pressure. The total porosity of sandy-argillaceous deposits decreases with depth from 40–60 to 15–30 %. The groundwater temperature usually does not exceed 40–60 °C, and the formation pressure corresponds to hydrostatic pressure and reaches 10–15 MPa.

With further subsidence of sedimentary strata to depths from 1–1.5 to 4–5 km, the temperature rises to 200–250 °C, which is typical for the middle stage of catagenesis. At these depths, the processes of compaction of rocks continue, although less intensely, due to increasing rock pressure and the extraction of free groundwater (sedimentary) from them to the daylight surface. Porosity (total) falls by 5–20 % on average. Here, in the zone of mesocatogenesis, with an increase in temperature, starting from 100 °C and above, mainly in clayey strata, the processes of separation of physically bound waters into the free phase are actively manifested [16].

In the zone of diagenesis, in subaqueous marine conditions, the processes of decomposition of organic matter (mainly microbiota) and desulfation of waters buried with sediments are actively proceeding. These processes lead to the accumulation of methane, carbon dioxide, hydrogen sulfide, as well as zinc, copper, iron, manganese and other components in the waters.

High concentrations of hydrogen sulfide in silt depressions enriched in organic matter lead to the formation of a hydrochemical hydrogen sulfide barrier in the diagenesis zone, the presence of which probably led to the accumulation of poor ores of the first (sedimentary) stage of the Atasu ore genesis.

Industrial ores (hydrothermal-metasomatic) are formed when thermal, metal-saturated hydrothermal fluids enter the hydrogen sulfide barrier zone from the catagenesis zone.

Poor ores of the third stage were formed from residual solutions.

Conclusions. The long and complex process of formation of the Atasu type stratiform mineralization during the Famennian and Early Carboniferous took place under conditions of high watering of the sedimentary section. At the same time, the issues of the possibility of intrusions into the subaquatic environment and the preservation of igneous rocks, especially dikes, were not covered in publications substantiating the role of magmatism in the formation of rich ores of the hydrothermal-metasomatic stage.

1. The presented data allow assuming that the role of volcanism and magmatism in the formation of ores of the hydrothermal-metasomatic stage of the Atasu type deposits is minimal. However, for the final solution of this problem, it is necessary to study the absolute age of syenite-diorites. trachybasalts, trachytes, as well as samarium-neodymium radioisotope.

2. The presence of stratified and underlying volcanogenic and magmatic formations at the base of the Daira Formation played a certain role both in creating a dissected paleorelief of the trough base and in local aquicludes, which formed specific hydrodynamic conditions for the circulation of hydrothermal fluids from the catagenesis zone and redistribution of vadose waters. The role of the positive forms of the pre-Famennian paleorelief requires a more complete separate consideration.

3. The genesis of Atasu type deposits is recommended to be considered as sedimentary-hydrothermal, associated with the processes of diagenesis and catagenesis occurring within sedimentary basins.

4. The validity of the authors' ideas is confirmed by the discovery in 1986 of industrial deposits of ferromanganese ores, such as Tur, Bogach and Karaadyr in the amagmatogenous Aydagarly graben-syncline, as well as the presence of occurrences of polymetals (Gavrilovskoye, Taldysay, etc.) in other Famenno-Carboniferous structures Sarysu-Teniz segment of the Devonian volcanic belt. All the deposits and manifestations of ferromanganese and polymetallic ores are of the stratiform type and are associated with carbonate-terrigenous formations of the Famennian sulcifer suite. This allows considering the Famennian-Carboniferous depressions (graben-synclines), devoid of manifestations of volcanism and magmatism, as very promising for identifying industrial deposits of the Atasu type.

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Про можливу роль магматизму у формуванні стратиформного зруденіння атасуйського типу (Центральний Казахстан)

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Мета. Вивчення геологічних особливостей великих промислових рудних об'єктів «атасуйського типу».

Методика. Критичний аналіз літературних і фондових матеріалів, порівняльний аналіз геологічних факторів, характерних для стратиформних руд, стадій та особливостей формування у залежності від процесів вулканізму, аналіз результатів ізотопного датування гірських порід.

Результати. Участь процесів вулканізму (магматизму) у формуванні родовищ залізомарганцевих і барит-поліметалічних руд «атасуйського типу» була мінімальною. Виражалося воно лише у створенні розчленованого дофаменського палеорельєфу, сприятливого для накопичення металоносних мулів, та у створенні локальних гідроупорів, що зумовили можливість циркуляції металоносних вод. Магматичні утворення є виступами найдавніших дофаменських живецько-франських вулканічних структур.

Наукова новизна. Дорудний вік субвулканічних інтрузій частково підтверджений результатами визначень абсолютного віку зі зразків, відібраних у кар'єрі родовища Ушкатин Ɨ, який становив 373 ± 4 млн. років, що відповідає середині франського ярусу. Наявність в амагматогенній Айдагарлінській грабен-синкліналі трьох залізомарганцевих родовищ «атасуйського типу» також підтверджує цю гіпотезу. Генезис родовищ «атасуйського типу» розглядається як осадово-гідротермальний, пов'язаний із процесами діагенезу й катагенезу.

Практична значимість. Прогноз щодо можливості знаходження родовищ «атасуйського типу» у грабен-синкліналях на всій площі девонського вулкано-плутонічного поясу.

Ключові слова: *Жаїльмінська грабен синкліналь, атасуйський тип, девонський вулкано-плутонічний пояс, генезис родовищ*

The manuscript was submitted 14.08.21.