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GEOMECHANICAL AND PETROPHYSICAL PARAMETERS OF THE HOSTING ROCKS OF ARGUNSKOE DEPOSIT

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Abstract. By 2023, it is planned to begin development of the Argunskoe deposit, which includes in its bowels up to 35 % of the uranium reserves of the Streltsovskoe ore field in East Transbaikalia. The complex geological and structural structure of the Argunskoe deposit and the exceptional heterogeneity of the host rock stratum, represented by granitoids, gneisses, crystalline schists, syenite-porphyry, marbled limestones, basalts and others, necessitate the identification of the physicomechanical properties of the host rocks to ensure safety and optimization of mining operations, as well as identifying patterns of localization of ore bodies. Significantly complicates the picture is a wide range of post-magmatic, hydrothermal-metasomatic and deformational transformations of rocks of various genesis. Samples of the host rocks of the Argunskoe deposit massif located near the ore bodies were taken. Their porosity and density properties were determined, elastic parameters were studied, and geomechanical tests were carried out in conjunction with mineralogical and petrographic study of rocks. In particular, the nature and intensity of mineral and deformation (structural-petrological) transformations are determined. Differences in the composition and properties of the host rocks were identified, petrophysical characteristics of the rocks, which may be important for the further exploitation of the Argunskoe deposit, were recorded. The research results suggested that dolomitic limestones, which are in maximum contrast with granites and gneisses, can act as a geochemical barrier to the filtration of ore-bearing solutions, contributing to the deposition of ore components. The influence of the nature and intensity of mineral and deformation (structural-petrological) transformations of rocks on their physical properties is shown.

Keywords: geomechanics, petrophysics, uranium deposit, ultrasound.

Introduction

Established in 1968, the Priargunskoe Industrial Mining and Chemical Union (hereinafter referred to as PJSC PIMCU) is currently the largest uranium mining enterprise in Russia. Uranium is mined underground on the basis of two operating mines - No. 1 (Antey deposit) and No. 8 (Malo-Tulukuevskoe deposit). The Antey deposit, localized at depths of 550–870 m in relatively homogeneous granitoids of the Streltsovskaya caldera basement, is currently the main source of uranium at the Streltsovskoe ore field located in East Transbaikalia, 460 km southeast of Chita. However, due to the predictable mining of its reserves by 2023, PJSC PIMCU made a decision about temporary suspension of this mine. In the near future, it is planned to put into operation mine No. 6 and on its basis the development of the Argunskoe deposit will begin, containing up to 35% of the uranium reserves of the Streltsovskoe ore field. At the moment, the work to create the necessary infrastructure and to prepare for the excavation is underway, as well as the drilling of exploratory and hydrogeological wells.

The Argunskoe deposit is located in the basement of the West lithologic-structural block of the Streltsovskaya caldera in the axial part of the east-northeastern Argunskoe deep fault zone and its intersection with the meridional fault, the main magma and ore bearing channel is formed. This part of the caldera contains the Krasnokamensk and Yugo-Zapadny volcanic apparatuses, therefore acid effusive of vent facies prevail in the geological section. Pecularity of the Western block is the heterogeneous composition of the basement, in which repeated processes of silicic alkaline metasomatism, acid leaching and hydrothermal transformations are intensely manifested.

Unlike other deposits of the Streltsovskoe ore field, at the Argunskoe deposit, along with structural factors, lithological control and the chemical composition of rocks were of particular importance in the processes of ore formation. Dolomitic limestones that are chemically contrasting with granites, played the role of a geochemical barrier to the filtration of ore-bearing solutions that facilitated the sedimentation of ore components (Fig. 1). As a result of favorable combination of hydrodynamic and geochemical factors, rich uranium and molybdenum deposits were formed, localized within three ore-bearing fracture zones isolated in space. The whole variety of ore bodies formed in ore-bearing zones is subdivided into two spatially interconnected morphological types - vein-like and stockwork-like [*Ishchukova*, 2007].

The need to study the physical and mechanical properties of the host rocks of the deposit is determined by a number of factors, including the regulatory requirements for the design and development of deposits [Pravila ..., 2018]; complicated complex structure of the Argunskoe deposit; identification of unopened “blind” ore bodies during geomechanical studies, modeling the stress-strain state of the massif and solving other scientific and practical problems. The survey results will form the basis for an up-to-date database of the Argunskoe deposit characteristics.

To date, the methods of structural-petrophysical analysis of rocks are used primarily in the study of the properties of hydrocarbon reservoirs (see, for example, [*Paul, Okwueze, Udo,* 2018; *Rashid, Hussein, Zangana,* 2020] etc.). However, the methods of structural and petrophysical analysis of ore deposits and crystalline rock massifs are being developed and become increasingly important. These methods are used to study the nature of greisens formation in tin-tungsten deposits [*Launay et al.*, 2019], to study the correlation problems and interpretation of petrophysical data in gold ore deposits [*Bourne, Dentith, Jumeau,* 2018], when considering automated interpretation of petrophysical data of rocks of iron ore deposits [*Kitzig, Kepic*, 2016]. To study crystalline massifs, an integrated approach is implemented, including geomechanical testing of the samples under study [*Gupta, Sharma,* 2012; *Kibikas, Carpenter, Ghassemi,* 2019]. The results of using this approach can be traced in this article.

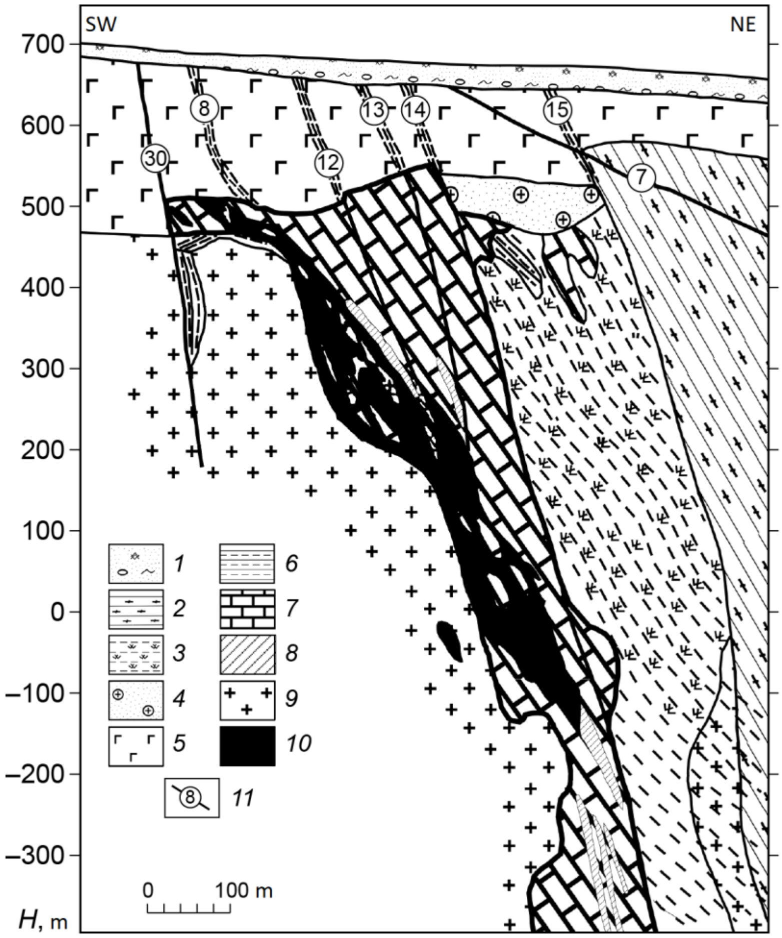

Fig. 1. Geological section of the Argunskoe deposit (according to [*Ishchukova*, 2007] with changes)

1 – loose deposits; *2* – Proterozoic fine-grained granite gneisses; *3* – amphibolites and amphibolite schists; *4* – basal conglomerates; *5* – basalts of the lower cover and their lava breccias; *6* – high alumina crystalline schists and micro schists (andalusite-quartz-micaceous schists with relicts of sedimentary rock structures); *7* – dolomites, dolomitic limestones, marls; *8* – molybdenum deposits; *9* – medium-uneven-grained intrusive-anatectic and metasomatic granites with substrate relics, migmatites; *10* – uranium ore deposits; *11* – faults

Mineralogical and petrographic characteristics of host rocks

It is extremely important to assess the influence of postmagmatic, metamorphic, hydrothermal-metasomatic processes from early high-medium-temperature (greisenization, kalifeldsparization, albitization, seritization) to late low-temperature (hydromicatization, argillization, microveinization) and deformational (structural-petrological) transformations of the original rocks on the nature of the leading type of deformations and variations of petrophysical parameters. Often, the nature and intensity of transformations are decisive in assessing petrophysical parameters, leveling the mineral-chemical composition and texture of the original host rocks. At the same time, high-medium-temperature (quartz, feldspars, biotite, amphibole) and low-temperature (quartz, hydromica, carbonate, chlorite, kaolinite, hematite, etc.) mineral deformational transformations (mylonitization, cataclase, blastesis, microbrecciations and veining) lead to the formation of textures of various types. The noted patterns were identified on the basis of a long-term detailed study of the standard deposits of the largest in Russia Streltsovsky uranium ore field - Antey, Argunskoe, Tulukuevskoe, Streltsovskoe, Dalnee and Novogodnee.

Photomicrographs of thin sections of the samples taken for the research, that make it possible to assess the heterogeneity of the rock strata of the Argunskoe deposit and different nature of mineral and deformation (structural-petrological) transformations, are shown in Fig. 2.

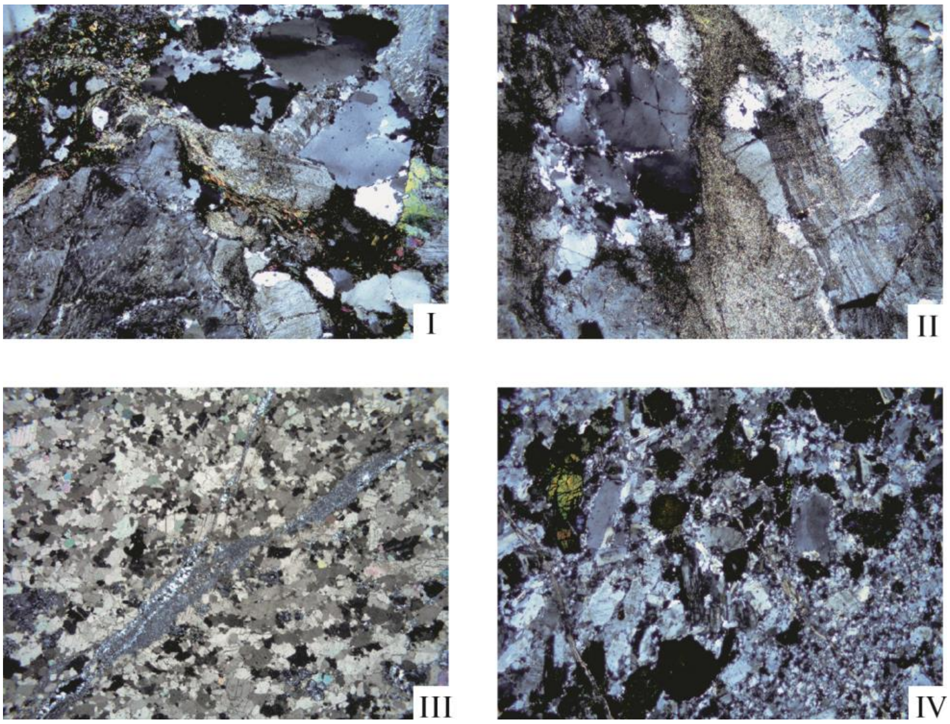

Fig. 2. The Argunskoe deposit. Thin sections of the host rocks: I (Ar-18-1) – hydromica and greisenized medium-uneven-grained metasomatic granite; II (Ar-18-2) – sericitized medium-uneven-grained metasomatic granite with the initial signs of disintegration; III (Ar-18-3) – Marbled (dolomitized) limestone with vein-metasomatic mineralization; IV (Ar-18-4) – Medium-fine-grained quartz-feldspar-biotite and quartz-plagioclase-biotite-amphibole schists and gneisses. The polarizers are crossed; the long side of the micrograph is 2.3 mm

Samples Ar-18-1 and Ar-18-2 are represented by metasomatic granites with different intensity of manifestation of high- and low-temperature processes. In sample Ar-18-1 (see Fig. 2, I) significant deformation-metasomatic transformations of both high-medium-temperature (silicic-alkaline metasomatism, greisenization) and low-temperature (hydromica) types are observed. In sample Ar-18-2 (see Fig. 2, II) high- and low-temperature cataclastic textures are not so clearly traced - here the silicic-alkaline and quartz-sericite metasomatism of the “areal” type (dynamometamorphic sericitization) is developed. Low-temperature metasomatism in this sample is presented mainly in the form of insignificant vein-metasomatic mineralization (hydromica).

Sample Ar-18-3 (see Fig. 2, III) is a marbled (dolomitic) limestone with rare lenticular-spotted interlayers of quartz-mica schists, vein-metasomatic mineralization and areas of silicification.

Sample Ar-18-4 (see Fig. 2, IV) combines medium-grained quartz-feldspar-mica crystalline schists and gneisses, as well as fine-grained granite gneisses with distinct gneiss-like textures and porphyroblastic structures. A characteristic feature of this sample is the predominance of high-temperature mineral transformations with the development of blastomylonite, blastocataclasite, and blastogranite structures. Unlike samples Ar-18-1 and Ar-18-2, in this sample, low-temperature mineralization is manifested in an insignificant amount.

Study of the porous density characteristics of host rocks

The study of porosity and density of samples of host rocks from the Argunskoe deposit was carried out using the method of hydrostatic weighing. At the same time, the authors compared two methods of saturation - free and forced with the use of evacuation and resaturation under pressure.

In the first case, the experiment was carried out in the indoor conditions. First, the samples were dried at the temperature of 105–110 ° C until the termination of the weight loss. Then they were placed in water and weighed on a balance immediately after dipping and then, as they were saturated, after 1 min, 10 min, 1 h, 1 day, 3 days, etc. until the end of the saturation process (weighing accuracy - 10 mg). The advantage of this method lies in its simplicity, availability of equipment and the possibility of studying additional parameters obtained only with gradual saturation and periodic measurements (conditionally instantaneous saturation and half-saturation period). The disadvantage of the method is the presence of residual gases in the pores preventing the complete saturation.

Forced saturation using evacuation and resaturation under pressure enables the complete saturation of the sample, but makes it possible to obtain only the values of its porosity and density. This requires additional equipment.

The purpose of comparing the described methods is to determine the magnitude of the discrepancy between the results obtained when using them. The calculations were performed according to the following formulas [*Burmistrov et al.*, 2009]:

$$\rho = \frac{P_d}{P_d - P_{fw}} \times \rho_w \,, \qquad (1)$$

$$\Pi_{эф.} = \frac{P_{fw} - P_{dw}}{P_d - P_{dw}} \times 100\,\% \,, \qquad (2)$$

where ρ is the density of the sample, g/cm^3; ρ_w=0.998 g/cm^3 is the density of water at the indoor temperature; P is the weight of the sample, g; subscript corresponds to: d is a dry sample in air; dw is a dry sample in water; fw is fully saturated sample in water; $\Pi_{ef.}$ Is effective porosity of the sample, %.

The density, determined by hydrostatic weighing, approximately corresponds to the natural mineral density of the rocks. Only if there is a large volume of closed pores it can noticeably differ from the true mineral density, but in most cases this difference is acceptably small [*Burmistrov et al.,* 2009].

The results of calculating the density and effective porosity of the samples obtained using the above saturation methods are displayed in the form of plots in Fig. 3.

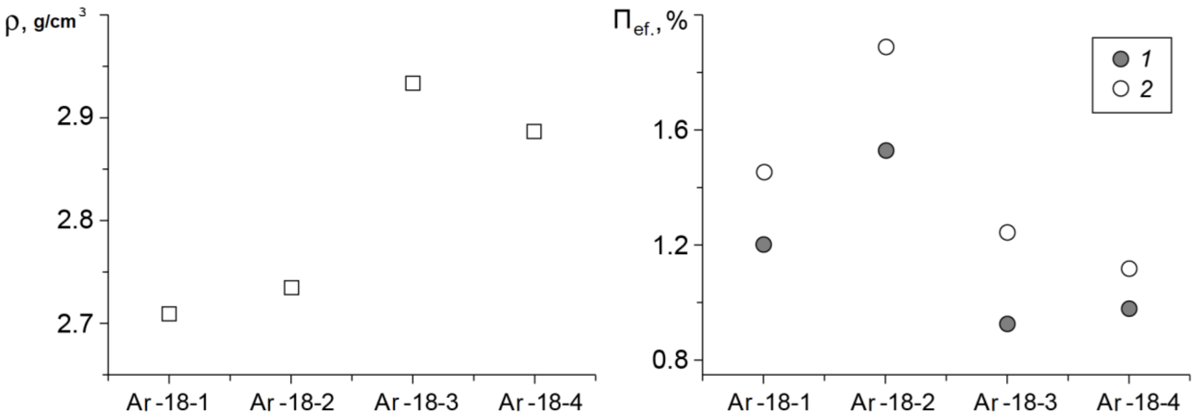

Fig. 3. The Argunskoe deposit. Plots of density (*left*) and effective porosity (*right*) values for four host rock samples. Density values were obtained by forced saturation, porosity values – by free (*1*) and forced (*2*) saturation

Density values ρ (see Fig. 3, *left*) are given only for the forced saturation method, as they are certainly the most accurate. Later they will be used to calculate mechanical moduli.

It can be seen that dolomitic limestone (sample Ar-18-3) has the highest density ρ=2.934 g/cm^3. Quite close values of ρ = 2.886 g/cm^3 belong to crystalline schist (sample Ar-18-4). Metasomatic granites are distinguished by the lowest density among the studied samples – ρ= 2.71 g/cm^3 (sample Ar-18-1) and ρ = 2.735 g/cm^3 (sample Ar-18-2).

It is natural that when considering the values of the effective porosity $П_{ef.}$, obtained by the free saturation method, an inverse relationship is observed (see Fig. 3, *right*). It can be seen that metasomatic granites have the highest effective porosity - in samples Ar-18-1 ($П_{ef.}$=1.2 %) and Ar-18-2 ($П_{ef.}$=1.52 %), and dolomitic limestones and crystalline schists have the lowest - for sample Ar- 18-3 $П_{ef.}$=0.92 % and for Ar-18-4 sample $П_{ef.}$=0.98 %. The values of the effective porosity calculated at forced saturation exceed $П_{ef.}$ values obtained at free saturation - 1.46 and 1.88% for metasomatic granites, 1.24% for dolomitic limestones, and 1.12% for crystalline schists. However, the general regularity in this case is violated only between samples Ar-18-3 and Ar-18-4, which is an insignificant discrepancy due to the differences in the magnitude of the numerical deviations between the values calculated using different saturation methods. For a sample of dolomitic limestones, this difference is 0.32%, and for crystalline schists - 0.14%.

Thus, a preliminary conclusion can be made that in the absence of the necessary equipment for evacuation and pressurization, free saturation can be used without significant loss in the accuracy of the obtained results. It should be noted that this issue requires a separate treatment consideration using more representative collection of samples.

At the same time, the fact that metasomatic granites are much less dense and more porous than dolomitic limestones is confirmed in the section of the Argunskoe deposit (see Fig. 1), where it can be seen that dolomitic limestones served as a barrier to the movement of ore-bearing solutions into the process of ore formation.

Study of the elastic properties of rock samples under atmospheric conditions

The existing methods for determining the elastic properties of rocks can be divided into static and dynamic. Static methods are based on measuring deformations of samples of the studied rocks under load, and dynamic methods are based on measuring the velocities of elastic waves excited in the samples in the range of sound and ultrasonic frequencies.

The most common in the practice of studying the elastic properties of rocks is the impulse dynamic method, when repeating pulses of ultrasonic vibrations are passed through the sample and elastic characteristics are calculated from the values of their propagation velocities. Determination of acoustic and then elastic properties by this method is usually carried out by direct acoustic scanning. Depending on the equipment, it is possible to work on both direct and reflected waves.

To scan the sample using direct waves, an ultrasonic emitter is pressed to one point, and to the other - a receiver (crystals of quartz, Rochelle salt, barium titanate ceramics, magnetostrictive transducers, etc.); the elastic wave velocity on the selected path is obtained by dividing the distance between two points by the travel time.

When working on reflected waves, the emitter is used as a receiver, registering waves reflected from the opposite surface of the sample. It should be noted that the values of the elastic modulus determined by dynamic methods are usually slightly higher than those obtained from static measurements. This discrepancy is due to the imperfect elasticity of the rocks; it is minimal for dense species and increases with decreasing rock density.

Using the density values of the samples obtained by hydrostatic weighing, according to the formulas presented in [*Burmistrov et al.*, 2009], the following elastic characteristics of rocks were calculated:

$$K = \rho\left(V_P^2 - \frac{4}{3}V_S^2\right); \quad (3)$$

$$G = \rho V_S^2; \quad (4)$$

$$E = \rho V_S^2 \frac{3V_P^2 - 4V_S^2}{2\left(V_P^2 - V_S^2\right)} = \frac{G}{2}\frac{3V_P^2 - 4V_S^2}{V_P^2 - V_S^2}; \quad (5)$$

$$\mu = \frac{V_P^2 - 2V_S^2}{2(V_P^2 - V_S^2)}. \quad (6)$$

Here K - bulk modulus or bulk compression modulus, GPa; V_P – velocity of longitudinal waves, km/s; V_S – velocity of transverse waves, km/s; G – shear modulus, GPa; E – Young's modulus, GPa; μ – Poisson's ratio.

To study the mechanical properties of the host rocks of the Argunskoe deposit, two types of cylindrical samples were drilled - 30 mm in diameter with 60 mm in height and 100 mm in diameter with a height from 88 to 106.5 mm, depending on the size of the hand specimen. For all samples (except for Ar-18-1), two cylinders of each type were made; for sample Ar-18-1, due to the small size of the hand specimen, one cylinder of each type was made.

The measurements of the velocities of elastic waves under normal conditions were carried out in accordance with GOST 21153.7–75 using a set of equipment consisting of "Olympus 5072 PR" generator-receiver of ultrasonic signals (made in the USA) and pairs of *P*- and *S*-wave sensors "Panametrics" (made in the USA). Each sensor can be used both as a source and as a recorder of elastic vibrations.

Since it is necessary that at least 5 wavelengths fit on the sounding path to measure the velocities of body waves, sensors with a natural vibration frequency of 1 MHz were used to study cylindrical samples with a diameter of 100 mm, and for samples with a diameter of 30 mm - 5 MHz

P-wave sensors generated and recorded displacements perpendicular to the sensor surface, *S*-wave sensors - linearly polarized displacements along the sensor surface. The signal from the sensor-recorder was applied to the input of the receiving amplifier and was redirected to a digital oscilloscope "TiePie508" (Netherlands), that converted the recorded waveforms into digital form and saved in files on the hard disk of the control computer.

The start of the waveform recording was synchronized with the start of the pulse signal. When measuring the arrival times of the waves, the necessary correction was made for the finiteness of the response rate of the sensors. To determine the time correction, before each series of measurements, control measurements of the wave propagation time in the sensor – sensor system were performed. The sensor response time was defined as the arrival time of the recorded signal. To improve the contact between the sensors and the sample surface, a polysaccharide gel was used for lubrication. For noise removal, registration was carried out with the accumulation of at least 64 repetitive pulses.

Below are the results of ultrasonic observations when determining the averaged values of the *P*- and *S*-wave velocities (Fig. 4), dynamic moduli and Poisson's ratio (Fig. 5) for samples of the host rocks.

It can be seen that the lowest values of the velocities of longitudinal and transverse waves were noted for metasomatic granites (see Fig. 4): for Ar-18-1 sample – V_P=5.38 km/s, V_S=2.95 km/s; for Ar-18-2 sample – V_P=5.10 km/s, V_S=3.37 km/s.

Crystalline schists and gneisses, on the other hand, are characterized by the highest velocities - the V_P values for the Ar-18-4 sample are in the range from 6.12 to 6.41 km/s, the V_S values - in the range from 3.4 to 3.6 km/s.

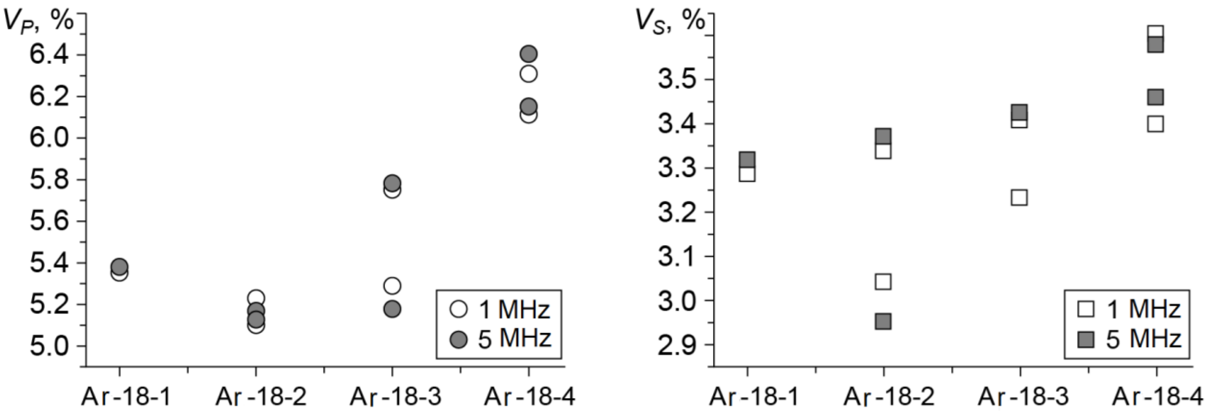

Fig. 4. The Argunskoe deposit. Velocities of ultrasonic longitudinal waves V_P, km/s (*left*) and transverse waves V_S, km/s (*right*) defined on the host rock samples

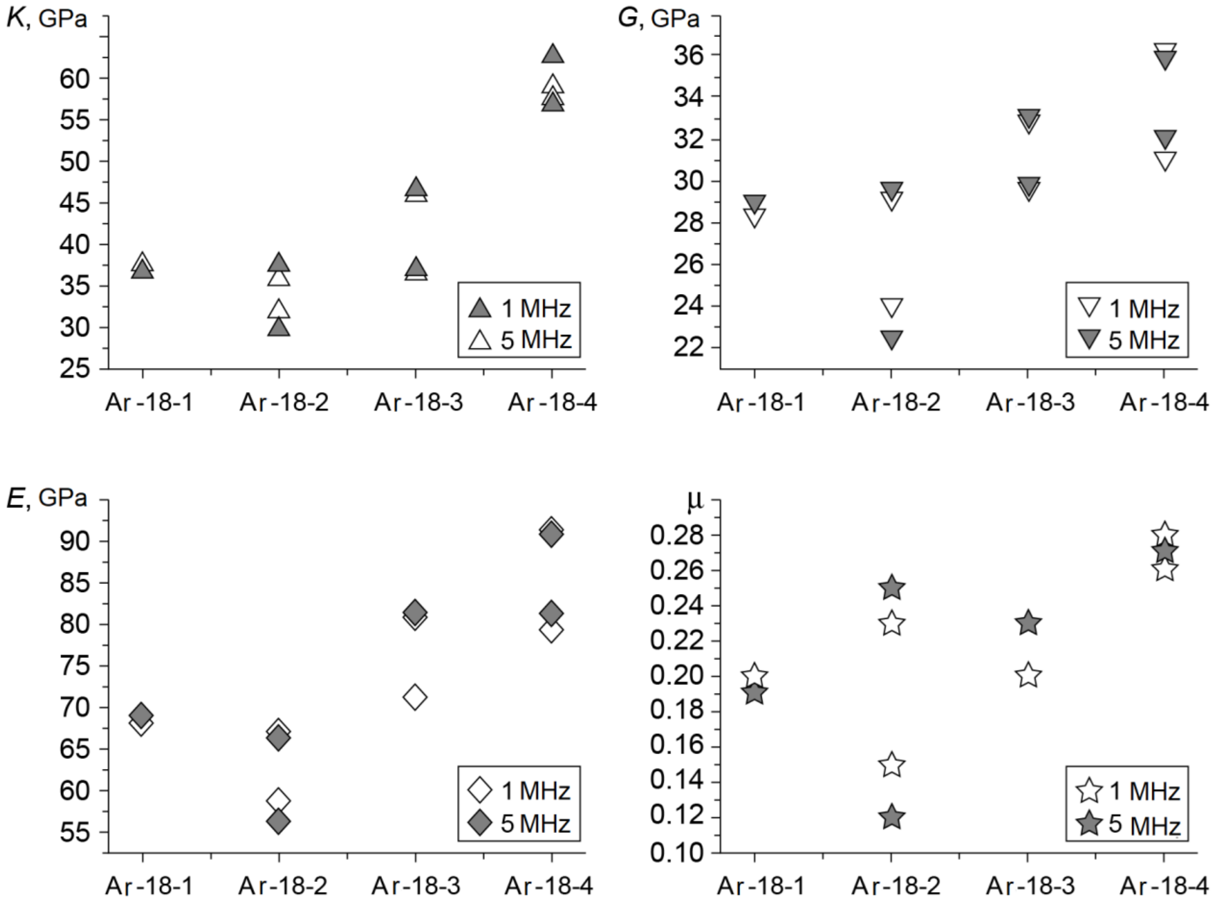

Fig. 5. The Argunskoe deposit. The values of the bulk modulus *K*, GPa (*above left*), shear modulus *G*, GPa (*above right*), Young's modulus *E*, GPa (*below left*) and Poisson's ratio μ (*below right*) of host rock samples

The velocities measured in marbled (dolomitic) limestone are in intermediate position. It is natural that the relations of dynamic moduli and Poisson's ratio values for different samples generally coincide with the picture obtained in the study of the velocities of ultrasonic waves in samples of the host rocks from the Argunskoe deposit (see Fig. 5).

Based on the results of studying the elastic properties of the samples under atmospheric conditions, it can be concluded that among the rocks of the Argunskoe deposit, crystalline schists and gneisses are the most massive and resistant to mechanical stress, while dolomitic limestones and, to a greater extent, metasomatic granites, on the contrary, are porous and mechanically weakened. The increased porosity and fracturing of the host rocks create favorable conditions for the circulation of ore-bearing solutions. This conclusion is confirmed by the geological section of the Argunskoe deposit (see Fig. 1), which shows that the rich uranium ore deposits are enclosed in massifs of granites and dolomitic limestones, while schists are barren.

Geomechanical tests

Geomechanical tests of core samples drilled from hand specimens were carried out at the Center for Petrophysical and Geomechanical Research of Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences in accordance with world methodological standards [*Ulusay, Hudson*, 2007; *Ulusay*, 2015]. As a part of this work, multistage tests were carried out on the samples, including ultrasonic sounding at pressures from 6 to 24 MPa (with a step of 6 MPa) and different radial stresses. Sounding frequency - every 30 s. GCTS RTR-4500 servo-hydraulic high-pressure test installation was used to create thermobaric conditions and to perform mechanical loading (Fig. 6); GCTS – ULT 100 system was used for recording the velocities of longitudinal and transverse waves along the sample axis under thermobaric conditions.

As a result of the performed tests, the following regularities were revealed. When considering the dependence of the velocity of longitudinal waves on the axial stress P_a (Fig. 7, *left*), it is clearly seen that the increase in P_a is most vividly responded to by the sample Ar-18-3 - marbled (dolomitic) limestone. When the pressure changes from 0 to 50 MPa, there is a sharp increase in the velocities of ultrasonic waves from 5.8 to 6.8 km/s, followed by a gradual increase up to 7.3 km/s. For the remaining samples, quieter trends are observed. These data indicate that dolomitic limestones in their micro- and macrostructure have a large number of pores, channels and cracks, which, due to the fragility of the rock, begin to close rapidly under increasing pressure.

Moreover, when studying the behavior of the velocities of ultrasonic waves, the difference in the values of velocities between the studied rocks becomes obvious. Samples Ar-18-1 and Ar-18-2, represented by metasomatically worked granite, correspond to the velocities of longitudinal waves in the range from 5.1 to 5.8 km/s with variations in axial pressure from 0 to 300 MPa. In dolomitic limestone (sample Ar-18-3), velocities vary from 5.1 to 7.3 km/s. Quartz-feldspar-mica crystalline schists and gneisses (sample Ar-18-4) differ by the highest initial velocity of longitudinal waves - 5.8 km/s, as well as the lowest velocity variation (up to 6.2 km/s) with increasing pressure.

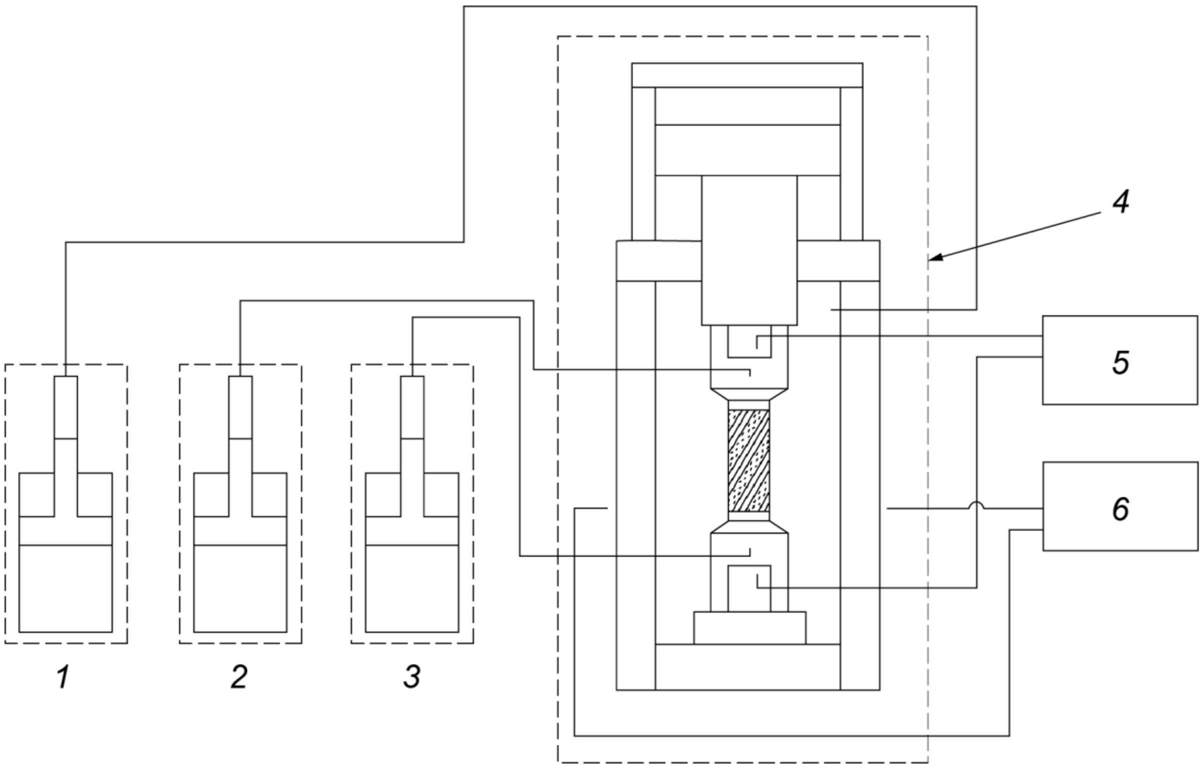

Fig. 6. Scheme of the servo-hydraulic test installation

1 – confining pressure amplifier; *2*, *3* – pore pressure amplifiers; *4* – axial manipulator; *5* – ultrasonic controller; *6* – temperature controller

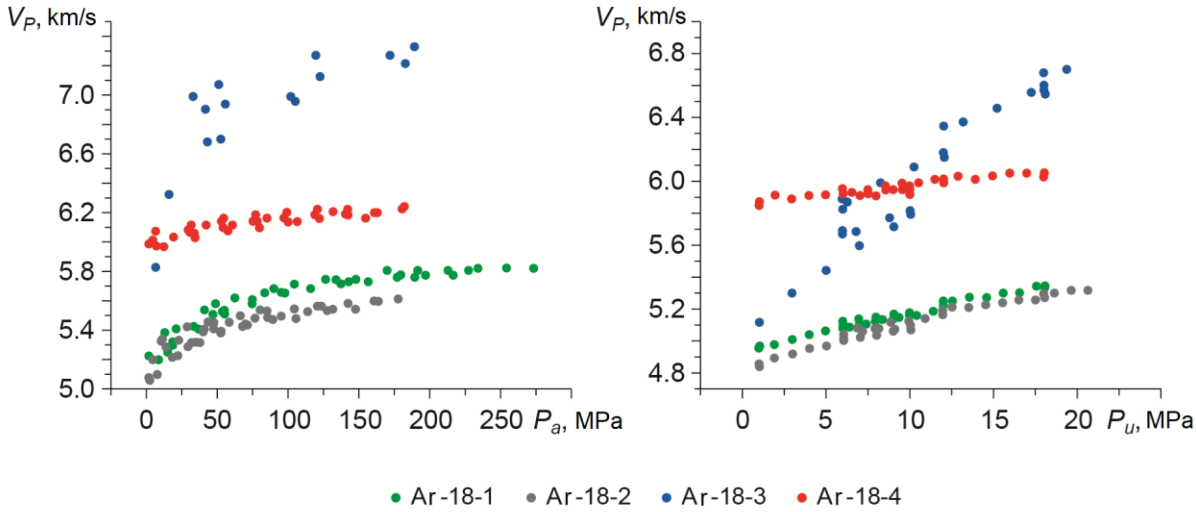

Fig. 7. Plots of the dependence of the velocity of longitudinal waves V_P, km/s on the axial pressure P_a, MPa (*left*) and confining pressure P_u, MPa (*right*)

The noted indicates that quartz-feldspar-mica crystalline schists and gneisses are the densest and mechanically homogeneous among the studied rocks. A similar pattern is observed when considering the dependence of the velocity V_P of longitudinal waves on the confining pressure P_u (Fig. 7, *right*).

As a result of static tests, it was found that the sample Ar-18-1 has the highest ultimate strength σ = 389.1 MPa, at the maximum confining pressure (Fig. 8). The values of σ obtained for marbled (dolomitic) limestone and metasomatic granites are in an intermediate position – = 321.1 MPa for the sample Ar-18-3 and σ = 235.4 MPa for the sample Ar-18-2. Sample Ar-18-4 failed the test at the stage of confining pressure application of 24 MPa. Thus, quartz-feldspar-mica crystalline schists and gneisses have the lowest ultimate strength, and the two samples of metasomatically altered granites are very different from each other.

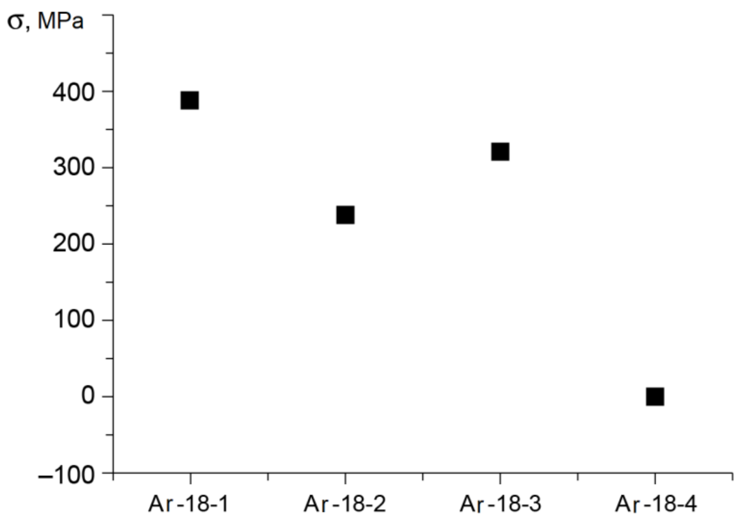

Fig. 8. Plot of the ultimate strength σ, MPa of the host rock samples at the maximum value of the confining pressure P_a=24 MPa

Presumably, this situation is explained by the fact that the most stable Ar-18-1 sample was subjected to intense metasomatic transformations of both high- and medium-temperature (silicic-alkaline metasomatism, greisenization) and low-temperature (hydromication) types, while in the Ar-18 -2 sample metasomatic transformations were not widely developed [*Minaev et al.*, 2019]. Differences in the mechanical behavior of the host granitoids of the Argunskoe deposit can also be caused by geodynamic factors, namely, by the vertical migration of the boundary of transition from elastic-brittle to elastic-plastic behavior of the substance to deeper horizons when a new portion of magmatic melts is introduced or during a new phase of tectogenesis [*Petrov, Andreeva, Poluektov*, 2014].

At the Argunskoe deposit, this pattern is most clearly manifested – there was noted a combination of mineral transformations with plastic and brittle deformations.

Conclusions

The results obtained in the study of the samples of host rocks from the Argunskoe deposit allow us to draw the following conclusions.

1. The studied samples of marbles, granites, crystalline schists and gneisses differ both in the nature and intensity of mineral and deformation transformations, and in petrophysical properties and geomechanical characteristics. At the same time, dolomitic limestones, that are the most contrasting in composition and properties with granites and gneisses, can act as a geochemical barrier to the filtration of ore-bearing solutions, contributing to the sedimentation of ore components.

2. In the course of dynamic tests, it was revealed that dolomitic limestones in their micro- and macrostructure have a large number of pores, channels and cracks, which, due to the fragility of the rock, begin to close rapidly under increasing pressure. Along with this, quartz-feldspar-mica crystalline schists and gneisses, characterized by the predominance of high-temperature blasto-mylonite and cataclasite structures and the practical absence of low-temperature mineralization, are the densest and mechanically homogeneous among the studied rock varieties.

3. Static tests showed that quartz-feldspar-mica crystalline schists and gneisses have the lowest ultimate strength, and the two samples of metasomatic granites are very different from each other. The latter is presumably associated with the different nature and intensity of the manifestation of high and low temperature metasomatic transformations and the corresponding cataclastic textures, as well as with a change in the stress-strain state in the section of the rock mass at various stages of tectogenesis.

Thus, the influence of the nature and intensity of mineral and deformation (structural-petrological) transformations of the host rocks on their physical properties is shown. Further verification of petrophysical parameters requires a detailed study of a more representative collection of spatially oriented samples from the Argunskoe deposit.

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