Introduction

The study of the geology, tectonics and material composition of the pre-Jurassic basement of the West Siberian megabasin was carried out by many researchers [1–5 and others]. At the same time, studies of the geology of the Arctic and the Arctic part of Western Siberia are of great importance in connection with possible oil-and-gas content of this vast and still insufficiently studied territory and its possible upcoming division between countries. It is known that the most important criterion here is the results of the study of the basement of the sedimentary basins of the Arctic. The Yamal Peninsula and its nearest margins are the main gas provinces of our country and one of places where the crystalline basement is available for direct study (albeit with great difficulty). The basements of oil and gas provinces are still one of few promising, but insufficiently studied objects. Interestingly, the granitoids of basements (in part, their metamorphic margins) are the most promising in the search for oil and gas [6–8 et al]. Core samples from wells, which uncovered rocks of the basement of Western Siberia, are unique because they are rare and extremely difficult to access, so it is necessary to conduct a comprehensive detailed core study for geodynamic reconstructions and to consider the geological evolution of the region. In this paper, the mineralogy of quartz-chlorite-mica schists from the pre-Jurassic basement of the northern part of the West Siberian megabasin (Lenzitskaya area) was first described. It was established that the formation of quartz-chlorite-mica schists took place under the conditions of the upper prehnite-pumpellyite facie of metamorphism along the sedimentary substance. Later the rocks underwent changes in the process of propitilization.

Geological setting of the Lenzitskaya area

The Lenzitskaya oil field was discovered during the drilling of the exploratory well No. 70 in 1985) located in the south-western part of the Tazovsky peninsula at the southern coast of the Gulf of Ob 265 km east of Salekhard within the Yamalo-Nenets Autonomous District (Fig. 1).

Historical [9], the well of Lenzitskaya No 70 at a depth below 3500 m helped to reveal rocks of the pre-Jurassic basement represented by green schists. The explanatory note to the State Geological Map of the Russian Federation [9] indicates that Upper Proterozoic undivided metamorphic formations are established at the Lenzitskaya area. It is noted that in the Medvezhye oil and gas exploration area located southward, the schists similar in mineral composition were found by wells No 1001 (within the interval of 4458–4605 m), as well as Sosninskaya (well No 16) and Ugutskaya (well No 73) oil and gas exploration areas. The Upper Proterozoic age of metamorphic schists is determined based on their similarity in composition and level of metamorphism with the metamorphites of the lower subsequence of the Sukhopit suite of the Upper Proterozoic of the Yenisei Ridge [10 et al.].
Research results and their discussion

The studied core is represented by fine-grained, highly deformed quartz-chlorite-sericitic shales (samples from a depth of 3502–3509 m, Fig. 2) and quartz-chlorite-sericitic-carbonate rock (depth of 3515–3516 m, Fig. 3). Microscopically, rocks have a grano-lepidoblast and granoblast structure. The mineral assemblage of the rocks is as follows: muscovite, aluminoceladonite, quartz, chamosite, calcite, plagioclase, pumpellyite. Rutile, fluorapatite, monazite, zircon, pyrite and chalcopyrite are found among accessory and ore minerals.

The rocks are fine-grained, greenish-gray in color; they have an interdigitation of thin beds of rock enriched in mica-quartz-carbonate substance (up to 2 mm thick) with a small amount of chlorite, and layers of quartz-chlorite-mica composition (up to 3 mm) with the presence of carbonate boudin. Intimate crumpling is often observed in the rock. In the lower part of the section (depth is 3516 m), the rocks have a medium-grained structure and are composed of calcite (60%), quartz (25%), mica (10%) and chlorite (5%). The quartz-sericitic-chlorite-carbonate rock has a schistous form due to light layers of quartz-calcite composition with a thickness of up to 2 cm and thin layers of a chlorite-mica aggregate with a thickness of up to 2 mm.

In quartz-chlorite-sericitic schists, quartz is represented by polygonal grains with the inclusion of muscovite and apatite. Some of the grains have an undulatory extinction. Grains size is up to 0.5 mm. Micro-folding is shown in the beds enriched with quartz material (Fig. 4). In the superposed folds of the straticules, grains of quartz, mica and chlorite are perpendicular to stratification in the rock. Quartz contains fine grains of short prismatic apatite and zircon as inclusions.

Mica forms fine-grained banded and crimped aggregates usually deformed and folded; it is often observed together with the laths of chlorite. The size of individuals is up to 0.5 mm. Individuals of accessory minerals such as zircon, monazite, apatite and rutile can be found among the chlorite-mica aggregate. According to the modern classification of micas [11], the obtained compositions correspond to muscovite (Table 1, an. 1, 3, 4) and aluminoceladonite (Table 1, an. 4). The content of SiO$_2$ in micas varies from 44.97 to 46.86 wt. %, Al$_2$O$_3$ from 29.94 to 35.33 wt. %. The content of FeO and MgO in aluminoceladonite is 5.91 and 2.86 wt. % respectively. The content of FeO impurities in muscovite is up to 4.62 wt. % MgO to 2.14 wt. %. In the micas, a constant admixture of Na$_2$O to 0.94 wt. % and TiO$_2$ to 0.45 wt. % is observed.

Chlorite in the rock tends to the mica aggregate, where it forms self-contained strips or lenses; the mineral also occurs in the form of elongated curved laths in the interstice of quartz and carbonate. Chlorite flake size does not exceed 0.7 mm. Mineral is pleochroic from yellow-green to bluish-green. In terms of composition, chlorite corresponds to magnesian high-alumina cha-
Figure 2. Quartz-chlorite-sericitic schist. The Lenzitskaya well No 77, depth is 3509 m. Incident light. The size of the field of vision is 3 mm.
Рисунок 2. Кварц-хлорит-серцитовый сланец. Скважина Лензитская № 77, глубина 3509 м. Проходящий свет. Размер поля зрения 3 мм.

Figure 3. Quartz-chlorite-sericitic-carbonate rock. The Lenzitskaya well No 77, depth is 3516 m. Incident light. The size of the field of vision is 3 mm.
Рисунок 3. Кварц-хлорит-серцит-карбонатная порода. Скважина Лензитская № 77, глубина 3516 м. Проходящий свет. Размер поля зрения 3 мм.

mosite (Table 1, an. 5–8). MgO content in chamosite is up to 13.99 wt. %. One can note MnO up to 0.31 wt. % and Cr₂O₃ to 0.37 wt. % among impurities in the mineral.

The studied rocks contain a large amount of carbonate (5–10%, sometimes up to 60% of the rock volume), which is often confined to areas with fine-grained quartz and forms quartz-carbonate accumulations and veinlets. Carbonate is represented by elongated and isometric, twinned grains up to 1 mm in size. According to microprobe analysis, carbonate corresponds to calcite. Among impurities in the mineral, FeO is noted up to 1.83 wt. %, MnO to 1.22 wt. % and MgO to 0.96 wt. % (Table 1, an. 14–17). There is a small amount of tabular grains of plagioclase with polysynthetic twinning up to 0.2 mm in size among the quartz-calccite aggregate. By chemical composition, the mineral corresponds to pure albite (An₀₋₁₋₀). The content of CaO in albite is up to 0.13 wt. % (Table 1, an. 9–12).

Pumpellyite-(Fe²⁺) was found by us in thin sections in the form of a fine-grained aggregate of green color in association with calcite and chlorite. It has been established by microprobe analysis that the content of FeO in the mineral reaches 9.71 wt. %. It can be confidently identified as pumpellyite-(Fe²⁺) by chemical composition with a high content of the pumpellyite-(Al) minal up to 34%. The crystallochemical formula of this pumpellyite is as follows: Ca₁.⁹₂(Fe²⁺₀.₆⁵Al₀.₃₄Mn₀.₀₂Ti₀.₀₁)₁.₀₂Al₁.₀₀(Si₁.₀₀O₄)Si₂.₀₆O₇.

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Table 1. Chemical composition of minerals from metamorphic schists, wt.%.

| Analysis No | SiO₂ | TiO₂ | Al₂O₃ | Cr₂O₃ | FeO  | MnO  | MgO  | CaO  | Na₂O | K₂O | F | Total |
|-------------|------|------|-------|-------|------|------|------|------|------|-----|---|------|
| Muscovite   |      |      |       |       |      |      |      |      |      |     |   |      |
| 1           | 46.86| 0.45 | 32.41 | 0.04  | 2.51 | 0.04 | 1.25 | 0.03 | 0.94 | 9.73| 0.21| 94.47|
| 2           | 44.97| 0.28 | 32.92 | 0.07  | 4.62 | 0.01 | 2.14 | –    | 0.80 | 8.68| 0.18| 94.67|
| 3           | 46.42| 0.28 | 35.33 | 0.05  | 2.42 | 0.07 | 0.57 | 0.02 | 0.96 | 9.54| 0.13| 95.79|
| Aluminoceladonite |      |      |       |       |      |      |      |      |      |     |   |      |
| 4           | 46.19| 0.22 | 29.94 | 0.08  | 5.91 | 0.01 | 2.86 | 0.02 | 0.73 | 8.29| 0.20| 94.45|
| Chamosite   |      |      |       |       |      |      |      |      |      |     |   |      |
| 5           | 25.04| 0.12 | 21.88 | 0.17  | 26.85| 0.21 | 13.37| 0.01 | 0.02 | 0.01| 0.17| 87.85|
| 6           | 25.02| 0.14 | 22.06 | 0.07  | 26.84| 0.31 | 13.39| –    | 0.03 | –   | 0.18| 88.04|
| 7           | 25.17| 0.07 | 21.86 | 0.05  | 26.30| 0.14 | 13.99| 0.01 | –    | 0.01| 0.16| 87.76|
| 8           | 24.73| 0.13 | 22.60 | 0.37  | 26.50| 0.27 | 13.20| 0.04 | –    | 0.02| 0.15| 88.01|
| Albite      |      |      |       |       |      |      |      |      |      |     |   |      |
| 9           | 68.21| –    | 19.32 | –     | 0.40 | 0.02 | 0.01 | 0.13 | 11.77| 0.02| –   | 99.88|
| 10          | 67.83| –    | 18.94 | –     | 0.22 | –    | 0.01 | 0.07 | 12.08| 0.03| –   | 99.18|
| 11          | 68.58| –    | 19.32 | –     | 0.51 | –    | –    | 0.07 | 12.11| 0.01| –   | 100.60|
| 12          | 68.32| 0.06 | 19.27 | –     | 0.42 | –    | –    | 0.05 | 12.38| 0.04| –   | 100.54|
| Pumpellyite-(Fe²⁺) |      |      |       |       |      |      |      |      |      |     |   |      |
| 13          | 38.10| 0.08 | 24.74 | 0.04  | 9.71 | 0.23 | 0.01 | 22.37| 0.00 | 0.01| 0.06| 95.35|
| Calcite     |      |      |       |       |      |      |      |      |      |     |   |      |
| 14          | –    | –    | –     | –     | 1.73 | 0.86 | 0.83 | 52.33| –    | –   | –   | 55.75|
| 15          | –    | –    | –     | –     | 1.82 | 0.73 | 0.73 | 51.81| –    | –   | –   | 55.09|
| 16          | –    | –    | –     | –     | 1.77 | 1.22 | 0.84 | 51.33| –    | –   | –   | 55.16|
| 17          | –    | –    | –     | –     | 1.83 | 0.97 | 0.96 | 51.91| –    | –   | –   | 55.67|

Note: here and in tab. 2 analyzes were performed in the laboratory of the Zavaritsky Institute of Geology and Geochemistry of the Ural Branch (UB) of the Russian Academy of Sciences (RAS) using the CAMECA SX 100 microanalyzer.
The increased content of Al₂O₃ (24.74 wt.%) is observed in the mineral; the content of FeO is slightly underestimated and there are almost no impurities (Table 1, an. 13). The presence of pumpellyite-(Fe²⁺) may indicate that the rocks were formed under conditions of prehnite-pumpellyite facies of metamorphism.

Rutile in the rock is the main accessory mineral; it is found both in the form of single individuals up to 0.5 mm in size and in clusters in the chlorite-mica aggregate. Almost all mineral individuals are oriented along schistosity. In thin sections, the mineral forms prismatic and acicular translucent grains of brown color with high relief. The content of TiO₂ in rutile varies from 98.54 to 99.91 wt. %. The composition of the mineral has an admixture of FeO₂ to 0.98 wt. %.

Apatite can be found in the interstice of quartz grains forming isometric and short prismatic grains, the maximum size of which does not exceed 70 μm by elongation. Moreover, the mineral is found in the form of clusters of grains of irregular shape in calcite. The chemical composition of phosphate corresponds to fluorapatite. There are FeO up to 0.33 wt. % and SiO₂ up to 0.40 wt. % among the impurities in the mineral. The fluorine content in the apatite is up to 4.21 wt. %; chloride is not found.

Monazite in the rock is represented by single grains of irregular shape in the chlorite-mica aggregate. Grain size is up to 20 microns by elongation. According to microprobe analysis, the mineral corresponds to monazite-(Ce) with a CeO₂ content of 27.0 wt. % and La₂O₃ 11.9 wt. %. Zircon forms widely-spaced and small short prismatic grains up to 30 microns in size by elongation.

Sulfide mineralization of the studied rocks is represented by pyrite and chalcopyrite. The dominant among the rocks is pyrite. The mineral forms widely-spaced isometric grains and chains located along the schistosity of the rock (Fig. 5). The size of the individuals of pyrite does not exceed 250 microns. The chemical composition of the mineral contains Co impurities up to 0.79 wt. % and Pb up to 0.29 wt. % (Table 2, an. 1-4).

Chalcopyrite occurs in the form of small elongated, irregularly shaped grains up to 40 microns in size in the interstice of pyrite. A small amount of Pb impurity is present in chalcopyrite (up to 0.18 wt. %, Table 2, an. 5–8).

Table 2. The chemical composition of sulfides from metamorphic schists, wt. %.

| Analysis No | Fe    | Ni | Co | Zn | Cu | Pb | Cd | S     | Total |
|-------------|-------|----|----|----|----|----|----|-------|-------|
| Pyrite      |       |    |    |    |    |    |    |       |       |
| 1           | 46.45 | 0.03| 0.20| 0.02| 0.01| 0.06| –  | 53.52 | 100.29|
| 2           | 46.54 | 0.01| 0.02| –   | 0.01| 0.24| –  | 53.12 | 99.94 |
| 3           | 46.12 | –  | 0.66| 0.07| –   | 0.29| –  | 53.80 | 100.94|
| 4           | 45.80 | 0.02| 0.79| 0.02| 0.02| –   | –  | 53.69 | 100.34|
| Chalcopyrite|       |    |    |    |    |    |    |       |       |
| 5           | 30.00 | –  | –  | –  | –  | 34.83| 0.18| 0.07 | 34.69 | 99.77 |
| 6           | 30.15 | 0.02| –  | –  | 34.62| 0.05| 0.03| 34.52 | 99.39 |
| 7           | 29.41 | 0.02| –  | –  | 34.28| 0.08| –  | 34.46 | 98.25 |
| 8           | 30.55 | –  | –  | –  | 34.81| 0.08| –  | 35.42 | 100.86|

Figure 5. A chain of pyrite individuals (white) in quartz-chlorite-sericitic schist. The Lenzitskaya well No 77, depth is 3509 m. BSE-image, CAMECA SX 100.

Рисунок 5. Цепочка индивидов пирита (белое) в кварц-хлорит-серицитовом сланце. Скважина Лензитская № 77, глубина 3509 м. BSE-изображение, CAMECA SX 100.
The temperature of rock formation in the range of 350–360 °C is calculated using a chloride thermometer [12]. The obtained estimated data are close to the upper boundary of the prehnite-pumpellyite facies of metamorphism.

The mineralogy of metamorphic schists from the Lenzitskaya well No 77 differs from the previously studied quartz-plagioclase-mica-chlorite schists from the pre-Jurassic basement of the southern part of Yamal (the West-Yarotsinskaya well No 300) by the presence of chamosite, calcite, pumpellyite-(Fe²⁺), chlorite and monazite. At the same time aluminous chlorite (dolobasite), goyazite, dolomite, phalerite, galena, cobaltite, native copper and silver were found in the schists from the Zapolno-Yarotsinskaya well No. 303 [13]. Sulphide mineralization, as well as a large amount of calcite and rutile in quartz-carbonate-chlorite-mica schists, could have formed after the rocks were worked out by late low-temperature solutions with propylitic alteration along cracks at the boundary of two media, metamorphic rocks of the basement and the superincumbent Jurassic-Cenozoic sedimentary strata [14]. Such metamorphic schists are established in the basement of the Priuralysky part of the West Siberian plate, where they have margins for granite masses and make up the major Shaimsk-Kuznetskov megagranitoclinium [15–17].

Conclusions

Thus, we first described in detail the mineralogy of quartz-chlorite-mica schists from the pre-Jurassic basement of the northern part of the West Siberian megabasin (Lenzitskaya well No 77, depth is 3502–3516 m). The mineral assemblage of rocks is represented by muscovite, aluminocladonite, quartz, chamosite, calcite, albite, pumpellyite-(Fe²⁺), rutile, fluorapatite, monazite-(Ce), zircon, pyrite and chloroplaty. Quartz-sericite schists similar in composition were found by us in the basement rocks of the Priuralysky part of the West Siberian plate in the Shaimsk-Kuznetskov megagranitoclinium. The formation of rocks occurred under the conditions of the upper prehnite-pumpellyite facies of metamorphism along the sedimentary substance. Later the rocks underwent changes in the process of propiltization.

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REFERENCES

1. Kontorovich A. E., Nesterov I. I., Salmanov F. K., Surkov, V. S., Trofimuk A. A. 1975, Geologiia nefti i gaza Zapadnoy Sibiri [Geology of oil and gas in Western Siberia], Moscow, 690 p.
2. Surkov, V. S., Trofimuk A. A. 1986, Megakompleksy i glubinnyaya struktura zemnyy kory Zapadno-Sibirskoy pily [Mega complexes and deep structure of the Earth’s crust of the West Siberian Plate], Moscow, 149 p.
3. Saunders D. A., England W. R., Reichow K. M., White R. V. 2005, A mantle plume origin for the Siberian traps: uplift and extensional in the West Siberian basin, Russia. Lithos, vol. 79, pp. 407–424. https://doi.org/10.1016/j.lithos.2004.09.010
4. Reichow M. K., Saunders A. D., White R. V., Al’Mukhamedov A. I., Medvedev A. Y. 2005, Geochemistry and petrogenesis of basalts from the West Siberian basin, Russia. Lithos, vol. 79, no. 3/4, pp. 425–452, http://dx.doi.org/10.1016/j.lithos.2004.09.011
5. Vysotski A. V., Vysotski V. N., Nezhdanov A. A. 2006, Development of the West Siberian Basin. Marine and Petroleum Geology, vol. 23, pp. 93–126. https://doi.org/10.1016/j.marpetgeo.2005.03.00
6. Areshev E. G., Gabrivtsev V. P., Dong H. L., Zao, N., Popov O. K., Pospelov V. V., Shan N. O., Shnip O. A. 1997, GeoLiya in neftegasonosnost’ fundamenta Zondskogo shefla [Geology and petroleum potential of the Sunda shield], Moscow, 288 p.
7. Ivanov K. S., Erokhin Y. V., Ponomarev V. S., Koroteev V. A., Radoslovich C. D’yakonov Y., Frank-Kamenetskii V. A., Gottardi G., Guggenheim S., Koval P. V., Muller G., Neiva D. M. R., Radoslovich V. A. 2013–2018. https://doi.org/10.1134/S1028334X13030129
8. Fedorov Y. N., Ivanov K. S., Koroteev V. A., Erokhin Y. V., Ponomarev V. S., Kormiltsev V. V., Klets A. G., Zao, N., Popov O. K., Pospelov V. V., Shan N. O., Shnip O. A. 1997, Granitoid basement complexes of Western Siberia. The state, trends and problems of the development of the oil and gas potential of Western Siberia: proceedings of the international conference, Tyumen, pp. 49–56.
9. Fedorov Y. N., Ivanov K. S., Sadykov M. R., Erokhin Y. V., Khiller V. V., Pavlova O. E., Pogromskaya O. E. 2016, Geological structure and fluid dynamics of the basement of the southern part of the Yamal Peninsula. Ekaterinburg, 242 p.
10. V. S. Ponomarev et al. / News of the Ural State Mining University. 2019. Issue 2(54), pp. 20-27

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Актуальность работы. Кристаллический фундамент Западной Сибири является перспективным на поиски нефти и газа, но недостаточно изученным объектом. Перспективными породами являются гранитоиды и отчасти их метаморфическое образование. Образования керна из скважин, в которых отрабатаны территории, где расположена Западная Сибирь, являются уникальными, так как являются реактивами и крайне труднообратимыми, поэтому необходимо проводить всестороннее детальное исследование керна для геодинамических реконструкций и рассмотрения геологической эволюции региона.

Цель работы. Определение вещественного состава кварцы-хлорит-слюдистых сланцев из доюрского фундамента северной части Западно-Сибирского мегабассейна, вскрытого северной частью Ленинградской области, для изучения его метаморфизма и заключительных этапов минерализации.

Вывод. Впервые описаны минералы кварцы-хлорит-слюдистых сланцев из доюрского фундамента северной части Западно-Сибирского мегабассейна. Установлено, что образование кварцы-хлорит-слюдистых сланцев происходило в условиях верхов притоков-прудов, что обусловлено рядом геологических факторов, включая метаморфизм и региональное зондирование.

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ЛИТЕРАТУРА
1. Конторович А. Э., Нестеров И. И., Салманов Ф. К., Сурков В. С., Трофимук А. А. Геология нефти и газа Западной Сибири. М.: Недра, 1975. 690 с.
2. Сурков В. С., Трофимук А. А. Мегакомплексы и глубинная структура земной коры Западно-Сибирской плиты. М.: Недра, 1986. 149 с.
3. Saunders D. A., England W. R., Reichow K. M., White V. R. A mantle plume origin for the Siberian traps: uplift and extension in the West Siberian basin, Russia // Lithos. 2005. Vol. 79. P. 407–424. https://doi.org/10.1016/j.lithos.2004.09.010
4. Reichow M. K., Saunders A. D., White V. R., A’Mukhamedov A. I., Medvedev A. Ya. Geochemistry and petrogenesis of basalts from the West Siberian Basin: an extension of the Permo-Triassic Siberian traps, Russia // Lithos. 2005. Vol. 79. № 3/4. P. 425–452. https://doi.org/10.1016/j.lithos.2004.09.010
5. Vyssotski A. V., Vyssotski V. N., Nezhdany A. A. Evolution of the West Siberian Basin // Marine and Petroleum Geology. 2006. Vol. 23. P. 93–126. https://doi.org/10.1016/j.marpetgeo.2005.03.002
6. Арещев Е. Г., Гаврилов В. П., Донг Ч. Л., Зао Н., Попов О. К., Поспелов В. В., Шан Н. Т., Шинь О. А. Геология и нефтегазоносность фундамента Зейского шельфа. М.: Нефть и газ, 1997. 288 с.
7. Иванов К. С., Ерохики Ю. В., Пономарев В. С., Федоров Ю. Н., Кормилцев В. В., Клен А. Г., Сажинов И. А. Гранитоиidotные комплексы фундамента Западной Сибири // Состояние, тенденции и проблемы развития нефтегазового потенциала Западной Сибири: материалы Междунар. конф. Юемен: ЗапСиБНИИГТ, 2007. С. 49–56.
8. Федоров Ю. Н., Иванов К. С., Садыков М. Р., Печерин М. Ф., Захаров В. Г., Захаров С. Г., Краснова А. А., Ерохин Ю. В. Строение и перспективы нефтегазоносности доюрского фундамента территории ХМАО: новые подходы и методы // Пути реализации нефтегазового потенциала ХМАО: науч.-практ. конф. Ханты-Мансийск: Изд-во НаукаСервис, 2004. Т. 1. С. 79–90.
9. Брадучан Ю. В., Василенко Е. П., Воронихин О. Ю., Горелик Ю. Е., Кравченко В. А., Лебедев Е. А., Кравченко Т. В., Матюхов А. Д., Рубин Л. И., Савельев С. Е., Чуйко Н. М. Нефтегазоносность дельты Лены: материалы региональной научно-практической конференции. Новосибирск: Институт геологии и геохимии УрО РАН, 2018. С. 101–109.
10. Лиханов И. И., Волков А. С., Косолапов А. Б., Лисов А. Р. Условия формирования углеводородных залежей в Западно-Сибирском бассейне: перспективы для геологической промышленности. Новосибирск: Изд-во Института геологии и геохимии УрО РАН, 2019. С. 7–20.
11. Ридер М., Скаццини Г., Дьяконов Ю., Франк-Каменetskii V.A., Gottardi G., Guggenheim S., Kobal 1987, Muller G., Neiva A. M. R., Radoslovich E. W., Robert J.-L., Sassi F. P., Takeda H., Weiss Z., Wones D. R. Nomenclature of the micas // Canadian Mineralogist, 1998. Vol. 36. P. 41–48. https://doi.org/10.1134/S1028334X11020048
12. Cathelineau M., Neiva D. A. Chlorite solid solution geothermometer the Los Asufres (Mexico) geothermal system // Contributions to Mineralogy and Petrology. 1985. Vol. 91. P. 235–244. https://doi.org/10.1007/BF00413350

В. С. Пономарев и др. / Известия УГГУ. 2019. Вып. 2(54). С. 20-27

26 Пономарев В. С. и др. Mineralogy of schists from the basement of the southwestern part of the Tazovsky peninsula of the West Siberian megabasin [Lenzitskaya oil exploration area, YNAD] // Известия УГГУ. 2019. Вып. 2(54). С. 20-27. DOI 10.21440/2307-2091-2019-2-20-27
Пономарев В. С. и др. Mineralogy of schists from the basement of the southwestern part of the Tazovsky peninsula of the West Siberian megabasin (Lenzitskaya oil exploration area, YNAD) // Известия УГГУ. 2019. Вып. 2(54). С. 20-27.