Shale rocks of the Spassk suite of the Lower Cretaceous as the prospective objects for extracting hydrocarbons

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Abstract

In connection with opportunities for extracting hydrocarbons from the condensing shale rocks there appears the necessity for a detailed research, especially in the territory of Ukraine. Previously, these strata were considered only as oil and source rocks. At present, it has been proved in the world that deposits enriched in organic matter can be both source and reservoir rocks.

In the Western region of Ukraine the black shale rocks of the Oligocene Menilite suite and the Spassk suite of the Lower Cretaceous are the most enriched in organic matter. These sediments are most common within the Inner zone of the Precarpathian foredeep (the Menilite suite), the Skybova zone of the Carpathians (the Menilite and Spassk suites) and the Krosno zone (the Spassk suite). This work is focused on the Spassk suite of the Lower Cretaceous, which lies within the Krosno zone, its detailed location, lithological and petrographic features. A thorough description of the mineral composition of the finished rock sections is provided. The carboniferous organic matter of the black shale rocks of the Spassk suite is described in detail. All other important mineral inclusions of prospective rocks, which occurred in finished rock sections within the studied regions, are characterized. The material, submitted in the article, is the basis for the continuation of thorough geological and geophysical researches within the selected perspective areas, and also the future possible production of industrial gas hydrocarbons.

Key words: *mineral composition, organic matter, shales.*

Nowadays, given the urgent need of humanity in hydrocarbon energy, the problem of search, exploration and development of new hydrocarbon deposits is increasingly being addressed. Due to the relevance of this issue, researchers have begun considering previously unpredictable sources of energy. That is why there is the necessity of searching at large and very large depths of the sedimentary shell of the earth's crust, at the continents and in shelf zones of seas and oceans, extracting coal bed methane, as well as natural oil or gas from black shale rocks. Earlier, the rocks of this type were considered purely as cap rocks, and later as source rocks, capable of generating and containing oil and gas hydrocarbons.

Due to the emergence of the possibility of extracting hydrocarbons from the sealed black shale rocks, there is a need for their detailed study. Previously, these strata were considered as oil and source rocks. At present, it has been proved in the world that the deposits enriched in organic matter can be both source and reservoir rocks.

Consequently, there is a need for conducting research work in order to identify specific strata, which can be both source and reservoir rocks. The specified rocks must contain a significant percentage of organic matter. In the Western region of Ukraine these are the rocks of two stratigraphic types of the Oligocene Menilite suite and the Spassk suite of the Lower Cretaceous. This has led to conducting detailed field and microscopic studies of substantiating the presence of a significant amount of organic matter.

By this time, the most active researches of black shale rocks within the Western region of Ukraine were conducted by the scientists N. A. Bykhover, V. B. Porfiriev, I. V. Greenberg, N. R. Ladyzhenskyi, K. A. Gapaburska, Yu. V. Koltun, V. I. Uziyuk, B. Y. Mayevskyi, L. S. Monchak and others [1–4].

These sediments are most common within the Inner zone of the Precarpathian foredeep (the Menilite suite), the Skybova zone of the Carpathians (the Menilite and Spassk suites) and the Krosno zone (the Spassk suite). That is why the given tectonic zones were selected as the main regions for the study of prospective areas for oil and gas exploration from sealed shale rocks.

Field studies related to the Spassk suite of the Lower Cretaceous, due to the lack of entrances to the day surface (they are opened only in the wells of Shevchenkovo-1, Lugy-1 and Mizun-1 in the Skybova zone), were conducted only in the Krosno zone, near the following settlements: Tershiv, Spas, Busovysko, Holyatin, Maidan, Strygalnya, Chorna Tysa, Yasinya. Figures 1–3 indicate the areas where these studies were carried out.

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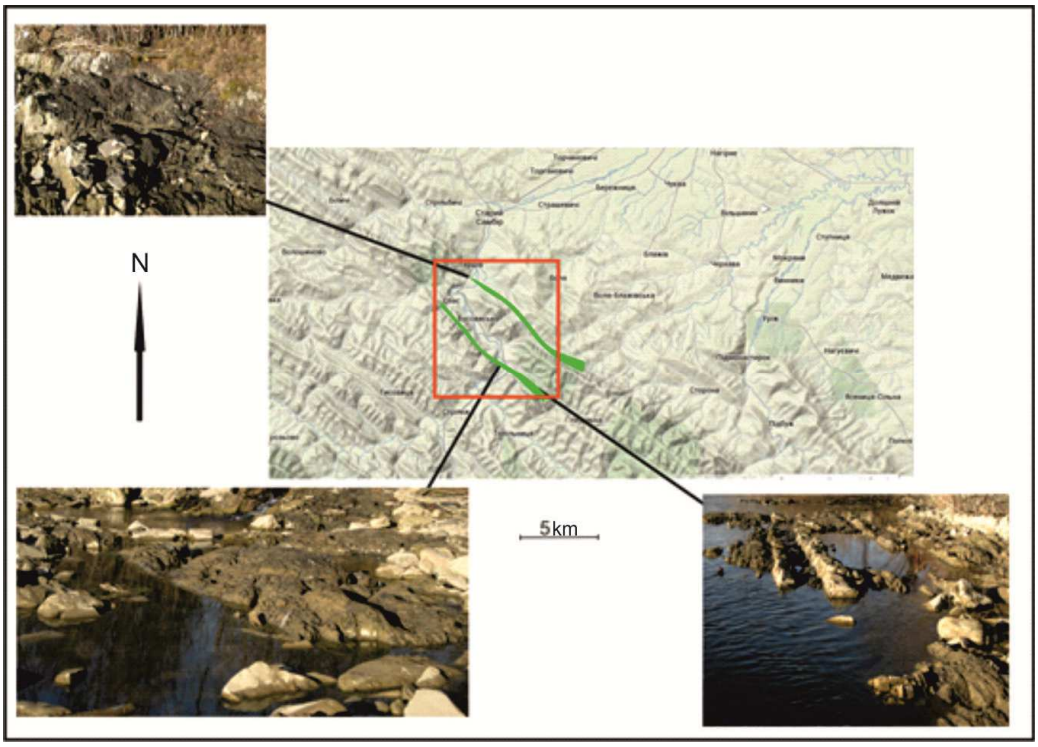

Figure 1 – The area for the research of the Lower Cretaceous Spassk rocks entrance to the day surface. The area of Busovysko, Tershiv and other settlements, Starosambirskyi district of Lviv region, the Krosno zone

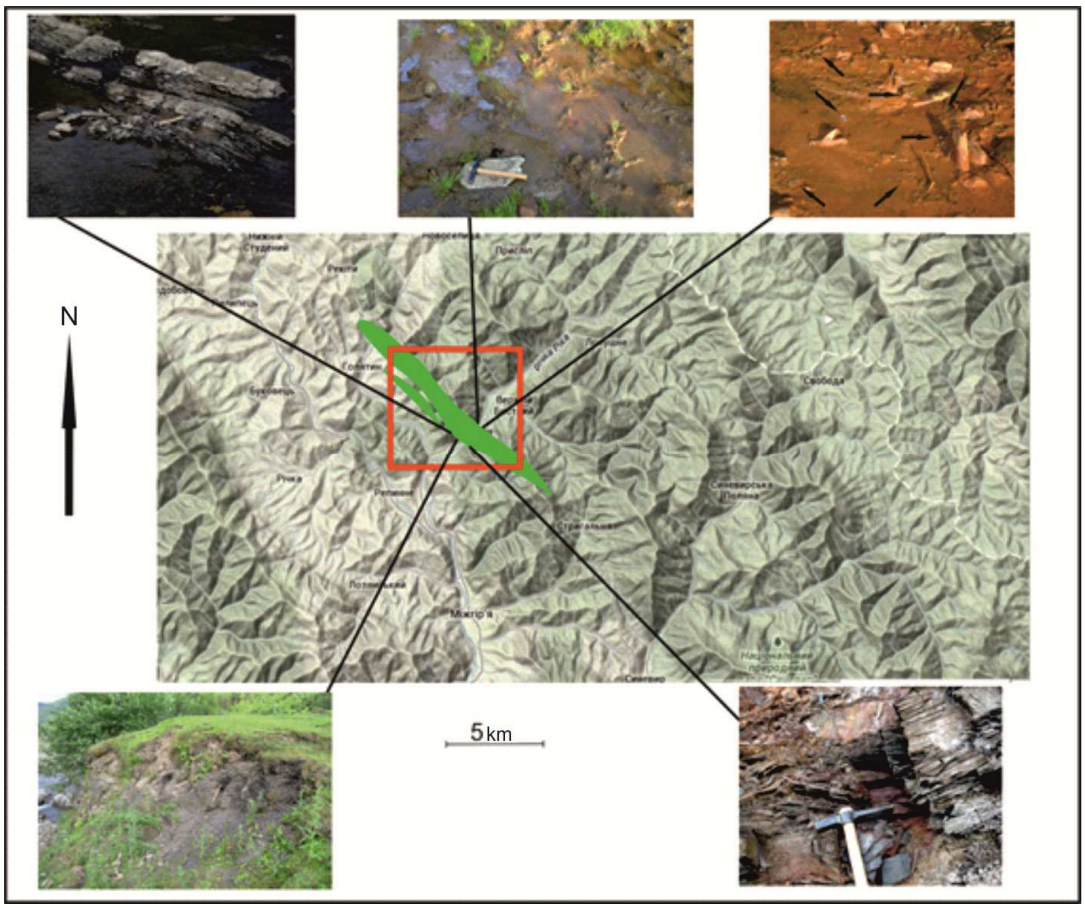

Figure 2 – The area for the research of the Lower Cretaceous Spassk rocks entrance to the day surface. The area of Maidan, Holiatyn and other settlements, Mizhhirya district of Zakarpattia region, the Krosno zone

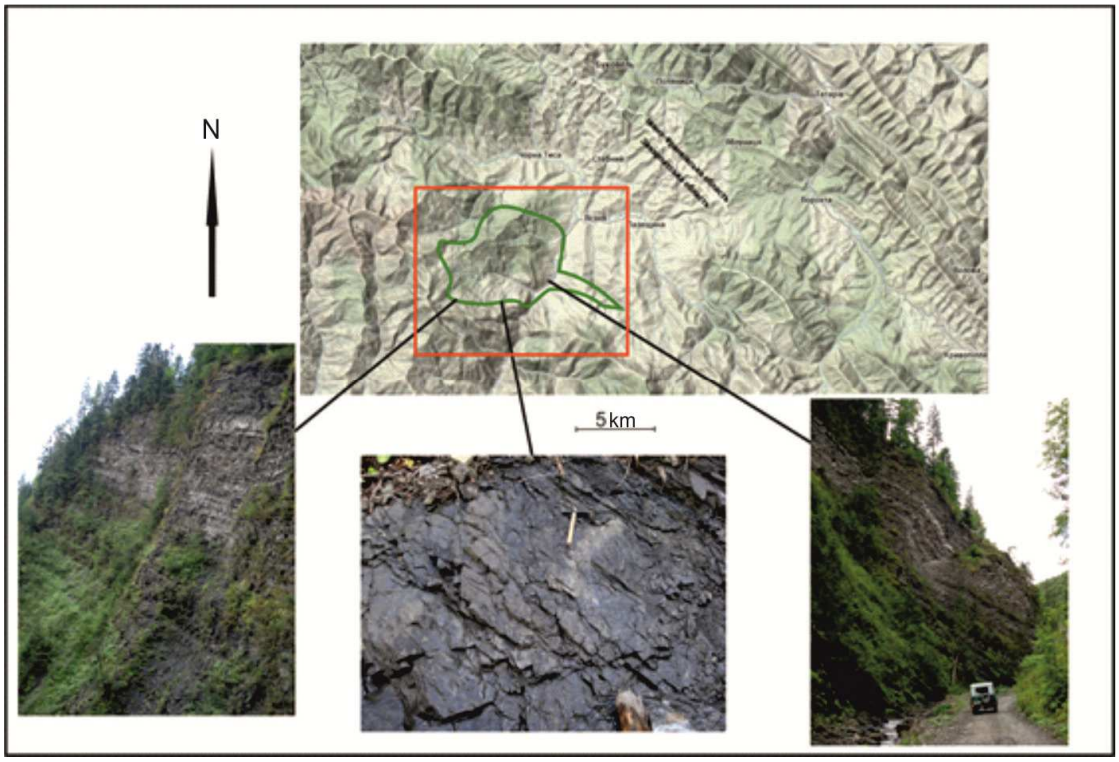

Figure 3 –The area for the research of the Lower Cretaceous Spassk rocks entrance to the day surface. The area of Yasinia settlement, Rakhiv district of Zakarpattia region, the Krosno zone

Consequently, it is suggested below to consider the results of microscopic studies of the Spassk suite of the Lower Cretaceous, based on the detailed description of the finished rock sections, made from selected samples within the above-mentioned settlements.

The finished rock sections, presented in Figures 4–6, are made from sealed shale rocks of the Lower Cretaceous Spassk suite, taken from the outcrops of Starosambirskyi district of Lviv region. The rocks are represented by argillites and siltstones. Clay mass with a high content of carbonated organic matter is 65–70 %. This substance has an admixture of iron oxides and is brownish in color. The structure of the clay mass is pelitic, and sometimes lumpy. According to the mineral composition, the clay substance is obviously kaolinite. Clastic material occupies 30–35 % and is represented by quartz, single grains of glauconite and quartzite.

Rocks are not very dense, voids make up about 7 %. Clastic material is deeply immersed in the organic-clay mass. The rocks are transitions from argillites to siltstones [5].

There are also brownish shale rocks of clay and siltstone type, extremely rich in fine-dispersed organic matter, among the rocks described above. Clastic material occupies 25–30 %, the rest is clay organic substance, which acts as a cement mass. It has a clearly expressed oriented shale structure, which is obviously due to the processes of sedimentation and diagenesis.

Organic matter is uniformly distributed throughout the rock and has the form of bundles and microfiber. Voids have not been found. Clay substance is predominantly kaolinite by mineral composition.

Sandstones are also found among rocks of the Spassk suite of this region. The clastic part of the material is 65–70 % and it is evenly distributed in the rock. The size of grains is from 0.1 to 0.3 mm. They are sorted quite well. The clastic components are angular and semi-fermented. Quartz dominates in mineral composition.

There are also isolated grains of glauconite. Cement is clayey, comprises high content of fine-dispersed organic matter. Voids have not been found. Consequently, it can be concluded that the sandstone rocks are fine-grained, dense and significantly enriched in organic matter [5].

The finished rock sections, presented in Figures 7–9, are made from sealed shale rocks of the Spassk suite of the Lower Cretaceous, taken from the outcrops of the Mizhhirya district of the Zakarpattia region. The rocks are represented by siltstones and argillites. Siltstones are from brownish to black in color. The clastic part is 50 %, 30 % is clay-organic mass, voids and microcracks occupy 20 %. Rock clasts are represented by quartz grains of angular, non-circular form 0.01–0.02 mm in diameter. Clay mass is composed of kaolinite. The carbonated organic material occupies 20 % of the cementing material and has a pelitic structure.

Microcracks and cavities are horizontally oriented determining the microlayer texture of the rock. Clastic material is deeply immersed in the cement mass. Consequently, siltstones, enriched with pelitomorphic, carbonaceous substance, are porous and microcracked.

Argilites are from brownish to black in color. The clay organic mass is 70 %, the clastic material is about 10 %, and voids and microcracks are about 20 %.

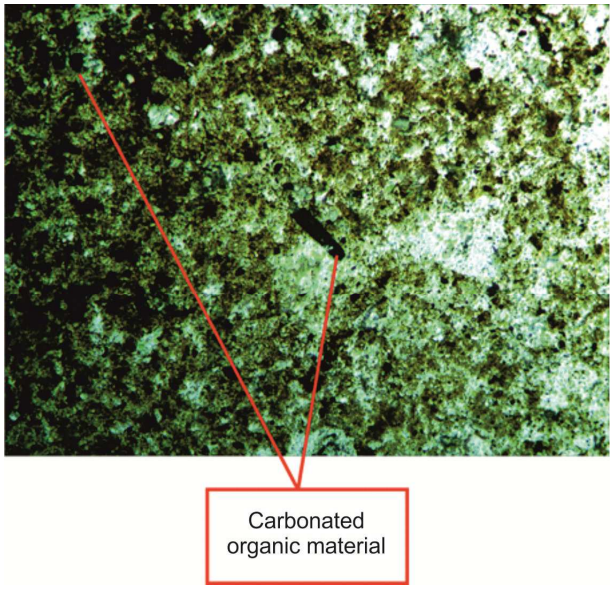

**Figure 4 –The finished rock section of the black siltstone, Nic. ||, ×178.
(The area of Tershiv village,
Starosambirskyi district of Lviv region)**

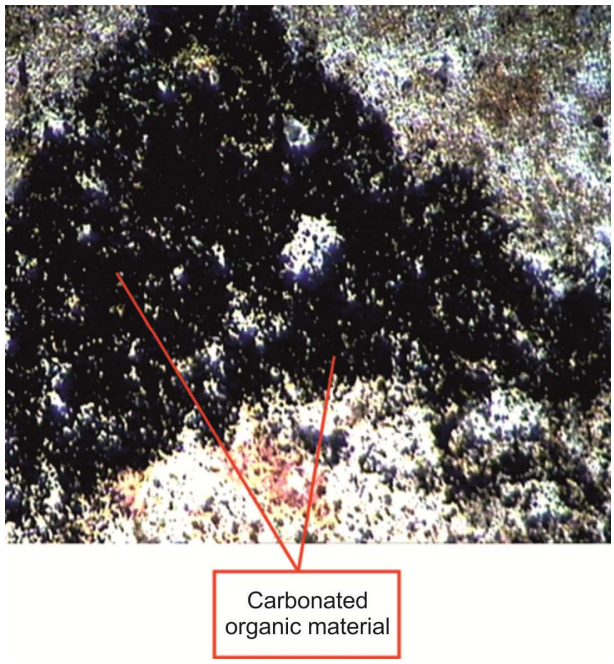

**Figure 5 –The finished rock section of the black siltstone, Nic. ||, ×178.
(The area of Busovysko village,
Starosambirskyi district of Lviv region) [6]**

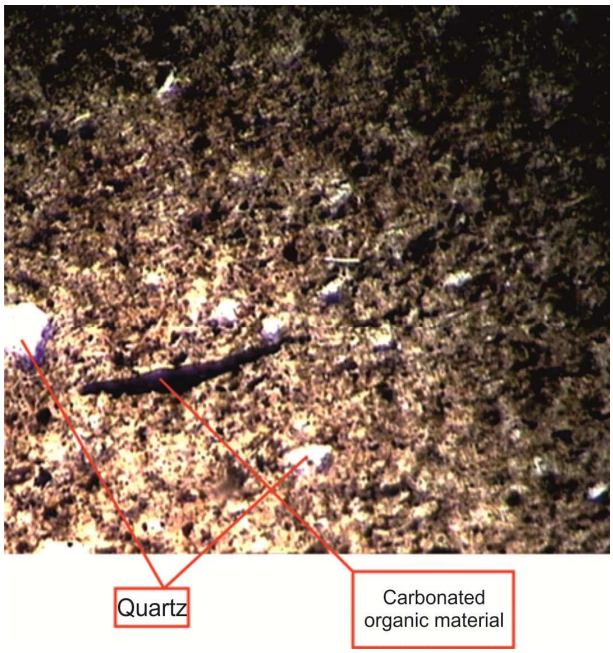

**Figure 6 –The finished rock section of the black siltstone, Nic. ||, ×178.
(The area of Busovysko village,
Starosambirskyi district of Lviv region) [6]**

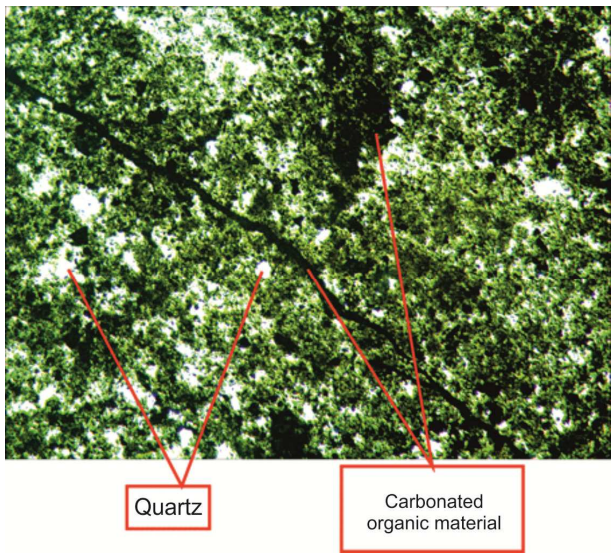

**Figure 7 –The finished rock section of the black argillite, Nic. ||, ×178.
(The area of Maidan village,
Mizhhirya district of Zakarpattia region)**

Clay mass is kaolinite by the mineral composition, the clastic part is represented by small grains of quartz, the organic matter occupies 40 % of the clayey mass and has a pelitomorphic structure, sometimes forming clumps of 0.05–0.06 mm. The rock is porous and microcracked, which provides a microlayer structure.

The finished rock sections, presented in Figures 10–13, are made from sealed shale rocks of the Lower Cretaceous Spassk suite, taken from the outcrops of Rakhiv district of Zakarpattia region. The rocks are represented by argillites and siltstones. Argillites are from brownish to black in color. Clay organic mass makes up about 70–75 %, the rest is clastic material and voids. Clay mass is brown in color, has a pelitic structure, and it is kaolinite by the mineral composition.

The organic substance is carbonated, has a pelitic and finely siltstone structure, a lumpy shape, and is evenly distributed throughout the volume of the rock.

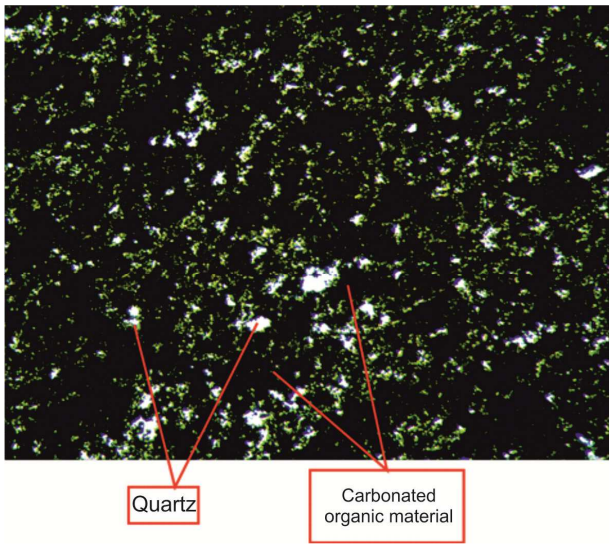

Figure 8 –The finished rock section of the black argillite, Nic. ||, ×178. (The area of Maidan village, Mizhhirya district of Zakarpattia region)

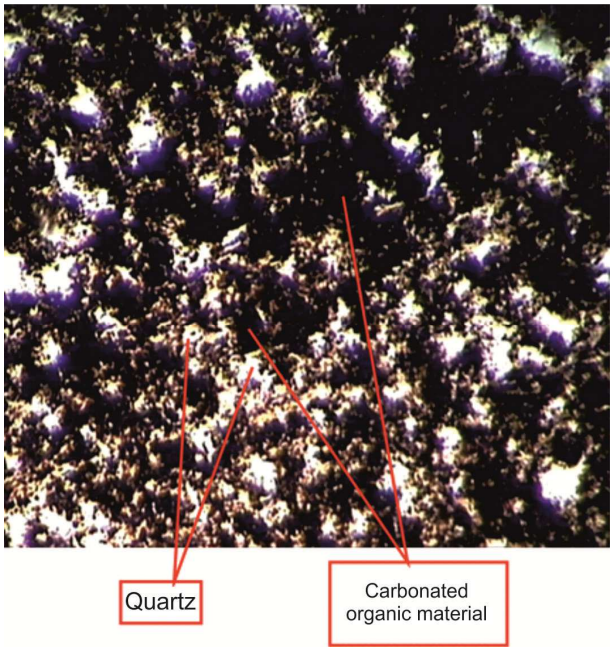

Figure 9 –The finished rock section of the black argillite, Nic. ||, ×178. (The area of Holiatyn village, Mizhhirya district of Zakarpattia region)

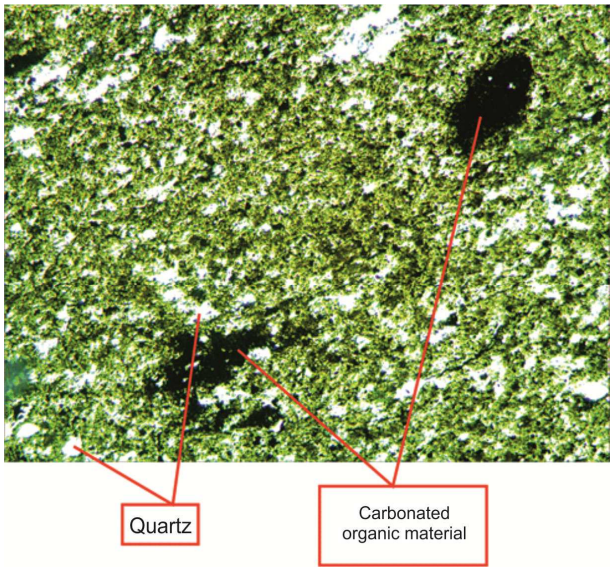

Figure 10 –The finished rock section of the black argillite, Nic. ||, ×178. (The area of Yasinya village, Rakhiv district of Zakarpattia region)

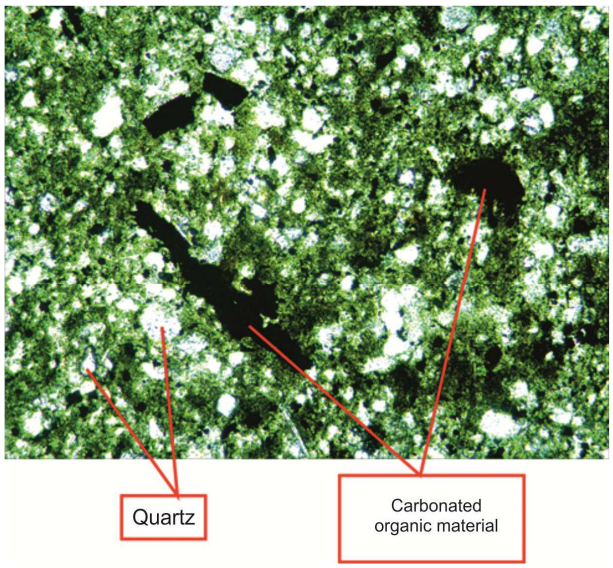

Figure 11 –The finished rock section of the black argillite, Nic. ||, ×178. (The area of Yasinya village, Rakhiv district of Zakarpattia region)

The clastic material is 25–30 % and it is represented by quartz, the size of 0.01–0.02 mm, that is, the siltstone size. The rock is porous. Voids make up about 12 % of the total volume of the rock and have irregular and branched shape, sometimes in the form of microcracks, which in general provides the rock with a microlayer structure. There can be found microcracks with the diameter of up to 0.04 mm, which are mainly filled with calcite. Thus, argillites are dark brown, porous, enriched with carbonated organic matter.

Siltstones have a clastic part that occupies 65 % and is evenly distributed in the rock. The cementing mass occupies 35 %. The grain size varies from 0.01 to 0.03 mm. The structure is fine-grained. The grain is corrugated and slightly coarse. The rock is weakly sorted. The cement is clayey, enriched with organic carbonaceous material, and it is kaolinite according to its mineral content.

Organic matter occasionally forms clumps up to 1 mm or larger and fills microcracks. There are inorganic inclusions of iron oxides. The clastic part is represented by grains of quartz and calcite, with single grains of glauconite.

Figure 12 –The finished rock section of the black argillite, Nic. ||, ×178. (The area of Yasinya village, Rakhiv district of Zakarpattia region)

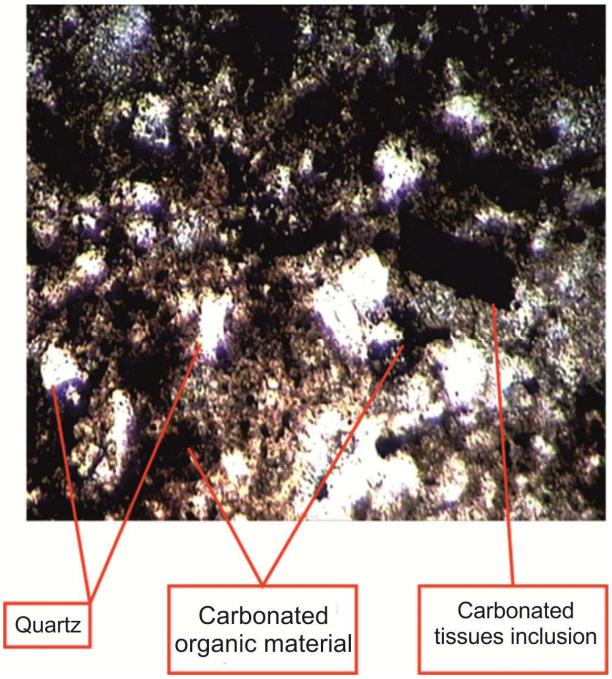

Figure 13 –The finished rock section of the black argillite, Nic. ||, ×178. (The area of Yasinya village, Rakhiv district of Zakarpattia region)

Consequently, siltstones are mainly fine-grained, calcareous, with high content of organic matter.

Thus it is possible to conclude that according to microscopic studies the content of organic matter sometimes reaches up to 70 % in many finished rock sections of the Lower Cretaceous Spassk suite, made of dark colored argillites and siltstones. This substance has a clearly expressed oriented shale structure, which is obviously due to the processes of sedimentation. The scattered organic matter is evenly distributed throughout the rock, in the form of bundles and small lumps. The presented rocks, in the main, are very dense.

Unlike the Oligocene Menilite sediments, the black shale rocks of the Lower Cretaceous Spassk suite are quite porous, and occupy about 12 % of the total volume of the rock. Sometimes an organic matter in this stratigraphic unit forms clumps of up to 1 mm, and microcracks are filled with them.

There can also be found residues of higher plants stems, algae in some sediments. There are presented individual finished rock sections of argillites and siltstones of black color, intensively saturated with organic matter, the content of which, according to microscopic studies, reaches 50 %, and in some finished rock sections even 70 %, which allows them to be classified as combustible shale.

Consequently, we can conclude that the organic matter has a clearly expressed oriented shale structure, which is obviously due to the processes of sedimentation. It is evenly distributed throughout the rock and has the form of bundles and small lumps. The presented rocks are mostly very dense.

It should also be noted that, unlike Menilite sediments, the black shale rocks of the Spassk suite are quite porous, and occupy about 12 % of the total volume of the rock. Sometimes an organic matter in this stratigraphic unit forms clumps of up to 1 mm, and microcracks are filled with them.

If you take into account the laboratory research and the printed sources, it should be noted that the average percentage of organic matter in the rocks of the Spassk suite is 2–8 %. However, as we can see, there are areas where these figures are significantly higher.

It should be noted that field geological studies of the Lower Cretaceous Spassk suite in the Krosno zone allowed defining a prospective area, in which further geological and geochemical studies were carried out. This has allowed the construction of geological and geochemical sections through the prospective area. On the basis of the received information, preliminary conclusions about the prospects of the site were made and the hydrocarbon potential of the black shale rocks was estimated according to the D_2 category.

It should also be noted that the rocks, located within the prospective area mentioned above, contain voids and microcracks, which sometimes occupy up to 20 % and the organic matter content is 40 %.

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УДК 552.578.3

Сланцеві скелі Спаського комплексу нижньокрейдового періоду як перспективні об'єкти видобутку вуглеводнів

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У зв'язку з виникненням можливості видобування вуглеводнів з ущільнених сланцюватих порід з'являється необхідність їх детального дослідження, особливо на території України. Раніше ці товщі вважались лише нафто-материнськими. На даний час у світі доведено, що збагачені на органічну речовину відклади можуть бути одночасно як материнськими породами так і породами-колекторами.

У Західному регіоні України найбільш збагаченими органічною речовиною є чорного кольору сланцюваті породи менілітової світи олігоцену та спаської світи нижньої крейди. Вказані відклади найбільш поширені у межах Внутрішньої зони Передкарпатського прогину (менілітова світа), Скибової зони Карпат (менілітова та спаська світи) та зони Кросно (спаська світа). Саме на спаській світі нижньої крейди, яка знаходиться в межах Кросненської зони, акцентована основна увага у даній праці, її детальне місцезнаходження, літологічні та петрографічні особливості. Надається грунтовна характеристика мінерального складу гірських порід у виготовлених шліфах. Детально описана присутня вуглефікована органічна речовина у чорних сланцюватих породах спаської світи. Також надається характеристика всіх інших важливих мінеральних включень перспективних порід, які траплялись у шліфах порід в межах досліджуваних регіонів. Матеріал, поданий у статті, є вихідним для продовження геологічних та геофізичних досліджень в межах виділених перспективних територій, а також в подальшому можливого отримання промислових припливів вуглеводнів газового ряду.

Ключові слова: *мінеральний склад, органічна речовина, сланці.*