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INVOLMENT OF MICROORGANISMS IN FORMATION OF SEDIMENTARY ROCKS, ORES AND MINERALS

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It is showed the Vernadsky's opinion according to which the life on Earth was all the time, about the impossibility of spontaneous genesis of living organisms from non-living natural bodies, the enormous role of microorganisms in the geological processes in the upper shell of the Earth during whole geological time.

It is demonstrated that the use of a scanning electron microscope has made great breakthrough in studies of microorganisms in sedimentary formations. Various forms of bacteria and blue-green algae have been found in Proterozoic jaspilites, shale, Cambrian phosphorus and other rocks, and biomorphic nanostructures in Cambrian deposits of glauconite as well.

Now the investigation of micro-organisms in sedimentary formations has been significantly developed, thus a new direction in paleontology – bacterial paleontology has appeared.

As a result of research of Upper Paleocene deposits of the Crimean Mountains we have found the coccoliths in limestone, fragments of flint sponges, diatoms and radiolarians in flint stones, reticulate bacterial formation in phosphorus, as well as mesh, plate and short-columnar grained microstructure formations of glauconites. It is not excepted that these nanostructures in glauconite nutrients are biogenic ones.

Key words: all the time life on Earth, microorganisms, scanning electron microscope, flint, phosphorus, glauconite, coccoliths, diatomite, silicon sponges, radiolarians.

Vernadsky in his scientific works often expressed and developed the idea that life on the Earth ever existed - from the very beginning of its birth as a planet. Scientist believed that life exists on other planets. He has not doubt in this [4]. While studying the vital functions of organisms, Vernadsky concluded that "continuous biological exchange of atoms and energy between living and non-living natural bodies of the biosphere, there are abysm in their structure and properties. This difference is a scientific fact, more precisely, scientific conclusion. The consequence of this is the denial of possibility of spontaneous origin of living organisms from non-living natural bodies in the modern conditions and those of all geological time..." [6, p. 171].

Vernadsky had not any doubts that living creatures, especially microorganisms play an important role in geological processes occurring in the upper shell of the Earth, i. e. in biosphere.

About the influence of microorganisms on geological processes was expressed by other scientists. In particular, N. Andrusov (1897) believed that the accumulation of sulfur and iron ores in sedimentary formations is associated with the activity of iron- and sulfur bacteria.

In 1943, A. Volohdin had described the round cells as iron-bacteria iron quarts of Kursk magnetic anomaly. Then these data were seen with skepticism. In 60-s of XX century the American and then Russian and Australian scientists discovered and described the fossils in

flints of Precambrian rocks. Then the flinted bacteria were supposed to be the unique phenomenon. Among individual organisms were cyanobacteria (blue-green algae) [10].

The great breakthrough in the study of microorganisms in sedimentary formations occurred due to the use of a scanning electron microscope. It was found that the old phosphorus and high-carbonic ores (black shale, bituminous rocks) are full of petrified organisms - cyanobacteria (Fig. 1).

Most scientists were surprised by the good conservation of cyanobacteria in the Proterozoic jaspilites, clay shale and Cambrian phosphates [10].

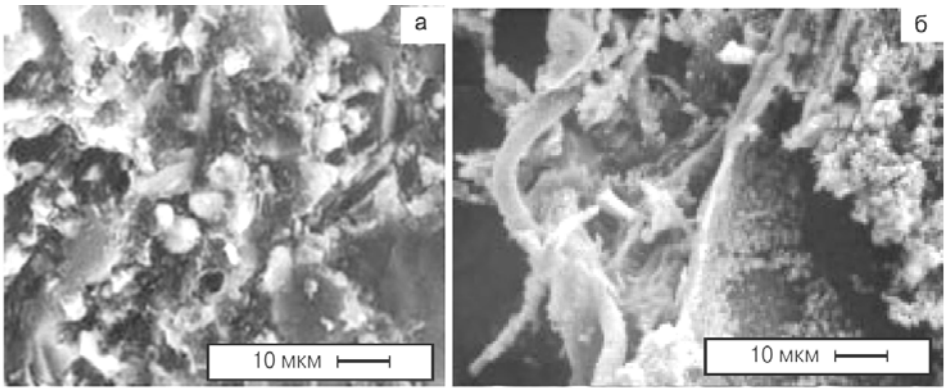

Fig. 1. Cyanobacteria: *a* – in shale of Proterozoic jaspilites; *b* – in Cambrian phosphorus.

As a result of experimental studies it has been found that cyanobacteria precipitate carbonates and phosphates from solutions thus being fossilized (flinted). This explained well their good preservation in ores. Previously, scientists believed that without solid shells algae should be decayed thus could not be kept in a fossil state [10].

In the studying of modern microorganisms not only individual scientists, but entire institutions are involved. Microorganisms include algae (blue-green, diatoms), bacteria, etc.

During evolution the organisms were adapted to the most difficult conditions. There are known bacteria that exist and reproduce at 65–80C (thermophiles), in an environment of strong salinity (halophilic), in water cooling the nuclear reactors and under conditions of huge radioactive exposure of 3–4 million roentgens and under high pressure - hundred atmospheres (barophiles). Such extreme resistance of microorganisms to different environmental factors allows them to exist in sediments of seas and oceans at depths of up to 11 km, on the surface of glaciers and snow in Arctic and Antarctica, in high mountains, desert, in the atmosphere at an altitude of 20 km and others [8].

Modern science knows about 30 thousands of algal species. Among them the most widespread are the blue-green ones and diatoms. Their shape is very various one: filamentous, cylindrical, shale-like, spherical, lamellar, dumbbell-like, bush-like and others. They have no roots and absorb necessary elements together from water by whole surface. Most of these are single-celled ones. The smallest algae cocolithoforides have a size of several microns [8].

In recent decades, the study of fossil organisms in sedimentary formations has become widespread in many countries. Thus the new trend in paleontology - bacterial paleontology has appeared in paleontology [10].

Now the formation of many sedimentary pelitomorphic limestone, phosphates, and highly carbonic argillaceous rocks with involvement of microorganisms has no doubt. This is confirmed by the results of our research. In pelitomorphic limestone, flint and phosphorus from the Upper and Paleogene deposits in the basin. Bodrak (Crimea), we found many fossil microorganisms [1, 3]. In particular, it was found that white pelitomorphic limestone of Turonian (mount Kreminna) and white and pink limestone near village Trudolyubivka, are full of coccoliths, however those age is not precisely defined (Turonian-Cognac?) (Fig. 2).

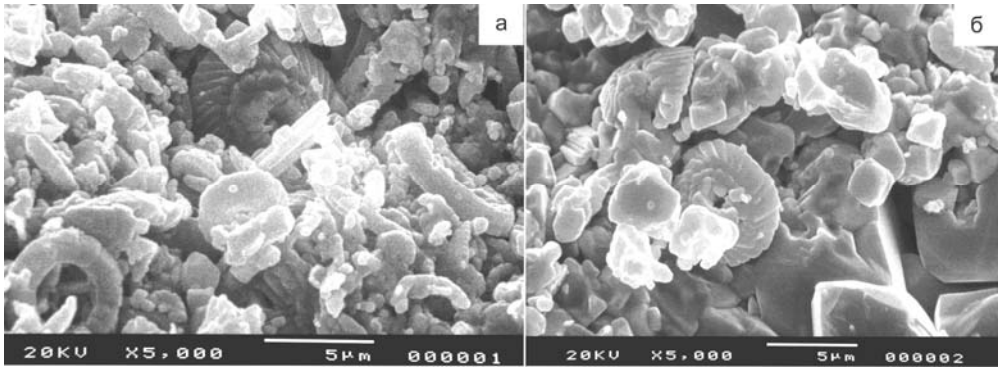

Fig. 2. Coccoliths the limestone: *a* - Turonian; *b* - Turonian-Cognac (?).

In the flints, bedding in the above deposits in the form of thin layers, nodules and sponge horizons, the silicon sponges, diatoms and radiolarians were founded (Fig. 3).

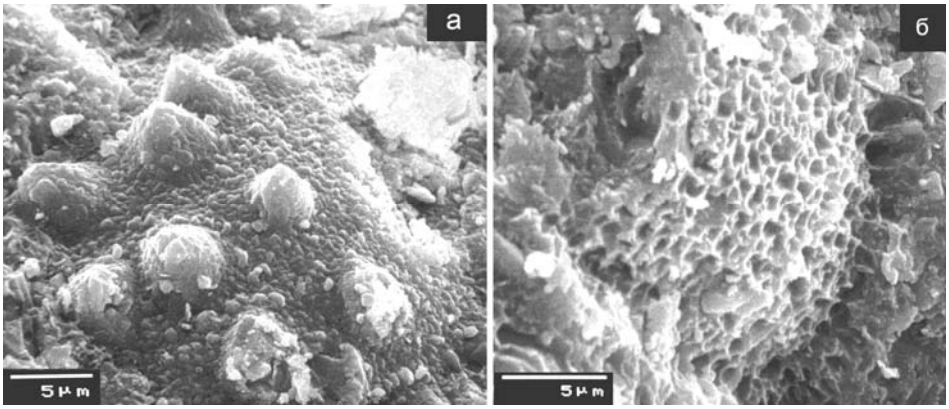

Fig. 3. Silicon sponge (*a*) and radiolarians (*b*) from sponge horizon of Maastricht.

Notably, they are not spread throughout the stratigraphic section of carbonate rocks, but only in its some intervals. It can be explained by that they were developed in conditions of high content of silica in seawater. This is due to the income of silicon into sea basin with hydrothermal solutions or as volcanic ash [3].

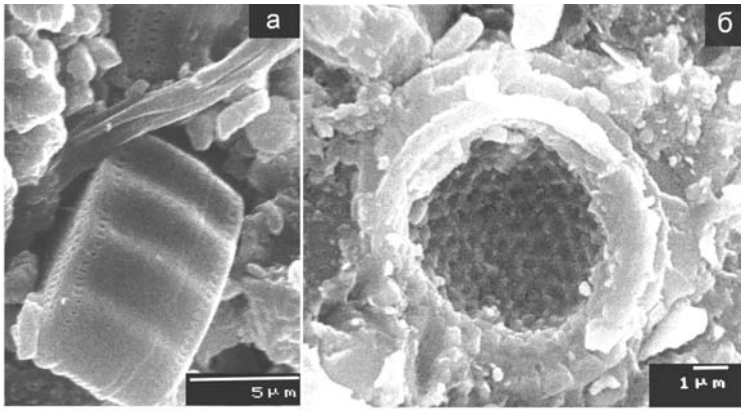

Fig. 4. Fragment of diatoms from flint stratum in Cenomanian marls (*a*) and coccoliths of sponge horizon of Maastricht marls (*b*).

Fossil microorganisms were found in phosphorus depositing on the eroded surfaces of marls of Maastricht and Thanet layers of Crimea [1]. They are coccoliths in phosphorus of black, light gray and orange, as well as mesh structures and bacterial fragments of sponges in capillaries fossilized algae (Fig. 5, b).

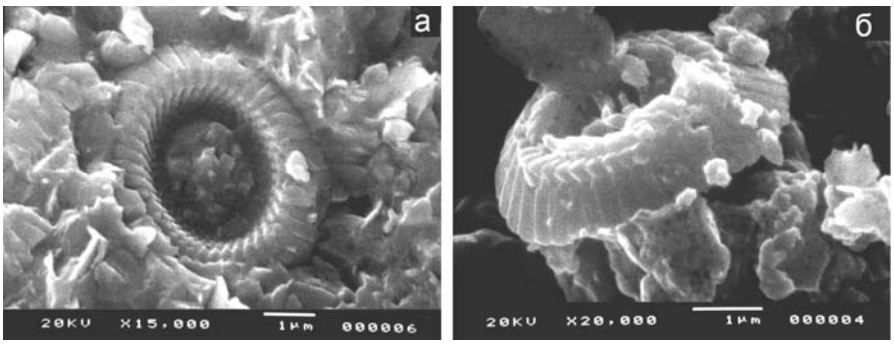

Fig. 5. Coccoliths in black (*a*) and light gray (*b*) phosphorus.

According to A. Rozanov, A. Zhigalov [9] the old phosphorus of Asia were formed by benthic and plankton organisms, mainly algae.

The results of electron microscopic study of the microstructure of glauconite of Paleogene deposits of Crimea are of great interest [2].

Structure of granular formations of glauconite from the surface is mesh one, and the inner is plate, laminar, short-column and mesh ones (Fig. 8–10). Perhaps this is the crystallins of glauconite or the form of fossil microorganisms.

By the way, V. Vernadsky in "Essays of geochemistry", concerning the formation of glauconite, was writing: "Its formation, obviously, no doubt, is connected with life, but the influence of last is not accurately known. The influence of living matter on formation of grains of glauconite is not apparent in concentration of remains of microorganisms (eg, shells of foraminifera, sponges needles, feces etc.) and in the formation of these grains in places rich of

life, but also in their structure... Grains of glauconite give a spongy mass of organic matter...” [5, p. 163]. The scientist also pointed that the influence of a living matter in these processes is obviously very difficult.

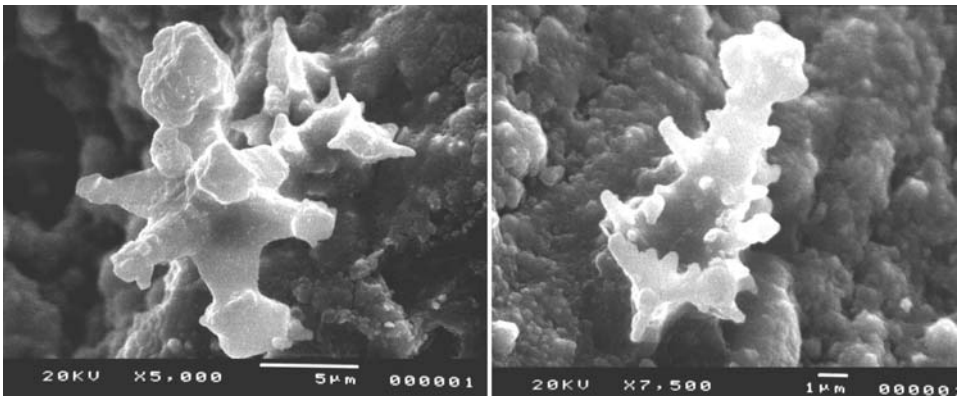

Fig. 6. Fragments of sponges in capillaries fossilized algae.

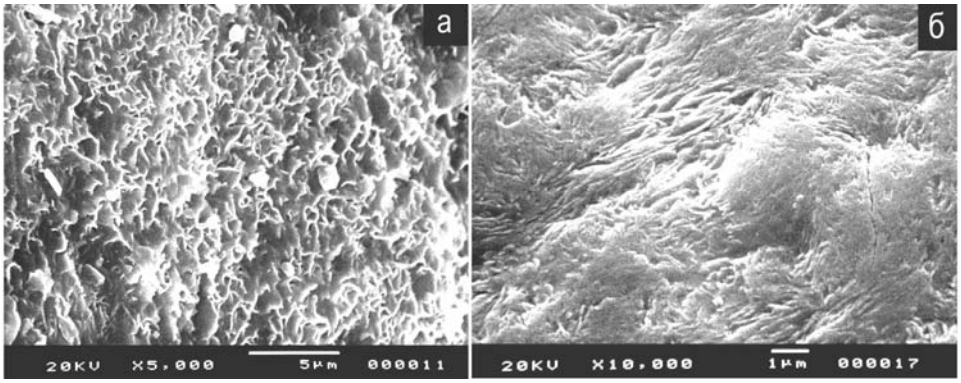

Fig. 7. Mesh microstructures of glauconite surface.

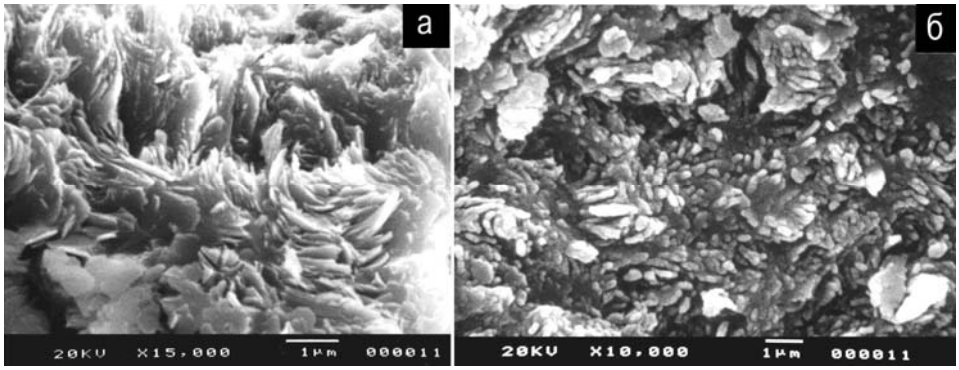

Fig. 8. Microstructures of glauconite: a – plate one, b – short column one

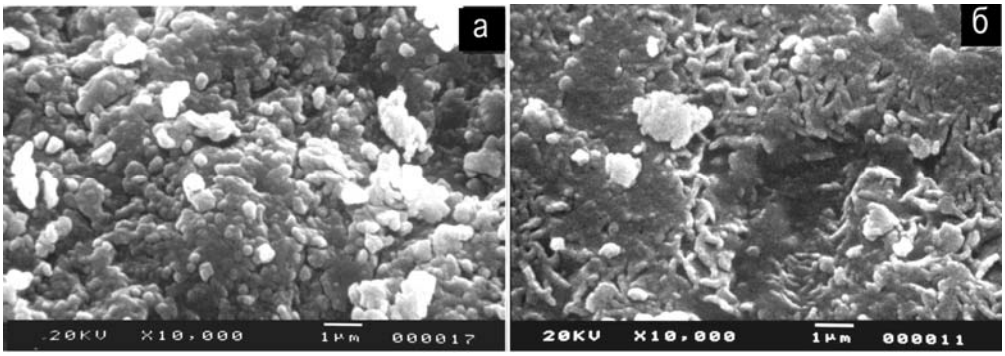

Fig. 9. Microstructures of glauconite: short column one (a) and mesh one(b)

About biogeochemical origin of layered silicate of glauconite-illite composition in deposits of Cambrian of North Verhoyannya were writing A. Heptner, T. Ivanovo, G. Ushatynska [7]. They noted that Al-glauconite in the nuclei of sponge was formed as result of transformation of primary silicate material with the active participation of microorganisms. As a result of electron microscopic study of Al-glauconite it is revealed a number bio-morphological nanostructures involved in the formation of nuclei sponge spikes. In particular, on the cleavage of green globular structures it is clearly visible a nanostructure of randomly bent finest scales (or petals) with regular, sometimes rounded edges. Across whole plate of cleavage the similar type of nanostructures, composed of aggregates of flakes collected in bunches like a cabbage stalk, is kept.

According to the authors, the cavity of spikes of living sponge were filled with organic fabric which after the death, obviously, was servicing as a favorable substrate for growth of microorganisms.

During the study of fossils in sedimentary deposits and their role in the formation of sedimentary rocks, ores and minerals, the prospects of new studies of participation of microorganisms in mineral formation are appeared more and more.

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УЧАСТЬ МІКРООРГАНІЗМІВ В УТВОРЕННІ ОСАДОВИХ ПОРІД, РУД І МІНЕРАЛІВ

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Висвітлено погляди В. Вернадського, згідно з якими життя на Землі існувало вічно, що свідчить про неможливість самовільного зародження живих організмів з неживих природних тіл, про важливу роль мікроорганізмів у геологічних процесах, що відбуваються у верхній оболонці Землі впродовж усього геологічного часу.

Зазначено, що великий прорив у вивченні мікроорганізмів в осадових утвореннях відбувся завдяки застосуванню сканувального електронного мікроскопа. У протерозойських джеспілітах, глинистих сланцях, кембрійських фосфоритах та інших давніх породах виявлено різні форми бактерій і синьо-зелені водорості, а в глауконіті з кембрійських відкладів – біоморфні наноструктури.

Тепер дослідження мікроорганізмів в осадових утвореннях набуло широкого розвитку і навіть з'явився новий напрям у палеонтології – бактеріальна палеонтологія.

Унаслідок дослідження верхньокрейдових палеогенових відкладів Гірського Криму виявлено коколіти у вапняках, фрагменти кремнієвих губок, діатомеї і радіолярії в кременях, коколіти, сітчасті бактеріальні утворення і фрагменти губок у фосфоритах, а також сітчасту, пластинчасту, пластівцеподібну і короткостовпчасту мікроструктури в зернистих утвореннях глауконіту. Не виключно, що ці наноструктури глауконітів біогенні.

Ключові слова: вічність життя на Землі, мікроорганізми, сканувальний електронний мікроскоп, кремені, фосфорити, глауконіт, коколіти, діатомеї, кремнієві губки, радіолярії.