

ON THE MICROÖRGANISMS OF THE LOWER LIMITS OF THE BIOSPHERE¹

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Studies on the underground waters (during oil drilling) from considerable depths in the region of Baku have shown the presence in them of sulfate-reducing, thiosulfate-oxidizing, denitrifying and other bacteria, indicating biogenic transformations of sulfur, formation of H₂S and of N₂ (Ushinsky, 1926; Ginsburg-Karagitscheva, 1933; Maliantz, Reinfeld). The first findings of bacteria at great depths naturally evoked doubts concerning the accuracy of the observations, since bacteria might penetrate from higher strata, but further studies have corroborated the evidence of the occurrence of microörganisms down to a depth of 2000 meters. If doubts could remain concerning the wide spread of bacteria reducing sulfates and nitrates, the finding of considerable numbers of purple sulfur bacteria in waters spouting from depths of 1400 to 1700 meters, (artesian wells) gave new and significant evidence concerning the extension of the depth of the biosphere.

The geological picture of the region, in which the exudance of "pink water" is observed from many drillings does not completely eliminate the possibility of the penetration of large numbers of purple bacteria from the surface. However, the evidence that they occur primarily at great depths is more conclusive.

Volodin first noted the appearance of "pink water" at a depth of 1500 meters. The well at first gushed oil with a slight admixture of water (2 to 15 per cent), and later the amount of water rose to 100 per cent. With the increase in water content of the oil, the pink color became less pronounced.

¹ Translated by Dr. M. Doudoroff.

The following considerations speak against any but a deep origin of the pink water:

One well opened December 19, 1933, gave 1500–2000 tons² daily. Pink water accompanied the oil at first in about 15 per cent ratio, later decreasing to 2 to 3 per cent, and was bright pink in color. After 3 months, the proportion of water rose to 60 per cent with the same bright color, while after 4 months, it reached 100 per cent, with a quantity up to 400 tons daily.

In other wells (more than 20), the general picture was the same. The water from the drillings has a salinity of 4.4 to 5.1° Baumé with a greater amount of sulfates than other waters from the same depths. The maximum H₂S concentration was 0.037 gram per liter. It is unquestionable that the “pink water” with the purple bacteria came from deep accumulations of water with the oil in the “dome.” It is quite possible that the bacteria developed at the interface of water and oil, forming a layer, as can be seen on the surface of the earth in basins with oil. Beyond the contour of the oil-bearing layer there are waters uncolored with H₂S, which penetrate the curved part of the contour (Malishek).

The first analyses of “pink water” by Maliantz and Reinfeld showed the presence of large numbers of *Chromatium* of various sizes and *Thiospirillum*, leaving no doubts that the color was due to sulfur purple bacteria.

To study these organisms, I used various media and found that they grow beautifully in organic media. The cherry-red color appears on the 4th to 5th day. Best results were obtained in anaerobic vessels, although some forms developed in the presence of air. By their appearance (in culture media) the bacteria belonged to the *Athiorhodaceae* not containing sulfur and to the *Thiorhodaceae* with sulfur. Many *Chromatium* of various sizes could be found, as well as forms resembling *Rhabdochromatium*.

Judging by the spectrum of the extracts of cultures, the cells contain both bacteriochlorin and bacteriopurpurin, the latter

² “t” in original; assumed to mean “tons.”

showing some modification differentiating it from both α and β bacteriopurpurins. It must be pointed out that in the darkness the bacteria showed almost no development, but several observations give evidence that the addition of crude oil to the water acts somewhat beneficially, and some *Athiorhodaceae* developed in the dark in the presence of oil.

The finding in oil of various microorganisms is one of the indications of its biogenic origin. The presence of purple sulfur bacteria may be due to the internment of marine algae with the accompanying microorganisms. If this is true, they must be considered relic organisms. Upon reaching the surface of the earth they develop under a layer of oil. This picture may be seen in many places in the vicinity of oil wells. Further studies must show the validity of the supposition that they are relic organisms.

The fact that along with the purple bacteria, underground waters contain not only anaerobic organisms, but also aerobes, such as the thiosulfate oxidizers, may be explained by the formation of oxygen at great depth in the splitting of water by x radiations of radium and mesothorium (according to Vernadsky, 1927) since the water has a radium-mesothorium character.

Thus we may conclude that the limits of the biosphere can be extended to 2000 meters.

REFERENCES

- Other Russian references may be found in the papers cited.
- GINSBURG-KARAGITSHEVA, T. L. 1933 Microflora of oil waters and oil-bearing formations and biochemical processes caused by it. Bull. Am. Assoc. Petroleum Geol., **17**, 52-65.
- GINSBURG-KARAGITSHEVA, T., AND RODIONOVA, K. 1935 Beitrag zur Kenntnis der im Tiefseeschlamm stattfindenden biochemischen Prozesse. Biochem. Z., **5**, 396-404.
- USHINSKY, N. G. 1926 The problem of the origin of sulphurated hydrogen on the coast of the Caspian Sea. Azerb. Oil Business, Nos. 8-9.
- VERNADSKY, V. E. 1927 The biosphere (Moscow-Leningrad, 1926); The Outlines of Geochemistry (Gosizdat, Moscow-Leningrad).