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RADIO-ECOLOGICAL ASSESSMENT OF BITUMINOUS DEPOSITS OF THE BAZHENOV FORMATION IN WEST SIBERIA

SUMMARY. Oil source thickness of the Bazhenov Formation in West Siberia, relating to the Volga horizon of Upper Jurassic, contains increased amounts of uranium minerals. The uranium content in clays and argillites of the Bazhenov Formation, according to some researchers, is 100 g/t, while the exposure dose by gamma logging of wells is up to 100 mR/hr (1 mSv/h).

The authors of this article set the task to assess the degree of danger of radioactive material resulting from the drilling of wells in the bituminous deposits of the Bazhenov horizon.

The analysis of a sample of bituminous mudstone of the Bazhenov Formation, conducted by the authors of the article in the Laboratory of Radiation Ecology of Tyumen State University, has shown the effective activity of 0,508 kBq/kg.

For this indicator, the analyzed material is equal to the first category of industrial products of oil – gas companies according to the Sanitary Norms and Regulations 2.6.6.1169 – 02. This means that the core of the Bazhenov Formation can be stored and disposed of as normal industrial waste. Effective activity of the Bazhenov Formation rocks, calculated on the basis of the data of other researchers (the uranium content of 100 g/t) is greater than 1.5 kBq/kg. In the latter case, the observed stone material should be classified as an industrial waste according to the second category according to the Sanitary Norms and Regulations 2.6.6.1169 – 02. Special sanitary-epidemiological certificate of Sanitary Inspection should be acquired to work with this material.

KEY WORDS. *The Bazhenov formation, natural radioactivity.*

In the stratigraphic section of Mesozoic cover of the West Siberian plate there are widespread deposits of oil-bearing Upper Jurassic Bazhenov Formation – of Lower Cretaceous presented in varying degrees of black bituminous argillites and clays with inbedded carbonate and silicon.

The Bazhenov formation soil units have an increased radioactivity index. Gamma-radiation intensity in gamma-ray logging varies from 30 to 100 mR/hr (0.3-1 mSv/hr), while the grey argillites laying higher in the Achimovsky deposits have only 8-12 mR/hr (0.08-0.12 mSv/hr). The highest level of radioactivity in the Bazhenov formation is

found in the Salymskiy, Nizhnevartovskiy, Kaimysovskiy and Srednyvasyuganskiy petroleum regions [2]. Anomalously high radioactivity of bituminous rocks of the Bazhenov formations is by 80-90% determined by high uranium content [3].

According to I.I. Pluman [4], the content of thorium and potassium in all the sedimentary rocks of the Mesozoic West Siberian Plate is almost equal, and various rocks differ from each other only in the uranium concentration, with the uranium concentration growing from sandstones to clay rocks. It concerns to the full extent the bituminous argillites of the Bazhenov formation that have anomalously high uranium content. The concentration of uranium in clays of the Bazhenov floor, according to I.I. Pluman [4], varies from 0.0004 to 0.0078% (table 1) According to V.V. Turyshev [5], the amount of uranium in the Bazhenov formation varies from 10 to 100 g/t (0.01%), i.e. it reaches the concentrations of economic value. The highest content of thorium in bazhenits, according to the same author, reaches 18 g/t, i.e. the radioactivity has distinctively uranium nature. Exposure dose rate in gamma-ray logging reaches 100 mR/hr (1 mcSv/hr).

Table 1

**The content of naturally radioactive elements in the rocks of
The West Siberian Plate [4]**

Rocks	Test portions	Uranium, 10-4%		Thorium, 10-4%		Potassium, %	
		from – to	average	from– to	average	from– to	average
Argillites	58	1,0–5,0	2,6	3,7–13,2	7,3	1,2–4,8	2,2
Bituminous argillites of the Bazhenov formation	94	4,2–78	23	0–20	7,8	0,3–4,0	1,8

After the laboratory-based core studies, systematization and generalization of geochemical materials conducted by I.I. Pluman [4], a good correlation between radioactivity and organic carbon and between radioactivity and chloroform bitumen was established.

During the sedimentation of bazhenits in upper jurassic time the occlusion of uranium compounds by organic compounds was going on. That's why in bazhenits the direct correlation between the amount of organic matter and uranium content is observed.

This article is devoted to the assessment of radiation hazards of bituminous sediments of the Bazhenov formation for the personnel of geological and oil and gas producing companies.

Due to the raised oil-and-gas bearing deposits radiation hazard the exploration, production, and original treatment of hydrocarbon crude is accompanied by the extraction of previously stored in geological structures significant amounts of radionuclides of natural origin of uranium and thorium series, as well as potassium-40, into daylight surface. As a result a dangerous rate of radionuclides of natural origin in the products and process waste may be found, especially when the oilfield is in operation for a long time.

In order to set up the rules for providing radiation security of the population and employees of oil and gas companies, limitation of people's life environment pollution

by radionuclides of natural origin, planning the scales and ways of radiational monitoring of people working with process waste, and for setting up the radiation-hygienic requirements to handle them in accordance with Sanitary Norms and Regulations 2.6.6.1169-02 the classification of process waste by effective specific activity of natural radioactive nuclides concentrated in them is given in Table 2.

Table 2

Classification of process waste [6]

Waste category	Effective specific activity of natural radioactive nuclides (A_{eff}), kBq/kg	Gamma-radiation intensity of natural radioactive nuclides contained in waste (H), mcG/h
First	$A_{\text{eff}} \leq 1,5$	$H \leq 0,7$
Second	$1,5 < A_{\text{eff}} \leq 10$	$0,7 < H \leq 4,4$
Third	$A_{\text{eff}} > 10$	$H > 4,4$

Waste separation as well as defining the waste category should be conducted by oil and gas companies according to the results of defining the content degree of natural radioactive nuclides by gamma ray spectral logging.

As the authors of the article stated the aim to evaluate the level of radioactive hazard of rock material obtained from well-drilling of bituminous sediments of the Bazhenov floor, now it is required to cite the data of effective intensity of bituminous argillites of the Bazhenov formation, calculated with the results obtained by the authors and the data taken from well-known sources.

The analysis of bituminous argillite sample taken from well №3 of the Tortasinskiy block, conducted in the laboratory of radiational ecology of Tyumen State University with spectrometric equipment "USK Gamma-plus" has shown the results presented in Table 3.

Table 3

Analysis of bituminous argillite sample from well №3of the Tortasinskiy block

Criterion, Bq/kg	Activity ^{226}Ra	Activity ^{232}Th	Activity ^{40}K
Result (A)	438	30	359

The effective activity of the sample calculated according to the formula $A_{\text{eff}} = A_{\text{Ra}} + 1,31A_{\text{Th}} + 0,085A_{\text{K}}$ equals 508 Bq/kg.

Basing on this criterion the sample analyzed is to be treated as the first category of oil and gas companies products in accordance with Sanitary Norms and Regulations 2.6.6.1169-02. It means that the sample of the Bazhenov formation may be stored and recycled as common production waste.

In the published works there is no data on defining the effective activity of bazhenits, that is why we used the data from I.I. Pluman [4] and V.V. Turyshev [5] on radioactive nuclides concentration in these deposits. As it was stated above, according to Turyshev, the amount of uranium in bituminous encrustations of the Bazhenov formation reaches 100 g/t and higher. The calculations show that in that

case Aeff exceeds 1.5 kBq/kg. This rock material is to be distinguished as production waste of the second category according to Sanitary Norms and Regulations 2.6.6.1169-02 [6]. The sanitary audit of the second category waste is to be conducted considering the level of pollution of people's life environment and evaluation of the radiation dose taken by employees and population. Sanitation and epidemiological certificate of State Sanitary & Epidemiological Surveillance Agency is to be obtained in order to work with them.

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