Effective porosity and mineral composition of marl from the Sumer Formation

Ефективна порестост и минерален състав на мергели от Сумерската свита

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Introduction

Previous studies on the problem of geological disposal of high level radioactive waste (HLW) in the country, carried out mostly by Geological Institute, BAS (Kozhukharov et al., 2000f[1]; Evstatiev, Kozhukharov, 2001; Karastanev et al., 2010f[2]), selected marls from the Sumer Formation as one of the most suitable host rocks for the purpose of constructing a deep geological repository.

In this study the mineral composition and effective porosity of marl from the Sumer Formation have been investigated as the determining characteristics for retardation capacity of the host environment against the radionuclide migration.

Materials and methods

The materials, analysed in this study, are clayey marl samples of the Sumer Formation from the following two boreholes: the P-6 borehole (BH) in the Varbitsa area (sample depth of 400 m) and the P-5 BH in the Golyamo Peshtene area (sample depth of 200 m).

The microstructural analyses were performed with a Scanning Electron Microscope (SEM), JEOL Superprobe 733. The observed samples were coated with fine layers of gold and carbon with a thickness of 20 nm.

The X-ray microanalysis was performed with an automatic X-ray diffractometry Guinier camera G670. The interpretation of the captured data was done using the IDR and EVAL programs from the Diffrac 11 Siemens software package. The quantitative determinations are made using the method of Peter-Kalman.

The effective porosity is defined by mercury porosimetry. The method is based on the Washburn equation for capillary potential, which describes the penetration of liquids into small cylindrical pores. The percentage part of the volume of the sample that is made up by connected pores is determined. The measurement is made by automatic porosimeter AutoPore 9200, MICROMERICS.

Results

The X-ray microanalysis found that the samples analysed have a multiphase mineral composition. Prevailing minerals are quartz (35.1%), calcite (23.9%) and illite (17.3%) (Fig. 1; Table 1). The same mineral phases are observed in the SEM investigations (Fig. 2). Particle size distribution analysis shows that the amount of clay fraction (less than 2 μm) is 29.2%. Carbonate content is measured at 26.9%.

The maximum volume of mercury penetrated into the pores of the specimen, gives the total pore volume of 0.0256 cm^3/g (Fig. 3). Effective porosity is 6.57%. Pores with a radius of less than 0.1 μm are prevailing, and their volume amounts to 82.4% of the effective porosity.

Conclusions

The study shows that the marls from the Sumer Formation possess characteristics that would ensure a high retardation capacity of the host rock against the migration of radionuclides. This conclusion is based on the following results:

[1] Kozhukharov, D. et al. 2000. *Studies of Perspectives Areas for Construction of a National Repository for Radioactive Waste.* Report of the contract 102/98, between the Ministry of Education and Science and the Geological Institute, BAS (in Bulgarian).

[2] Karastanev, D., D. Evstatiev, K. Stoykova, R. Nakov, A. Benderev, A. Radulov, D. Solakov, K. Todorov, E. Vasilev, P. Ivanov. 2011. *Study of the Possibilities for Implementing Deep Geological Disposal. Task 4 – Analysis and Zonation of the Territory of Bulgaria, Selection of Potential Host Rocks for Deep RAW Disposal*. Contract Report (SERAW Nr 208041) (in Bulgarian).

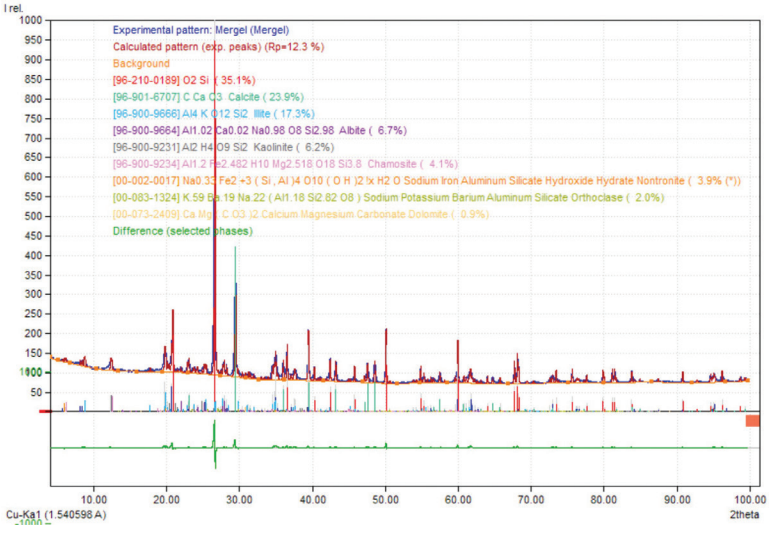

Fig. 1. X-ray diffractogram

Table 1. Percentage of major mineral phases in marl of 400 m depth (P-6 BH, Varbitsa area)

Mineral	Amount (%)
Quartz	35.1
Calcite	23.9
Illite	17.3
Albite	6.7
Kaolinite	6.2
Chamosite	4.1
Na nontronite	3.9
Na orthoclase	2.0
Dolomite	0.9
Unidentified peak area	5.5

– the low effective porosity (below 7%) and the small size of the prevailing pores (less than 0.1 μm) suggest a very low hydraulic conductivity;

– the relatively high content of the clay component (<2 μm) 29.2% in the marl (the clay minerals form thin films whose surface is electrically charged) determines the retention of various chemical elements (Mg, Na, Ca, Cs, Sr) contained in the waste;

– the content of carbonates in the marl is also high – about 27%, which in turn allows maintaining a permanent high pH level and provides a chemically stable environment;

– the high amount of quartz (35.1%) gives the marl good mechanical properties and provides favourable thermo-chemical conditions for HLW disposal.

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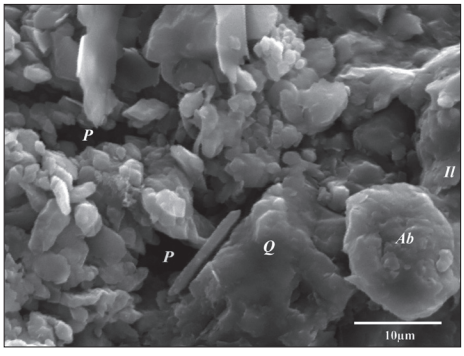

Fig. 2. SEM image of marl of 200 m depth (P-5 BH, Golyamo Peshtene area) – microporosity (P), quartz grains (Q), albit grains (Ab) and Illite (Il) are seen in the marl matrix

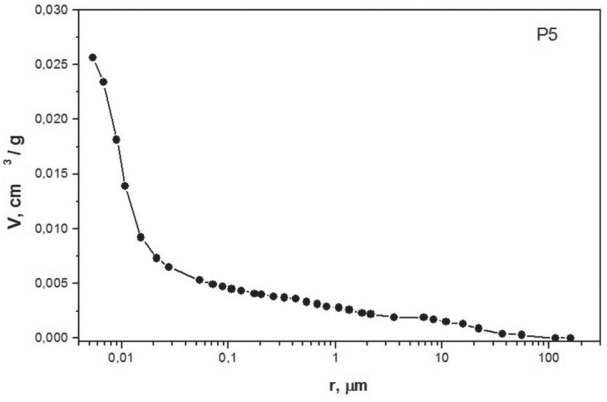

Fig. 3. Pore volume distribution by pore radius

References

Evstatiev, D., D. Kozhukharov. 2001. Current status of the site selection for RAW disposal in Bulgaria. – In: *Third Worldwide Review* "*Geological Challenges in Radioactive Waste Isolation*". Ernest Orlando Lawrence Berkeley National Laboratory, California, USA, 55–67.