Forecast of changing migration condition for harmful solutions on the basis of the study of geological structures development

V.I. Starostin
R.N. Sobolev
A.B. Volkov
V.A. Petrov
A.N. Sysoev

Geological Faculty, Moscow State University, Moscow 119899, Russia.

Department of rare-metal Geology and Radiogeoecology, Institute of Ore Deposits, Geochemistry, Mineralogy and Petrography (IGEM), Russian Academy of Sciences, Staromonetny per. 35, IGEM, Moscow, 109017 Russia.

Fracture and intercrack porosity of lithosphere blocks of different rocks determine ground-water flow. Rocks of low porosity are favourable for the burial of high-toxic and radioactive waste; these are clay, salt beds, basic and, partly, acid magmatic rocks The seepage in intercrack space of such rock blocks is negligibly small and the main mode of ground-water flow relates to fractures.

Crack systems developing in deep geological structures are controlled by tectonophysics and petrophysics conditions. Study of fracture characteristics in consideration of modern geological conditions allows us to make a three-dimensional model of geological environment, which is sufficient for the forecast of harmful solution distribution by means of ground water flow simulation. The modern tectonic strain field has to be taken into account also; it determines the permeability of existing joints as a function of their location within either contracted or expanded blocks and individual orientation of every crack in relation to principal axis of stress.

The study of the geodynamic situation surrounding the assumed burial site should be performed on several scales. 1) Geomorphological methods provide an idea of the regional tectonic phenomena. Characteristics revealed at this stage are: type of geodynamic regime (it is defined according to the dominant block movements), orientation of principal axis of regional stress field, main faults and block displacements, periods of chief stages of tectonic activity. 2) Analysis of crack systems with note of orientation, aperture and extension spacing between cracks, study of secondary mineralization and surface striations. These investigations can be performed on the earth surface, in mines and boreholes and provide the most important data for constructing the model of geological environment Moreover analysis of coupled crack systems and crack striations allows us to establish orientation of the stress field on some stages. Most of the striations were formed by the last tectonic displacements and are the only measurable geological results of these movements. So the kinematic analysis thereof is the most solid way to establish the modern tectonic conditions. 3) Investigations of micro-jointing and plastic deformations of intrafracture rocks by means of laboratory methods are performed in the most important places: mines of the future burial, the nearest faulted and sheared zones etc. The ultrasound analysis of elastic anisotropy of rocks makes it possible to recogize zones of incipient jointing and to study the nature of pore space. Results of plastic deformations studied in fine sections indicate location of mechanically weak zones and modes of rock deformation.

The net result of the above-mentioned researches is the three-dimensional model of geological environment which permits us to simulate the ground-water flow. Geological blocks vary in permeability may be separated in the studied volume. The simulation methods provide ensurence of the complete insolation of burial for a short period about 1000 years.

Development of the existing crack systems can be predicted on the basis of the comprehensive investigation of tectonic processes. A forecast of additional system originationis more complex task whichrequires study of physical properties of geological blocks. At the limits of the upper levels of the earth's crust a dominating majority of rocks possesses distinctly developed elastic properties. Under the conditions of prolonged tectonic impacts exceeding the creep limit these rocks behave like elastico-viscous substances and undergo significant plastic deformations. In this case the elastic properties of rocks become of

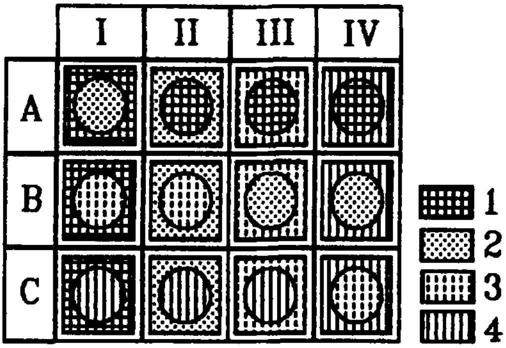

FIG. 1. The spatial crystalline rock massifs combinations as double system relations of the main typpes of petrophysical media. Type of medium: 1, viscous–rigid; 2, plastic–low-rigid; 3, brittle–low-rigid; 4, brittle–rigid.

secondary importance; besides the rigidity, the deciding role is played by the viscosity of rocks. These two parameters determine the behaviour of rock massif in the field of tectonic strain.

In this connection a proposal was made to divide all natural complexes on the basis of the available petrophysics and geodynamic data into four types of petrophysical media.

1) Viscous-rigid type of geological media unites geological sequences that are chiefly composed of basalts, diabases, basaltic andesite porphyrites, gabbro and other rocks of basic composition. The rocks of this type possess high compression rigidity and are capable of considerable plastic deformation when the tectonic strains exceed the limit of elastic rock deformation.

2) Plastic-low-rigid type of geological media is represented by rock piles with the highest abilities for plastic deformation. They are, for example, schists, fine laminated terrigeno-carbonate layers and salt beds. These rocks are weakly subjected to jointing (exclusive of layered or cleavage subparallel jointing systems); this type is characterized by active development of different scale plicative elements (from crenulation to regional fold systems).

3) Brittle-low-rigid type is formed by blocks of rocks that are predisposed to cracking even in result of quite insignificant tectonic strains. They are, for instance, coarse bedded tuffs and acid tuffites.

4) Brittle-rigid type is characterized by high rigidity value also. However in the case of exceeding this value, the rocks of this type (granitoids, acid lavas, quartzites) can be jointed easy. Experience of ore-bearing geological structures study allows us to state that the most favourable situations for radwaste disposal are blocks of the viscous-rigid type surrounded by sequences of plastic-low-rigid rocks (A-II Fig.l). In these conditions every tectonic strains can be damped at the expanse of plastic deformations of the plastic-low-rigid buffer. Internal structure of the protected massif is not subjected to considerable tectonic influence. In this connection the new fracture systems will not have any chance to arise inside the massif and respectively the storage facilities will not be exposed to dangerous deformations.

As the first example of such geological situation can be considered the geological structure of Petchenga ore area (Kola Peninsula). The territory is well-known due to drilling of the Kola superdeep borehole. This structure is situated within the stable craton and characterized by a combination of the weakly deformed intrusives of basic-ultrabasic composition (viscous-rigid type) with the enveloping and over lying plastic sedimentary rocks (plastic-low-rigid type). The second model characterizes abovementioned connection of types in the geosyncline belt conditions. This is Blyava volcano-tectonic structure that located at the western slope of the South Urals. The central part of the volcanic brachysyncline is composed by sediments of the Silurian volcanogenic complex namely the magmatic rocks of basic and intermediate composition (viscous-rigid type). These rocks are underlied by sedimentary and volcanogenic-sedimentary Cambrian and Ordovician rocks (limestones, sandstones, tuffaceous argillithes, calcareous comglomerates) corresponding to plastic-low rigid type. In both case the plastic-low-rigid envelopes were subjected to intensive disharmonic folding under tectonic strain, whereas the viscous-rigid blocks were protected from considerable deformations. The above-described way of environment investigation is based on the significant role of geological surrounding in multibarrier strategy, and can be used for optimization of processes that are directed toward the selection of favourable geological blocks for radwaste disposal.