Influence of external factors on the crack growth in rock materials

Panfilov P. (1), Kochanov A.N. (2), Panfilov G.P. (1), Zaytsev D. (1)

(1) Ural Federal University, Yekaterinburg, Russia

(2) IPKON RAS, Moscow, Russia

e-mail: peter.panfilov@urfu.ru

Properties of rock materials (RMs) with developed hierarchical structure depend on many factors, among which the most important are presence of structural defects and influence of envi-ronment. One of methods to simulate their influence on strength of RMs is laboratory experiment. Small-size samples allows caring out mechanical testing and examination of surface on the same samples. This report presents data of this kind of research carried out by the authors over the past few years. Following RMs were used as model materials: magmatic RMs - granite; sedimentary RMs - sandstone, jasper, coal; metamorphic RMs -quartzite, serpentinite and marble. Studies were carried out on cylindrical specimens with diameter 6 mm and thickness 3 mm. Part of gran-ite samples contained cracks resulting from the explosive effects of the original workpiece. Me-chanical tests of were carried out by diametrical compression scheme at room temperature, both in air and in water. Development of cracks in samples was studied using an optical microscope, and morphology of fracture surfaces was examined by a scanning electron microscope. At macro-scopic scale, all samples showed brittle deformation behavior, regardless of the type of RMs and the environment. Presence of such defects as cracks and large pores in samples did not lead to qualitative changes in behavior of RMs. Under influence of water in granite, quartzite, serpentin-ite, and sedimentary RMs, there was slight decrease in strength and deformation before the fail-ure, which did not affect the morphology of fracture surfaces of samples. It was brittle transgranu-lar fracture, whereas in jasper, marble fracture mode was brittle intergranular fracture. Hence, the embrittlement of RMs of the first two groups by reducing the cohesive strength of grain bounda-ries under the action of water can be eliminated, since there were no brittle intergranular fracture on the fracture surfaces. This feature can be explained by Rehbinder's effect, when under influence of water the process of nucleation and movement of defects of plastic deformation - disloca-tions - is activated. Trajectory of dangerous cracks in RMs was determined by geometry of load-ing and did not depend on environment. When tested in magmatic RMs and sedimentary RMs in air, the length of main cracks is comparable to diameter of sample, and when tested in water, it was 60-70% of diameter of sample. Crack width in samples tested in air was 2-3 times greater than in samples deformed in water. Main cracks consisted of porous microcracks, which have a tendency to merge with each other. Similarly, cracks develop in the neck on flat specimens of duc-tile metals. The length of microcracks in samples, unlike their width, did not depend on environment. Hence, at microscopic scale, magmatic RMs, as well as metamorphic and sedimentary RMs, exhibit viscous-elastic behavior. This can be explained by the fact that at microlevel for this type of RMs, because of their structural features, there is mechanism for stress accommodation, which competes with crack growth, irreversible deformation or microplasticity. This work was supported by Russian Science Foundation (No. 15-19-10007).