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Geochemical Modeling of Mineralogical Changes in Rock and Concrete in Interaction with Groundwater

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Abstract : Geochemical modeling of mineralogical changes of various materials in contact with an aqueous solution is an important tool for predicting the processes and development of given materials at the site. The modeling focused on the mutual interaction of groundwater at the contact with the rock mass and its subsequent influence on concrete structures. The studied locality is located in Slovakia in the area of the Liptov Basin, which is a significant inter-mountain lowland, which is bordered on the north and south by the core mountains belt of the Tatras, where in the center the crystalline rises to the surface accompanied by Mesozoic cover. Groundwater in the area is bound to structures with complicated geological structures. From the hydrogeological point of view, it is an environment with a crack-fracture character. The area is characterized by a shallow surface circulation of groundwater without a significant collector structure, and from a chemical point of view, groundwater in the area has been classified as calcium bicarbonate with a high content of CO2 and SO4 ions. According to the European standard EN 206-1, these are waters with medium aggression towards the concrete. Three rock samples were taken from the area. Based on petrographic and mineralogical research, they were evaluated as calcareous shale, micritic limestone and crystalline shale. These three rock samples were placed in demineralized water for one month and the change in the chemical composition of the water was monitored. During the solution-rock interaction there was an increase in the concentrations of all major ions, except nitrates. There was an increase in concentration after a week, but at the end of the experiment, the concentration was lower than the initial value. Another experiment was the interaction of groundwater from the studied locality with a concrete structure. The concrete sample was also left in the water for 1 month. The results of the experiment confirmed the assumption of a reduction in the concentrations of calcium and bicarbonate ions in water due to the precipitation of amorphous forms of CaCO3 on the surface of the sample.Vice versa, it was surprising to increase the concentration of sulphates, sodium, iron and aluminum due to the leaching of concrete. Chemical analyzes from these experiments were performed in the PHREEQc program, which calculated the probability of the formation of amorphous forms of minerals. From the results of chemical analyses and hydrochemical modeling of water collected in situ and water from experiments, it was found: groundwater at the site is unsaturated and shows moderate aggression towards reinforced concrete structures according to EN 206-1a, which will affect the homogeneity and integrity of concrete structures; from the rocks in the given area, Ca, Na, Fe, HCO3 and SO4. Unsaturated waters will dissolve everything as soon as they come into contact with the solid matrix. The speed of this process then depends on the physicochemical parameters of the environment (T, ORP, p, n, water retention time in the environment, etc.).

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