Modeling evaluation of flooding of the old deep uranium mine by water from tailings pond

J. Novák [1], J. Maryška [2] and J. Mužák [3]

Abstract: The contribution is devoted to the description and the application of the mathematical model of groundwater flow and reactive-transport on the problem of flooding of the deep uranium mine by water from tailings pond. The planned flooding of the Hamr I mine will significantly affect the hydrogeological situation in all the area of the Stráž block. Intensive underground water flow changes will occur in the first two years of flooding process. That is why the unsteady unsaturated flow and reactive-transport model was used. The problem of flooding the mine goes together with liquidation of the chemical treatment plant tailings' pond. The flooding by alkalized tailings pond free water will avoid future acidification of mine water as a result of decomposition of oxidized pyrite minerals.

Currently used DIAMO GWS model is a 3-D finite element groundwater flow model coupled with kinetic/equilibrium geochemical reaction component using the concept of a mixed-hybrid element for simulations of reactive transport in saturated and unsaturated media. The model developed by DIAMO group comprises two basic modules: the finite element transport module in its primary formulation and a reactive module based on mixed-hybrid formulation.

The model solves a mass balance in the grid element throughout the 3-D domain in time steps by an inter-element aqueous solution transfer. Calculation of the thermodynamic equilibrium of solution concentrations entering the element is followed by quantification of ox-redox reactions in given solution and interaction between the solution and rock forming minerals. Then, the thermodynamic equilibrium is recalculated based on concentration changes followed by computation of sorption/desorption.

Above-mentioned numerical model was used for simulation of groundwater flow and chemical substances migration in the process of flooding of Hamr I deep mine.

The modeled area of interest covers approximately 120 km^2. Finite element mesh covering the area contains 975 nodes and 1833 planispheric elements. Elements in the area of mining blocks are equilateral triangles with side of approx. 80 meters. Larger elements are placed around southern and eastern edges, where the length of triangle side is approx. 800 meters. Spatially the area is divided into 12 layers with vertical thickness 5 to 20 meters. The mesh contains 21 966 elements altogether. The view on the finite element mesh can be seen on Figure 1.

[1] Research Assistant, Dept. of Modeling of Processes, Technical University in Liberec, Halkova 6, 461 17 Liberec 1, Czech Republic, novak@diamo.cz
[2] Associate Professor, Dept. of Modeling of Processes, Technical University in Liberec, Halkova 6, 461 17 Liberec 1, Czech Republic, jiri.maryska@vslib.cz
[3] Research Assistant, Dept. of Computational Methods, Institute of Computer Science, Academy of Sciences of the Czech Republic, Pod Vodarenskou vezi 2, 182 07 Prague 8, Czech Republic, muzak@cs.cas.cz

General Newton boundary condition is the only type used in model. Upper and lower plane is assigned impermeable. Piezometric head measured in survey drills is given on model boundaries. Most important influences in the area are:

- hydro-barrier Stráž (injection 8.0 m3/min)
- drainage channels (pumping 9.0 m3/min)
- mine drainage (pumping 17.5 m3/min)

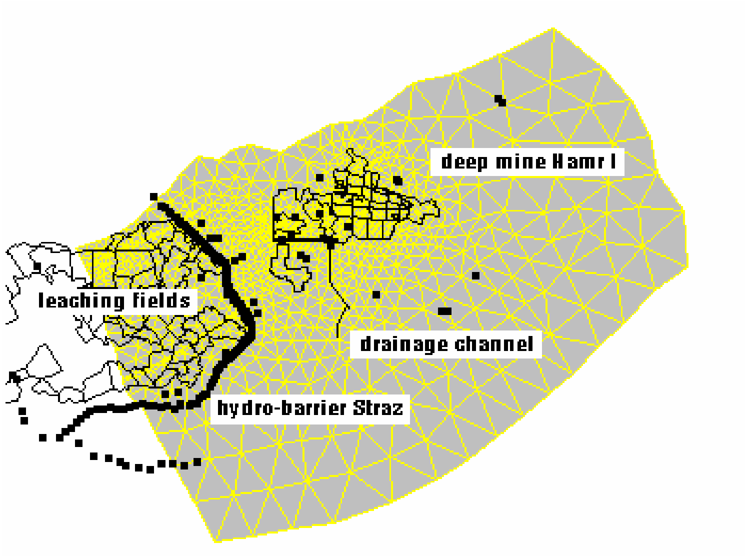

Figure 1 – Finite element mesh.

The process of flooding can be divided into two stages, differing in the chemical composition of water. In the first stage, alkalized tailings pond free water is used for flooding. The reason is need of liquidation of tailings pond. The flooding by alkalized tailings pond free water will avoid future acidification of mine water as a result of decomposition of oxidized pyrite minerals. In the second stage, natural groundwater from the neighborhood is flowing into the area of mine.

Results of computational simulation of one particular scenario of flooding can be seen on figures 2 and 3.

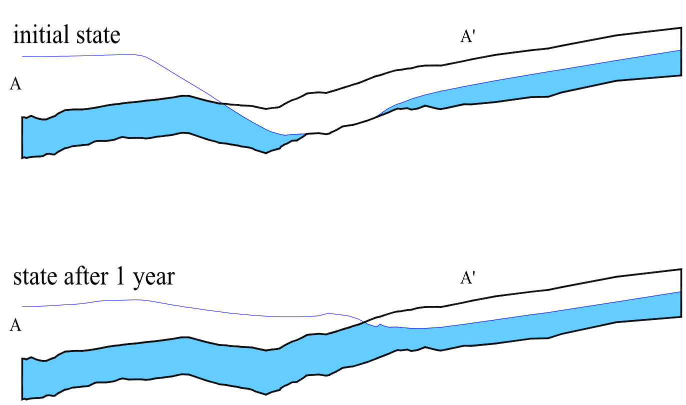

Figure 2 – Evolution of water level during the flooding process.

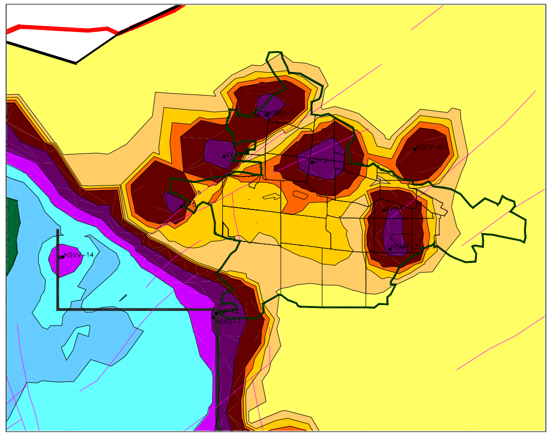

Figure 3 – Distribution of contaminants in the area of deep mine after one year.

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