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NUMERICAL SIMULATION OF CONTROL OF REMEDIATION OF URANIUM DEPOSIT STRÁŽ

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Introduction. The chemical mining of uranium on the deposit Stráž has caused large contamination of groundwater of cretaceous collectors in Stráž block of Northbohemian cretaceous table. The low cenomanian aquifer where the uranium deposit is placed is mainly afflicted. In the cenomanian collector there is now more than 4.8 mil. tons total dissolved solids (TDS) mainly SO_4^{2-}, Al, Fe, NH_4^+ etc. The total salinity reaches up to 80 g/l. The upper laying turonian collector is drinking water reservoir for larger region. Its contamination is weaker than in cenomanian collector [6].

The contamination of cenomanian aquifer represents the potential risk for turonian drinking water sources. After finishing the remediation of Stráž deposit the cenomanian piezometric surface will arise on the original level before starting the mining activities. Such level will be higher than turonian water level in the area of Stráž deposit. Then the intercollector transfer of the contaminated waters from cenomanian aquifer to turonian through low-turonian semi-aquitard which is weaken by large amount of wells and probably by natural non-homogenities can also happen.

Models used. Use of complex 3D Transport – Reaction Model can be divided into two separate parts. First modelling step is a quantification of overflow between individual mesh elements calculated out of calibrated mixed-hybrid flow model. Two different types of mathematical models are used to accomplish the task:

- Flow model based on a primary formulation of finite element method, which calculates spatial distribution of piezometric head and flow velocity vectors in selected points of area considered (finite element mesh nodes). This model exactly describes hydraulic situation in the area. It's a very fast and stable system, used for pre-calculation of additional boundary conditions for mixed-hybrid model. For the simulation a MDL3DUSat [11] program is used.

- Flow model based on mixed-hybrid formulation of finite element method [3]. This model strictly complies with exact water balance at inter-element faces. It is slow and more complicated system. For simulation a MDL3DESat [12] program is used.

In the second part transport-reaction model based on a finite volume method [1][2] is used for calculations using pre-calculated advective velocity field in the area

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considered (see Fig. 1). For the simulation a MDL3DTSat [13] program coupled with ChemAMMc [5][14] chemical reaction module is used.

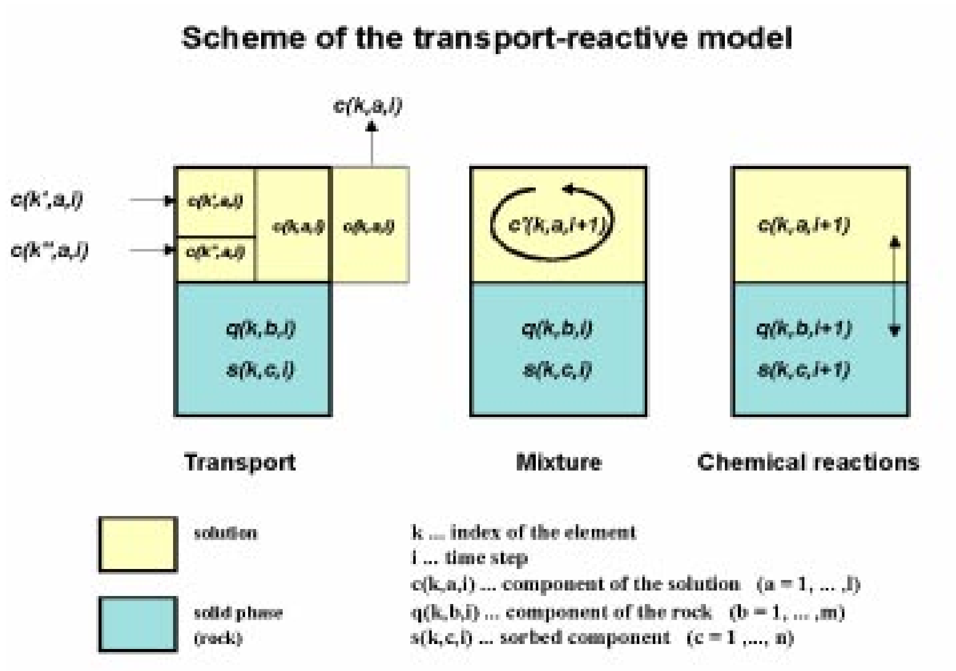

FIG.1: *Scheme of the transport-reactive model*

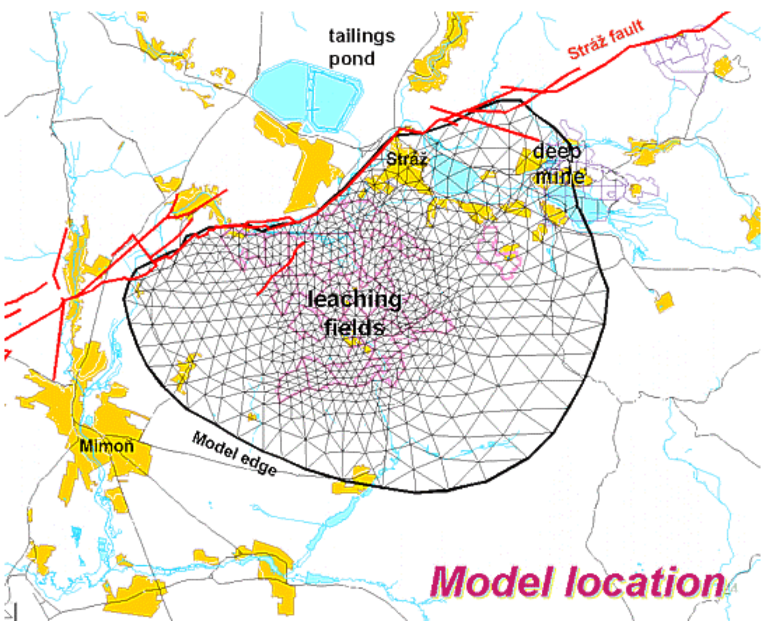

FIG. 2: *Finite-element mesh and its location*

Modelling. The finite-element mesh covering about 40 km^2 consists of about 16 000 spatial elements. In the leaching fields area the length of the triangular edge is 100 - 150 meters, vertically the horizon is split into 9 - 13 layers [8] (see Fig. 2). The geological boundary-lines [9] were constructed from a database containing information about almost 10 thousand wells. Permeability parameters are defined on the bases of hydrogeological model calculations (calibration) and their vertical distribution is defined more precisely using the GTIS (Geo-Technological Information System) data. The initial conditions [7] (the concentrations of contaminants in solution) in the leaching field area are defined from the monitoring wells [4].

Chemical processes are solved by two different methods. A decay of caolinit caused by the sulphuric acid is solved using the thermodynamic-kinetic model. This model was developed from the balanced thermodynamical model for solutions and rocks of the Stráž deposit. The thermodynamic system of the balanced model consists of 18 main components of solution, 32 minerals, 110 chemical reactions between the solution components and 44 reactions between minerals and the solution. The main components of the solution can occur in 184 different forms. In the first stage the kinetic model was reduced to 5 components and 11 equations. The model solves a leaching of Al from the rock and its precipitation in the form of alunit or aluminium hydroxid. At the same time the concentration of H_2SO_4 and the total amount of sulphur ion is changing.

Different technological scenarios are decided by the top-management of the company. The scenario respects market situation, price development, inflation and other economical and ecological influences. These factors define the technologies needed for transformation of withdrawn substances into marketable products. Various scenarios are then modelled to evaluate the economical and ecological demands. Modelling results are then given back to the top-management to select the proper remediation strategy.

Model results. One of the calculated scenarios is presented below.

Initial state of distribution of TDS concentration is shown on Fig 3 [10]. The target parameter of remediation is concentration of TDS on the level of 8 g/l TDS. In that case, the drinking water sources in turonian aquifer will not be afflicted. The target parameters of remediation will reached in 2032 (see Fig 4). To reach the parameter it will be necessary to remove 3 550 000 tons of TDS (see Fig 5). Cumulative remediation costs will be close to 45 mld Kč (see Fig 6).

At the end of underground remediation, when no more pollutants are withdrawn from the ground, the remediation continues on surface. All the buildings and factories have to be taken away, all the pumping wells sealed and the surface replanted with grass and trees. The expenses on this final stage are lower then during the pumping (contaminant removal) stage, but still have to be calculated into the total remediation costs. Absolute end of remediation works is planed at the year 2041.

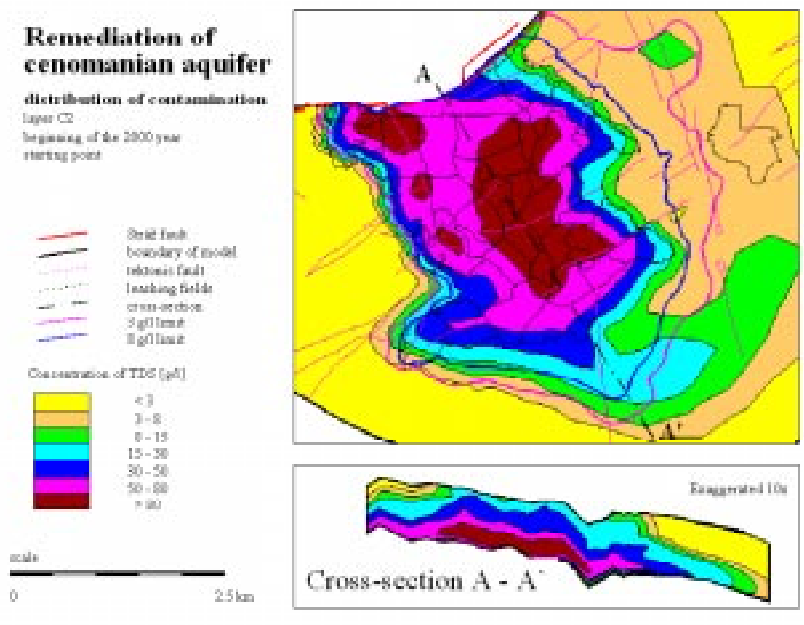

FIG. 3 : *Initial state in the 2000 year*

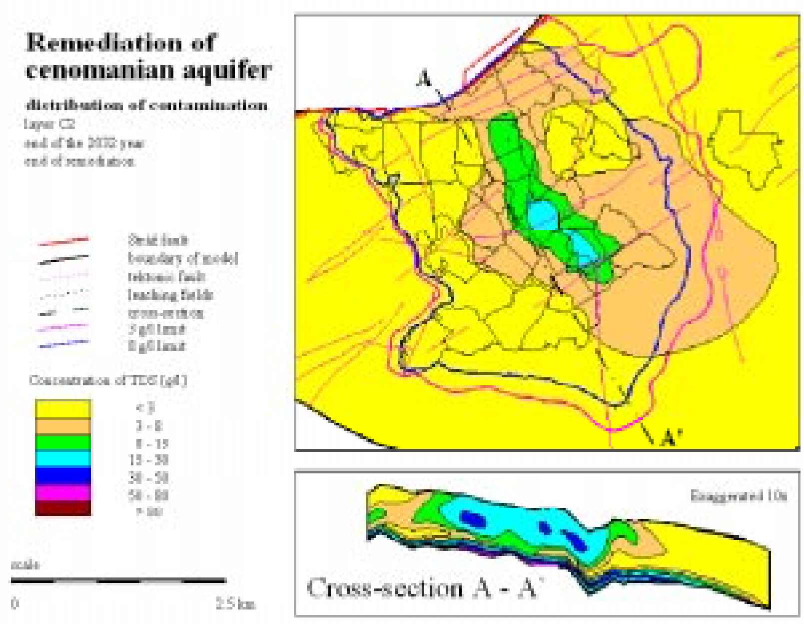

FIG. 4 : *Target state in the 2032 year*

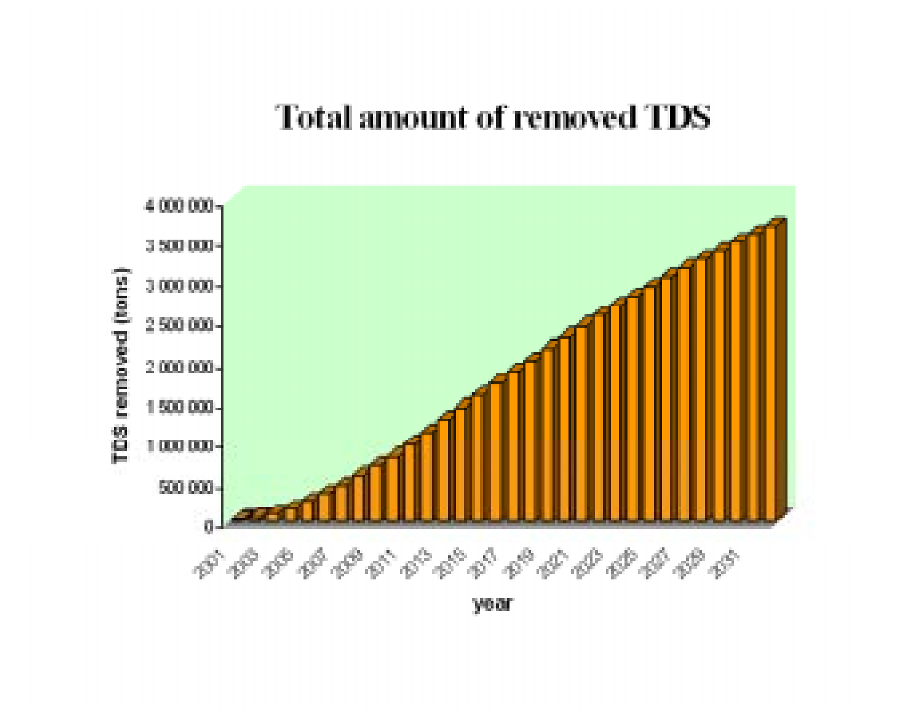

FIG. 5 : *Total amount of removed TDS*

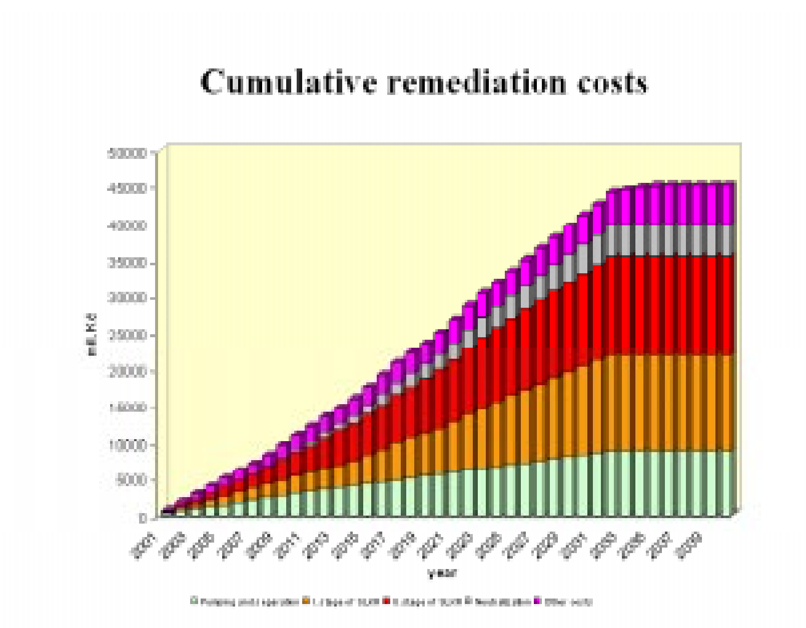

FIG. 6 : *Cumulative remediation costs*

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