Groundwater modelling using numerical simulations started in the 1960s. At that time numerical and physical models used in the first half of the twentieth century were developed further. The first membrane and analogue models were employed in, for instance, hydraulic system integrators and electro-hydrodynamic analogy models (AEHD). In the 1980s numerical models appeared on the scene, and thanks to the universal access to PCs and user-friendly software, have now become common tools for hydrogeologists.

Groundwater modelling is commonly used for yield calculations of groundwater pumping wells and to determine hydrodynamic fields. Calculations of groundwater travel time from recharge to discharge zones conducted on the basis of such models enable concept determination in groundwater resource protection and development solute transport prognosis. Results of groundwater flow models are being used in descriptions of groundwater circulations and estimates of groundwater renewable resources and safe yields amongst different kinds of hydrogeological structures.

Groundwater mathematical modelling is an effective tool in protection strategies for the Main Groundwater Basins. It is also commonly applied to risk assessment and for estimating the influence on groundwater resources during projected processes of mine dewatering systems. In the papers included here, there are examples of practical applications of groundwater numerical models designed for the evaluation of groundwater fluxes, the determination of hydrodynamic fields in areas of complex hydrogeological systems or of models designed for geothermal energy use. Also addressed are the problem of groundwater model scale as well as cases of groundwater flow simulations through the unsaturated zone using the VS2DI code.

Continuous progress can be observed in mathematical modelling and descriptions in models of processes taking place in the groundwater environment are becoming increasingly better. In order to obtain more precise models, field measurements need to be more detailed, which holds true also for laboratory tests of processes that take place in the unsaturated zone or for the correctness of hydrogeological parameters applied to models of different scales. Models are designed that lead to the identification of geothermal systems and predictions of thermal and medicinal water exploitation. Mathematical models that permit characterisation of deep-lying geological structures and groundwater systems excluded from hydrogeological water cycles are still being developed. Interesting aspects to such analyses will be models that simulate the behaviour of fluids and rocks during hydraulic fracturing and exploitation of shale gas and oil.

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