

Long-term hydrodynamic response induced by past climatic and geomorphologic forcing: the case of the Paris basin, France.

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Abstract

In the framework of safe underground storage of radioactive waste in low-permeability layers, it is essential to evaluate the mobility of deep groundwater over timescales of several million years and to define accurate initial hydrodynamic conditions of geopropective hydrodynamic simulations. On these timescales, the environmental evolution of a repository should depend upon a range of natural processes that are primarily driven by climate and geomorphologic variations. We investigate the response of the Paris basin groundwater system to variations in its hydrodynamic boundary conditions induced by past climate and geodynamic changes over the last five million years. We calculate the natural pressure field of the Paris basin system previously at any groundwater exploitation. This stage could be then used to simulate hydrodynamic situation under future boundary conditions.

For the purpose of this work, a three-dimensional transient modelling of the Paris basin aquifer/aquitard system was developed using the code NEWSAM (Ecole des Mines de Paris, ENSMP). The geometry and hydrodynamic parameters of the model originate from a basin model, NEWBAS (ENSMP), built to simulate the geological history of the basin over its 248 My evolution. Geomorphologic evolution is deduced from digital elevation model analysis, which allows to estimate river-valley incision and alpine surrection. Climate forcing results from palaeoclimate modelling experiments using the LMDz atmospheric general circulation model (Institut Pierre Simon Laplace) with a refined spatial resolution, for the present, the Last Glacial Maximum (21 kyr BP) and the Middle Pliocene (3 Myr). The water balance is computed by the distributed hydrological model MODSUR (ENSMP).

We present the simulated evolution of piezometric heads in the system in response to the altered boundary conditions, in particular in the vicinity of ANDRA's Bure potential repository site within the Callovo-Oxfordian argillaceous layer. For the present, the comparison of head patterns between steady state and time dependent simulation shows little differences for aquifer layers close to the surface but suggests a transient state of the current system in the main aquitards of the basin and in the deep aquifers, characterized by abnormally low fluid potentials. The dependence of the boundary-induced transient effects on the hydraulic diffusivity is illustrated by means of a sensitivity study.

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