THE IMPACT OF THE LAST GLACIATION ON GROUNDWATER FLOW IN THE NORTHERN BALTIC ARTESIAN BASIN (BAB): A NUMERICAL STUDY

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Several evidences of subglacial recharge of meltwater are found in groundwater flow systems that were overridden by ice-sheets during past glaciations, in North America and in northern Europe. Numerical models confirmed that subglacial recharge can disturb the regional flow of groundwater to a very large extent and over several thousands of years after the final retreat of ice-sheets. Such mechanism is of particular relevance to freshwater resources and to the safety of deep nuclear waste repositories. However, calibration of subglacial recharge models is challenging, because field data are missing to simulate this process and other glacial processes under past environmental conditions.

In Estonia, the northern Baltic Artesian Basin offers a good case-study for developing better grounded models of subglacial recharge, because many field data have been collected during the last decades. Evidences of subglacial recharge include the most negative values of $\delta^{18}O$ ever measured in groundwater in Europe (c. -22‰), as well as low salinity, high excess air and cold recharge temperatures inferred from noble gases. ^{14}C dating indicates ages ranging from 30 to 19 ky BP. Those geochemical and isotopic evidences suggest that subglacial recharge took place during the Last Glacial Maximum (LGM), during which the entire region was recovered beneath the Fennoscandian ice-sheet.

To test this hypothesis of recharge, two 2D cross-sectional models were built which cross the northern BAB along a NW-SE direction. Groundwater flow and $\delta^{18}O$ transport were simulated from the beginning of the LGM until present-day. $\delta^{18}O$ was used as a tracer for distinguishing initial pre-LGM groundwater, glacial meltwater, and modern recharge. To account for the uncertainty related to the hydraulic properties and to the numerical representation of subglacial recharge, several sets of hydraulic properties and several scenarios of subglacial recharge were tested in a few thousands simulations. The numerical code FEFLOW was used.

Many simulations provide a satisfying fit between the observed and the computed values of $\delta^{18}O$, which means that subglacial recharge is a likely mechanism to explain the present-day distribution of $\delta^{18}O$ in groundwater in the northern BAB. Simulations show that meltwater entirely recharged the shallow part of the basin. After the retreat of the Fennoscandian ice-sheet, meltwater was preserved in confined aquifers and flushed away elsewhere by modern recharge. Large volumes of meltwater were also probably preserved beneath the Baltic Sea. Beside these local findings, these simulations also show that simplifying the representation of subglacial recharge with respect to previous studies was a good strategy, as it succeeded to reproduce field data while providing results easier to interpret. The technique offers an interesting perspective for future hydrogeological models of subglacial recharge.

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