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On talik formation related to geological radioactive waste storage

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The safety against radioactive waste stored deeply in the underground is principally at risk where groundwater can attack the metallic waste canisters. For a performance assess-ment of a geological repository, it is therefore imperative to know the groundwater flow system over the projected lifetime of the repository. According to the current legislation in Germany, this will be a million years /STA 17/.
Over the past million years, several cold ages have occurred and have brought permafrost conditions basically to all potential sites for a radioactive waste repository in Germany (e.g. /VAN 93/). It can therefore be expected quite safely that any conceivable repository will sooner or later be subject to these conditions again. This is significant because permafrost will have a considerable impact on groundwater flow as the ground freezing tends to sepa-rate aquifers in the underground hydraulically from the surface.
However, it is also known that even under permafrost conditions there are local volumes of unfrozen ground, called taliki, connecting the surface waters with unfrozen aquifers. Flow of contaminated waters from a possible leakage in the repository could thus be directed towards such taliki and reach the surface concentrated in single spots (e.g. /JOH 16/). Taliki are thus a key feature in the assessment of a possible exposure of the biosphere to harmful radioactive substances.
Talik formation is presently quite intensively investigated in the framework of global warm-ing and thereby refers to melting processes (e.g. /PAR 18/). In case of geological storage of radioactive waste, by contrast, the question is rather, where open taliki will remain in an otherwise increasingly freezing ground. Taliki are not accessible to direct observation even though they can be detected by laborious field work. Insight into the processes of talik formation might therefore alternatively be gained by numerical modelling.
A surprisingly large variety of mathematical formulations can be found in the literature that describe groundwater flow under freezing conditions including ice formation and may be applied to the problem at hand. To ensure that all relevant processes are appropriately addressed in an own model of choice, though, general balance equations for groundwater and heat flow are developed from scratch without prematurely introducing assumptions and restrictions. These balance equations are supplemented by constitutive equations and equations of state (EOS) covering also sub-zero temperature conditions. Additionally, a computationally less demanding set of EOS valid in the temperature range between 20℃ and +60℃ and hydraulic pressure up to 20 MPa has been developed. The ensuing math-ematical model is then numerically realised in the framework of the code COMSOL Mul-tiphysics.
For realistic boundary conditions at the model surface, the air temperature evolution over the last 400,000 years determined from ice cores from Antarctica /JOU 07/ has been adapted to the location of present Germany. Heat flux from inner earth can be shown to be approx-imately constant over this time period of time. First results from modelling ground temperatures during the beginning of an ice age confirm a thermal shadowing of the cooling ground under large aquatic surface features.

Participation

In-Person

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Presenter: KRÖHN, Klaus-Peter (GRS gGmbH)

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