Supplement of Saf. Nucl. Waste Disposal, 2, 87–87, 2023
https://doi.org/10.5194/sand-2-87-2023-supplement

SaND
Safety of Nuclear
Waste Disposal
Open Access

Supplement of

Climate scenarios, groundwater models, and uncertainties in long-term safety

Marc Johnen et al.

Correspondence to: Marc Johnen (marc.johnen@grs.de)

2nd International Research Symposium of BASE on Safety of Nuclear Disposal - safeND 2023
13th to 15th September 2023 – Berlin

Climate scenarios, groundwater models, and uncertainties in long-term safety

Marc Johnen[1], Judith Flügge[1], Jens Wolf[1], Klaus Fischer-Appelt[2], and Frank Charlier[2]
[1]Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH, 50667 Cologne, Germany
[2]Lehrstuhl für Endlagersicherheit, RWTH Aachen University, 52062 Aachen, Germany

Introduction

Over the assessment period of one million years, a repository for high-level radioactive waste (HLW) is affected by various processes and developments that must be considered in long-term safety-assessments. The climatic development of a site has a significant influence on future development of a repository. However, predictions are complicated by the dynamics of the climate and are subject to uncertainties. The aim of this study is to evaluate uncertainties for climate-induced processes that are relevant for the safety-assessment based on numerical groundwater models.

Triggers and impacts of climate changes

The evaluation of future climate scenarios plays a fundamental role in assessing the long-term safety of a repository for HLW. Earth orbit parameters, solar radiation, meteorites impacts, vulcanism, plate tectonics, and material cycles, also influenced by anthropogenic impacts, cause changes in climate. These triggers have influence on temperature and pressure conditions and can lead to processes like glaciation, permafrost, sea level changes, erosion and subrosion, and isostatic adjustment.

Methods

- Model geometry and parameterization based on the generic site models for clay from the RESUS and ANSICHT projects [2], [3] (Fig. 1).
- Flow and transport code d³f++ with advection, dispersion, diffusion, sorption, decay, and density driven flow taken into account [1].

Different climate states are represented by changing boundary conditions for flow and density driven flow:

1. Present climate (generic values from [2] and [3])
2. Permafrost (frozen water in upper layers reduce permeability)
3. Glacier (100 m and 1000 m; higher pressure on model surface)
4. Sea level changes (higher pressure on surface with salt water intrusion)
5. Glacial channels (areas with higher permeability in affected layers)

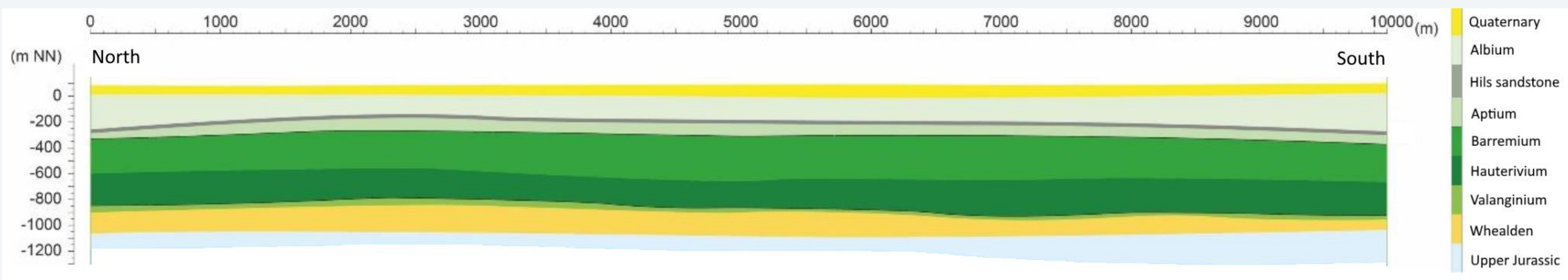

Fig. 1: Geological cross-section through the "ANSICHT North" model with stratigraphical units after [3].

Results

- Flow velocities are to be assessed as favorable in the containment-providing rock zone (CRZ) according to the StandAG [4] in all modelled climate scenarios (Fig. 2 and 3).
- Permeability changes in upper layer for Permafrost has nearly no influence on flow velocity in CRZ and non-sorbing tracer concentration distribution (Fig. 3 and 4).
- Around 25 m above and below the repository represented as tracer source, the concentration after 100,000 years is proportionally 0.1 % of the entered tracer concentration; the concentration front has not reached the CRZ (Top Barremium at around -300 m) (Fig. 4).
- Slight distribution of concentration in flow direction and in depth because of the given boundary conditions; effect is stronger with thick ice sheet load of 1000 m (Fig. 4).

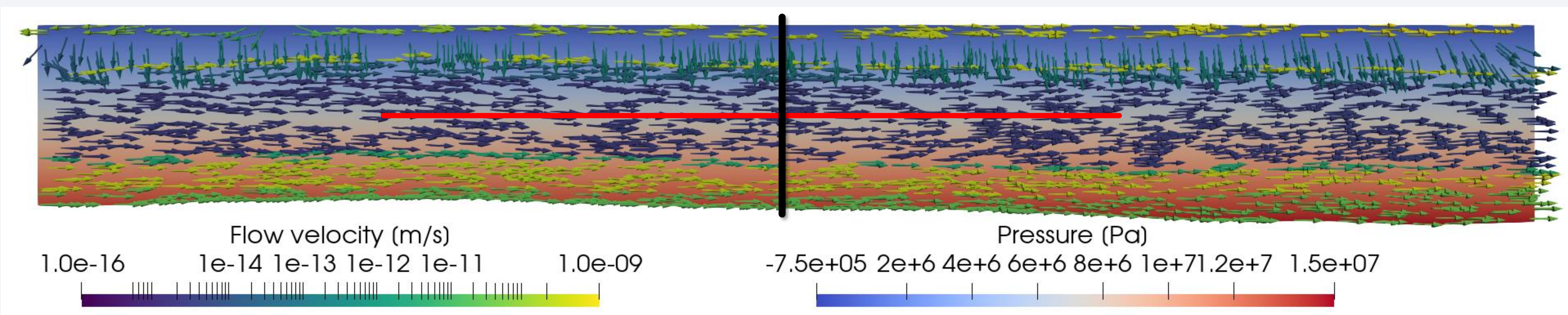

Fig. 2: Velocity vectors and pressure distribution for present climate scenario (red line: repository area, black line profile Fig. 3).

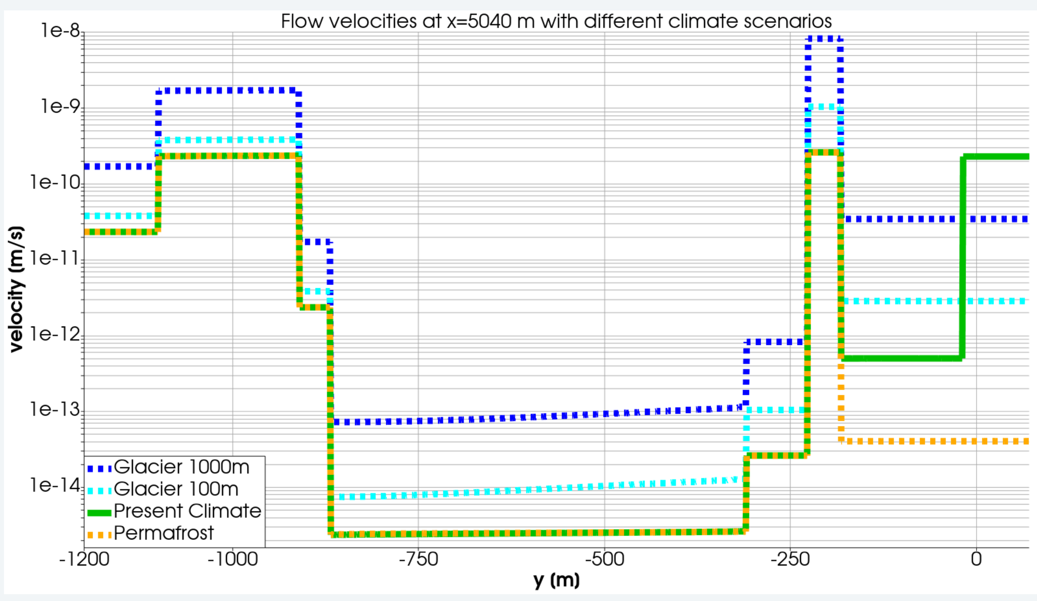

Fig. 3: Velocity profile at x=5,040 m (black line in Fig. 2).

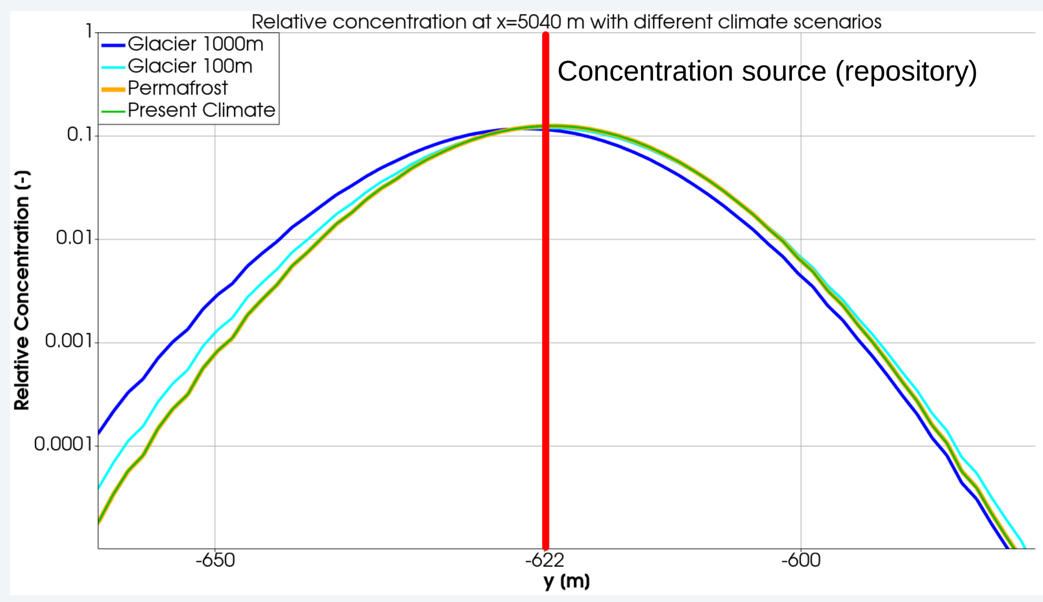

Fig. 4: Rel. concentration at x=5,040 m after 100,000 years.

Conclusion and outlook

- Flow velocities changes through different considered climate states but also depending on generic boundary conditions.
- In low permeable claystone the concentration front is slow and does not reach the CRZ; future simulations with higher permeabilities.
- ➢ Running sea level change and glacial channel models and implement transient changes of parameters for climate cycles.
- ➢ Additional parameter variations simulations for example with adsorption to study the influence on flow and transport for the different parameters.

Financed by the Bundesgesellschaft für Endlagerung mbH (BGE)

Literature

[1] Schneider, A. et al. (2020): Groundwater Flow and Transport in Complex Real Systems. GRS-566, Braunschweig.
[2] Jobmann, M. et al. (2017): Sicherheits- und Nachweismethodik für ein Endlager im Tongestein in Deutschland – Synthesebericht. DBE TECHNOLOGY, Peine.
[3] Rübel, A. & Gehrke A. (2022): Aktualisierung der Sicherheits- und Nachweismethodik für die HAW-Endlagerung im Tongestein in Deutschland. GRS-668, Braunschweig.
[4] Deutscher Bundestag (2020): Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für hochradioaktive Abfälle, Standortauswahlgesetz – StandAG.

CONTACT
Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH,
Schwertnergasse 1, 50667 Cologne, Germany
marc.johnen@grs.de

www.grs.de