Statistical analyses on the relevance of thermal data for the safety-related assessment of repository systems

First results from the project ThermoBase

Federal Institute for Geosciences and Natural Resources

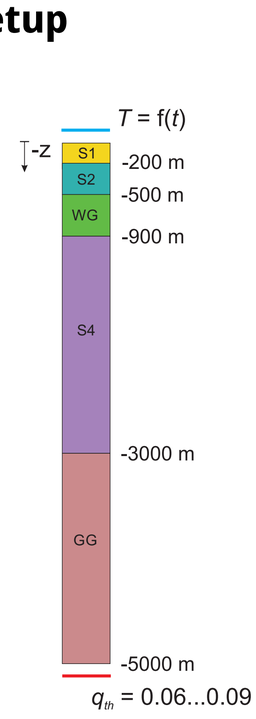
Jobst Maßmann, Maximilian Bittens, Vera Noack

Project Thermobase

The ThermoBase project aims to investigate the thermal field in sedimentary areas in Germany. It was initiated by the Federal Company for Radioactive Waste Disposal (BGE) and motivated by design calculations and safety analyses that are to be carried out as part of the site selection process for a high-level radioactive waste repository. This research project is carried out jointly by the GFZ Helmholtz Centre for Geosciences and the Federal Institute for Geosciences and Natural Resources (BGR).
This contribution addresses stochastic FE computations from the BGR on the influence of parameters on the transient temperature field in the underground. Based on research previously completed by the BGR [1, 2], comparative numerical analyses of the temperature distribution for typical geological situations in Germany are conducted. The focus is on the configuration of thermal material parameters, boundary conditions, and the uncertainty in these parameters.

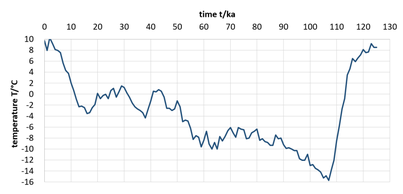
1D: column model

Setup



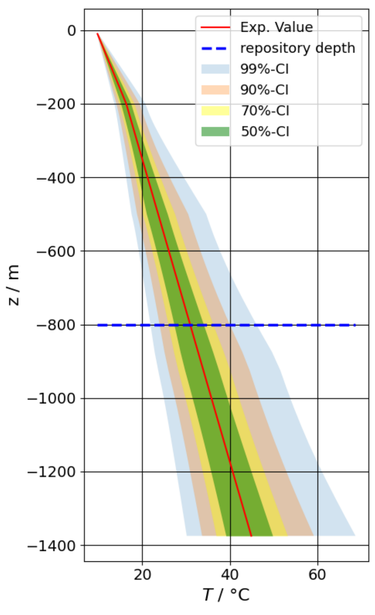
q_{th} = 0.06...0.09 W/m²

	heat conductivity (W/m/K)	specific heat capacity (J/kg/K)
S1	1.5 ... 3.0	1000 ... 1300
S2, WG, S4	1.5 ... 5.5	800 ... 1300
GG	3.0	800

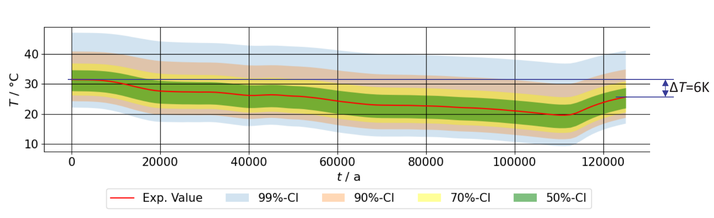


Assumed temperature evolution at the surface

Results



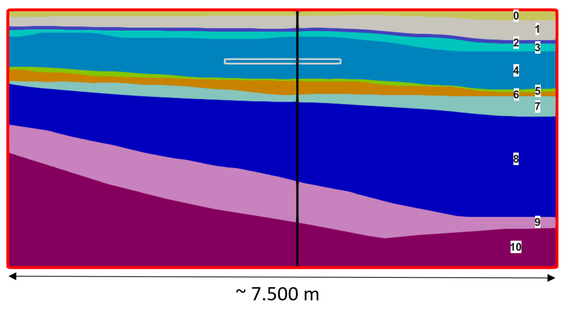
Computed stationary temperature profile with confidence intervals (CI); in repository depth, a temperature between 25 and 40 °C can be expected (90 % certainty)



Computed temperature at -800 m with confidence intervals (CI); a potential glaciation may lead to 6 K temperature decrease.

2D: generic repository system in Lower Crataceous

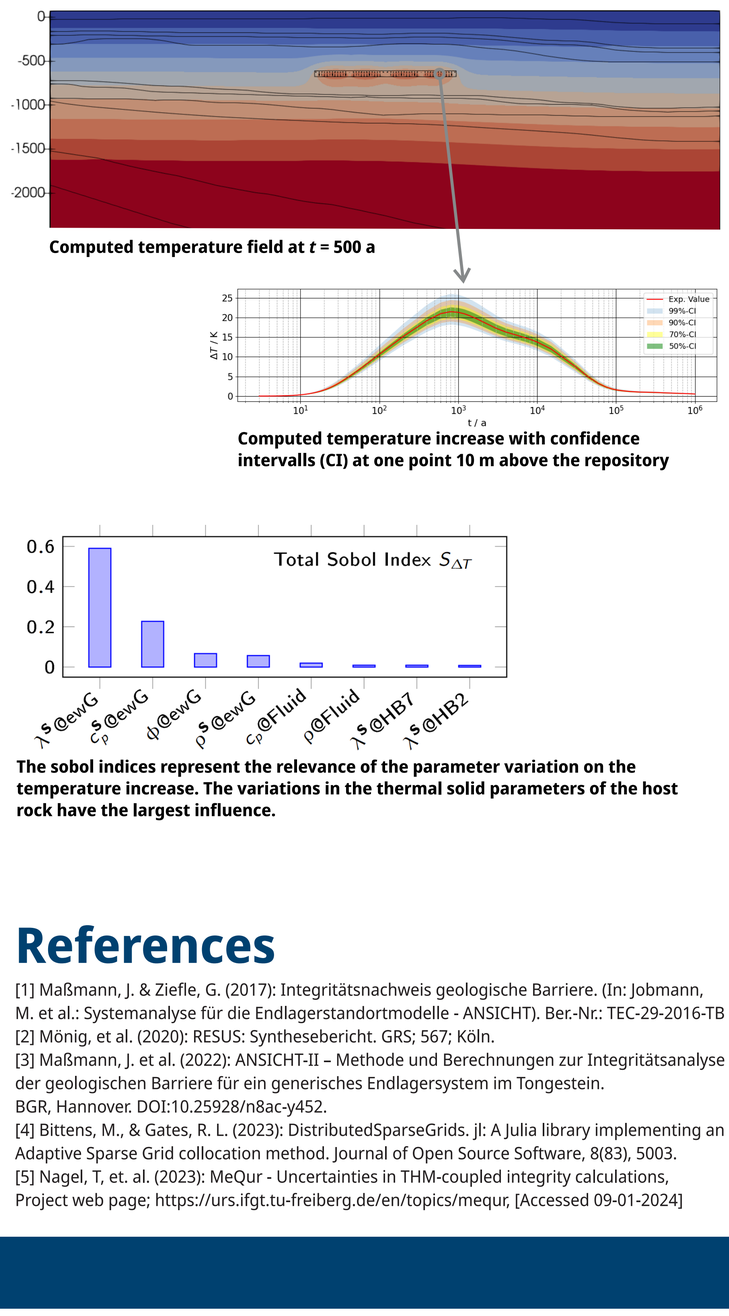
Setup



geology		HB	porosity ϕ	solid density ρ^s / (kg/m³)	solid heat conductivity λ^s / (W/m/K)	solid specific heat capacity c_p^s / (J/kg/K)
Quarternary	q	0	0.3 ... 0.5	2350 ... 2700	2.4 ... 4.46	740 ... 974
Cretaceous	krl	1	0.24 ... 0.4	2350 ... 2700	1.86 ... 3.46	740 ... 974
	S3	2	0.08 ... 0.13	2350 ... 2650	1.97 ... 3.67	740 ... 974
	krp	3	0.23 ... 0.38	2350 ... 2700	1.82 ... 3.38	740 ... 974
	krb, krh	4, ewG	0.04 ... 0.28	2350 ... 2700	1.35 ... 2.51	740 ... 974
	krv	5	0.16 ... 0.26	2350 ... 2700	1.66 ... 3.08	740 ... 974
	wd	6	0.1 ... 0.16	2350 ... 2650	1.55 ... 2.87	740 ... 974
Jurassic	jo	7	0.11 ... 0.19	2700 ... 2950	1.99 ... 3.69	585 ... 820
	jm, S2, ju	8	0.11 ... 0.19	2350 ... 2700	1.98 ... 3.68	740 ... 974
Triassic	S1, k	9	0.05 ... 0.09	2350 ... 2860	1.86 ... 3.45	740 ... 974
	so, m, su, sm, z	10	0.11 ... 0.19	2150 ... 2700	2.07 ... 3.84	740 ... 974

fluid specific heat capacity c_p^f / (J/kg/K)
3380 ... 4150

Results



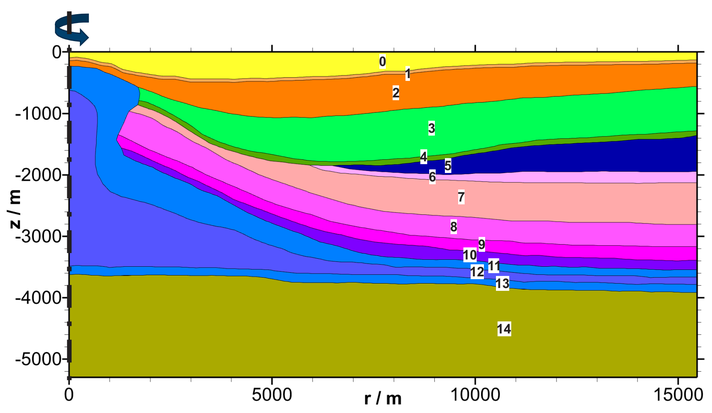
Computed temperature field at *t* = 500 a

Computed temperature increase with confidence intervalls (CI) at one point 10 m above the repository

The sobol indices represent the relevance of the parameter variation on the temperature increase. The variations in the thermal solid parameters of the host rock have the largest influence.

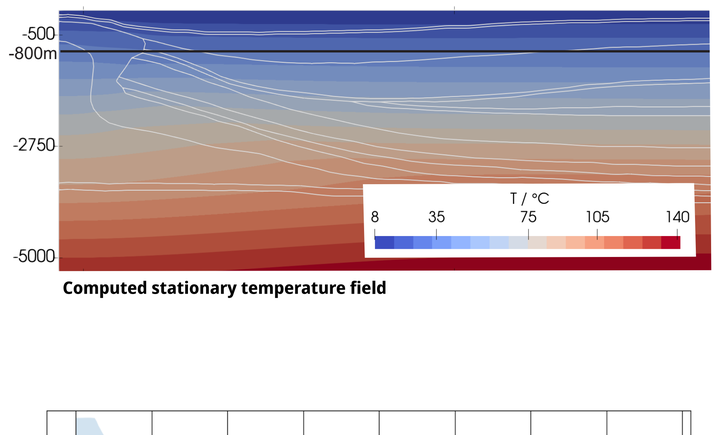
2D-rot-sym: generic repository system in a salt dome

Setup

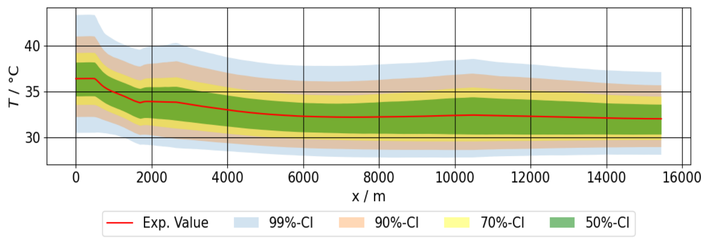


geology		HB	heat conductivity (W/m/K)
Quarternary and Tertiary	q-toloc	0	1.5 2.5
	tolR	1	1.5 2.1
	teo-tpa	2	1.5 2.5
Cretaceous	kro	3	1.9 2.5
	kru	4	1.9 2.5
Jurassic	ju	5	2 2.8
Triassic	ko	6	2.2 2.6
	ku	7	1.7 2.5
	m-so	8	1.7 2.7
	sm	9	1.7 2.7
	su	10	1.7 2.7
Permian	z2-z7	11	2.3 4.3
	z2	12	3.2 6
	z2-z1	13	2.3 4.3
bedrock	gg	14	2.2 3.4

Results



Computed stationary temperature field



Computed temperature at -800 m; in the saltdome an increase of 5 K is expected

THERMO BASE
TEMPERATURMODELL SEDIMENTÄRER TEILGEBIETE

References

[1] Maßmann, J. & Ziefle, G. (2017): Integritätsnachweis geologische Barriere. (In: Jobmann, M. et al.: Systemanalyse für die Endlagerstandortmodelle - ANSICHT). Ber.-Nr.: TEC-29-2016-TB
[2] Mönig, et al. (2020): RESUS: Synthesebericht. GRS; 567; Köln.
[3] Maßmann, J. et al. (2022): ANSICHT-II – Methode und Berechnungen zur Integritätsanalyse der geologischen Barriere für ein generisches Endlagersystem im Tongestein. BGR, Hannover. DOI:10.25928/n8ac-y452.
[4] Bittens, M., & Gates, R. L. (2023): DistributedSparseGrids. jl: A Julia library implementing an Adaptive Sparse Grid collocation method. Journal of Open Source Software, 8(83), 5003.
[5] Nagel, T, et. al. (2023): MeQur - Uncertainties in THM-coupled integrity calculations, Project web page; https://urs.ifgt.tu-freiberg.de/en/topics/mequr, [Accessed 09-01-2024]