Numerical analyses of THM processes in clay host rock: OpenGeoSys vs FLAC3D

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Introduction

As part of the work package HITEC of the European research framework EURAD, modelling of the near-field damage caused by the excavation of galleries and the effect of thermal pressurisation and of the far-field risk of tensile or shear failure in clay was carried out. A 2D generic model was built to compare the numerical codes and study the behaviour of the different host rocks in the near-field. The following work presents a benchmark exercise between two different codes on the numerical modelling of the THM processes taking place in the near-field of a disposal gallery in BOOM clay. The commercial code FLAC3D in the version 5 and the newest version 7 as well as the open source software OpenGeoSys (OGS) were used for the modelling activities.

Methods

The geometry of this near-field model is a cross-section of a heating gallery with a diameter of 1.25 m and host rock perpendicular to the gallery axis (Figure 1, left). In OGS, the model is 2D (Figure 1, middle), but the model in FLAC3D is a 3D model with a thickness of 1m (Figure 1, right).

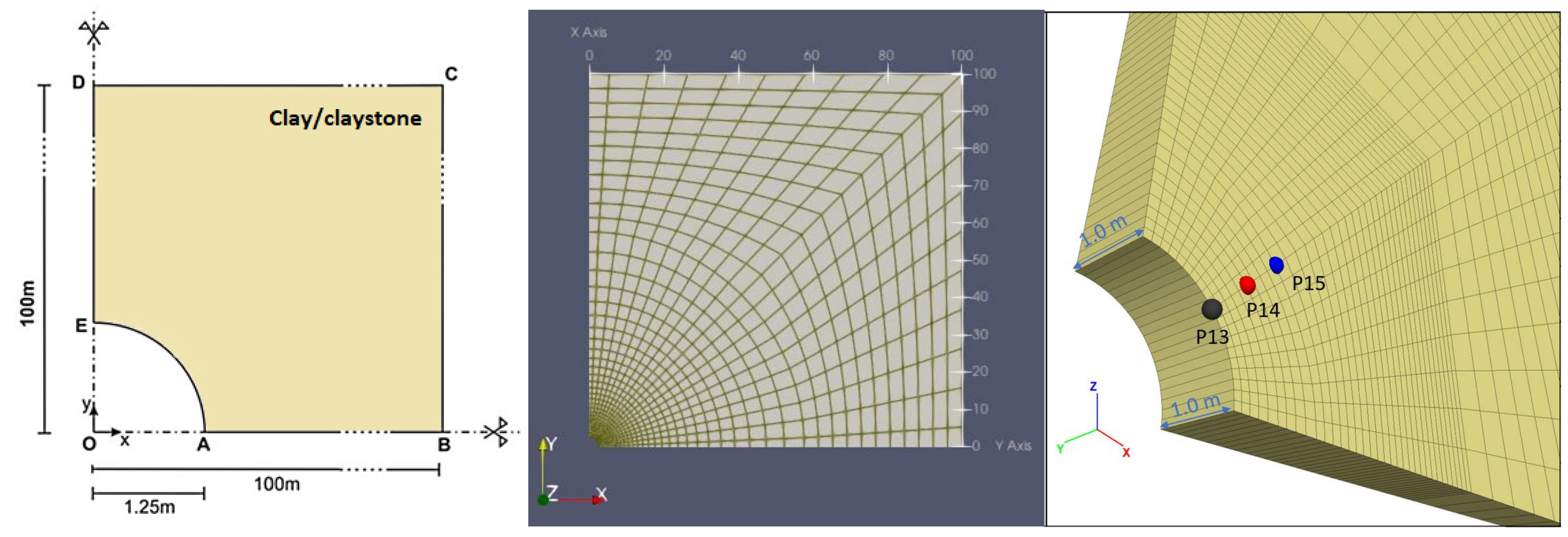

Figure 1: Geometry of the model (left), detail of the grid in OGS (middle) and in FLAC3D (right)

The benchmark consists of an excavation phase in the first 24 hours, a waiting phase with drained gallery walls lasting up to six months, and a heating phase with impermeable walls and a heat source of 200W/m in the gallery up to the end of the simulation after ten years.

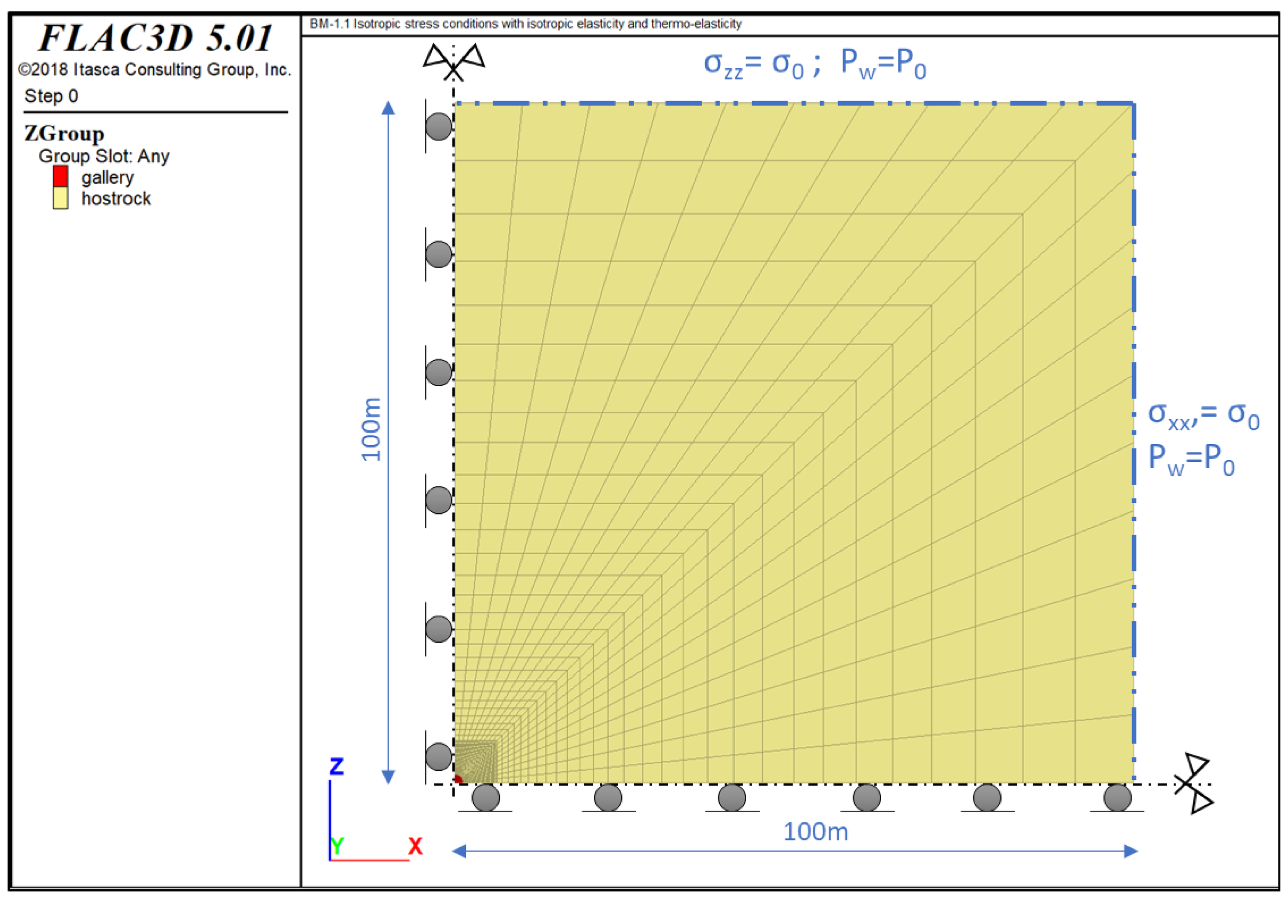

Figure 2: Boundary conditions using the model in FLAC3D v5 as an example

Results

Most discrepancies can be observed in the pore pressure evolution. Some oscillations could be observed in the pore pressure evolution in FLAC3D. A small discrepancy over time occurs between the temperature and displacement evolution in OpenGeoSys compared with the FLAC3D counterparts. The following figures show temperature, displacement, and pressure evolution during the three stages (excavation, waiting, and heating) using both codes.

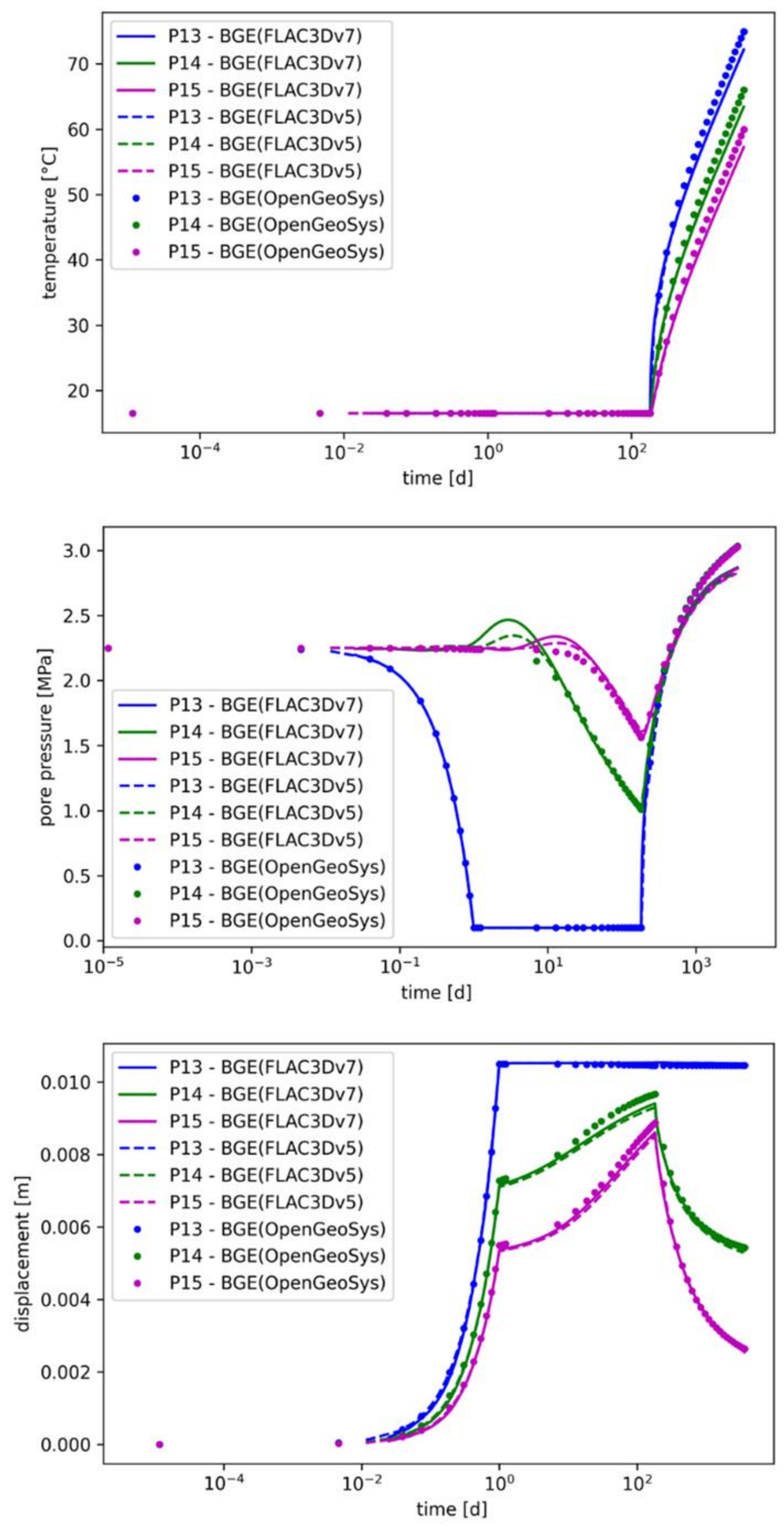

Figure 3: Result comparison of the temperature (top), pressure evolution (mid), and radial displacement (bot) with isotropic material parameters

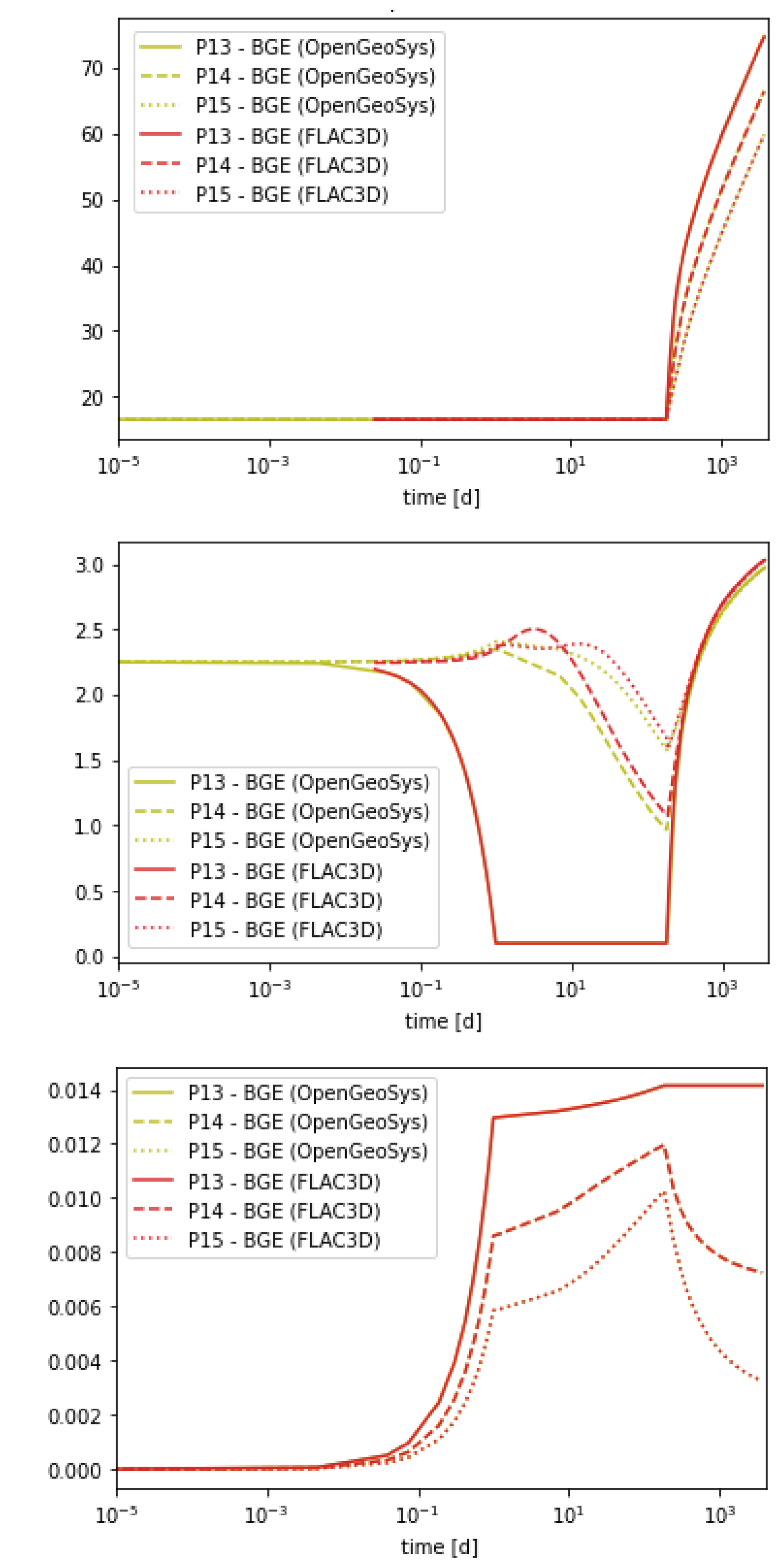

Figure 4: Result comparison of the temperature (top), pressure evolution (mid), and radial displacement (bot) with anisotropic material parameters. (FLAC3D with v7 only)

Conclusions

Most discrepancies occur in the pore pressure evolution. A small discrepancy over time can be observed between the temperature evolution in OGS compared with the FLAC3D counterparts due to the different averaging procedure of thermal conductivity of the porous media assumed in the different codes. The temperature and also the displacement evolution show a good conformity in the results between the codes. However a noticeable difference between the two FLAC3D versions is observed during the waiting phase for the isotropic case. OGS also leads to higher displacements in the waiting phase compared with FLAC3D. This may be explained by the different numerical frameworks (finite elements for OpenGeoSys and finite difference method for FLAC3D) on which the codes are based. All results fit well in the heating phase.

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