Saf. Nucl. Waste Disposal, 2, 65–65, 2023
https://doi.org/10.5194/sand-2-65-2023

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Safety of Nuclear
Waste Disposal
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On the influence of initial stress on final stress in data-calibrated numerical geomechanical models

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Received: 31 March 2023 – Accepted: 24 May 2023 – Published: 6 September 2023

Abstract. The prognosis of the state of stress in the subsurface can be improved by using numerical models in addition to data from stress measurements, as such models allow for consideration of variability stemming from structural complexities and an inhomogeneous distribution of rock properties. These models are generally set up in two consecutive steps. In the first step one an initial stress is established that accounts for gravity and a reasonable ratio of horizontal to vertical stress. This represents a reference stress state in the absence of tectonic stress and ensures equilibrium with gravity: i.e. no strain is produced once gravity acts. In the second step tectonic stress is included via displacement boundary conditions which induce horizontal differential stress to come up with the final stress state. Both initial stress and tectonic stress are chosen in such a way that calibration data are reproduced by the model at the locations and depths where the data were measured.

We present generic models to investigate whether the choice of initial and tectonic stress affects the final state of stress in areas of the model domain where no stress data are available. We find that there is in general an ambiguity as different combinations of initial stress and tectonic stress yield the same final state of stress at the points where data are available. However, in those areas of the model domain where calibration data do not exist, these different choices of initial stress and tectonic stress produce differing results. These deviations are largest in the vicinity of lithological interfaces. We find that this ambiguity is reduced if more stress data exist, particularly in not just one lithology and at one depth. On the other hand, if more data are available, it becomes increasingly more difficult to find a combination of initial and tectonic stress to match them all. In view of the uncertainties of the data, such deviations between modelled stress and data may be expectable to some degree. However, such deviations may indicate that inelastic rock properties do play a role in some lithologies.