Rock mechanical modelling at Clay Technology

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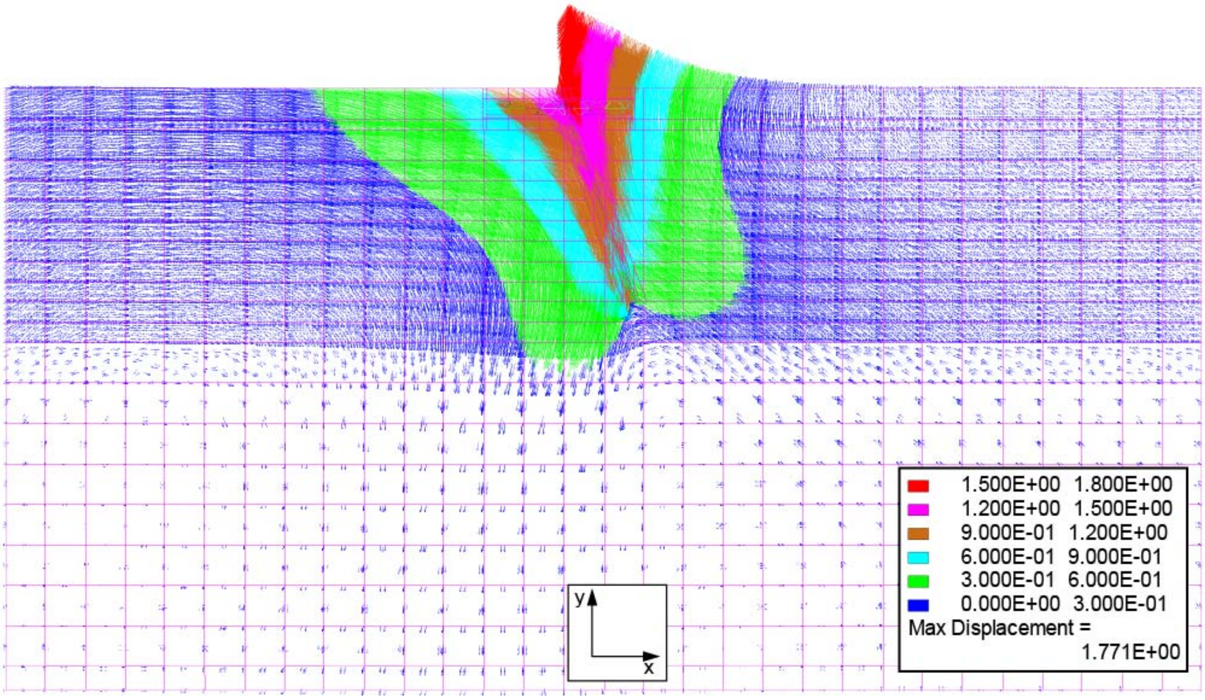


Dynamic 3DEC earthquake modelling. The figure shows rock displacement vectors along a vertical cross section through a magnitude 6 earthquake 10 seconds after rupture initiation (SKB TR-08-11).

Over the last 20 years, Clay Technology has been the main contributor to the assessment of the thermal, thermo-mechanical and hydro-mechanical behaviour of the rock mass within and around the projected Swedish nuclear waste repository in connection with layout decisions and risk analyses. These contributions regard all phases of the repository evolution: construction/operation, the heated period after completed deposition and closure, and all phases of future glacial cycles. Contributions include (examples, with report numbers in parentheses):

- Conceptual descriptions of mechanical geosphere processes of potential importance to the long-term performance of the nuclear waste repository and protocols for handling of these processes in the safety assessments SR-97 (SKB TR-99-07), SR-Can (SKB TR-06-19) and SR-Site (SKB TR-10-48).
- Methods and protocols for thermal dimensioning of the nuclear waste repository, i.e., for establishing rules for a safe but efficient spacing between the-heat generating waste canisters (SKB TR-03-09, SKB-R-09-04).
- Thermo-mechanical analyses on different scales for different assumption regarding the repository site, including the finally selected one, i.e., the Forsmark site in south-eastern Sweden (SKB R-06-88, SKB R-06-89, SKB TR-10-23).
- Hydro-mechanical analyses of the pore pressure evolution at different depths below future ice covers and assessment of the associated risks of hydraulic jacking (SKB R-09-35).

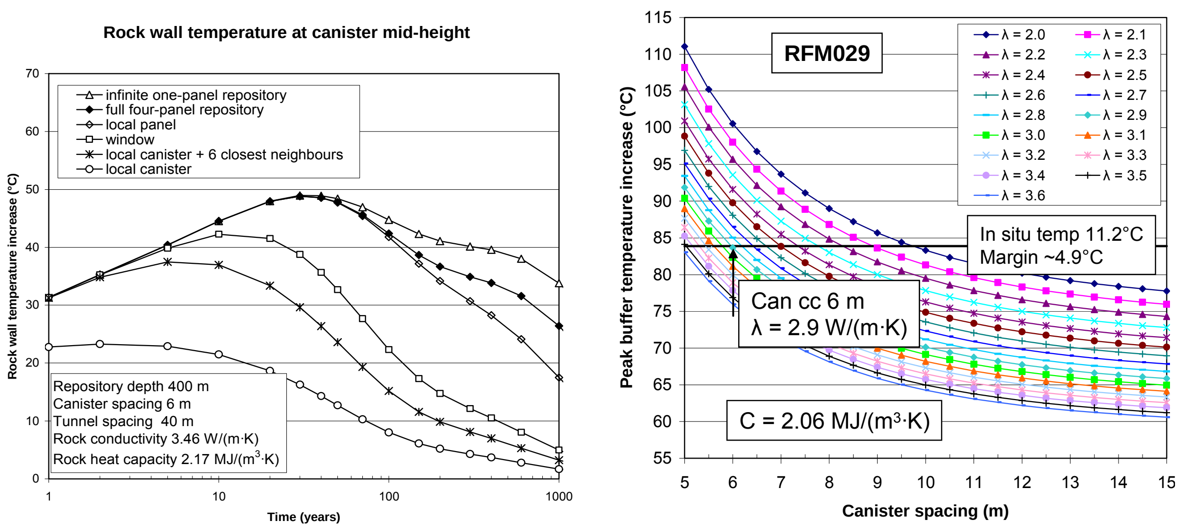
- Assessment, based on dynamic, explicit modelling of earthquake rupture, of the potential for reactivation of host rock fractures in response to earthquakes occurring in the vicinity of the repository (SKB R-04-17, SKB R-06-48, SKB TR-08-11).

Clay Technology has also been involved in the rock mechanics aspects of most of the large scale field experiments conducted at SKB's underground research facility at Äspö, e.g., the APSE and CAPS experiments (SKB IPR-05-19, SKB IPR-08-08, SKB TR-10-37). These tests are both aimed at improving the understanding of the conditions controlling the process of stress-induced brittle failure, spalling, in the walls of repository openings. Recently, Clay Technology has been responsible for the numerical evaluation of the behaviour of the Prototype Repository rock mass conducted in connection with the dismantling of the densely instrumented outer section of this experiment (SKB R-13-10).

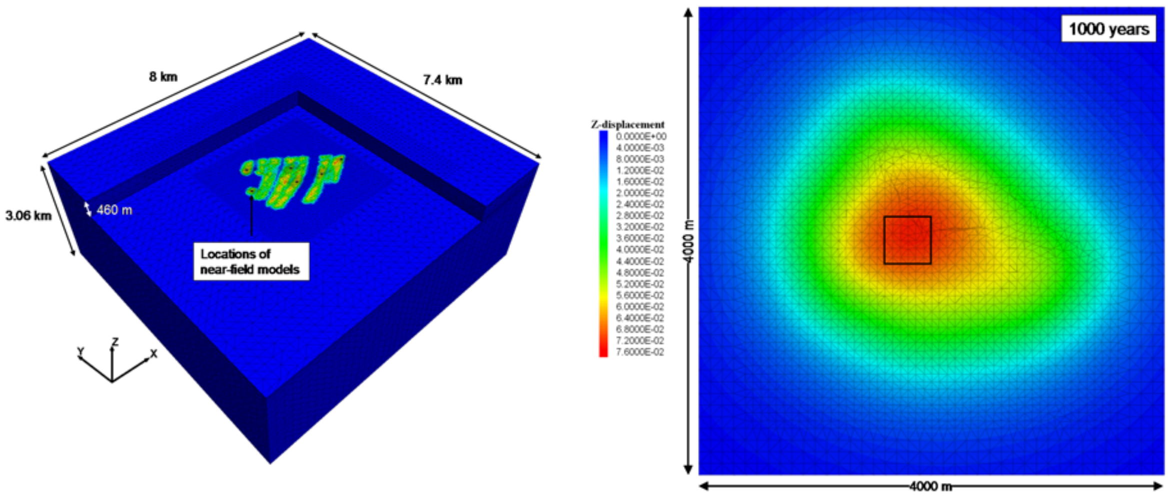
In the field of seismicity as a potential risk for nuclear waste repositories, Clay Technology is also providing services to POSIVA, i.e., the company responsible for disposal of nuclear wastes in Finland. Up to the present day, Clay Technology has prepared three reports addressing the potential for faulting at the Finnish repository site at Olkiluoto as well as possible implications of postglacial faulting (POSIVA WR 2011-13, WR 2012-08, WR 2013-37).

At present, Clay Technology's rock mechanics group uses analytical solutions, the distinct element codes 3DEC and UDEC, the finite difference code FLAC and the finite element program Code_Bright as main tools. The figures below are examples from some of the reports prepared for SKB.

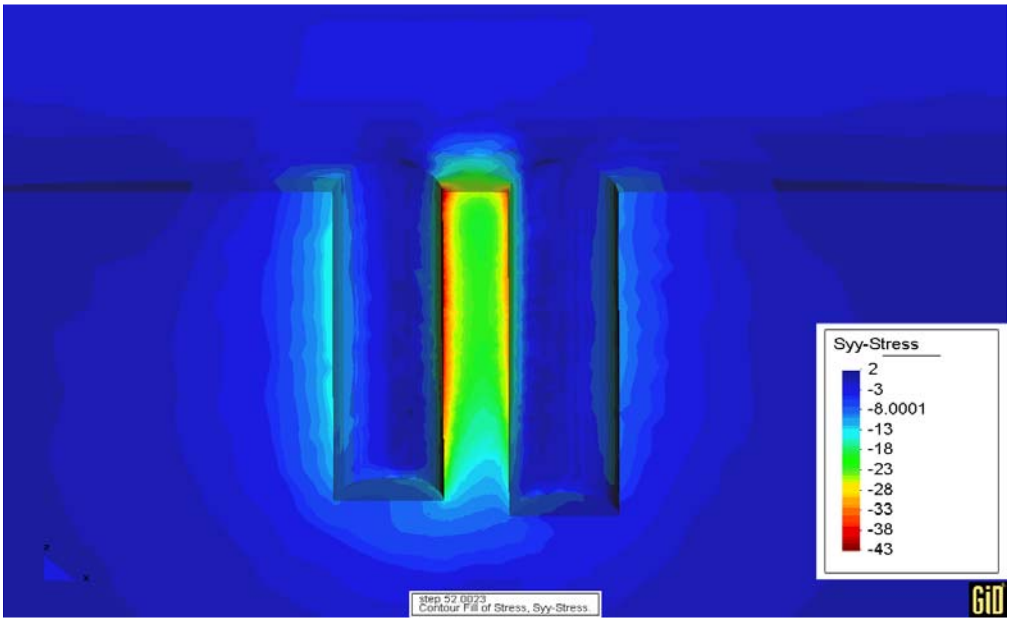
All Clay Technology reports (including those given in parentheses here) can be downloaded from SKB's (www.skb.se) or POSIVAS' (www.posiva.fi) webpages.



Use of analytical solutions. Left: Contributions to local deposition hole rock wall temperature from nearby and distant canisters (SKB R-09-04). Right: Nomographic representation of relation between rock thermal conductivity, canister spacing and the peak increase of the temperature of the bentonite barrier surrounding the waste canisters (SKB TR-10-23).



3DEC large scale thermo-mechanical analyses of Forsmark nuclear waste repository. Left: model outline with canisters positioned according to Forsmark layout at 460 m depth. Right: Heave of ground surface at time of maximum heave 1000 years after deposition. The maximum heave, averaged over the 400 m x 400 m square indicated in the figure, is 75 mm (SKB TR-10-23).



Code_Bright simulation of the pillar stability test (APSE). The contours show the y-component (perpendicular to the tunnel) of the thermally induced stresses. In the pillar between the two deposition holes the maximum thermally-induced tangential stress is in the order of 40 MPa (SKB IPR-05-19).