

Proposed Master Project at NTNU: Swelling of Clay/Shale: A numerical investigation

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Background: Swelling of Shale-rocks create several problems [1] during underground drilling operations, such as stuck-pipe/drill-bit. However, swelling of shale-rocks can close the gaps between rock (wellbore) and casing –therefore no cementing is needed – which can save a lot of time and money and such a “natural” closing ensures “no-leakage” during further drilling and production phases. The field experience reveals that some shale-rocks are good candidate for swelling and some are not. There are several parameters that can influence the swelling behavior, such as- porosity, clay-quartz contents, stress difference between field and drilling zone etc. Therefore, to plan a safe and efficient drilling through shale-rocks, we should understand the swelling mechanism of shale/clay.

Problem formation: To investigate swelling problem we have introduced a discrete element model (DEM), based on Monte-Carlo technique. We define a probability of swelling for all the clay grains in the shale-rock sample that includes the effect of stress-difference, porosity, temperature etc. The time evolution of grain swelling results in bulk swelling behavior of the sample and the simulation result qualitatively matches [2] with the observations of shale/clay swelling experiments [3,4].

The aim of this Master project is to study the Monte-Carlo based DEM for the entire parameter space by varying several important inputs like porosity, clay-quartz contents, stress difference etc. The DEM simulation codes are developed in-house and are available for re-use and further improvement.

Other aspects: As this problem is linked to practical field operations, we would like to develop a KPN proposal for NFR this year. Results from the Master project will be used in the proposal as important ground works and the Master student will be encouraged to join the KPN project if he/she wishes to pursue a [research career](#) on this topic. We (PoreLab) have applied (to NWO) for a joint research project with University of Delft on the topic “*Deformable Clay*”. The Master student will get a chance to interact with the team members (both from NTNU and Delft) if the project gets funding.

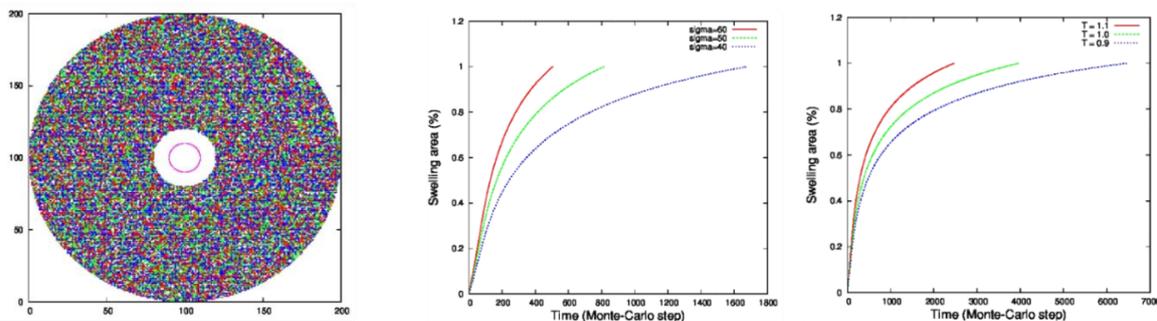


Fig: The DEM model for Shale rock sample with clay and quartz grains (left). Swelling amount with time for different stress levels (middle) and temperature levels (right).

References:

- 1.E. Fjær, R. M. Holt, P. Horsrud, A. M. Raaen and R. Risnes, *Petroleum Related Rock Mechanics* (Elsevier, 2008).
- 2.S. Pradhan, *Swelling behavior of shale/clay: Discrete element modeling, based on Monte-Carlo technique*, Interpore 2019, Valencia, Spain.
3. M. Deriszadeh and R.C.K. Wong, *Transp Porous Med* (2014) 101:35–52 DOI 10.1007/s11242-013-0229-8.
4. E. Rybacki, J. Herrmann, R. Wirth and G. Dresen, *Rock Mech Rock Eng* (2017) 50:3121–3140.