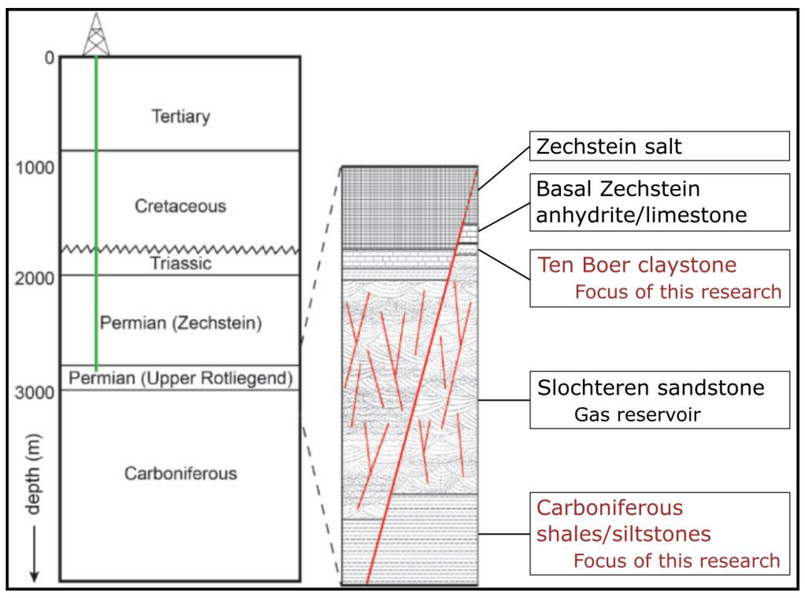
Utrecht University

Faculty of Geosciences
Department of Earth Sciences
High Pressure and Temperature Laboratory

DeepNL

Coupling rock mechanical experiments with detailed mineralogical analyses to better understand compaction in the clay-rich formations enveloping the Groningen gas field

M.K. Sep, S.J.T. Hangx, J.H.P. de Bresser, J.P. Trabucho Alexandre



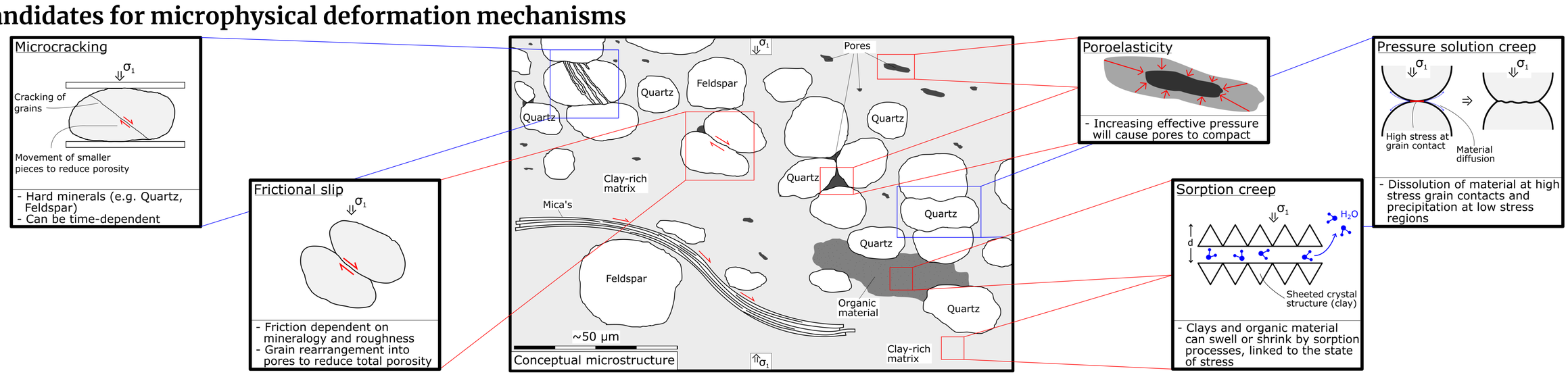
Schematic stratigraphy of the Groningen gas field (figure after Spiers et al. [2017]).

Introduction

Extraction of fluids, such as natural gas, from subsurface reservoirs can cause surface subsidence and induced seismicity, as seen in the Groningen area in the Netherlands. In the Groningen gas field, most compaction occurs in the porous Slochteren sandstone. However, the overlying Ten Boer claystone and the underlying Carboniferous shales, directly bounding the reservoir, will slowly equilibrate to the pore pressure of the reservoir rock. This causes additional deformation on top of the compaction of the Slochteren sandstone itself.

The reservoir-bounding formations have a very low permeability and a high clay content, meaning that the expected microscale deformation mechanisms are likely different from those in the Slochteren sandstone. Understanding the role of all formations in the stratigraphy of the Groningen gas field is key to make accurate predictions for the evolution of the Groningen gas field. In this project, the impact of fluid extraction on the creep behaviour of the Ten Boer claystone and the Carboniferous shales is investigated.

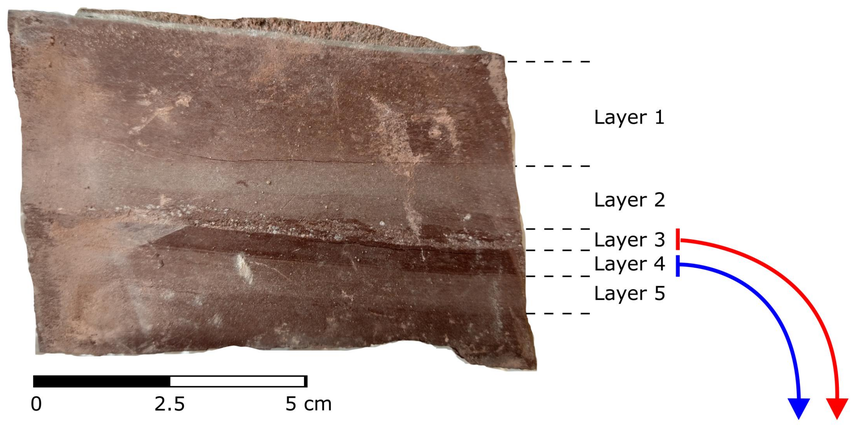
Candidates for microphysical deformation mechanisms

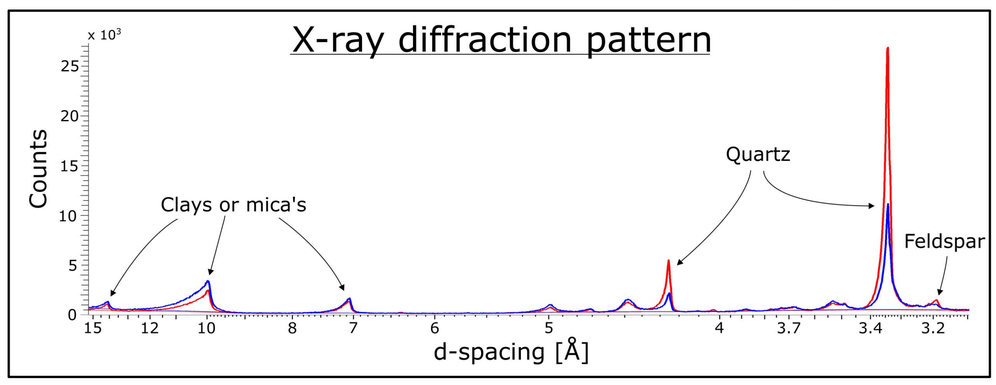


Characterisation of Groningen claystones

- Mineralogy has a strong influence on the deformation mechanisms.
- The Ten Boer claystone and the Carboniferous shales are strongly layered, with compositional differences on a cm-scale.
- We use quantitative XRD-analyses to characterise this heterogeneity.
- We perform additional, highly-detailed XRD-analyses on the clay and mica portion of the samples to find their exact mineralogy.

Ten Boer claystone, 2859 m depth

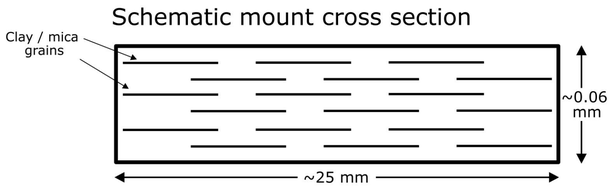




Clay analysis

- Separate clays/mica's based on grain size (< 2 µm)
- Prepare a mount with grains aligned horizontally

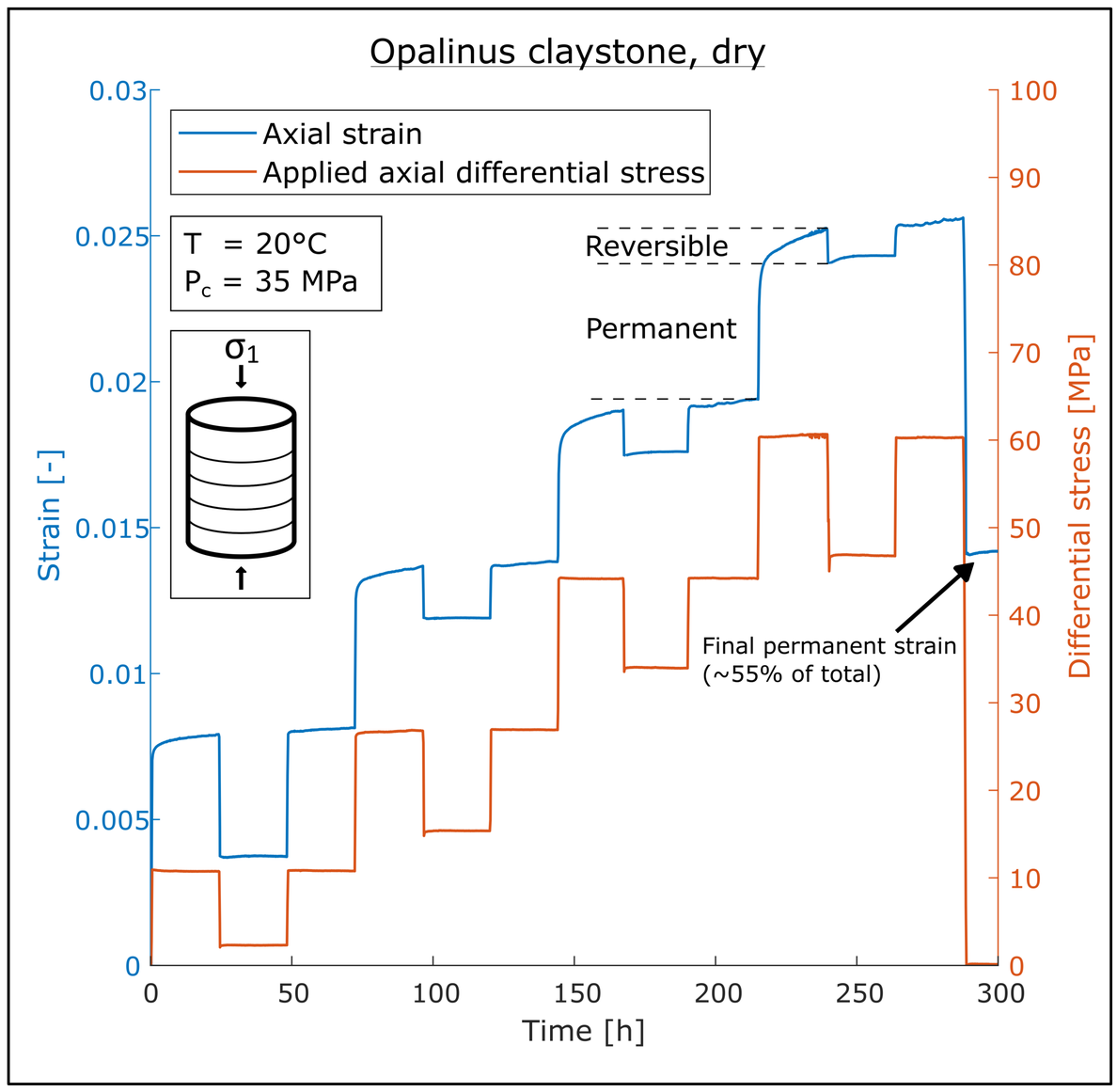
Schematic mount cross section



- Measure X-ray diffraction pattern of the clay/mica fraction
- Remeasure after using chemical treatments to distinguish between different clay minerals and mica's

Rock mechanical experiments

- We perform triaxial stress-stepping experiments under in-situ conditions relevant to Groningen gas field.
- Samples of Opalinus claystone (material analogue to the claystones in Groningen), Ten Boer claystone and Carboniferous shales.
- Our goal is to investigate the active deformation mechanisms.
- The method allows to distinguish between reversible (elastic) and permanent (inelastic) deformation.
- Significant portion of the deformation is time-dependent.



Contact: m.k.sep@uu.nl

References

1. Spiers, C. J., S. J. T. Hangx, and A. R. Niemeijer (2017), New approaches in experimental research on rock and fault behaviour in the Groningen gas field, Netherlands Journal of Geosciences, 96(5).