X-RAY MICRO CT FOR STRUCTURAL AND COMPOSITIONAL ANALYSIS OF CORES AT DIFFERENT SCALES (DECI- TO MICROMETER)

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Summary: For geomechanical investigations it is essential to get information about the mineral composition, its spatial distribution, pores, and fractures to increase the understanding of deformation processes. In this study a clay core of 100 mm diameter was sub-sampled down to ~30 mm and finally 3 mm diameter and analyzed by X-ray CT and various conventional petrophysical analysis.

1. MATERIAL AND MECHANICAL TESTING

The specimen (diameter 100 mm, length 180 mm) was derived from the Underground Rock Laboratory Mont Terri (Switzerland) from the sandy facies of the Opalinus Clay (Kaufhold et al., 2013). The claystone was investigated under undrained condition by triaxial strength tests until a failure was developed. After the mechanical testing the core was embedded in resin for stabilization.

2. X-RAY CT RESULTS FOR DIFFERENT SCALES

The 100 mm Opalinus Clay sample was first scanned with the speed|scan CT 64 (GE Ahrensburg, Germany). The scan was recorded within 13 seconds at a spatial resolution of approx. 0.3 mm. The reconstruction was performed automatically (Ambos et al., 2014), therefore the 3D data could be evaluated after 30 seconds. The CT results show good contrast resolution due to its high power (up to 72 kW), layering within the core can be nicely detected (see figure 1a). Cracks and pores are spatially resolved down to 0.5 mm.

Secondly, a CT scan of the same sample was recorded with the v|tome|x L300 (GE Wunstorf, Germany) with a scan time of 145 min and a spatial resolution of approx. 60 µm. Fractures are much better resolved and can be nicely segmented.

For the 30 mm and 3 mm samples a nanotom m system (GE Wunstorf, Germany) enabled for 120 min scans a resolution of 18 µm and 3 µm respectively. Due to this high resolution one can detect tiny fractures down to approx. 3 µm (see figure 1b). A small zone around that point, where the shear and disking fracture intersect each other, can be characterized as a so-called mylonitic zone; i.e. an area with many small fractures and cracks where particles have been rearranged on the fracture surface.

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3. CONCLUSIONS

The fast analysis with X-ray CT based on medical scanners (speed|scan CT 64) is suitable to give an overview of large core. However, microfocus (v|tome|x L300) and nanofocus tubes (nanotom m) can provide much more detailed images necessary for special high resolution core analysis.

The overall aim of the investigation of the Opalinus Clay is to understand the rock deformation processes upon mechanical stresses. This behavior is largely governed by microstructure thus CT is a key method.

Within the intersecting area of the two main fractures, a so-called mylonitic zone with a particle reduction was observed on the open shear failure using CT and SEM techniques. However, it is not known, until now, when and how this zone was developed. As far as the authors are aware, this is the first time that experimental deformation shows such a mylonitic zone.

Additionally, chemical and mineralogical methods are used to identify homogeneous areas which can be considered representative of the entire rock. Hence, the CT information gathered from a small volume can be used to understand the mechanical processes of the entire rock.

References

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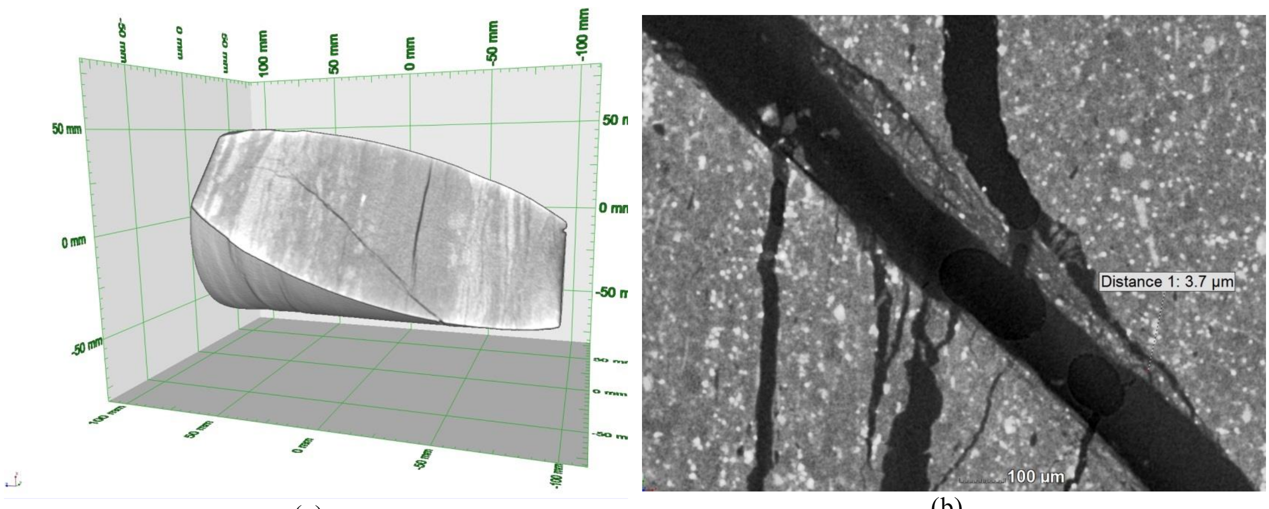

(a) (b)

Figure 1: (a) Virtual sliced 3D view of the speed|scan CT result shows inner structure (layering, cracks).
(b) High resolution virtual slice of the nanotom m CT data (Cracks width ~ 3.7 µm).