The relationship between failure behavior of Opalinus Clay and sedimentary subfacies types

(Mont Terri underground rock laboratory, St. Ursanne, Switzerland)

Background

The Mont Terri rock laboratory was built in 1996 for characterizing and investigating the Opalinus Clay as a potential host rock for intermediate and high radioactive level waste. The Mont Terri consortium consists of 14 partners (Universities, private and federal research institutes) which currently run about 40 experiments in the totally 600 m long system of galleries and niches.

One of those experiments hosted by swisstopo is the so called SO (Sedimentology of Opalinus Clay) experiment. This experiment focuses on the detailed description of sedimentary structure and stratigraphical features of the Opalinus Clay. The aim is to provide a sound basis for the interpretation of geophysical logs, seismic investigations and petrophysical characteristics of the rock mass. Initial descriptions of the Opalinus Clay have been carried out at the very beginning of the rock laboratory (Bläsi, 1996, 1996, Bläsi et al., 1996). However, the Underground Research Laboratory has grown in the meantime and thus new outcrops are available to investigate various subfacies types.

Current studies are focused on the sandy facies. The lateral and vertical variability of the sandy facies was documented in detail by Jaeggi et al. (2011). Another study investigated the mineralogy and diagenesis utilized thin sections and mini-cores (Peters et al. 2011). The most recent study deals with small scale sedimentary structures and is based on detailed small scale mapping and thin section analysis (Müller et al. 2012) (Figure 1).

Many rock mechanical tests have been conducted on the Opalinus Clay. Most of these mechanical tests utilized specimens from the shaly facies. The mechanical properties of other facies types such as the sandy facies were only barley investigated and the geological knowledge gained from above mentioned small scale mapping and thin section analysis were not sufficiently considered. This is of particular interest since new studies demonstrated that the mineralogical composition may have an influence on the mechanical properties. For example Klinkenberg et al. (2009) showed that the failure strength of the shaly facies decreases with increasing carbonate content due to localized accumulations of shell fragments. However, a clear link to the existing detailed small scale mapping with an adapted sampling strategy which encompasses all available subfacies types is still missing. The aim of this proposal is to fill up this gap and to profit from the detailed geological knowledge about the sandy facies, which has been elaborated in the framework of the SO experiment and other experiments the past 1.5 years.

Study Area

The Mont Terri rock laboratory is located within the southern limb of the Mont Terri anticline, the northernmost fold of the Jura mountain range, a fault-bend fold which developed above a frontal ramp (Nussbaum et al., 2011). The rock laboratory, which can be accessed from the town of St. Ursanne by an access gallery of the Mont Terri
highway tunnel, is situated about 1 km from the southern portal and 300 m below ground. The sandy facies of the Opalinus Clay is nicely outcropped in the so-called TT-niche, a niche which has been excavated in 2008 by road header. The rock mass in the niche is not covered by shotcrete and thus directly accessible.

**Objectives and Approach**

The main objective of this study is to elaborate the relationship between observed geology, sedimentary structures and mineralogy and the rock mechanical behavior. In order to reach this goal, a sampling program shall be elaborated first in collaboration with swisstopo and ETH, focusing on structural (lamination, nodules) and mineralogical (quartz rich, carbonate rich, argillaceous) end-members as well as transitions in between.

Then in collaboration with the swisstopo drilling team and geologists on site the drilling campaign, core mapping and subsequent sampling procedure including conditioning is closely accompanied and supported by the student. A first set of samples will be used for the preparation of stained thin sections for a later description and analysis (sedimentary structures, texture, fraction and distribution of carbonates, quartz and other minerals).

At ETH a testing program on oriented samples parallel and vertical to bedding from end members (Figures 2 and 3) and different subtypes is carried out for the evaluation of rock mechanical parameters using uniaxial compressive test and brazilian test. During the mechanical tests the acoustic emission activity will be monitored. Furthermore it is planned to extract thin sections from the deformed rock samples as well and to perform further analysis concerning rock fabric and mineralogy using XRD and XRF.

Final data interpretation includes the use of qualitative and quantitative approaches for the correlation of geological information with rock mechanical parameters (tables, cross plots, statistics). The MSc Thesis has to be written in English.

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Figure 1: Extract from the existing small scale mapping available for niche TT.
Figure 2: Photomicrograph of homogeneous and rather isotropic part of the sandy facies

Figure 3: Photomicrograph of heterogeneous anisotropic part of the sandy facies