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Solid Earth Discussions

Interactive comment on "The response of Opalinus Clay when exposed to cyclic relative humidity variations" *by* Katrin M. Wild et al.

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Dear reviewer,

we would like to thank you for the valuable comments on our paper. Please find our answers below.

Anonymous Referee #1 Received and published: 23 January 2017 This is an interesting contribution, investigating the evolution of strength, volumetric strains in Opalinus Clay (OPA) subjected to experimental cyclic variations of relative humidity (RH). Authors show that after 4.5 cycles of RH variations (cycles between 66% and 93% RH) OPA displays irreversi-ble volumetric strains mostly perpendicular to the specimen's bedding. Surprising, fabric's damages induced by cyclic variation of RH have only very minor effect on the strength of the material. The paper is a valuable scientific

contribution, concise and well-written I recommend publishing it. However, I have the following comments: (1) In introduction (Section 1), many contributions are cited about RH cycling experiments on shale but some recent contributions (mostly from the LMS laboratory at Ecole C1 Polytechnique, Orsay, France) including the following of dehydration damages based digital image correlation are not mentioned though they are very relevant for the topic: Wang L. L., Bornert M., Chancole S., Heripré E., Yang S. (2015). Micromechanical experimental inves-tigation of mudstones. Géotechnique letters 4, 306-309. Wang L. L., Bornert M., Chancole S., Yang S., Heripré E., Tanguy A., Caldemaison D. (2013). Micro-scale experimental investigation of the swelling anisotropy of the Callovo-Oxfordian argillaceous rock. Clay Minerals, 48: 391–402. Yang, D. S., Bornert, M., Chanchole, S. et al. (2012). Dependence of elastic properties of argillaceous rocks on moisture content investigated with optical full-field strain measurement techniques. Int. J. Rock Mech. Mining Sci. 53, 45–55.

We carefully studied these interesting contributions and we included most of the references in different section of the paper. Furthermore, we added the paper by Pham et al. (2007).

Pham, Q.T., Vales, F., Malinsky, L., Nguyen Minh, D., Gharbi, H. (2007). Effects of desaturation-resaturation on mudstone. Physics and Chemistry of the Earth, 32, 646-655.

(2) About sampling (Section 2.2): authors indicate that samples were immediately sealed in vacu-um-evacuated Al-foil after core extraction. But when sample were drilled? And when experiments were performed? Desbois et al. (2014) showed that clay-rich geomaterials can be water de-saturated even when they are preserved in vacuum-evacuated Al-foil. Could you discuss about the original hydric state of your specimen at the date of experiment? Desbois G., Urai J.L., Hemes S., Brassinnes S., De Craen M., Sillen X. (2014). Nanometer-scale pore fluid distribution and drying damage in preserved clay cores from Belgian clay formations inferred by BIB-cryo-SEM. Engineering Geology, 170:117-131.

The samples were drilled in November 2012 and tested between September 2014 and November 2015. The authors are aware of the fact that clay-rich geomaterials can be water de-saturated even when preserved in vacuum-evacuated Al-foil. However, the initial water content of the specimens ranged between 6.95 and 7.34 % (see section 3) and is therefore identical with the water content we measured on the cores right after core extraction (published in Wild 2016: 7.0-8.1%).

Wild, K.M. (2016). Evaluation of the hydro-mechanical properties and behavior of Opalinus Clay. Doctoral Dissertation, No. 23875, ETH Zürich, Switzerland, 222 pp.

(3) In Section 4.2 (Strain and damage), authors write that macroscopically detectable fissuring was observed. Do you have examples you can show? How thick are these fissures? Do they run through the entire specimen? Strength measurement does not show significant change but macroscopic damages are visible. This is rather contra-intuitive, but measurements are here to demonstrate it. Ok, but could you try to explain why strength does not change significantly though the presence of severe macroscopically damages?

Figure 1 shows an example of the observed macroscopically detectable fissuring. The fissures are very small (««1mm) and do not run through the entire specimen. We have observed a similar behavior during other test series (Wild et al. 2015). In this study we equilibrated Opalinus Clay samples in desiccators with a relative humidity ranging between 19 and 98% and we performed Brazilian Tensile Strength Tests and Unconfined Compressive Strength tests. During drying the specimens showed server damage due to desiccation cracks, but the strength increased by a factor of 2 to 3. For a suction > 56 MPa the strength could not be increased further with increasing suction. This is due to the net contribution of suction to the strength (see Wild et al. 2015). Thus, the increase in strength is dominated by the increase in suction and to a lesser degree by the formation of desiccation cracks (i.e. the possible effect of desiccation cracks is masked by the dominant effect of suction). The latter is difficult to quantify.

(4) In Section 5 (Conclusion), the last sentence is interesting “The experimental study demonstrates that environmental variations, in particular long-term variations in RH can lead to irreversible volu-metric strains that contribute to long term deformations of underground excavations and favour processes that are considered to control self-sealing in Opalinus Clay.” But I think it is a bit over-looked because long-term deformation and self-sealing are not studied in this contribution. May I suggest to the authors to rewrite the sentence with a more hypothetical form?

We agree and changed the sentence.

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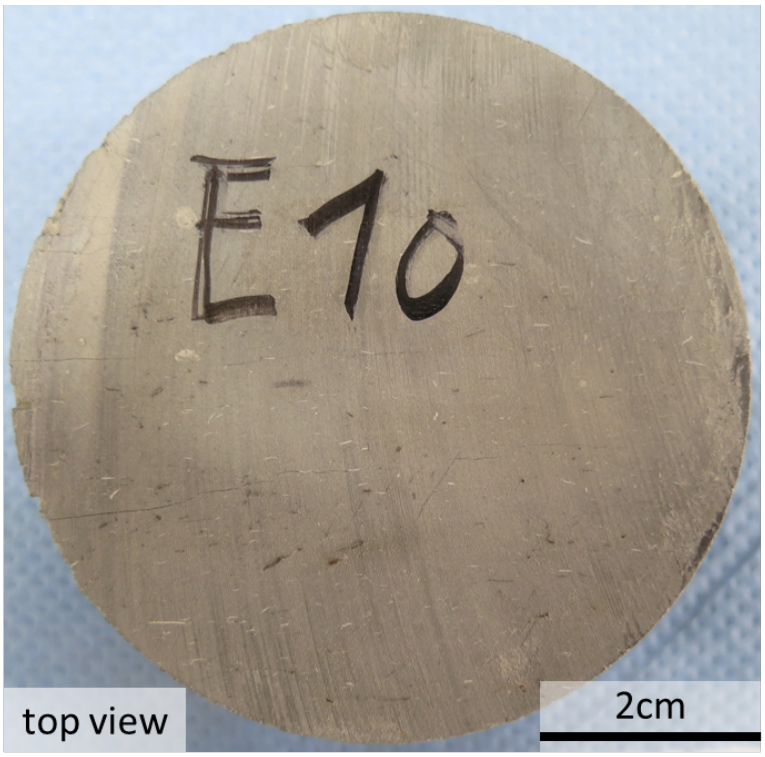

Fig. 1.