

REVIEWER 1

Line 83: implemented as mentioned

Line 98-100: has been added

Line 109: *reference was included in the revised version.*

Line 156 – 170: thanks for the advice. We have rephrased this part of the manuscript.

Line 208-205: *good comment – text added to the revised version*

Line 212: changed as mentioned

Line 212 – 215: *the reviewer is right in pointing out that the interpretations of the observations are more difficult than yet explained. A detailed discussion, however, would be highly speculative. Therefore, the interpretation is relativized:*

the red marked text was added behind “Assuming that these small lineaments were no XRF artefacts, it can be supposed that a crack started to form there. ... Therefore it can only be assumed that the small lineaments observed both with the XRF scanner as well as with the SEM could be the starting point for crack formation.

This interpretation, however, only represents an option. As an alternative crack formation may also coincide with material heterogeneities such as bedding features. Observations presented here do not allow for an unambiguous conclusion because the crack apparently formed outside the investigated area.

In addition, the figure will be modified as recommended!

Line 216: correct, figures have changed places and now fit.

Line 227-229: good advice, thanks! Implemented as mentioned

Line 253: changed as mentioned

Line 261: changed as mentioned

Line 262-264: *Reviewer requested a more detailed explanation of the features which could be resolved. Sentence “the zoomed in view...” was replaced by the following text:*

At least three types of cracks could be distinguished based on the improved resolution imaging. Long diagonal cracks which sometimes split up into several subparallel branches were observed. These are the shear fractures constituting the shear failure plane. Secondly, some cracks following bedding plane features were observed. They may have formed by tensile failure. Finally, a system of small stacked cracks orientated more or less perpendicular to the large shear fractures could be observed. They may have formed later than the large shear fractures as they are truncated by the shear fractures. Generally, shearing normal to the main shear failure plane is expected to be almost negligible. Therefore, these stacked cracks probably formed by tensile failure.

Line 298-301 & table 1: good points, thanks. We will add substantially details as also recommended by reviewer 2 about the crack counting workflow and quantification, in order to clarify the points mentioned

Line 302-306: In fact, the large dispersion is caused by three different effects:

- By “resolution” (i.e. partial volume effects)
- By the “effective segmentation resolution” and
- By the fact that we are looking at different sample volumes and hence “miss” larger apertures as we increase the resolution and accordingly decrease the volume of interest (due to the limited field of view of the CT devices)

We will describe this section and the workflow and effects a little more in detail in order to fit your recommendations properly.

Line 310-312: *good comment – it’s much clearer to refer to ‘shear cracks’ and “disking crack’.*

Line 335-336: the reviewer requested to be more precise in this sentence: “Nevertheless on the top of the shear zone a darker zone is identifiable, which is a result of particle reduction.”

This sentence was replaced by:

“Nevertheless on the top of the shear zone a darker zone was observed which may have resulted from a loosening of the material resulting in lower density”

Line 348-349: The reviewer requested to be more precise in the following sentence:

“Close up SEM images (Figure 12) prove that the claystone did not simply break as one would expect from broken glass.” The following text was added: *“Such an appearance of the cracks points towards shear failure. Cracks induced by tensile failure would miss a mylonitic zone and hence be closer to “broken glass”.”*

Line 354-355: the reviewer requested to be more precise in the following sentence:

“It is not clear whether the mylonitic zone formed just before breaking or if it formed by the relative movement of both sides of the crack.” The following text was added: *“However, taking into account the amount of local deformation and particle dislocation required to form the mylonitic zone, a formation before breaking would be very difficult to explain.”*

REVIEWER 2

Line 23: Seems more or less to be the same for us, but we have changed it as recommended.

Line 45-47 in page 2: Probably, the authors' background is rock engineering or geological engineering? This is partially correct but not exactly. This sentence could be sandy soil, sandstone or other rocks. This part is more rather general topic so it may be good to include more general material like soil as well.

"and soil" was added

Line 62 in page 2: This reference seems to be conference paper. Probably, this reference paper has been upgrade as Toshifumi Mukunoki, Takahiro Nakano, Jun Otani and Jean-Pierre Gourc (2014), Study of cracking process of clay cap barrier in landfill using X-ray CT, Applied Clay Science, Vol. 101, pp. 558-566, DOI 10.1016/j.clay. 2014.09.019

Ref was added

Line 94 in page 4 What are these (file 13001, drilling BLT-A6) information?

Explanation was added

Line 101 in page 4 How authors did conduct this work? How can you keep the failure condition after testing? It is better to explain more because this approach is important but not so easy, I imagine.

This is an important point. In line 100 it is explained that the sample was stabilized by a resin directly after testing.

Line 108 in page 5 Do you mean "triaxial compression testing"? it is better to show the picture of testing scene. If you did triaxial compression test, how much the confining pressure? Was the samples saturated? The information of this session is very little. Authors should add more testing condition.

The following information was added: "confining pressure 6 MPa, natural water content was preserved"

Line 126 in page 5 Is this hydrogen chloride "solution"? Is there any information about concentration? It is necessary to explain the concentration.

"solution" was added

Line 166: The factor of 10 refers to the scanning resolution.

Line 193 in page 7 “The aim of the present study was to investigate crack formation which could be related to microstructural features or mineralogical heterogeneities (as fine bedding, fossil shells, etc.).” This sentence should be appeared in the beginning of this section to clarify the authors concept.

Was moved

Line 243 “Segmentation”

We have added a brief description about the segmentation procedure.

Line 256: we replaced “achieve” with “reach”

Line 277 in page 12 Please add the some reference which authors referred. / Line 288 in page 12 this seems to be the first reported CT data set of such a zone. This sentence is not clear about author’s point. Please explain more.

We are not aware of any suitable references. Maybe you can provide some?

Line 299-301 “number of cracks”.

Well, we have some doubt that “upscaling” to large cores is that easy. Hence we avoided to extrapolate any data about this. The crack number detection has just been performed in order to outline the importance of resolution and detail detectability as a “function” of investigation scale. We will be a bit more precise about our intention within this section and will rephrase slightly.

Line 313 in page 14: Mircostructural Investigation Your title is "X-ray Computed Tomography Investigation of Structures in Opalinus Clay from Large Scale to Small Scale after Mechanical Testing". The main tool of this paper is CT so it would be better to summarize this chapter by the observation obtained from CT in the last paragraph. Maybe I am wrong because authors described the aim of this study is the visualization of the shear failure in various scales to get more information about the deformation process on line 81-83 in page 3; however, I am concerned about the structure of last chapter. It may be better if authors summarize the conclusion with more CT data.

About the same was requested by Rev1, more explanations were about visualization of cracks were added to the revised version. In addition, the title of the chapter was modified according to R2’s statement.

Line 356-357: Well, we showcase 2D images, nevertheless, the quantification of the structures has been performed on the 3D data sets.

Line 374 in page 16: This paper did not mention about any water contents

In the revised version it is stressed that the natural water content of the Opalinus clay was preserved. A determination of the water content was not possible because the water content of an undisturbed sample had to be preserved and after the tests the sample had to be sealed by a resin.

General comments Reviewer's pages C4-C5:

Points have all been addressed