

# Responses to comments by reviewer #1

**Zeynal Abiddin Erguler (Referee)**

Received and published: 06 February 2021

Ref: se-2021-4-RC1

Dear Authors,

Please be informed that I read carefully your manuscript. I would like to say that the content and outputs of your research are very important for scientists investigating fracture closure and self-sealing of mudrocks. I have only below given minor comments on your manuscripts:

**Response:** We sincerely thank Zeynal Abiddin Erguler for his constructive comments and valuable suggestions, which greatly helped to improve the manuscript's quality. In the following, we provide a point-by-point response to the comments, where comments are in black, and our responses are in blue. In addition, any changes regarding "author responses to reviewer #1" applied in the revised manuscript are also marked.

(1) Lines 16 and 403: The needle penetrometer cannot be used for geophysical characterization of rock materials. Only mechanical properties can be predicted by this index test. I suggest authors do not trust too much on predicted geophysical values and so the related empirical approaches of previous studies. Actually, you do not need these predicted parameters for this manuscript. Please apply proper modification.

**Response:** We agree. However, Aydan et al. (2014) demonstrated that ultrasonic P- and S-wave velocities can be roughly estimated by the NPI ( $R^2 = 0.76$  and  $R^2 = 0.76$ , respectively), which was derived empirically from various tested lithologies.

Hence, we also applied the published empirical relationships in our study, compared and discussed the results in context to other studies in the literature. Finally, we were able to derive the following conclusion (page 23, line 464 in the marked manuscript):

*"[...] it can be assumed that the relationship of ultrasonic velocity and NPI is probably rather weak."*

This statement actually supports the reviewer's comment. Hence, we would like to keep this information in our manuscript as we also intend to demonstrate the limitations of needle penetrometer testing (NPT), which is at least valid for the studied claystone.

(2) The introduction part is very long and so it is very hard to see the main motivations of this study. This part should be shortened. Since there are many previous studies on physical and hydro-mechanical properties of Opalinus Clay, the contribution of this study should be more strong to convince readers to read the entire paper.

**Response:** We also agree. The introduction was therefore shortened in the marked manuscript. In order to emphasize the novelty and contribution as well as the scientific significance of the study more clearly, the last section of the introduction was adapted as follows:

*"Hence, the objective of this study is to investigate the hydro-mechanical properties of the EDZ in the Opalinus Clay of the Mont Terri URL using on-site measurements on the exposed rock surface. In this study, a nondestructive and holistic determination of hydraulic and mechanical parameters of the fractured rock mass around a small tunnel is conducted by applying a combined approach using a transient-flow air permeameter, a microscope camera and a needle penetration test. Beside the bulk rock properties of the claystone, mechanical and hydraulic apertures of different fracture types of*

*the EDZ are quantified and discussed in this study, since these discontinuities can significantly control the overall material behavior. Furthermore, alterations within the EDZ of a non-lined niche due to several years of direct air exposure of the rock surface are investigated and discussed.”*

(3) Some of relationships given in Figure 6 (Fig 6c, d, f, g, h, and i) are not statistically significant. I recommend removing them.

**Response:** We partially agree. For some of the parameters shown in Figure 6, the deviation of the NPI derived values from the existing literature data sets is very large. Particularly for the determination of the Brazilian tensile strength and the Young's Modulus parallel to bedding, the needle penetrometer test results in a significant underestimation of the respective values, which was explained by the presence of bedding-parallel microcracks.

However, this information is essential for the application of this method to the investigated host rock (and possibly also for other anisotropic claystone formations in future investigations). Thus, the mentioned relationships between the NPT data and the literature data in Fig. 6 (subfigures c, d, f, g, h and i) should also be retained from our point of view. In the last part of Section 3.2, however, it is clearly stated that for the Opalinus Clay the method is mainly suitable for determining the uniaxial compressive strength and that bedding-parallel measurements can lead to a poor estimation (page 23, line 474 in the marked manuscript).

(4) The manuscript looks very long. It would be a little difficult to read without getting bored for those who do not work on this subject. Please shorten your manuscript by removing unnecessary evaluations, discussion and outputs of previous studies.

**Response:** We agree. Apart from the introduction according to comment (2) above, also some discussion parts of Section 3 were shortened (page 14, lines 258-273 and page 15, lines 294-301 in the marked manuscript).

Except for the discussion on predicted P-wave and S-wave velocities, the content of this manuscript looks interesting. So I recommend minor revision for this submission.

Regards

Zeynal