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Solid Earth Discussions

Interactive comment on "Micro- and nano-porosity of the active Alpine Fault zone, New Zealand" *by* Martina Kirilova et al.

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In this research article the porosity distribution core samples of the Deep Fault Drilling project of the New Zealand Aloine Fault were investigated. Based on Synchrotron X-ray microtomography (3D data set) in combination with TEM analysis (2D data set) the porosity data were interpreted with respect of the permeability, fluid mobility and the possibility of fluid overpressure and their effects on the seismic cycle. The authors were able to show that fluid overpressurization in the Alpine Fault core controlled the mechanical behaviour of the fault and could be responsible for future rupture initiation.

The article is very well written and organized and provide very important data and interpretation to understand more in detail the processes, which control the seismic

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cycle of active fault zones.

I only have minor comments on the manuscript

General comments:

1. Portion/fraction of weak minerals related to fluid overpressure in relation to pre-existent weak minerals (clay minerals in gouge zone / fault zone) - Abstract (line 25-29) and chapter 5.3 line 245-261:

You analyses gouge material, especialy clay minerals. In chapter 2. you mentioned that the gouge material is a reworked product probably as a result of ultracomminution due to multiple shear events under brittle conditions. The local presence of authigenic smectite clays (Schleicher et al., 2015) and calcite and/or chlorite mineralization within sealed fractures and in the gouge matrix (Williams et al, 2017) indicate that mineral reactions are restricted to an alteration zone within the fault core.

You conclude that due to fluid overpressure a weak mineral phase was introduced into the fault zone. My Question: What portion/fraction of the gouge material is related to the fluid overpressure and what part related to former events, e.g. ultracomminution together with fluid mobility/sealing, without fluid overpressure. Because when you already deal with a weak clay-rich rock and afterwards another weak phase in fluid-overpressurized pores is precipitated (e.g. clay, graphite), than the influence of this minor third weak phase (volume weighted with respect to the existing surrounding weak fault rock) on the already existent rheology is relatively low. Please clarify this point.

2. Analytical detection of 1 μm-sized pores

line 185-187: On figure 8b pores have sizes comparable to the small range of pores segmented on XCT images (> 1.3 μm in diameter), and thus we conclude that both nano- and micro pores within the Alpine Fault core are distributed on grain and phase boundaries, especially of clay minerals (Fig. 8).

MB-comment: In Fig. 8b the pores are extremely flattened /elongated and only the

long axis show a value > 1 μm. I am not sure if you can measure with synchrotron and a voxel size resolution of 1.3 μm such elongates pores where the calculated diameter is <1.3 μm. Please clarify this point.

Following points are minor comments:

Line 136: High resolution TEM images

MB-comment: Actually, your TEM images are not High Resolution images. The definition of high resolution TEM imaging means that you work with an Angstrom resolution in order make visible the atomic structure and that is not the case for your microstructures

line 200-201: To address this possibility more data for systematic analyses of pore orientations are needed

MB-comment: Please compare your observations/data with published papers, which contain similar TEM porosity analysis in clay-rich rocks.

line 229-231: Thus, the comparatively lower porosity estimates of the Alpine Fault core than other active faults (e.g. the Nojima Fault, Surma et al., 2003, and the San Andreas Fault, Blackburn et al., 2009) can be attributed to the fact that the Alpine Fault is late in its seismic cycle (Cochran et al., 2017).

MB-comment: Do you refer to the latest seismic event in the year 1717 and the average seismic cycle of 291 $\pm$ 23 years? please clarify this - because maybe the reader already forgot that you have mentioned this point at the begin of the paper

Figure 1 Line 403 (Figure 1):

MB-comment: Please provide GPS data of the drilling site

Figure 8 (a)

MB-comment: I presume the dark structures are the pores - please point directly with

arrow-tip onto the structures. Otherwise it is a little bit confusing, especially for readers who are not familiar in reading TEM images

Figure 8 (c)

MB-comment: where are the quartz/feldspar grains with the strain shadow? Is it the grain in the middle of the image? Than please shift the text "Ellipsoidal pores" to an area in the image where it does not cover an essential part of the image.

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