

Review of paper entitled, “Controls on fault zone structure and brittle fracturing in the foliated hangingwall of the Alpine Fault” by Williams, J. N. et al.

General Comments

Concise and clearly written. The topic is of wide interest, and is introduced well. Some of the figures are too small and/or are poorly labelled. Captions are commonly disorganized, and do not actually describe the content of the different parts of the figure. The photographs, in particular, are commonly not very clear or helpful.

I would have liked to have seen a physical explanation for why vertical unloading during exhumation should favour the development of the foliation-parallel fractures. The paper does not do this, so citing this scenario as an “explanation” is not particularly convincing. Similarly, the explanation of “development of fault wedges” (where? how?) or dynamic earthquake stressing from below, as causes for variously oriented gouge filled fractures in the damage zone is not well enough discussed or supported, in my opinion.

Abstract

Abstract is concise and clearly stated on the whole.

Line 21: Suggest “principal slip zones [of]” is moved ahead of “Alpine Fault”

Line 38: suggest “rather than the footwall” is added to the end of this sentence.

Introduction

To the point and well stated.

Goals are clearly identified.

Line 69-70: brackets in brackets

Line 74: add “s” to “Alpine fault”

Tectonic Setting

Lines 95-100: Along-strike changes in slip rate are not what has led to the tripartite division of the Alpine fault. This statement is quite misleading.

Line 108: replace “form” with “occur in spatial sequence towards the fault”
After “(Figure 2)” start a new sentence. At the beginning of this, replace “which are” by “These”.

Line 111: For clarity, insert a comma after “metabasitic mylonites”.
Also, the subsequent “or” should be replaced by “and”

Line 112. Start a new sentence at “reflect” [i.e., “These reflect..”]

Line 117: Insert “brittle overprint” after “This”

Line 122: “projection of outcrops” is unclear in meaning or logic, as written. “Measurements” of what? Why does a seemingly artificial projection process at the surface require a planar zone at >4 km depth? What are the assumptions?

Line 125: I disagree that the AF necessarily has a dip of 45 degrees at >4 km, or that the data mentioned by the authors demonstrates this, and I note that the statement is not supported by any references.

Methodology

In Section 3.1 need to start out by pointing out the known shallow dip of the fault at DFDP-1?

Line 140: If the DFDP-1 holes are up to 150 m deep, why was only 25 m of core investigated for this study? Explain.

Line 152. Insert comma after “Appendix A”

Line 156. “Distances” is vague. How measured, in what direction?

Line 160: They were measured not “collected”

Line 163: What uncertainties in the measured quantities (e.g., fracture density) are introduced by assuming a generic “thrust” fault dip of exactly 30° when the actual fault dip may be different than that?

Line 164: an extraneous comma.

Line 166: it is a method, not a “methodology”. The “-ology” is a little pretentious, in my opinion.

Line 180: I disagree that Norris and Cooper (1995) demonstrated that the Alpine fault dips c. 45° below the Amythyst tunnel locality. Also, “circa” is a time term, not a spatial or angular term.

Line 181: See my statement above regarding line 163 and uncertainties tied to an assumed fault dip.

Lines 187-190: “intense fracturing” adjacent to “minor” faults is not measured, nor was it captured in the cores (due to their poor recovery). For the paper, only quite intact cores (i.e., the least fractured intervals) were imaged by CT from which corresponding fracture densities were derived. How representative are these fracture density estimates likely to be? Are they maxima or minima?

Shouldn't this sampling bias be acknowledged and implications for using the results be mentioned?

Lines 198-200: This statement is only true if the top vs. bottom of each piece of core was marked as they came out of the ground. Please elaborate.

Line 199: What is the “known orientation,” how was it measured, and what are the uncertainties in this assigned dip/ or dip direction?

Results

Line 214: What are the criteria used to distinguish “fractures” from “foliations” in the BHTV? To what degree can one be confident that these criteria “work”? How about your comparison of the BHTV plots with the cores?

Line 217: What is meant by “type of fracture”? Vague and unclear. Do you mean “host rock type”?

Line 221: It would be good and appropriate here to site a statistical measure of fault attitude “clustering” rather simply stating qualitatively that one subset of the data is “more clustered” than the other. The plots are not very convincing on their own.

Line 251: Be exact. This is in the Alpine Schist.

Discussion

Lines 269-274. Authors refer to the field-observed fractures at >160 m from fault as being “mostly open.” Given they are observed at the face of an outcrop in a high rainfall setting, can one be sure that they do not have gouge in them at depth a short distance below the exposed ground surface? See your lines 258-259. Do you really know that they are open? In the Amethyst road tunnel, which is >160 m from the fault, many of the observed foliation-parallel fractures are gouge filled (personal observation).

Lines 306-307: I am unconvinced that the transect data has demonstrated a “confining pressure” cause/effect for foliation-parallel fracturing/or not. This is an interpretation—not a fact.

Line 332: I have no idea what “broadly oriented” means.

Lines 321-322 and Line 331: These statements seem to contradict one another: The fracture density is spatially constant—but it isn’t(?). Please clarify and be exact and consistent.

Line 336: “They are considered necessary” By whom? Why? This is weak and inexact language.

Line 348: I have no idea what an “intensive” fracture is.

Line 368: depends on your definition of “fault zone” As you point out, this is not an absolute or clearly defined quantity. And what do you mean by “total” fault zone width? Are there other measures of “partial” fault zone width?

Line 379: unclear what is meant by “this set”

Lines 390, 393, 394: more apparent self-contradictions:

Is the distance <360 m or is it c. [sic] 500 m? This is VERY confusing. The role of gouge infilling/ or not in these descriptions is not well explained.

Line 397: “development of fault wedges” is a vague physical “explanation” for the occurrence for a spatial zone of gouge-filled fracturing. This interpretation has not been well explained or justified.

Fig. 1. I disagree that “all active onshore faults” are depicted in this figure. The heavy black line (road) is not labelled or explained, and it is shown far too bold, in my opinion. The road should not be the most conspicuous line feature on this map (but is), in fact it should probably not be shown at all. Why is the transport route even relevant? Lettering/font in the key is too small to be legible.

Fig. 2. Location of image in part a) is not stated.

Fig. 5. Yellow symbols in c) are faint and hard to read. Same for purple symbols in d) and red symbols in a).

Symbols are illegibly tiny and the lettering in the key are too small.

Fig. 6. Where were the samples in a, b, and c collected? What intervals?

OK I now see this is stated at the bottom of the caption (It makes more sense to cite the interval for parts a, b, c as part of the caption for parts, respectively. This is more efficient.

Caption for c should say “In this sample [of what rock type?], fractures show a preference to be aligned...”

Fig. 7. Pole symbols and lettering in b are too small.

Fig. 8. This caption is disorganized, inexact, and confusing. The photos are of limited use at the scale they are presented and they lack adequate labelling and discussion. What are the yellow arrows pointing to? The features in each photo should be labelled on the figure and sequentially and individually discussed and in the caption. What is the scale of g)? e) is almost unreadably muddy. The caption should identify what particular samples were chosen for the CT scans in the lower row of images (parts c, f, and i) and how these 3 chosen CT scans may relate to any of the other samples or field photos in this figure.

Fig. 9 “Coincident with lithological diversity” is inexact and physically nonsensical. How can something coincide with a “diversity” Do you mean a *contact*? I can’t see any “gouge filled fractures” in part c (despite the arrows)