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# *Interactive comment on* "The internal structure and composition of a plate boundary-scale serpentinite shear zone: The Livingstone Fault, New Zealand" *by* Matthew S. Tarling et al.

**Matthew S. Tarling et al.**

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We thank the reviewer for his detailed and constructive comments. We agree with all comments and intend to incorporate all the reviewers' suggestions into the revised manuscript. Below we include a point-by-point response to the reviewers' comments.

Reviewer comments are in **bold**, author responses are in *italics*.

**General comments: I reckon that references should be in chronological. Labels within field figures are all very small and difficult to read.**

*The references will be revised and changed to be ordered chronologically in the text. We will make sure that all labels and annotations within the figures are clearly legible, and we will increase the font point sizes where necessary to improve legibility. Unfortunately, some of the figures that were submitted in the original .pdf were converted to a lower resolution than we would have liked, which may have rendered some of the text difficult to read. We will ensure that final figure versions are submitted at highest resolution.*

Specific comments:

**Page 2, line 16 and following. There are several more studies that document with some detail the processes and the structure of serpentine-bearing fault zones. Some potential additions to the list: Maltman, 1978; Williams, 1979; Twiss and Gefell, 1990; Alexander Harper, 1992; Gates, 1992; Bailey et al., 2000, Hirauchi and Yamaguchi, 2007, Bellot, 2008, Melosh, 2019. In the following lines: it might be worth mentioning with some more details what these studies say about the structure and deformation of serpentinite-bearing faults. Limiting the discussion to the characteristic scaly fabric is a bit over simplistic. In the discussion, it might be useful to highlight the differences with the previous knowledge about serpentinite faults.**

*We will revise the introduction to expand the overview of serpentinite-bearing shear zones worldwide and include the suggested references. Additionally, in response to comments by Reviewer 1, we will also provide specific reference to several examples* *of other serpentinite-bearing shear zones around the world.*

**Page 8, line 30: there is a question mark after "Vannucchi et al., 2003" what does it means?**

*Errors in referencing such as this question mark (and others throughout the text) will be addressed. The reference in question missing here is "Vannucchi 2019".*

**Page 9, line 19. See also Melosh, 2019, G3**

*References will be updated to include Melosh 2019.*

**Page 10, line 4: How did you identify these minerals? how large are the grains?**

*The minerals were identified with scanning electron microscopy energy-dispersive X-ray spectroscopy (SEM-EDS) and Raman Spectroscopy (where crystallographic symmetry permits; details in Tarling et al 2018; Rooney et al. 2018). Grains are typically tens of microns in size, but can be up to mm-scale. The text will be updated to include these details.*

**Page 10; line 16: The temperature range in which chrysotile and lizardite are stable is much wider than 300-350 C. The absence, or instability, of antigorite may well set the high temperature boundary, but not the lower boundary. Since two close terranes have zeolite facies (T<200 C) and Prehnite-Pumpellyte facies (T<300 C) metamorphic imprint, it is possible that the Livingstone fault was active at temperatures lower than 300 C.**

*Following the advice of the reviewer as well as a similar comment made by Reviewer 1, we will apply a more conservative stance with regards to the temperature range and broaden our initial estimates. We will expand our treatment of the evidence for the temperature estimates, including the instability of antigorite, the general lack of the assemblage antigorite + brucite, the metamorphic facies in the wall rocks and the dominance of a chrysotile + lizardite assemblage. Additionally, the general lack of incohesive brittle fault rocks in the serpentinite shear zone would argue against any significant very shallow, low temperature deformation. Overall, the lines of evidence are compatible with a temperature range of 250-350 C.*

**Page 11, line 5: I think a paper in revision does not qualifies as previous literature.**

*We will remove the paper in revision from the reference list.*

**Line 8-10: this is a very interesting observation. Do you have an estimation of the thickness of the mantle section in the other outcrops of the ophiolite adjacent to the Livingstone fault? I would be interesting to understand this change in thickness. For instance, are there any changes in kinematics or amount of displacement that could account for this change in thickness of the deformed mantle portion?**

*These are interesting questions raised by the reviewer. We have not mapped in detail the ultramafic sections of the ophiolite belt adjacent to the Livingstone Fault, although crude estimates of thickness can be obtained from satellite/aerial imagery and other field observations (including other published articles and maps). Based*



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*on this, we have not noted any specific changes in shear zone kinematics that could be related to the thickness of the ultramafic portions of the ophiolite or the width of the serpentinite shear zone. However, we believe that this kind of correlation would require a more targeted project, focusing specifically on whether there is a correlation between shear zone structure/kinematics and the structure (e.g. thickness, degree of serpentinisation) of the wall rocks. These questions may form the basis for future field work. Unfortunately, we lack constraints on shear zone displacement due to the absence of clear offset markers or boundaries, and thus any correlations between displacement and e.g. kinematics/wall rock structure, are currently not possible to constrain.*

**Page 12, line 12: ": : :P-T conditions". Maybe a reference or two are necessary here.**

*We will add references to support the notion that the interpretations reached regarding the structure, importance of pressure-solution, and metasomatic reactions are relevant to a wide range of P-T conditions.*

**line 21. from the sentence it looks like that the references talk about pressure solution producing the scaly fabric of serpentinites. They are only some examples of work about pressure-solution weakening of faults in general. Maybe add "similarly to what happens in other faults"? or something similar.**

*We will change the text to include "as observed similarly in other faults" to highlight that the references refer to the general role of pressure-solution in the formation of fault fabrics.*

**line 34: it might be worth to metionting that the association of serpentinites /ultramafics with tremolite (and chlorite and talc) is well documented in the literature (e.g. Cronshaw 1923; Nishiyama 1990; Boschi et al., 2006; Bach and Klein 2009 among many others). In particular at the contact with different lithologies (rodingites but also metasediments).**

*We will revise this sentence to highlight the well-documented association of serpentinites and metasomatic products such as tremolite, talc and chlorite, particularly at the contacts between serpentinite and silicic and calcic lithologies.*

**Page 13, line 24. This statement about overpressure induced by metasomatic reactions is a bit vague. I would suggest to either remove it or present the evidence for such a phenomena (I don't think Fig. 6a is enough).**

*We will revise the statement to remove mention of fluid overpressure and instead present the observations that metasomatic reactions zones are associated with vein networks and the reaction hardening and embrittlement of metasomatised portions of the shear zone. We note that metasomatism in the Livingstone Fault forms the focus of another paper currently in revision, and we would prefer to leave details of the metasomatic reactions for that other paper.*

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