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Interactive comment on "A revised map of volcanic units in the Oman ophiolite: insights into the architecture of an oceanic proto-arc volcanic sequence" *by* Thomas M. Belgrano et al.

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We thank Dr Goodenough for her effort in reviewing our manuscript and are glad that she enjoyed the read and found the work sound.

A full list of revisions will be posted together with the revised manuscript after the discussion period has closed. In this reply we address the main points of discussion raised by the Reviewer.

Regarding the name we use for the ophiolite, we agree that this could be more consistent in our text. We had intended the 'Oman ophiolite' to denote the part of the ophiolite within Oman, but this is evidently not entirely clear to the reader. On the other hand, using the name 'Oman–UAE ophiolite', although unambiguous, could imply that our field area extends into the UAE, which it does not. As there are other ophiolites in Oman, we thus favour the traditional 'Semail ophiolite' designation, and we will update the manuscript accordingly.

Concerning the northern and southern limits of our mapping area, outcrops of volcanic rocks outside of our area are indicated by the existing regional maps in the south-eastern ophiolite blocks, along the western side of the ophiolite, and in the UAE. The stratigraphy and geochemistry of the volcanic rocks in these areas has long been overlooked in favour of the more extensive outcrops along the Batinah coast, which lie within our mapping area. Our mapping area was chosen so as to cover the majority of outcropping volcanic rocks and prospective tenements for VMS exploration. The extent of the 1992 Batinah Aeromagnetic survey, which does not reach into UAE, also defined the area over which we could infer the presence of volcanics under cover.

In addition to these reasons, our decision to exclude the southeastern blocks was largely due to the practical constraints of mapping with a small team, with limited time, from a base in Sohar. It may be relatively straightforward to take the methodology outlined in this study and apply it to the sparsely outcropping volcanics south of the Semail and Tayin blocks. A comparable geophysical survey exists for that area, and the Washihi VMS deposit, currently in the mine development phase, is located in the Tayin block.

Based on the evidence for subduction zone influence in the southeastern blocks as described by de Graaff et al. (2019), Haase et al. (2016), MacLeod et al. (2013), Rollinson and Adetunji (2013, 2015), we suspect that the volcanic rocks in these blocks could be rather similar to those in our mapping area. It is feasible that the idea of a weaker 'Phase 2' overprint in the southeastern blocks stems from differences in the outcrop quality of the volcanic sequence.

As with the southeastern ophiolite blocks, it should be relatively straightforward to continue mapping the different volcanic units into the UAE, with the excellent British Geological Survey maps as a base and with our study as a guide. As suggested, we will add a few sentences describing the extent of volcanic outcrops outside of the mapping area to Section 1.4.3. Scope of new map.

With reference to the question of whether some of the magnetic anomalies could be related to shallow intrusions beneath the volcanics, this is a valid and interesting point. As tested with field magnets, the intrusive rocks are generally less magnetic than their volcanic equivalents. However, in well-exposed areas, negative anomalies over the intrusives are only well-resolved when the bodies are of considerable size (greater than ∼200–500 m across) and are emplaced in strongly-magnetized volcanics. For example, in Fig. 14, the reduced-to-pole magnetism of a large gabbro–tonalite intrusive complex can be seen as weak, and comparable to that of the sheeted dykes. This indeed implies that another possible source of patches of low magnetism could be hidden, shallow intrusions, and we will add this point the list in Section 5.4. However, as these intrusions only make up ∼8 vol% of the upper crust, and even less of the volcanic sequence, we expect this effect to be minor overall.

With regards to the spatial relations between the Lasail seamounts and the late intrusive complexes, our map rather supports a comagmatic connection between the Alley lava units and the intrusive bodies. Late intrusive complexes often do underlie or appear in the vicinity of the Lasail seamounts (e.g. Fig. 14), but there are also many cases where Lasail accumulations are not underlain by late intrusives. There are other arguments in favour of the Phase 2 intrusive complexes being related to the Alley lavas. Firstly, the greater proportion of Alley volcanics relative to Lasail suggests that Alley should have a more significant proportion of intrusive equivalents. Secondly, the intrusive complexes characteristically span a range of compositions, from gabbroic to tonalitic, often within single complexes (Lippard et al., 1986). This compositional series is characteristic of the Alley lava suite, but not of Lasail. For instance, in Fig. 14 the entire Lasail accumulation is made up of pale, primitive basalts, whereas the underlying intrusive complex consists of roughly equal portions of gabbro and tonalite. Similarly, the well-documented plutonic complex in the Lasail mine area, depicted in the south-eastern corner of Fig. 16, is made up of gabbros and quartz diorite (Tsuchiya et al., 2013). Though this complex has been linked to the Lasail lava unit on the basis of its location, the intrusive complex and emanating dyke swarms cut through Alley lavas on its eastern side, showing it is rather related to late Alley phase magmatism. This major intrusive complex is shallowly emplaced under the lavas surrounding it (Tsuchiya et al., 2013), and thus underlies, and probably feeds, the significant accumulations of Felsic Alley lavas found just to the north of the exposed intrusives. While considering the intrusive–extrusive connection, we did notice a loose spatial association between upper-crustal ultramafic intrusions (wehrlites where checked) and the Lasail unit. Wehrlite bodies are not exceedingly common in the upper crust, but where they do occur, they usually underlie, or are intruded into, Lasail lavas (e.g. just south of Wadi Hatta; the small ultramafic body in Fig. 14; around Wadis Hilti–Ahin; Wadi Mahmum; Wadi Hawasina, beneath the Ghuzayn deposit). The particularly primitive, wet melts associated with both wehrlite and Lasail lava petrogenesis may further support this connection (Belgrano and Diamond, 2019; Koepke et al., 2009). We can add some sentences to the manuscript on these observations, and welcome any other thoughts on the subject.

References cited:

Belgrano, T. M. and Diamond, L. W.: Subduction-zone contributions to axial volcanism in the Oman-U.A.E. ophiolite, Lithosphere, doi:10.1130/L1045.1, 2019.

de Graaff, S. J., Goodenough, K. M., Klaver, M., Lissenberg, C. J., Jansen, M. N., Millar, I. and Davies, G. R.: Evidence for a Moist to Wet Source Transition Throughout the Oman-UAE Ophiolite, and Implications for the Geodynamic History, Geochemistry, Geophysics, Geosystems, 0(0), doi:10.1029/2018GC007923, 2019.

Haase, K. M., Freund, S., Beier, C., Koepke, J., Erdmann, M. and Hauff, F.: Constraints on the magmatic evolution of the oceanic crust from plagiogranite intrusions in the Oman ophiolite, Contributions to Mineralogy and Petrology, 171(5), 1–16, doi:10.1007/s00410-016-1261-9, 2016.

Koepke, J., Schoenborn, S., Oelze, M., Wittmann, H., Feig, S. T., Hellebrand, E., Boudier, F. and Schoenberg, R.: Petrogenesis of crustal wehrlites in the Oman ophiolite: Experiments and natural rocks, Geochemistry, Geophysics, Geosystems, 10(10), doi:10.1029/2009GC002488, 2009.

Lippard, S. J., Shelton, A. W. and Gass, I. G.: The Ophiolite of Northern Oman, Blackwell Scientific Publications Ltd. [online] Available from: https://books.google.ch/books?id=PCkcAQAAIAAJ, 1986.

MacLeod, C. J., Johan Lissenberg, C. and Bibby, L. E.: "Moist MORB" axial magmatism in the Oman ophiolite: The evidence against a mid-ocean ridge origin, Geology, 41(4), 459–462, doi:10.1130/G33904.1, 2013.

Rollinson, H. and Adetunji, J.: Mantle podiform chromitites do not form beneath mid-ocean ridges: A case study from the Moho transition zone of the Oman ophiolite, Lithos, 177, 314–327, doi:10.1016/j.lithos.2013.07.004, 2013.

Rollinson, H. and Adetunji, J.: The geochemistry and oxidation state of podiform chromitites from the mantle section of the Oman ophiolite: A review, Gondwana Research, 27(2), 543–554, doi:https://doi.org/10.1016/j.gr.2013.07.013, 2015.

Tsuchiya, N., Shibata, T., Yoshikawa, M., Adachi, Y., Miyashita, S., Adachi, T., Nakano, N. and Osanai, Y.: Petrology of Lasail plutonic complex, northern Oman ophiolite, Oman: An example of arc-like magmatism associated with ophiolite detachment, Lithos, 156–159, 120–138, doi:10.1016/j.lithos.2012.10.013, 2013.

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