

Interactive comment on “Fluid–rock interactions in the shallow Mariana forearc: carbon cycling and redox conditions” by Elmar Albers et al.

Melanie Sieber (Referee)

melanie.sieber@gfz-potsdam.de

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I've thoroughly enjoyed reading the manuscript titled "Fluid-rock interactions in the shallow Mariana forearc: carbon cycling and redox conditions" by Albers, Bach, Klein, Menzies, Lucassen and Teagle. This interesting study investigates an unique suit of carbonate bearing metavolcanic and metasedimentary clasts from the Mariana forearc. The study demonstrates how forearc carbonation may affect the cycle of carbon in subduction zones, a topic of great interest for Earth scientists. I think this paper would make an excellent contribution to Solid Earth after some revisions (detailed below) that are mainly concerned with clarifying minor points and exploring further implications of forearc serpentinite carbonation.

C1

My main concern relate to:

1. The authors claim textural and chemical equilibrium, which I do not find to be sufficient supported by the observations. Please discuss the concept of equilibrium or adjust the text.
2. The tables are generally well presented. However, I suggest providing more petrographical information in Table 1. This would make it much easier for the reader to follow the paper and to always know what samples and localities you are talking about. For instance, which sample is the fully serpentinitized dunite? Can you please indicate samples with 'shallow' and 'deep' carbonates. That information is provided in the text, just adding it to the Table 1 will make it easier to follow the results and discussion.
3. The discussion would become more substantial by estimating the extent of carbonation. This would be particularly interesting in context of the long-term C-cycle. Did you establish the abundances of newly formed carbonates?
4. Figure 4 only displays the upper limit for the shallow carbonates. It would be of advantage to compare the REE pattern, Ce and Eu anomalies between those populations since this is one of the main aspects in the paper.
5. Figure 8: (1) Why is the shaded field, representing the $\log a_{\text{H}_2(\text{aq})}$ and T of your deep carbonates, shaped with a maximum at 160°C? Is the Eu-anomalie more pronounced in the high T -carbonates? Or did I misunderstand? In which case please explain. I think, the scatter in REE pattern is too large to argue for an Eu-anomalie. Thus, I think, you can't say much to the $\text{Eu}^{2+}/\text{Eu}^{3+}$ ratio. (2) Based on O-isotopes you calculated T between 130-175°C and between 220-310°C (see Figure 7). If so, the shaded field in Figure 8 should have a gap between 175-220°C.
6. Figure 9: Its great to have a cartoon illustrating the discussed process. However, I was surprised by the indicated overgrown textures of carbonates around other minerals. I cannot find a description of such overgrown or zoning in the text. Please elaborate

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on this.

7. The English need work and the paper would be improved by a careful going over with style as a primary consideration. Some mistakes are highlighted in the pdf, but this is by far not comprehensive.

Additionally, I have a couple of minor suggestions and remarks:

Abstract

- I suggest to include in the abstract (see your last sentence), that not all the carbon will be released into fluids under the forearc, some carbon will also be subducted deeper.

Introduction

Line ~31: "These observations are in line with experiments that demonstrated the increase in solubility of calcite in aqueous fluids with increasing pressure and temperature (Caciagli and Manning, 2003), suggesting that an efficient release of C from downgoing slab should occur even at relatively shallow levels." An 'efficient' release of CO₂ into fluids is not only related to the solubility of carbonates. Please include that the 'efficiency' of CO₂ release also depends, for instance, (1) the amount of fluid e.g. release of pore water and dehydration and (2) on the proportion of calcite and other carbonates in the slab.

Methodology:

Line 20: Please mention that you used Raman spectroscopy for phase identification.

Electron microscopy: Please include which elements you measured by EPMA. Why did you not include Sr in the EPMA analyses? Sr is likely above detection limit at least for the aragonites. Isotope Analyses: How representative is your sampling? How much material did you crash for picking carbonates?

Results

4.2.1 Petrography

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- Are mineral phases ordered with decreasing abundance? Did you establish phase abundances? The proportion of newly formed carbonates would be a first indicator on the extent of carbonation of serpentinites. Knowing the proportion of deep formed carbonates would also add much to your discussion on the C cycle.

- "Several generations of carbonates are observed" → you mention only two generations of carbonates calcite and aragonite; are there more?

- There seems to be some confusion on equilibrium: For example, you mention that "intergrown or ... straight crystal contacts (is) indicative of chemical equilibrium". I assume you mean textural equilibrium. Further, you state in Line 25, that an intergrowth of aragonite and calcite evidences equilibrium to a fluid. I do not agree to this. Please explain or adjust.

- It is often not clear to me, what sample you are referring to which makes the petrographic description confusing; e.g. Line 22 23 "... in two samples". Which samples? "Two other metavolcanic clasts..." In which sample are they? "One of those..." ???

4.2.2 Mineral chemistry

- "Major and trace elemental compositions in the carbonates are highly variable. Magnesium and Fe concentrations vary from <10 μg g⁻¹ to up to ~14000 μg g⁻¹ and ~1600 μg g⁻¹, respectively." I am not surprised, you sampled very different rock types and you are dealing with different carbonates (calcite, aragonite) so it can be expected that the Mg and Fe content are variable. Did you establish the Mg# of the host rock? It would be interesting to set those into context with Mg# of carbonates.

- The section is better written compared to the petrographic description, but some clarifications are needed: Can you think of a way to report your results more systematic and in context to the lithology? When are you considering the entire data-set and when do you refer to a particular sample?

- Figure 4: I would like to see the variability of REE in "shallow carbonates". Are

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chondrite normalized REE patterns of shallow carbonates also spreading by an order of 2-3? Further, I would like to compare the Ce- and Eu-anomalies between shallow and deep carbonates.

4.2.3

- Figure 5: You mentioned in 4.2.2 that some aragonites have Sr concentrations of up to 1.5wt%: did you analyse the Sr-isotopy of those aragonites or does Figure 5 only include data for calcites?

Discussion

5.1 - "Quartzite breccias have not been previously described from the serpentinite mud volcanoes. We suggest that this sample represents lithified sedimentary siliceous ooze from the subducted Pacific plate". Please include the indicated alternative explanations for the occurrence of quartzite.

5.2 - "We suggest that the deep carbonates formed from dehydration fluids in the subduction channel soon after they were released from the downgoing slab". I agree that the fluids released from the subducting slab formed carbonates in the subduction channel. However, your observations do not support time estimation.

- see main comment to Figure 8.

- "Our data suggest that simple devolatilization reactions (e.g., Kerrick and Connolly, 2001) do not account for the mobilization of C within these shallow portions of the subduction system. Instead, we suggest that fluid-induced dissolution of carbonate (e.g., Poli et al., 2009) is the more likely process that leads to the release of C under shallow forearc conditions." I agree that your data shows that carbonic fluids are released from the subducting slab and react with serpentinites. However, I don't see from your data that you can rule out that devolatilization reactions are an additional source of C released from the slab. Please explain or modify.

- If I understand correctly, you argue that serpentinization may not occur simultaneous

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to carbonation in the subducting channel. So the composition of the released fluid may have become more carbonic over time. What do you think may have caused this?

- rest of the discussion is very interesting. My only request is to correct the typos and to explain the overgrowth of carbonates indicated in Figure 9 (see main comments above).

Melanie Sieber

Please also note the supplement to this comment:

<https://www.solid-earth-discuss.net/se-2019-51/se-2019-51-RC2-supplement.pdf>

Interactive comment on Solid Earth Discuss., <https://doi.org/10.5194/se-2019-51>, 2019.