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Interactive comment on "Experimental study on the electrical conductivity of quartz andesite at high temperature and high pressure: evidence of grain boundary transport" *by* K. S. Hui et al.

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Thanks for your valuable comments and suggestions. According to your comment, we have amended our manuscript point by point and sentence by sentence. (1) The language is amended by a professional company named Stallard Scientific Editting. We think that the revised manuscript could be understood by readers. (2) The obtained impedance spectra are fitted by an equivalent circuit made of a series of R1-C1 and R2-C2-W (R1 and C1 correspond respectively to the resistance and capacitance of grain interior conduction process, and R2, C2, and W correspond respectively to the resistance, capacitance, and Warburg element of grain boundary conduction pro-

cess). (3) The conduction mechanism for grain boundary is discussed in the revised manuscript. We indicate that the conduction mechanism for grain interior and grain boundary conduction process are the small polaron conduction and ion conduction, respectively. The response is as follows:

1. Details on the experimental setup, collection of data and the interpretation are missing and should be included in the revised version of the paper. Thanks for the valuable suggestion. We have described the experimental setup, collection of data, and the interpretation very carefully in the revised manuscript.

2. The paper is written in poor English, the diction should be corrected by an expert. The language of this paper was amended by a professional company named Stallard Scientific Editting. We hope that the revised version is acceptable for publication.

3. The authors should include in the revised version more details on the low frequency part of the frequency spectrum. This is essential for an understanding of the low frequency response and its interpretation in terms of conduction mechanisms. We have explained the low frequency impedance more carefully. A Warburg element is necessary for the equivalent circuit. We consider that the alkali ions promote the grain boundary conduction process. The main conduction mechanism is the ion conduction.

4. Ni- electrodes are mentioned in the text, Pt- electrodes in Figure 1 (line 147-151). Thanks for the valuable suggestion. We have change "Pt- electrodes" to "Nickel electrodes" in the revised manuscript.

5. The low frequency end looks more like a Warburg impedance thus reflecting reactions at the electrodes rather than typical RC response. We thank the reviewer for providing us with the useful reference. We consider that a 45° slope in the complex impedance plane at low frequency is a Warburg impedance. The interpretation of impedance arc at low frequency is added in the revised version, and Figures 2, 4, 6, and 7 was amended accordingly. Besides, the grain interior conductivities are recalculated, and Figures 5 and 8 are amended accordingly.

6. 166: definition of R. The equation converts measured impedances into specific properties, was this done for each individual conduction process, or the overall bulk conductivity. The resistance (R) is for the given conduction process rather than the overall conduction process. This definition has added in the revised version.

7. 183: What do you mean with this sentence, explain in more detail. The ratio of grain boundary (σgb) to grain interior (σgi) conductivity represents their respective contributions to total conductivity; it varies with temperature and pressure. We have explained this sentence in detail in the revised version.

8. 192: (Figure 4) or table 2? ground boundary – mistyping for grain... We have amended "ground boundary" to "grain boundary" in the revised version.

9. 195-196: a further table summarizing sigma gi and sigma gbi would be helpful for the reader to follow the argumentation of the authors. The values of σgb, σgi and σt (corresponding to Figure 6) have been listed in Table 2. We hope that readers could understand the relationship between σgb, σgi and σt.

10. 223-227: Explain in more detail, what is the sense of the comparison of thermally activated semiconduction with those of partially molten samples. Was an optical inspection of partial melting performed? Previous studies indicate the temperature of partial melting for hydrous andesite is close to 1073K, and for anhydrous andesite is higher than 1273 K (Tee C.T. et al., 2014). We consider that partial melting could not occur under conditions of 723-973 K in our study. Numerous studies indicate that the electrical conductivity of partial melting rocks is higher than those without melting. Therefore, we consider that discrepancies in temperature, melting condition and water containing are the important influential factors that result in lower values in our study than previous studies.

11. 230-236: This paragraph needs more explanation. If polaron conduction is assumed to be the principle conduction process, than redox reactions at the electrodes have to be considered especially in the low frequency region of the spectrum. What is

the contribution of the alcali? Thanks for the valuable suggestion. A Warburg element was adopted to fit the grain boundary resistance; and it indicates that the grain boundary conduction process occurred via ion diffusion. A large quantity of alkali ions are contained in the quartz andesite (Na2O: 4.98 wt.%; K2O: 4.16 wt.%). Therefore, the grain boundary conduction mechanism for quartz andesite is the ion conduction. The effects of ion content on the electrical conductivity of quartz andesite require further research.

12. 242: Reference: Dai and Karato 2014 a,b. We refer to the wrong references, and have deleted them.

13. 240-250: Oxygen fugacity: Due to the experimental setup (MgO and Ni-foil) the fO2 concentration of ferric iron is rather low. Estimated or measured oxygen partial pressure? We estimated the values of oxygen fugacity using formula for solid oxygen buffer [NNO (Ni+NiO)] [Log (fO2)P,T=A/T+B+C(P-1)/T; A=-24930,B=9.36 and C=0.046]. Oxygen partial pressure is 10-15−10-24 bar under conditions of 0.5−2.0 GPa and 723−973 K in our study. The effects of oxygen fugacity on the electrical conductivity of quartz andesite require further research.

14. Figure 3: Scaling of the y-axis kOhm or Ohm? The scaling of y-axis should be "Ω", and we have amended "kΩ" to "Ω" (Figure 3) in the revised version. 15. Figure 5: Considering the shape of the Cole-Cole-Plots grain interior conduction is more than twice as high than grain boundary conduction. This is not reflected in Figures 4 and 5, these diagrams suggest that gi and gb conductivity are of the same value. Thanks for the valuable comment. The grain boundary conductivity is recalculated. The relationship between the grain interior and grain boundary conductivity are shown in Figure 6 and Table 2. The grain interior conductivity is distinctly higher than grain boundary conduction.

16. Figure 6: What is the definition of total conductivity, is this the equivalent of bulk-conductivity? We consider that total conductivity is the equivalent of bulk conductivity

(Roberts and Tyburczy, 1991; Tyburczy and Roberts, 1990). It is only a different expression way.

17. Figure 7: Urgently needs a more detailed definition in the figure captions to be understandable for the reader. We simplify this figure caption, and the sentence “The ratio represents the leading role of grain boundary or grain interior conductivity in the conduction process” is added at the end of the figure caption. We hope that the revised version will be understandable for the reader.

18. Does the paper address relevant scientific questions within the scope of SE? Yes. Does the paper present novel concepts, ideas, tools, or data? No. Are substantial conclusions reached? Not really, should be more specific Are the scientific methods and assumptions valid and clearly outlined? Yes, but hard to understand due to diction. Are the results sufficient to support the interpretations and conclusions? Except for fO2, yes. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? No. Do the authors give proper credit to related work and clearly indicate their own new/original contribution? Yes. Does the title clearly reflect the contents of the paper? Yes. Does the abstract provide a concise and complete summary? Yes. Is the overall presentation well structured and clear? Yes. Is the language fluent and precise? No A principle concern on this paper is the quality of the English diction. It must be corrected. A reader non familiar with the used techniques cannot easily follow the argumentation of the authors. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? Yes. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? Yes, more details in the experimental and discussion section of the paper. Are the number and quality of references appropriate? Yes. Is the amount and quality of supplementary material appropriate? Yes. Thanks for these valuable comments and suggestions.

Please also note the supplement to this comment:

http://www.solid-earth-discuss.net/7/C994/2015/sed-7-C994-2015-supplement.pdf

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