

Interactive comment on “Effect of chemical composition on the electrical conductivity of gneiss at high temperatures and pressures” by Lidong Dai et al.

Anonymous Referee 1[#]

This is a much improved submission that most questions have been well answered. I would just want to know how to exclude the effect of iron content on the bulk conductivity. Why the total $K^+ + Na^+ + Ca^{2+}$ is the main contributor? Also it is of strange that DS13 contains less Fe_2O_3 than DS12 because DS13 contains biotite 3 times than DS12 and the main Fe carrier in these samples should be biotite. It is better to provide the EPMA data of individual mineral in table 2.

Thanks for your very valuable and professional comments and suggestions.

In the present work, three different gneiss samples were selected to explore the effect of chemical composition on the electrical conductivity under conditions of 623–1073 K and 0.5–2.0 GPa. The chemical composition of sample was efficiently controlled by the weight percentage of total content for $Na_2O + K_2O + CaO = 7.12\%$, 7.27% and 7.64%. According to our obtained results, we found that the electrical conductivities of gneiss samples increased with the rise of the total content of alkali- and calcium ions. As a matter of fact, just as described by the anonymous comments, we designed the initial experimental procedure in order to explore the relationship of hydrous mineral of biotite content influence on the electrical conductivity of gneiss at high temperature and high pressure. However, unfortunately, after we finished a series of conductivity measurements, we did not obtain any available regular change with the content of biotite. All of these obtained results disclosed that the electrical

conductivity for gneiss presented a regular variation of the total content of alkali- and calcium ions, which was not related to the content of biotite. According to previously published conductivity results for phlogopite single crystal by Li et al. (2016), they extrapolated that the main charge carriers are probably K^+ and F^- , and fluorine may play a critical role in electrical conduction. And furthermore, Dai et al. (2014) measured the electrical conductivities of granite with different chemical composition at high temperature and high pressure, and they also adopted the total content of alkali- and calcium ions to establish one functional relationship of electrical conductivity and chemical composition. As we known, the mineralogical assemblages (main rock-bearing minerals are quartz, plagioclase and biotite) between granite and gneiss are almost same. In addition, the activation enthalpies for granite (0.44~1.18 eV) by Dai et al. (2014) were very approximate to our present obtained results (0.35~0.87 eV) for the gneiss samples at relevant temperature regions, and the charge carriers of granite were supposed to be K^+ , Na^+ and Ca^{2+} . So, in the present studies, the main contributor for conductivities of gneiss samples is related to K^+ , Na^+ and Ca^{2+} . As for the iron-related small polaron conduction, it is also of one popular conduction type that Fe-bearing silicate minerals and rocks, such as olivine, pyroxene, garnet etc. [e.g. Xu et al. 2000; Wang et al. 2006; Dai et al. 2009; Yang et al. 2012]. As usual, as a dominant conduction mechanism of small polaron, it is believed that the activation enthalpy is larger than 1.0 eV. In conclusion, it is difficult to extrapolate it as a Fe-related conduction mechanism in the present studies.

Indeed, it is possible that the main charge carrier of biotite is the iron-related

defect such as the small polaron. In the compilation of this manuscript, according to the optical microscope observation, the biotite content for No DS13 gneiss is close to three times than No DS 12 gneiss, as shown in the mineralogical assemblage of Table 1. However, in light of chemical composition of whole rock analysis by X-ray fluorescence (XRF) in Table 2, the Fe_2O_3 content of No DS13 gneiss is less than No DS12 gneiss. In consideration of the iron content discrepancy in each biotite, it should be no problem and reasonable. Maybe, if we considered the iron content influence on the electrical conductivity of biotite at high temperature and high pressure, it is one good method of adopting an electronic microprobe analysis to determine the chemical composition. In one previously published paper for gabbro, it is mainly consisted of two dominant mineralogical assemblage (e.g. clinopyroxene and feldspar), and we can also select the X-ray fluorescence (XRF) and electronic microprobe analysis at the same time [Dai et al. 2015]. The XRF and EPMA analysis also were conducted for eclogite in another one our recently published eclogite conductivity with two dominant mineralogical assemblage (e.g. garnet and omphacite) [Dai et al. 2016]. However, in our present work, the mineralogical assemblage is composed of three complex mineralogical assemblage (e.g. quartz, plagioclase and biotite), and it is too complex to acquire any useful information for the explanation of conduction mechanism by EPMA analysis. It is also similar that the influence of chemical composition on the electrical conductivity of granite also only adopted the X-ray fluorescence (XRF) analysis to gain the chemical composition of whole rock [Dai et al. 2014]. And therefore, in the revised manuscript, we did not provide the electronic

microprobe analysis results for each individual minerals, and the gneiss sample was considered as a whole to determine the chemical composition influence on its electrical conductivity at high temperature and high pressure.

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