Laboratory-based conductivity structure in the mantle transition zone

T. YOSHINO[1], A. SHIMOJUKU[1] AND T. KATSURA [2]*

[1]Institute for Study of the Earth's Interior, Okayama Univ., 682-0193 Misasa, Japan
(tyoshino@misasa.okayama-u.ac.jp, simojuku@misasa.okayama-u.ac.jp)
[2]Bayerisches Geoinstitut, Univ. Bayreuth, 95440 Bayreuth, Germany
(*correspondence: tomo.katsura@uni-bayreuth.de)

It is essential to assess the species and amount of volatile components in the mantle for understanding its dynamics and evolution. For this reason, we studied conductivity of the upper-mantle minerals as a function of temperature and incorporated water content. Our measurements on hydrous olivine, wadsleyite and ringwoodite demonstrated that, although the water incorporation to these minerals increases their conductivity, this effect is relatively small. In contrast, other research groups claimed significantly larger effects. Our measurement was criticized due to lack of impedance spectroscopy for wadsleyite although we adopted this method for olivine and partly ringwoodite. For this reason, we reinvestigated conductivity of hydrous wadsleyite by means of impedance spectroscopy.

Our measurement demonstrated that conductivity of a fluid phase released from hydrous wadsleyite masks that of wadsleyite itself above 1000 K. It was also found that the impedance arcs in the Nyquist plot are significantly distorted when the fluid phase is released, probably because impedance arcs of the grain boundary fluid and reaction on the electrodes overlap with each other. The measurement results given by our conventional low frequency method and impedance sprectroscopy show excellent agreement. These observations prove appropreateness of our previous conclusion.

We constructed a laboratory-based conductivity model of the upper mantle using our experimental data. This model shows the following features. The conductivity jump at 410-km depth is very small even if it exists. In contrast, the conductivity jump at 520-km depth is remarkable. There is no evidence from conductivity for presence of water in the mantle transition zone beneath the Pacific Ocean. Very high amount of water (0.5 %) would be required to explain the high conductivity beneath the Philippine Sea if it is explained by hydration of the upper-mantle minerals.

In situ iron isotope analyses of pyrites from 3.5 to 3.2 Ga sedimentary rocks of the Barberton Greenstone Belt, Kaapvaal Craton

KAZUMI YOSHIYA[1], YUSUKE SAWAKI [2], TAKAZO SHIBUYA[2], SHINJI YAMAMOTO[3], TSUYOSHI KOMIYA[3], SHIGENORI MARUYAMA[1] AND TAKAFUMI HIRATA[4]

[1]Dept. of Earth and Planetary Sci., Tokyo Institute of Technology, Japan (yoshiya.k.aa@m.titech.ac.jp)
[2]Japan Agency for Marine-Earth Sci. & Tech., Japan
[3]Dept. of Earth Sci. and Astro., Komaba, Univ. Tokyo, Japan
[4]Dept. of Geology and Mineralogy, Kyoto Univ. Japan

The Barberton Greenstone Belt (BGB), South Africa consists of volcano-sedimentary successions and sedimentary rock sequences deposited between 3.5 and 3.2 Ga, and is subdivided into three groups: the Onverwacht, Fig Tree, and Moodies Groups. Several putative morphological fossils (filamentous and sphere type) and trace fossils were reported from the Hooggenoeg and Kromberg Formations in the Onverwacht Group [1,2,3]. On the other hand, isotopic data suggest the activities of sulphate-reducing bacteria and photosynthetic bacteria at 3.4 Ga [4]. Dissimilatory iron reduction (DIR) is also considered to be one of the earliest metabolisms on Earth [5], but the previously reported oldest isotopic evidence for the DIR by bacteria is from 2.9 Ga [6]. We report the in-situ iron isotope analysis of individual pyrites in sedimentary rocks from the BGB, using femtosecond laser ablation multi-collector ICP-MS technique (fs-LA-MC-ICP-MS) [7]. We obtained a large variation of iron isotope data from -1.9 to +3.6 ‰ in δ^{56}Fe values, from 94 pyrite grains in 16 samples: five cherts from the Hooggenoeg Formation, eight cherts from the Kromberg Formation, one sandstone from the Fig Tree Group, and three sandstones from the Moodies Group. The δ^{56}Fe values of pyrite from Hooggenoeg Formation show positive values, whereas those from the Kromberg Formation show wide variation from positive to negative values. The negative δ^{56}Fe values of pyrites with a nadir down to -1.9 ‰ in the Kromberg Formation indicates DIR by bacteria. This result shows that the activity of iron-reducing bacteria can date back to, at least, the middle Archean.

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