Effect of redox state of iron on viscosity of sodium silicate melts

SOHEI SUKENAGA[1], HIROKI YAMADA[2], TORU WAKIHARA[2], KOJI OHARA[3], SEIJI KAMADA[4], PIERRE FLORIAN[5], HIROYUKI SHIBATA[1], MARIA RITA CICCONI[6], AND DANIEL NEUVILLE[7]

[1]IMRAM, Tohoku University, Katahira 2-1-1, Aoba-ku, Sendai, 9808577 Japan. sukenaga@tagen.tohoku.ac.jp, shibata@tagen.tohoku.ac.jp

[2] Department of chemical system engineering, the University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 1138656, Japan. h_yamada@chemsys.t.u-tokyo.ac.jp, wakihara@chemsys.t.u-tokyo.ac.jp

[3] Japan Synchrotoron Radiation Institute (JASRI), 1-1-1, Kouto, Sayo-cho, Sayo-gun, Hyogo 6795198, Japan. ohara@spring8.or.jp

[4] Frotier Research Institute for Interdisciplinary Sciences, Tohoku University, Aramaki aza Aoba 6-3, Aoba-ku, Sendai 9808587, Japan. seijikmd@m.tohoku.ac.jp

[5] CEMHTI-CNRS, 1D, avenue de la Recherche Scientifique 40571 Orléans, France. pierre.florian@cnrs-orleans.fr

[6] Department of Materials Science and Engineering, Institute of Glass and Ceramics, Friedrich-Alexander-University Erlangen-Nürnberg, Martensstr. 5, D-91058 Erlangen, Germany. maria.rita.cicconi@fau.de

[7] Géomatériaux, CNRS-Institute de Physique du Globe de Paris, Sorbonne Paris Cité, 1, rue Jussieu 75238 Paris, France. neuville@ipgp.fr

Iron is one of the most important elements in natural silicate melts (i.e. magmas) as well as in high temperature melts used for metallurgical industries (i.e. slags). It is well known that structural role of iron drastically changes depending on the iron redox state (Fe^{2+} or Fe^{3+}). However, the knowledge of its effect on the physical properties (e.g. viscosity) is very limited [1]. In this study, iron sodium silicate melts (initial iron concentration: 10 mol% as Fe_2O_3) are equilibrated in O_2, air, Ar or Ar-1%H_2 atmospheres at 1773 K. Then, the viscosity of the melts with a variety of redox state of iron has been measured at temperatures above their liquidus and close to their glass transition. The redox state of the quenched glassy samples was determined using X-ray absorption and Mössbauer spectroscopy. The viscosity of the sodium silicate melts decreases with increasing the Fe^{2+}/Fe^{3+} ratio. Pair distribution functions of the quenched samples show that distances between iron and oxygen atoms increased with increasing Fe^{2+}/Fe^{3+}. Our findings here indicate that Fe^{2+} acts as a network modifier whereas Fe^{3+} works in part as a network former.

Ref. [1] D. B. Dingwell (1991), *Am. Mineral.* 76, 1560.