American Mineralogist, Volume 100, pages 2152–2158, 2015

Evidence for Nb^{2+} and Ta^{3+} in silicate melts under highly reducing conditions: A XANES study

Camille Cartier[1], Tahar Hammouda[1,*], Maud Boyet[1], Olivier Mathon[2], Denis Testemale[3,4] and Bertrand N. Moine[5]

[1]Laboratoire Magmas et Volcans, Université Blaise Pascal, CNRS, IRD, OPGC, 5 rue Kessler, 63038 Clermont-Ferrand, France
[2]ESRF European Synchrotron Radiation Facility, 71 avenue des Martyrs, 38000 Grenoble, France
[3]Institute Néel, Department MCMF, 25 Avenue des Martyrs, 38042 Grenoble, France
[4]FAME Beamline, ESRF, 71 Avenue des Martyrs, F-38043 Grenoble, France
[5]Laboratoire Magmas et Volcans, UMR CNRS 6524, Université Jean Monnet, 23 rue du Dr P. Michelon, F42023 Saint-Etienne, Cedex 02, France

Abstract

Niobium (Nb) *K*-edge and tantalum (Ta) L_{III}-edge XANES spectra were acquired at the part-per-million concentration level in silicate glasses quenched from chondritic melts equilibrated at 5 GPa and under moderately to highly reducing conditions (IW-1, IW-4.5, IW-7.9). Standard materials have also been analyzed for Nb and Ta, and the data were used to construct the calibration curves of E_0 (threshold energy) vs. valence. Under moderately reducing conditions our results are consistent with niobium and tantalum being mainly pentavalent in the silicate melts as also suggested by previous studies. We do not exclude that at IW-1, a small fraction of Nb and Ta could be reduced, leading to a mean formal valence slightly lower than five. At IW-4.5, Ta is mainly in the form Ta^{3+}, and at IW-7.9, Ta appears to be Ta^{1+}, whereas Nb is divalent (Nb^{2+}). The possibility for Nb and Ta to be present in reduced forms has implications for the behavior of the two elements during the processes of differentiation on planetary bodies formed in the reduced parts of the early Solar System. Element partitioning is a function of size and valence, and our results show that high field strength elements could be reduced, which could change their chemical affinity. This may also be important for the Earth and Moon formation and early differentiation, as exemplified by the "Nb paradox."

Keywords: Niobium, tantalum, XANES reduction, silicate glass, Nb paradox