American Mineralogist, Volume 104, pages 1800–1805, 2019

Electrical conductivity studies on silica phases and the effects of phase transformation

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Abstract

Starting with the same sample, the electrical conductivities of quartz and coesite have been measured at pressures of 1, 6, and 8.7 GPa, respectively, over a temperature range of 373–1273 K in a multi-anvil high-pressure system. Results indicate that the electrical conductivity in quartz increases with pressure as well as when the phase change from quartz to coesite occurs, while the activation enthalpy decreases with increasing pressure. Activation enthalpies of 0.89, 0.56, and 0.46 eV, were determined at 1, 6, and 8.7 GPa, respectively, giving an activation volume of –0.052 ± 0.006 cm^3/mol. FTIR and composition analysis indicate that the electrical conductivities in silica polymorphs is controlled by substitution of silicon by aluminum with hydrogen charge compensation. Comparing with electrical conductivity measurements in stishovite, reported by Yoshino et al. (2014), our results fall within the aluminum and water content extremes measured in stishovite at 12 GPa. The resulting electrical conductivity model is mapped over the magnetotelluric profile obtained through the tectonically stable Northern Australian Craton. Given their relative abundances, these results imply potentially high electrical conductivities in the crust and mantle from contributions of silica polymorphs.

The main results of this paper are as follows:

• The electrical conductivity of silica polymorphs is determined by impedance spectroscopy up to 8.7 GPa.

• The activation enthalpy decreases with increasing pressure indicating a negative activation volume across the silica polymorphs.

• The electrical conductivity results are consistent with measurements observed in stishovite at 12 GPa.

Keywords: Electrical conductivity, impedance spectroscopy, single crystal, quartz, silica, coesite, high pressure