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The electrical conductivity of albite feldspar: Implications for oceanic lower crustal sequences and subduction zones

George M. Amulele[1,2,†,‡], Anthony W. Lanati[1,3,*,†], and Simon M. Clark[1,4,§]

[1]Australian Research Council Centre of Excellence for Core to Crust Fluid Systems (CCFS), School of Natural Sciences, Macquarie University, Balaclava Road, North Ryde, Sydney, New South Wales 2109, Australia
[2]Earth, Environmental and Planetary Sciences, Case Western Reserve University, 10900 Euclid Avenue, Ohio 44106, U.S.A.
[3]Institut für Mineralogie, Westfälische-Wilhelms-Universität Münster, Corrensstrasse 24, 48149 Münster, Germany
[4]School of Engineering, Macquarie University, Macquarie Park, New South Wales 2113, Australia

Abstract

Volatile-sensitive electrical soundings are becoming more widely adopted, with large nationwide arrays currently being acquired globally. This boom in new data is despite several key uncertainties relating to the electrical responses of a wide range of minerals that make up crustal regions. Complications include the influence of mineral chemistry, hydrous or nominally hydrous phases, and oxygen fugacity on charge-carrying ion activity within a mineral substrate. Feldspars are the most abundant mineral group in the Earth's crust, comprising about 60% of its mineral assemblages and are particularly prevalent within subduction zones and lower crustal sequences. These areas are known locations where ore systems are commonly rooted, making them among the most widely studied regions in the Earth. To date, few studies exist that cover the electrical behavior of the feldspar mineral albite. To help address some of these issues and complications, we have undertaken electrical conductivity investigations on a single crystal of gem-quality albite ($Ab_{49}An_{48}Or_3$) from Nuevo Casas Grande, Chihuahua, Mexico. Electrical conductivity measurements using impedance spectroscopy were performed at a pressure of 1 GPa over a temperature range of 373–1273 K in a multi-anvil high-pressure apparatus. Experiments were carried out using different metal electrodes: molybdenum, nickel, and rhenium to vary the oxygen fugacity during the experiments. FTIR measurements of the starting and final materials confirm that the initial samples are completely dry but absorb an average of 67 ppm H_2O by mass during the experiments from the surrounding pressure medium materials. We observe no correlation in the amount of water absorbed in the feldspar to the oxygen fugacity under water-undersaturated conditions. Our investigations show that the activation enthalpy increases from ~0.77 to ~1.0 eV from the nominally hydrous to the completely dry feldspar. The activation enthalpy decreases with increasing oxygen fugacity for comparable water contents. An oxygen fugacity exponent of –0.069 is calculated at the nominal water content measured in the experiments, indicating an electrical conductivity mechanism that also involves the mobility of hydrogen.

Keywords: Electrical conductivity, impedance spectroscopy, single crystal, feldspar, albite, high-pressure, multi-anvil apparatus