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Electrical properties of iron sulfide-bearing dunite under pressure: Effect of temperature, composition, and annealing time

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Abstract

The detection and quantification of metal sulfides in host rocks by electrical measurements have been priorities for field and laboratory studies, motivated by mineral prospecting and fundamental interest in the mantle structure or core/mantle differentiation, among other reasons. Here, we reanalyze electrical data for a dunite host with added FeS or Fe-S-Ni (Saxena et al. 2021), and report additional experimental runs along with electron microprobe analyses. The applied pressure was 2 GPa; impedance spectra were acquired while annealing at 1023 K (below the metal-sulfide solidus), and while varying temperature from 570 to 1650 K. Addition of 6.5 or 18 vol% FeS strongly enhances conductivity of the bulk sample compared with that of the dunite host, though values are 100–100 000 times less than those of pure FeS. These results indicate that most metal sulfide content is not part of a viable conductive path, even for the 18 vol% quantity. Nevertheless, the relatively high conductivity and weak temperature dependence of the 18 vol% sample reveal that contiguous paths of solid or molten FeS span the electrodes. The sample with 6.5 vol% sulfide also exceeds the percolation threshold for temperatures as low as ~100 K below the eutectic melting point, likely because FeS softens. Conductivity is nearly unchanged upon crossing the eutectic temperature, however a decline over 1400–1500 K reveals that the 6.5 vol% molten FeS forms a fragile electrical network in dunite. Samples with $Fe_{50}S_{40}Ni_{10}$ or $Fe_{40}S_{40}Ni_{20}$ (at%) are less conductive than pure dunite at temperatures below ~1450 K. This surprising result, likely caused by a reducing influence of Fe or Ni metal, does not support the use of FeS as an analog for compositions with nickel or excess metal. Our findings suggest that probing the electrical network of metal sulfides as solids complements other studies focused on connectivity of molten metal sulfides.

Keywords: Impedance spectroscopy, electrical conductivity, metal sulfide, xenolith, percolation threshold