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Experimental investigation of the effect of nickel on the electrical resistivity of Fe-Ni and Fe-Ni-S alloys under pressure

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Abstract

Electrical resistivity experiments were conducted on three alloys in the iron-rich side of the Fe-Ni(-S) system (Fe-5 wt% Ni, Fe-10 wt% Ni, Fe-10 wt% Ni-5 wt% S) at 4.5 and 8 GPa and up to 1900 K using the multi-anvil apparatus and the 4-electrode technique. For all samples, increasing temperature increases resistivity. At a specified temperature, Fe-Ni(-S) alloys are more resistive than Fe by a factor of about 3. Fe-Ni alloys containing 5 and 10 wt% Ni present comparable electrical resistivity values. The resistivity of Fe-Ni(-S) alloys is comparable to the one of Fe = 5 wt% S at 4.5 GPa and is about three times higher than the resistivity of Fe = 5 wt% S at 8 GPa, due to a different pressure dependence of electrical resistivity between Fe-Ni and Fe-S alloys. Based on these electrical results and experimentally determined thermal conductivity values from the literature, lower and upper bounds of thermal conductivity were calculated. For all Ni-bearing alloys, thermal conductivity estimates range between ~12 and 20 W/(m·K) over the considered pressure and temperature ranges. Adiabatic heat fluxes were computed for both Ganymede's core and the Lunar core, and heat flux values suggest a significant dependence to both core composition and the adiabatic temperature. Comparison with previous thermochemical models of the cores of Ganymede and the Moon suggests that some studies may have overestimated the thermal conductivity and hence, the heat flux along the adiabat in these planetary cores.

Keywords: Iron-nickel alloys, metallic cores, electrical resistivity, multi-anvil apparatus, Ganymede, the Moon