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Thermal Conductivity of Fe-S-Si Alloys at the Conditions of the Tops of the Cores of Small Terrestrial Planetary Bodies from High-P,T Resistivity Experiments

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The light elements accompanying Fe into the cores of terrestrial planetary bodies may have a significant impact on the thermal conductivity of the region. This thermal conductivity has vast consequences for the heat budget and heat transport mechanisms throughout the core, with implications for magnetic dynamo formation. S and Si have been identified as two likely light elements in the cores of multiple terrestrial planetary bodies. One composition in this study, Fe-16wt%S-2wt%Si, mimics the light element composition of the core of the asteroid 4 Vesta as estimated from studies of HED meteorites.

To find thermal conductivity of Fe-S-Si planetary cores, resistivity experiments were performed on Fe-S-Si alloys at static pressures up to 20 GPa in either a 1000-ton cubic anvil press or a 3000-ton multi-anvil press. During heating into the liquid state, resistance across the sample and temperatures at both ends of the sample were measured *in situ* at ~25 K intervals. Post-experimental analysis included electron microprobe analysis as well as geometry measurements for calculating resistivity from resistance.

Thermal conductivity results, estimated from electrical resistivity results according to the Wiedemann-Franz Law, are shown in Fig. 1. After the start of melting at ~1250 K, an increase in S results in a clear decrease of thermal conductivity, as expected. For an alloy with a moderate amount of S (16wt%) and a small amount of Si (2wt%), more than double the electrical resistivity of pure Fe was found. For Fe-S-Si cores, then, the light elements greatly increase the likelihood of an excess of total heat flow from the core to the mantle compared to the adiabatic heat flux at the top of the core, in which case thermal convection would arise in the core. In the case of early Vesta, the estimated adiabatic heat flux of 0.3-0.4 mW/m^2 found in this study is much lower than the value of >10 mW/m^2 for core-mantle boundary heat flux [1]. This means that, considering light alloying elements, early Vesta likely experienced thermal convection in its core, resulting in its magnetic dynamo.

References:

[1] Weiss, Gattacceca, Stanley, Rochette & Christensen (2007), *Space Science Reviews* 152, 341-390.