POROSITY AND PORE GEOMETRY INFLUENCE ON METEORITE THERMAL CONDUCTIVITIES

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Introduction: Thermal properties of planetary materials and their meteorite analogs are rare; only a handful of samples have been measured at temperatures relevant to the asteroid belt, though such measurements are ongoing. To date, our group has measured 17 meteorites for thermal conductivity (κ) from 5-300K using a Quantum Design PPMS system at Boston College [1,2]; a few others have been measured at specific temperatures by other means [3,4].

Opeil et al [2] observed that measurements of κ along one axis differed from those across another axis, suggesting that the orientation of pore space (particularly planar cracks) relative to the direction of thermal flow is an important factor in thermal conductivity. In order to explore the effect of variation in pore geometry on thermal conductivity in a controlled manner, and understand thermal conductivity for extremely porous structures (such as the "fairy castle" structures that may characterize the surfaces of some asteroids) that are not coherent enough to measure in a physical apparatus such as the PPMS, we have developed computer simulations of heat conduction in porous materials.

Technique and Results: We have developed a Python code to propagate heat energy through a 100 x 100 x 100 grid. One side (x = 0) is set as the "source", with the temperature at a constant high value and the opposite end (x = max) is designated as a "sink" at one degree (K) cooler. The program runs until the heat flow in at x = 0 matches the heat flow out at x = max, from which κ is calculated. Future versions of the code will include effects such as radiative heat transfer and inhomogeneities in the medium.

We have tested numerous pore configurations, including oriented cracks (such as might be induced by shock events), micropores, gaps between individual grains, and fairy-castle-type structures. Our first results show that κ does not vary simply with porosity as a numeric value but is strongly dependent on the geometric characterization of the pore space. This is particularly true with oriented cracks. In cases where cracks were oriented parallel to thermal flow, κ at 40% porosity was still just under half the value for a solid block of material. Cracks perpendicular to heat flow had a much stronger effect, reducing κ by half at only 10% porosity, and above 40% porosity, κ had dropped to below 1% of nonporous material.

References: [1] Opeil C. P. et al. (2010) *Icarus* 208:449-454. [2]Opeil C. P. et al. (2012) *Meteoritics & Planetary Science* 47:319-329. [3] Yomogida K and Matsui T. (1983) *Journal of Geophysical Research* 88:9513-9533. [4] Matsui T. and Osako M. (1979) *Memoirs of the NIPR Special Issue* 15:243-252.