THE UNRESOLVED PROBLEM WITH DERIVING A LUNAR TEMPERATURE PROFILE FROM HEAT PRODUCING ELEMENTS. P. M. Bremner[1], H. F. Haviland[1], A. Mallik[2], M. Diamond[3]. [1]NASA Marshall Space Flight Center (paul.m.bremner@nasa.gov), [2]U. Arizona, [3]U.C. Berkeley.

Introduction: Despite more than four decades of research, the present-day internal state and structure of the Moon is still debated. Previous studies have used total lunar mass, moment of inertia, bulk composition, gravity, as well as Apollo seismic data, to infer the Moon's internal structure [2,5,7]. However, first-order questions about lunar structure and evolution remain, including: (a) the presence of a metallic core surrounded by a layer of low rigidity, likely a fingerprint of gravitational overturn which may have occurred very early in lunar history; (b) existence of a present-day remnant of an overturned Fe-Ti-rich layer that formed below the crust and sank to the core-mantle boundary; and (c) the evolution of the internal structure starting from crystallization of an early magma ocean. Constraining the thermal state of the present-day lunar interior is a primary challenge to improving estimates of internal structure. The existing estimates of lunar thermal profiles (selenotherms) derived from inversions of seismic [2], gravity [5], and electromagnetic [4] data differ by around 800°C; far too broad a range to constrain the internal lunar structure [1].

Primary Goal

Highlight high-to-extreme selenotherms calculated from radioactive decay contributions

Constraining the heat producing element (HPE) concentrations and distribution in the various reservoirs of the Moon would directly inform the thermal state of the interior. Estimates of bulk lunar mantle HPE concentrations can range from that of an ordinary chondrite (U = 0.0068 ppm; Th = 0.025 ppm; K = 17 ppm) to higher estimates (U = 0.039 ppm; Th = 0.15 ppm; K = 212 ppm) based on measurements of Apollo pyroclastic glasses that might represent the least fractionated, near-primary lunar mantle melts. We show preliminary results of selenotherms from lunar interior models whose material properties were calculated using the Birch-Murnaghan equation of state. The selenotherms were calculated by incorporating the HPE estimates into a 1D spherical thermal conduction equation. The total lunar mass and moment of inertia of each interior model were calculated and compared to physical observations.

The focus of this presentation is to illustrate the difficulties of producing a 1D conductive thermal profile near or within geophysically based estimates through accounting for HPE, as well as to highlight future effort to address these problems. Our preliminary search found that incorporating the HPE estimates into a simple 1D spherical thermal conduction equation tends to yield selenotherms on the hot edge or hotter than geophysically derived estimates. At the extreme, the higher HPE concentration estimates yield an impossibly hot mantle with temperatures in excess of 4,000 K, melting large portions of the lunar mantle. This study highlights the importance for future in-situ observations and sample analysis to better constrain this issue.

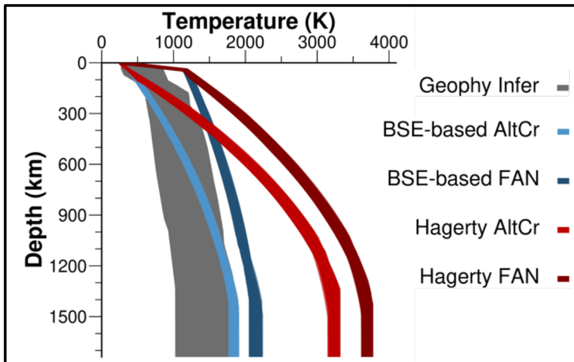

Figure 1: Preliminary selenotherm results compared to the range of geophysically inferred temperatures (gray region). There are four sets of 187 lunar models shown. Each set applied HPE concentration estimates as combinations of:

Mantle - bulk silicate Earth (BSE-based) or [3]

Crust - [6] (FAN) or average of Apollo samples (AltCr)

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