

Marshall Space
Flight Center



The Unresolved Problem with Deriving a Lunar Temperature Profile from Heat Producing Elements

P. M. Bremner*, H. F. Haviland, A. Mallik, M. Diamond

*paul.m.bremner@nasa.gov

LEAG 2021

Selenotherm and its evolution is critical to deciphering the Moon's interior and history

- Selenotherm is important for:
 - Petrology of the interior
 - Thermoelastic and chemical properties of the current and early moon
 - Combined with surface heat flow to model mantle dynamics and evolution
- **Our work focuses on developing selenotherm constraints and building an evolving framework to iteratively search for lunar interior models**

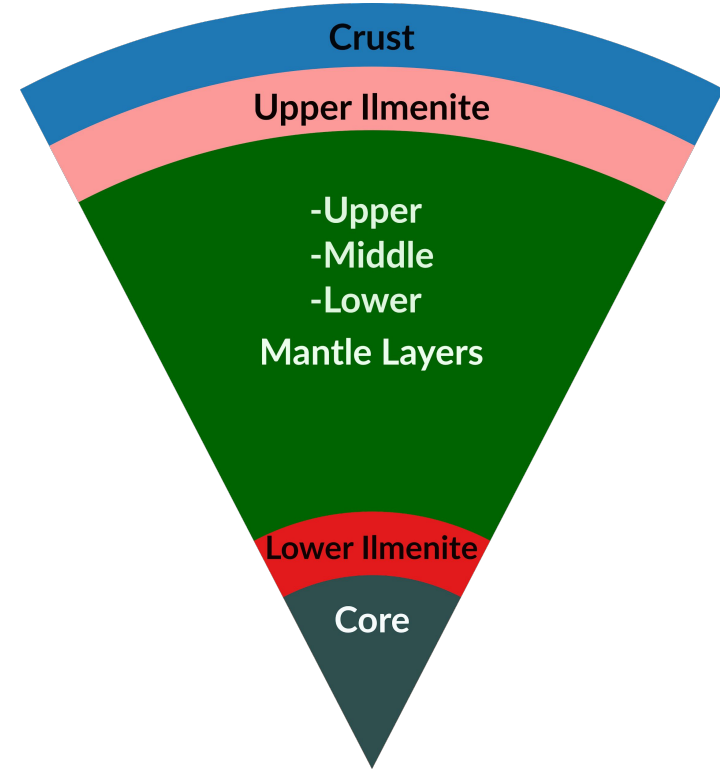
Many factors contribute to lunar heating, including radioactive decay

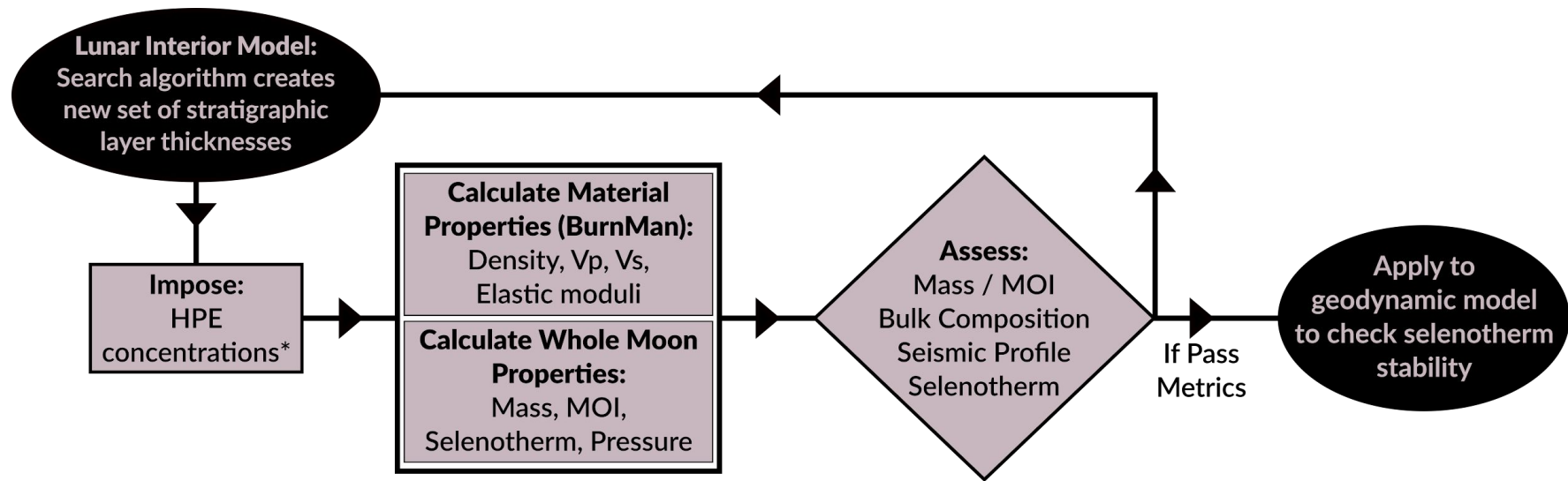
Multiple estimates for heat producing element concentrations

... Ahead, thermal profiles from four examples when applied to a layered model

Each layer has its own:

- Petrologic composition
- Thermal conductivity
- Concentration of heat producing elements





187 preliminary results shown for four sets of estimated HPE concentrations through combinations of:

Mantle:

- *bulk silicate Earth (BSE)*
- *Hagerty et al. (2006)*

Crust:

- *Apollo 16 **FAN**: assumed representative of plagioclase crust (Peplowski et al. 2016)*
- ***AltCr**: average of Apollo crustal samples with little to no KREEP influence*

HPE estimate based on:

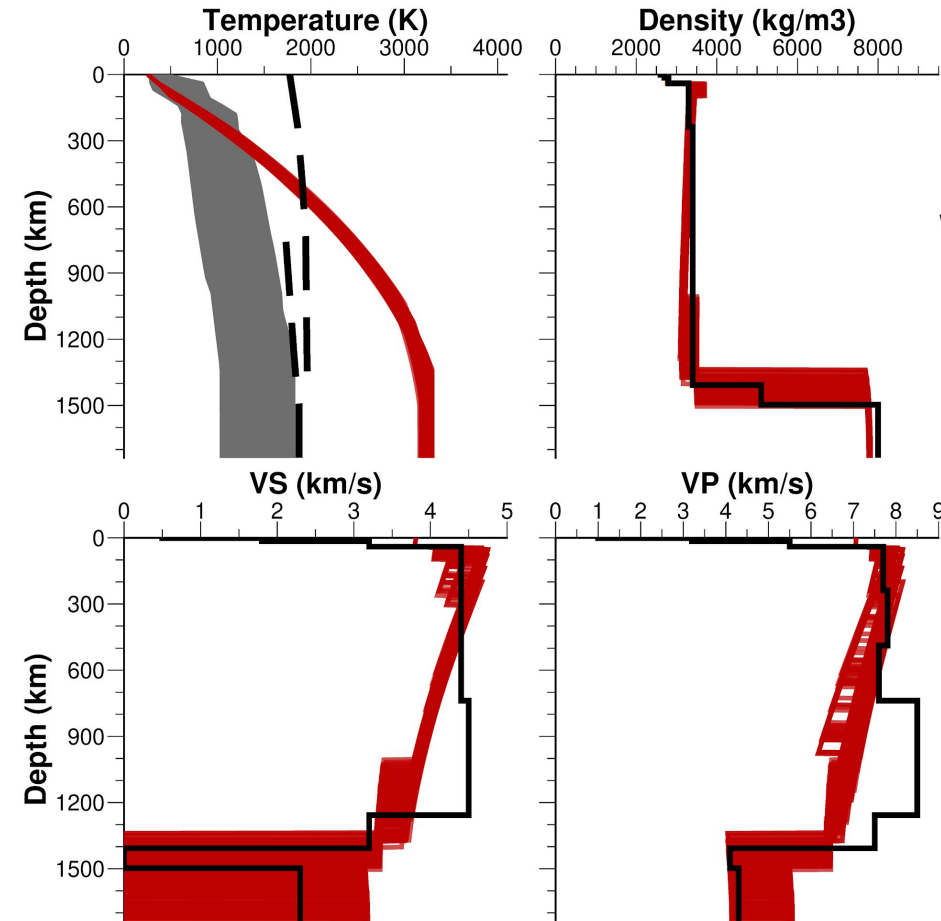
- Hagerty et al. (2006)
- AltCr crust

Geophy Infer* —

Perid/Fo92 ---

Weber et al (2011) - - -

Hagerty/AltCr —



Results:

- Excessively hot mantle
- Much lower density and V_p, V_s compared to Weber et al., 2011
- Poor fit to Mass/MOI

*Gagnepain-Beyneix, J et al. (2006)

*Khan A. (2006, 2007)

HPE estimate based on:

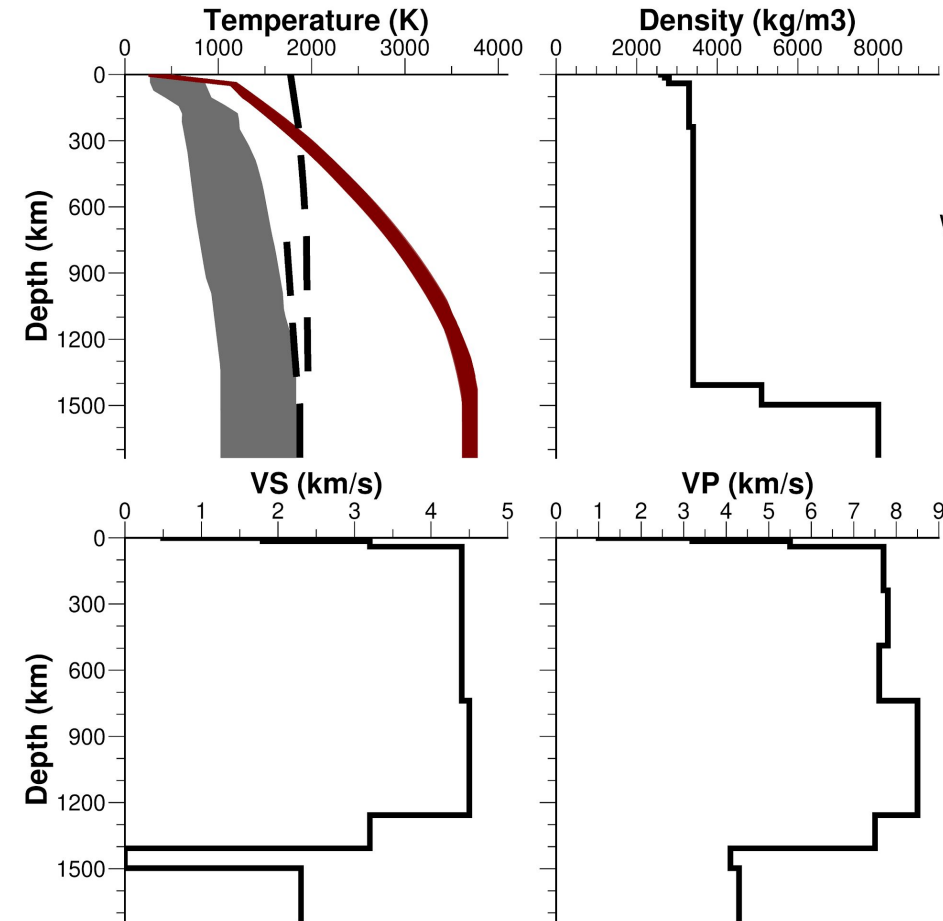
- Hagerty et al. (2006)
- FAN crust

Geophy Infer —

Perid/Fo92 - - -

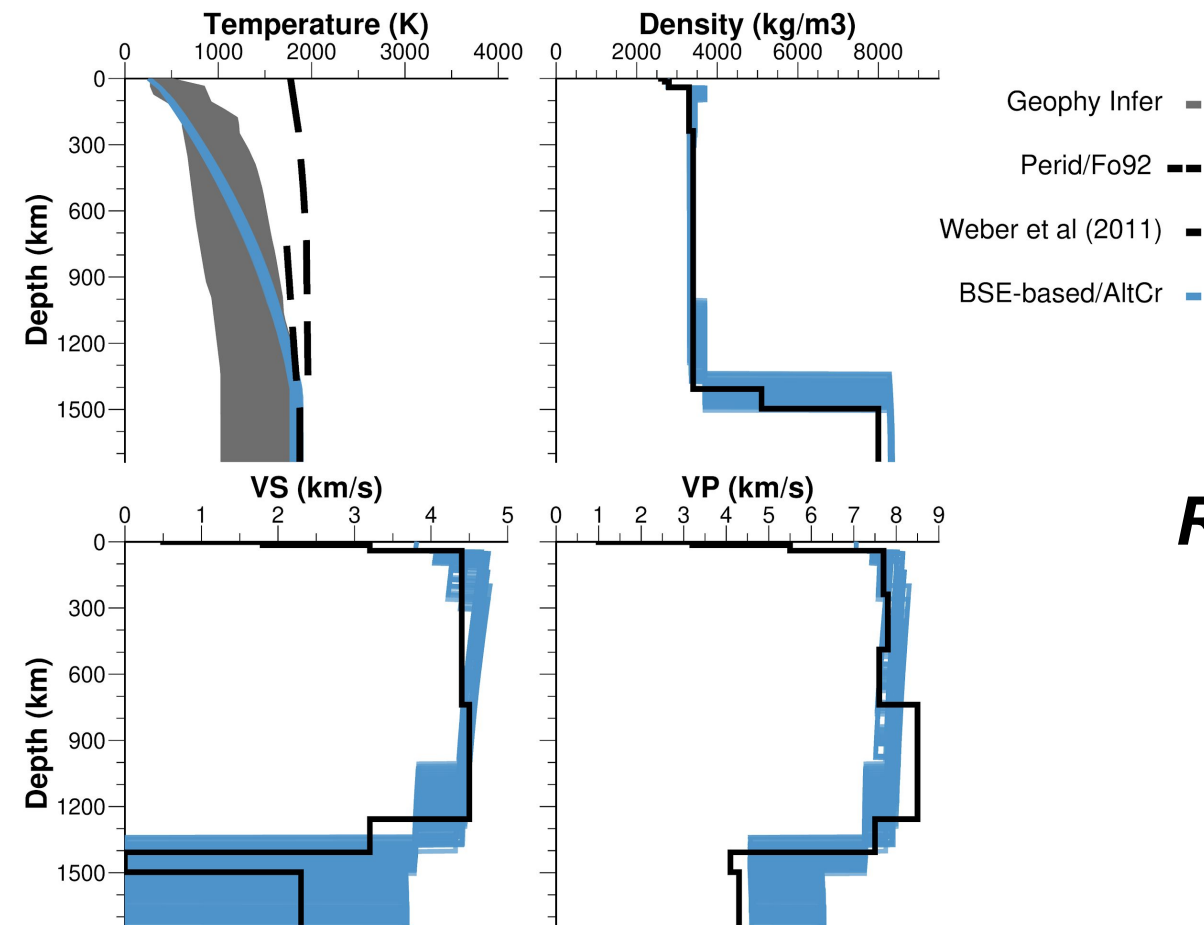
Weber et al (2011) - - -

Hagerty/FAN —



Results:

- *EOS breaks down! Too hot*

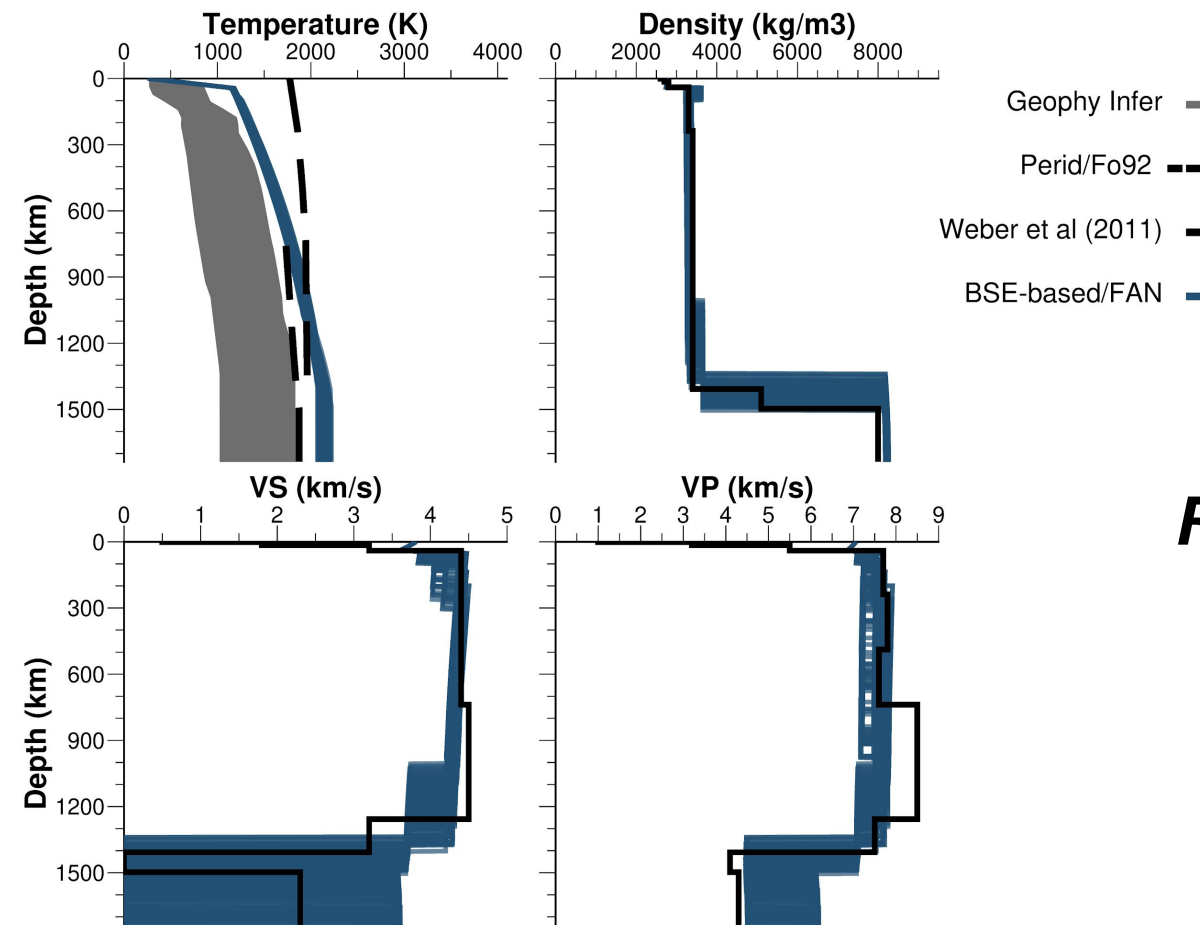


HPE estimate based on:

- bulk silicate Earth (BSE)
- AltCr crust

Results:

- Reasonable selenotherm
- Uncertain fit to Apollo seismic travel times
- Visually, density compares well but does not fit Mass/MOI



HPE estimate based on:

- bulk silicate Earth (BSE)
- FAN crust

Results:

- *Selenotherm at or over olivine solidus*
- *Low density and V_p, V_s compared to Weber et al., 2011*
- *Poor fit to Mass/MOI*

Selenotherm and its evolution is critical to deciphering the Moon's interior and history

- Selenotherm is important for:
 - Petrology of the interior
 - Thermoelastic and chemical properties of the current and early moon
 - Combined with surface heat flow to model mantle dynamics and evolution
- **Our work focuses on developing selenotherm constraints and building an evolving framework to iteratively search for lunar interior models**
- Initial search results show not all HPE estimates are possible
- Future missions needed to improve constraints (e.g., sample return, heat flow, crustal porosity)
- We are searching for lunar models that simultaneously meet constraints, e.g.:
 - Mass/MOI
 - Seismic observations
 - Thermal and material properties
- We welcome input from the community!