AGU100 ADVANCING EARTH AND SPACE SCIENCE

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Thermal Properties of Glassy and Molten Planetary Candidate Lavas

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1. Background

A Fundamental thermal properties

- Heat Capacity (C_P)
- Thermal Diffusivity (D)
- Thermal Conductivity (k)

are influenced by rock properties:

- *composition*,
- *crystal and bubble* content,
- *density*
- *temperature*

$$k = C_P \, D \, \rho$$

B Geochemistry and physical properties are diverse across the solar system.

C Wide range of thermal properties for terrestrial lavas documented (Hofmeister et al. 2016)

➥ **Variations in thermal properties for planetary lavas expected**

D *Magmatic process are modeled with constant values of C_P, D, and k, ignoring the effect of temperature and composition, introducing errors in modeling magmatic processes*

2. Methods

A Synthesis of analog glasses shown in Figure 1 (Sehlke and Whittington 2016).

B Composition determined by electron probe micro-analysis (EPMA)

C Specific heat (C_P) measured using differential scanning calorimetry (DSC)

D Thermal diffusivity (D) measurements by laser flash analysis (LFA)

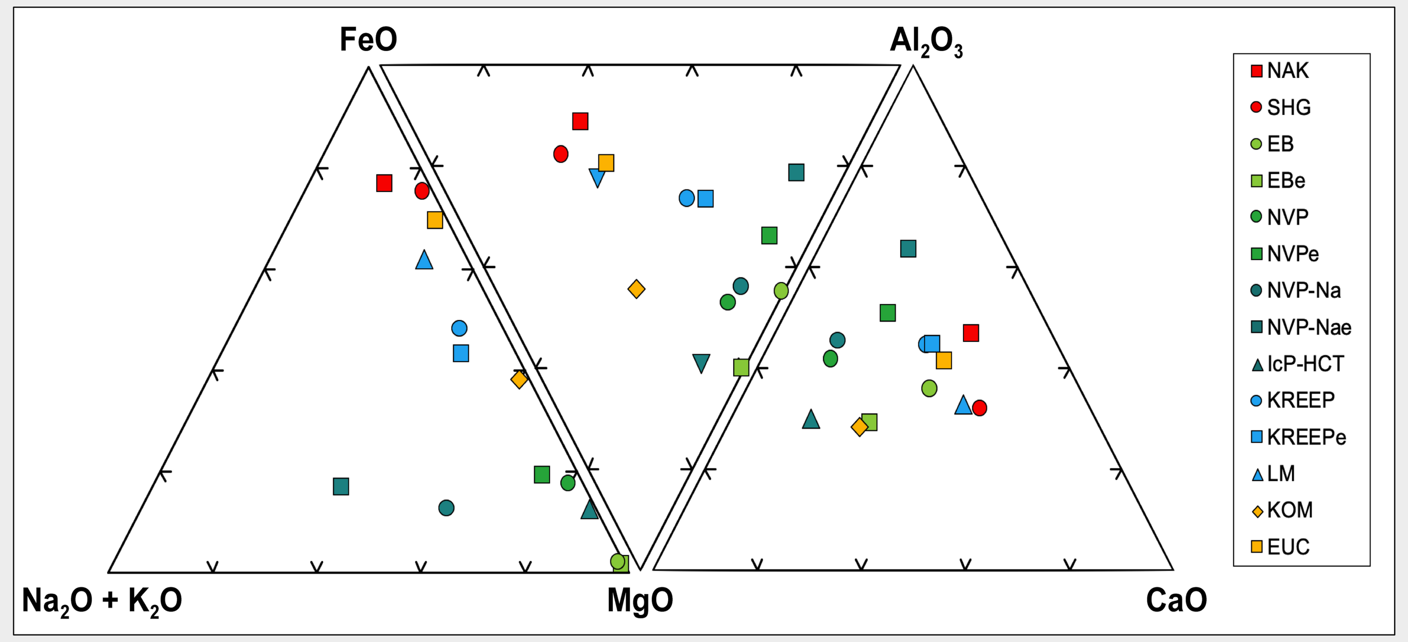

Figure 1. Composition of analog glasses and melts. Symbol color grouped by solar system object, whereby red = Mars, green = Mercury, blue = the Moon, yellow = Io & Vesta.

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3. Results

Heat capacity (C_P)

A **Glasses** range between **0.8 to 1.3 J g⁻¹ K⁻¹**

B **Melts** range between **1.3 to 1.7 J J g⁻¹ K⁻¹**

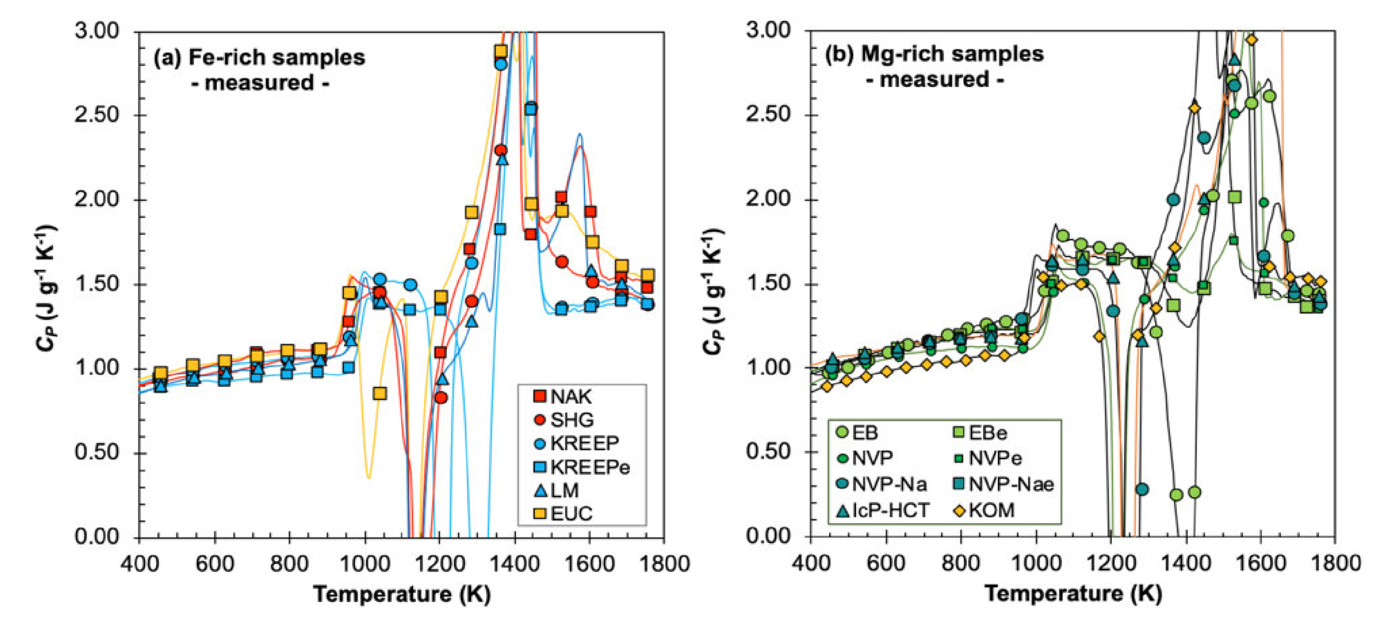

Figure 2. Data for heat capacity (C_P) measurements. Negative and positive peaks represent crystallization and melting, respectively.

Thermal Diffusivity (D)

C Heat diffusion for **glasses is 0.54±0.06 mm² s⁻¹** at room temperature and decreases to **0.46±0.08 mm² s⁻¹ near 750 °C**

D For **melts** (above ~ 850 °C), D drops to **0.36±0.06 mm² s⁻¹**.

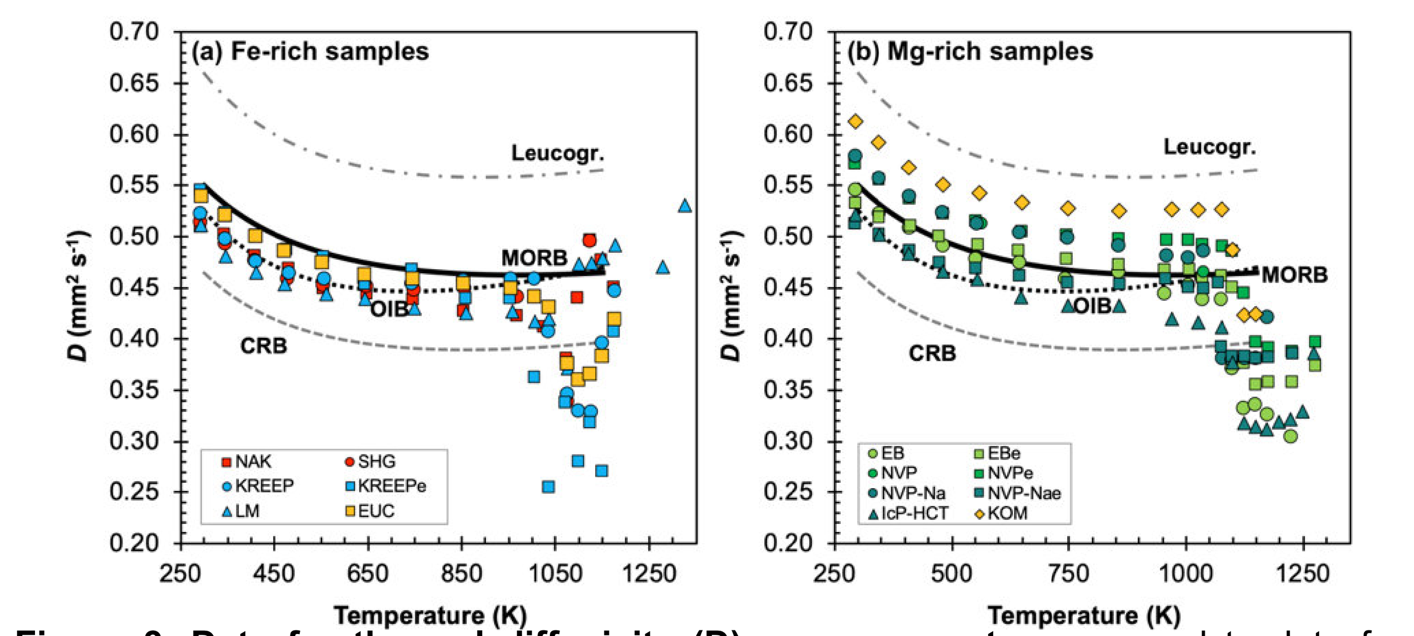

Figure 3. Data for thermal diffusivity (D) measurements, compared to data for terrestrial lavas (Hofmeister et al., 2016). Same symbols as in Figure 2, lines represent data for terrestrial lavas from Hofmeister et al. 2016)

Thermal Conductivity (k)

F Large spread for k of planetary lavas, between terrestrial MORB and Leucogranite

G In most cases, k becomes smaller with increasing temperature, which is dominated by heat capacity and density

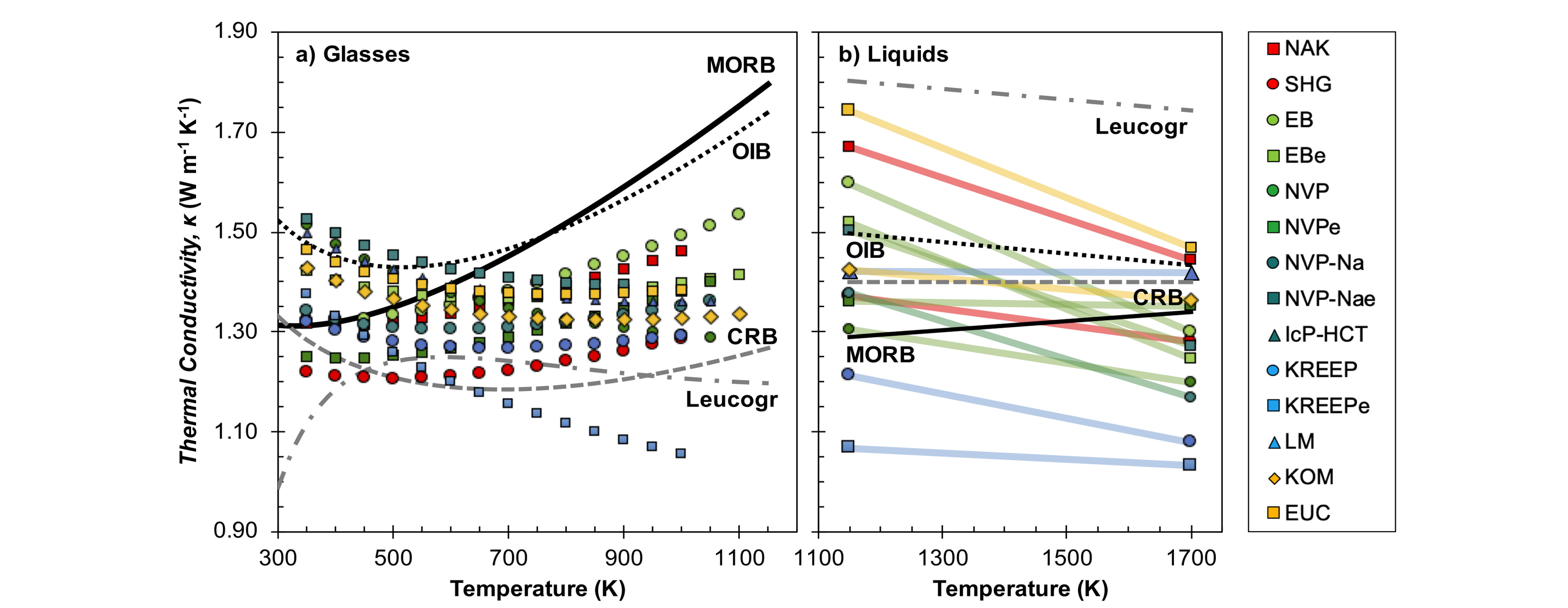

Figure 5. Thermal conductivity (k) calculated using D and C_P data (ρ modeled), compared to data for terrestrial lavas (Hofmeister et al. 2016).

Thermal Diffusivity Model

E Our model reproduces the measured data with a low 2σ uncertainty of only 0.042 mm² s⁻¹ based on hybrid structural-compositional variable **$K_2O \times Mg\# \times SM \times NBO/T$** (Figure 4).

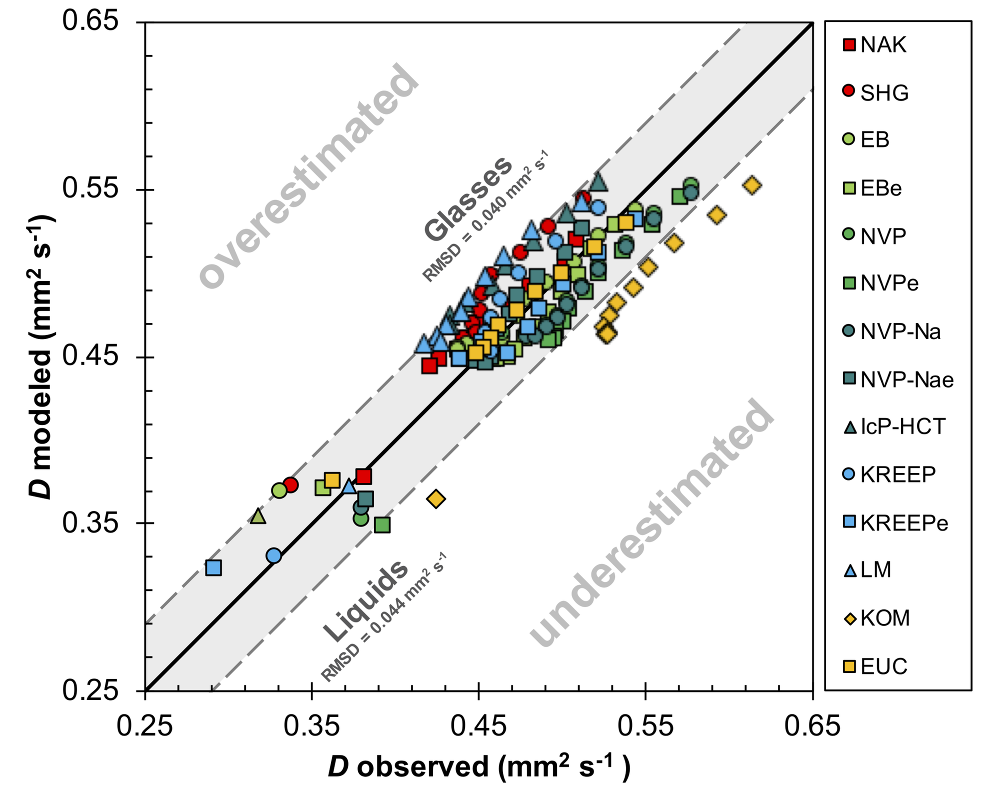

Figure 4. Thermal diffusivity (D) model for glasses and melts based on their chemical composition only. D_{glass} can be modeled for different temperatures, but D_{melt} is not because only one data point can be collected due to rapid crystallization/devitrification crossing the glass transition temperature (~775±50 °C).

4. Discussion and Conclusions

A All investigated planetary analog melts have much lower thermal conductivities than the crystalline upper mantle from which they are generated (k ~2.8 Wm⁻¹K⁻¹).

➥ partially molten regions producing these melts will also have low thermal conductivities

➥ slowing conductive heat loss

➥ enhancing the productivity of ascending mantle undergoing decompression melting.

B This feedback mechanism may contribute to the large volumes of magma produced, and observed as extended lava flow features.

5. Future work

A Thermal diffusivity measurements of the melt needed, as well as varying crystal and bubble content to model magma and lava emplacement more realistically