THERMAL INERTIA AND THERMAL CONDUCTIVITY MEASUREMENTS OF WELL-CHARACTERIZED MARS ANALOG ROCKS. A. A. Ahern1, A. D. Rogers1, R. J. Macke2, B. J. Thomson3, R. Kronyak4, G. Peters4, E. Carey4. 1Stony Brook University Department of Geosciences, Earth and Space Science Building, Stony Brook, NY 11767 (alexandra.ahern@stonybrook.edu). 2Vatican Observatory, V-00120, Vatican City State. 3Dept of Earth & Planetary Sciences, Univ of Tennessee Knoxville, Knoxville, TN 37996. 4NASA Jet Propulsion Laboratory, Pasadena, CA 91109.

Introduction: Mars surface rocks have diverse physical and chemical properties, as observed in orbiter and rover imaging and characterization. The physical properties (e.g., grain size, indentation, cementation, porosity, vesicularity, etc.) of rocks can provide crucial information as to their petrogenetic origins and diagenetic histories.

Thermal inertia (I) is the intrinsic property of a material that describes how efficiently that material can absorb, conduct, and re-radiate heat. It is given by in eq. 1:

\[ I = \sqrt{k \rho c}. \] (eq. 1)

Here, \( k \) is the bulk thermal conductivity (W/mK), \( \rho \) is the bulk density (kg/m³), and \( c \) is the specific heat capacity (J/kgK); \( I \) is given in units of Jm²K⁻¹s⁻¹/².

\( I \) has been widely used in planetary studies as a proxy for the physical characteristics of rocks and sediment (e.g., grain size, cementation quality, or porosity) of the near sub-surface (upper few cm) [1-3]. Orbital and rover-based observations have used surface temperatures derived from emissivity measurements over diurnal and seasonal cycles in an attempt to define the \( I \), and thus, the physical nature, of the martian surface [4-10]. Studies described in [11-15] have also been conducted on geologic particulates to relate grain size, shape, density, and sorting to \( k \) values, these being the only studies done at Mars-relevant atmospheric pressures. Other work has been done to model the behavior of \( k \) of both consolidated and unconsolidated particles at martian pressures [16,17]. However, there are no comprehensive studies linking physical properties of Mars-relevant rocks with \( k \) values, and thus, \( I \) values at Mars atmospheric pressures. Some studies have reported \( I \) or \( k \) values of singular or small batches of rocks but methods and conditions between different lab setups vary greatly [18-20].

The goal of this work is to present a suite of well-characterized rock samples of known physical properties with \( k \) values, all measured in the same conditions. We explore the relationships of quantified physical properties (bulk density, porosity, uniaxial compressive strength) and chemical properties (bulk mineralogy, major element analyses) with thermal properties (\( I \) and \( k \)).

Methods: Samples used in this study represent the range of rock types observed or expected on the martian surface. These samples are summarized in Table 1. Grain density (\( \rho_b \)) measurements were done on each sample at the Vatican Observatory using a Quantachrome Ultrapycnometer 1000 ideal-gas pycnometer with gaseous nitrogen. Bulk density (\( \rho_b \)) measurements were also conducted at the Vatican Observatory with a NextEngine model 2020i Scanner HD Pro laser scanner and Geomagic Verify software. Porosity was then calculated according to:

\[ P = 1 - \left( \frac{\rho_b}{\rho_g} \right). \] (eq. 2)

These values are reported in Table 1. Select samples were previously measured for uniaxial compressive strength (UCS) and were reported in studies [21-23] (Table 1).

Thermal measurements were conducted at Stony Brook University in the Vibrational Spectroscopy Lab using sensors produced by C-Therm Technologies. The rock measurements specifically used the C-Therm Modified Transient Plane Source (MTPS) and Flex Transient Plane Source (Flex TPS) sensors (Figure 1). These sensors use interfacial heat reflectance, i.e. the sensors supply known quantities of heat to the sample set against them, measure the drop in voltage as heat moves into the sample, and convert the change in voltage to thermal inertia values. The MTPS sits atop a metal cylinder, upon which the rock sample is placed. The Flex TPS is sandwiched between two discs of the rock sample and heat moves out of the top and bottom of the sensor. Measurements done with C-Therm equipment are non-destructive and sample preparation merely consists of cutting and polishing rocks to produce flat, smooth surfaces that sit flush against sensor planes. The largest challenges come in getting proper sensor-sample contact of grainy or friable samples and we expect errors from these samples to be higher than those with flatter or smoother surfaces.

Single measurements with C-Therm sensors take 90-150 s. This includes equilibrating, heating, and sampling. Sensors only heat by 1-3° C per measurement. Therefore, individual measurements are more energy and time-efficient, and simple to collect when compared with other methods that often require much more heating and equilibration time [e.g., 11-15,
Due to these benefits, we are able to take many thermal measurements at a time to ensure reproducibility. In this study we have measured each rock sample in ambient P/T conditions 30 times (3 groups of 10 measurements per sensor contact). We also have measured each sample 15 times (3 groups of 5 per sensor contact) in 1 mbar increments between 1-10 mbar. Pressure is maintained within 0.1% of the set pressure using a Nor-Cal Intellisyis IQ+ throttling butterfly valve. This was done in a glass vacuum cylinder at ambient T.

**Results:** The results of the thermal measurements at 1 bar and 6 mbar pressures compared with physical properties are given found in Table 1 & Figure 1. Work on links between chemical properties is still in progress.

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