DIRECT CURRENT (DC) RESISTANCE PROPERTIES OF ASTEROID ANALOGUE MINERALS AT LOW TEMPERATURES. T. J. D. C. Saturnino[1], J. Freemantle[1], and M. Daly[1]. [1]Centre for Research in Earth and Space Science, York University, Toronto, ON M3J 1P3, Canada. (dacruz@yorku.ca).

Introduction: Electrical properties of meteorites are valuable for understanding the formation and evolution of their asteroid parent bodies and the solar system [1,2]. For instance, electrical conductivity data from meteorites can be used for modeling the thermal evolution [3] and electromagnetic heating [4] of their asteroid parent bodies. Additionally, electrical conductivity can be used to assess the extent a planetary body was subject to paleo solar winds [3].

Previous meteorite electrical conductivity studies have been performed at temperatures as high as 1073K (800ºC) [5]. Brecher et. al. [3] executed measurements at a lower temperature range, from 90K to 300K (-183°C to 27°C). Because asteroids do not have atmosphere their surfaces can reach cryogenic temperatures (below −150°C or 123K) [6]. To understand how electrical properties of asteroids behave at these temperatures, we measure Direct Current (DC) electrical conductivity of terrestrial samples in that temperature range. The equipment used for this work allow us to measure electrical properties as low as 5K to 300K (-268°C to 26°C).

Methods: To complete this study, select minerals representative of asteroid compositions, mostly carbonaceous, were chosen as analogue material: calcite, serpentine, anorthite, albite, olivine, augite, hematite, pyrrhotite, dolomite, quartz, anorthite, albite, olivine and magnetite. Basalt samples will also be analyzed. The DC conductivity tests are completed using a mini Cryogen-Free Magnet System (CFMS) from Cryogenic Ltd. The system performs electric measurements between 1.6K and 400K and has the ability to conduct these measurements in a magnetic field up to 5 Tesla. Measurements of resistance varying from 100 nΩ to 1 GΩ with an accuracy of 0.1% across range of 1Ω to 1MΩ are possible. It has voltage range capacity of 10 nV to 100 V and current range from 1 nA to 1 A for DC electrical conductivity [7].

The composition and structure of the samples will also be assessed using a Scanning Electronic Microscope (SEM).

Applications: Understanding the DC conductivity of rocks is essential for calculating the energy loss of, for example, radar signals in planetary surfaces. We can break the complex dielectric permittivity and complex magnetic permeability into their real and imaginary components, where the real component represents the amount of energy that can be stored, while the imaginary component expresses the amount of energy lost [8]. The electrical DC conductivity is associated with the complex dielectric permittivity in its imaginary part as an additional function of $\sigma_0/\varepsilon_0\omega$, where: σ_0= DC conductivity; ω = angular (radian) frequency; ε_0 = permittivity of free space (8.85x10-12 F/m)[9].

Preliminary results: Figure 1 shows the voltage (V) versus current (I) for a serpentine sample at 300K with the applied current ranging from 10^{-11}A to 10^{-5}A. Using Ohm's law, we find the resistance (R) of the sample via the slope is ~0.36 Mohms. We find the electrical resistivity (ρ) by considering the dimensions of the specimens : ρ=R(A/ℓ), where A is the cross-sectional area and ℓ is the length. The calculated electrical resistivity of serpentine is 581.68Ωm and the associated electrical conductivity (σ=1/ρ) is 1.719×10^{-3} S/m. The derived resistivity is within what is expected for serpentine, which is between 2×10^{2} Ωm to 3×10^{3} Ωm [10].

It is worth highlighting the non-ohmic behavior of the serpentine on the VI graph at 300K (Fig. 1), which is characterized by a slight bend in the data. For serpentine this pattern was found from 125K to 300K. This same behavior was also observed for magnetite samples at 75K and below (Fig. 2).

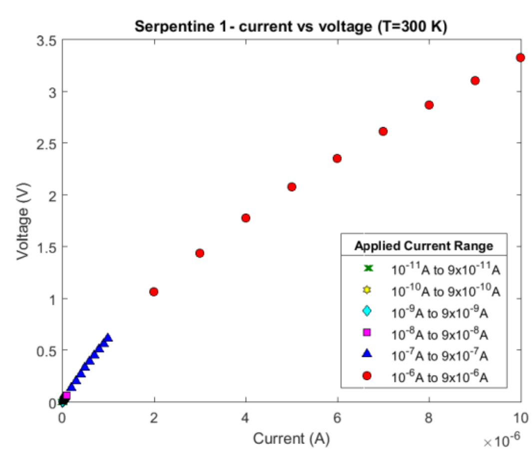

Fig. 1 Voltage versus Current graph of serpentine sample at 300K with a range of applied current from 10^{-11}A to 10^{-5}A.

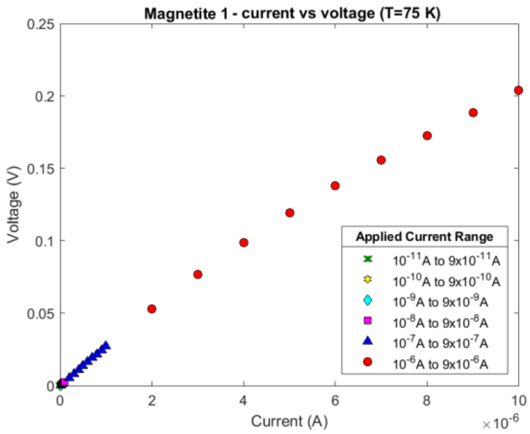

Fig. 2 Voltage versus Current graph of magnetite sample at 75K where a non-ohmic behavior was observed.

Conclusions: Magnetite is commonly associated to serpentinization of ultramafic rocks [11]. Magnetite's structure changes below 125K from a cubic symmetry (above 125K) to monoclinic (below 125K), which is known as the Verwey transition temperature [12]. We attribute the non-ohmic behavior of serpentine observed to magnetite despite the anomalous behavior of serpentine persistent at room temperature. When magnetite was analyzed, the anomalous pattern occurred only below 100K, which supports the theory that magnetite may affect the electrical conductivity of serpentine.

References: [1] Ip W. H. and Herbert F. (1983) *The Moon and the Planets*, 28, 43-47. [2] Consolmagno G. J. et. al. (2010) *EPSC V*, 2010-215. [3] Brecher A. et. al. (1975) *Earth and Planetary Science Letters*, 28, 37-45. [4] Duba A. (1987) *NASA SEE N89-14998 06-88.* [5] Schwerer F. C. (1971) *The Moon*, 2, 408-422. [6] Mantovani J. G. (2014) *ASCE International Conference on Engineering, Science, Construction and Operations in Challenging Environments*, 14,27-29. [7] Cryogenic Ltd. *Cryogen-Free Measurement System (CFMS) Brochure v.4*, 24p. [8] (Stillman D. and Olhoeft G. (2008) *Journal of Geophysical Research*, 113, 1-14. [9] Feldman Y. et. al. (2012) *Advances in Chemical Physics*, 133, 1-125. [10]Telford W. M. et. al. (1976) *Applied Geophysics, Cambridge University Press*, 860p. [11] Andeani M. et. al. (2013) *Lithos*, 178, 70-83. [12] Tarnawski Z. et. al. (2004) *Acta Physica Polonica A*, 106, 771-775.