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Martian magnetic minerals signature detection by Shallow Radar (SHARAD)

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Near-global thermal infrared mapping by the Thermal Emission Spectrometer (TES) on Mars Global Surveyor has revealed unique deposits of crystalline gray hematite (a-Fe2O_3) exposed at the Martian surface in the Sinus Meridiani region. The material is an in-place, rock stratigraphic sedimentary unit characterized by smooth, friable layers composed primarily of basaltic sediments with 0-20% crystalline gray hematite.

Shallow Radar (SHARAD) is a ground penetrating radar (GPR) provided by the Italian Space Agency (ASI) and selected by NASA for the Mars Reconnaissance Orbiter (MRO) mission. The goal of this nadir-looking altimeter with synthetic aperture capabilities is to investigate the surface and subsurface of Mars providing data about the crustal composition of the planet. The sounder operates using a 20 MHz carrier and a bandwidth of 10 MHz (from 15 to 25 MHz) to achieve a theoretical vertical resolution of 15 m in free space, maintaining an acceptable penetration capability of approximately 1500 m. Performance of the instrument can however be highly dependent on the operating environment and in particular on the reflectivity of the surface and the subsurface, on the effect of the ionosphere and on the level of clutter echoes, which in turn depend on the surface topography.

Laboratory measurements of electrical and magnetic properties of grey hematite at Mars ambient temperatures in the ground penetrating radar frequency range have produced surprisingly strong dielectric relaxations as well as the expected magnetic properties. At the average Mars surface temperature of 213 K hematite has a strong dielectric relaxation near 15 MHz which is strongly temperature dependent. Between day and night this relaxation will move through the frequency range of SHARAD that may be capable of identifying the temperature dependence.

Several works regarding the effect that magnetic materials should have on the signal transmitted by ground penetrating radars like SHARAD have been proposed in the past. Since a vast data set has been acquired by the sensor over Sinus Meridiani the present study aims to validate previous works underlining the limitation that surface geometry induces on the data analysis.