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Medium pressure magnetism of natural ferrimagnets: a Martian story of impacts and pyrrhotite

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Effect of pressure on magnetism has important implications to understand the natural magnetization of solar system materials, mostly carried by FeNi alloys, Fe oxides and sulfides. At a depth of 100 km in the Earth static pressure of 3 GPa is encountered, but temperature is above the Curie points of the above minerals. On the other hand large dynamic pressures at moderate temperatures are encountered during asteroid impacts.

To help understanding the demagnetization of the Martian crust around large impact craters ($>$500 km diameter) we have investigated one candidate ferrimagnetic mineral in martian rocks: monoclinic pyrrhotite (Fe_7S_8), with a Curie point at 600 K. Previous Mössbauer investigations evidenced a RT transition from ferrimagnetism to paramagnetism at a poorly calibrated pressure. Neutron scattering study on a pyrrhotite powder under pressure was conducted in ILL. We observed a collapse of the main magnetic peak in between the runs at 2.6 and 3.1 GPa pressures (calibrated using the NaCl line). This interval for the pressure transition was confirmed by an independent experiment where we monitored the saturation remanent magnetization loss after application of a nearly isotropic static pressure: remanence is fully demagnetized in between 2.75 and 3 GPa. Precise calibration of this transition pressure allows a comparison between the map of magnetization of the martian crust (black bold and thin lines: 40 and 20 nT contours) and of the modelled isolines of peak shock pressure during the impact (gray contour in GPa). The topographic map of Mars below shows a good correspondance between magnetization loss and the $>$2 GPa zone around the two larger impacts, thus

conforting our hypothesis that remanence of martian rocks is carried by pyrrhotite. Other Solar System perspectives of MP neutrons studies will be discussed.

References

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