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The effect of irradiation on the magnetic properties of rock and synthetic samples: Implications to irradiation of extraterrestrial materials in space

Bezaeva N., Gattacceca J., Rochette P., Duprat J., Rizza G., Vernazza P., Trukhin V., Skripnik A.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2015, Pleiades Publishing, Ltd. We report here the results of laboratory analog experiments to consider the potential effects of solar energetic particles (SEP or solar-flare-associated particles) and galactic cosmic rays (GCR) on the magnetic properties of extraterrestrial materials. We carried out proton bombardment experiments (with irradiation energies E1=400, E2 =850 keV and three irradiation fluences in 10^{14}–10^{16}p/cm^2 range) and lead-ion bombardment experiments (E =1 GeV) on (previously demagnetized by 120 mT alternating magnetic field) rock and synthetic samples with the following magnetic carriers: metallic iron and nickel iron, Ti-rich and Ti-free magnetite, pyrrhotite. Irradiation experiments resulted in either further demagnetization or magnetization of irradiated samples depending on the type of magnetic mineralogy and type of ionizing radiation involved. Apart for the formation of radiation-induced remanent magnetization (RIRM), we observed major changes in bulk magnetic properties, i.e., a moderate to dramatic decrease (up to 93%) in the coercivity of remanence Bcr for all iron-bearing phases (iron-in-epoxy and Bensour meteorite samples). Contrary to iron-bearing samples, several magnetite-bearing samples experienced a radiation-induced magnetic hardening (increase in Bcr). Magnetic hardening was also observed for Ar^{2+} ion-irradiated nickel iron-bearing HED meteorites, measured for comparison with the previously stated results. Therefore, the combined effect of SEP with GCR may magnetically soften iron-bearing materials and harden magnetite-bearing materials. In order to answer the question wether RIRM may account for natural remanent magnetization of meteorites and lunar samples, physical mechanism of RIRM formation and potential dependence of RIRM intensity on the background magnetic field present during irradiation event should be investigated.

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Keywords

argon ions, extraterrestrial materials, irradiation, lead ions, meteorites, protons, rock magnetism