Estimating paleointensities from chemical remanent magnetizations of magnetite using non-heating methods

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Résumé

Many meteorites experienced aqueous alteration on their parent body. During this process, magnetite usually forms sometimes and acquires a chemical remanent magnetization (CRM) if growing in the presence of a magnetic field. The epoch of aqueous alteration on planetesimals encompasses the lifetime of the solar nebula. Therefore, magnetite-bearing meteorites are potential sources of invaluable data regarding the intensity of the solar nebula magnetic field and its influence on planetary accretion. The major limitation encountered in meteorite paleomagnetic studies is the lack of an empirical law relating a CRM characterized using non-heating methods and the magnetizing field intensity. This issue is usually bypassed using the empirical law for non-heating methods calibrated for thermoremanent magnetizations (TRM), resulting in poorly constrained paleointensities. Here, we present a study where we determine such an empirical law through a series of CRM acquisition experiments. Magnetite is grown in weakly magnetic sedimentary rocks and synthetic samples in a magnetic field while heated at 350∘C for 5 hours in an argon atmosphere. We find that all samples exhibit a high-coercivity magnetization parallel and proportional to the field applied, identified as a CRM carried by magnetite. We determine the CRM empirical law by retrieving the applied field intensity using non-heating methods. The empirical coefficients differ from the TRM ones by a factor of 2.4 to 3.2 depending on the method. We use these coefficients to revisit the paleointensities published for the CM chondrite Murchison and the C2 ungrouped Tagish Lake. This empirical law opens the door to the study of numerous magnetite-bearing meteorites potentially carrying a CRM, as well as samples returned from space missions. This includes samples from the asteroid Ryugu brought back by the JAXA Hayabusa 2 mission, samples from the asteroid Bennu that will be brought back by the NASA mission Osiris-REx and samples that are currently collected in Jezero Crater on Mars.

Mots-Clés: Chemical remanent magnetization, meteorites, magnetite, solar nebula magnetic field

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