# New view on the paleomagnetic record of samples from asteroid Ryugu

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The JAXA Hayabusa 2 mission returned ~5 g of material from the C-type asteroid Ryugu. Ryugu material contains abundant magnetite and pyrrhotite, formed during aqueous alteration on its parent body. The timing of aqueous alteration is not yet well constrained, with estimates ranging between 1.8 and 6.8 Myr after CAI formation (Yokoyama et al., 2022; McCain et al., 2023). Given these uncertainties, aqueous alteration on Ryugu's parent body may have occurred during the lifetime of the solar nebula magnetic field (i.e., up to ~5 Myr after CAI formation; Weiss et al., 2017). Magnetite and pyrrhotite may therefore carry a chemical remanent magnetization reflecting the intensity of this field.

Rock magnetic and paleomagnetic data of Ryugu samples were recently published (Nakamura et al. 2022; Sato et al., 2022). The authors measured the NRM of two samples (0.425 mg and 1.556 mg) and demagnetized the NRM using alternating fields (AF). They identified stable remanence components in both samples up to 24 mT and 32 mT, respectively, which they interpreted as evidence that Ryugu material experienced a 41- to 390-µT solar nebula field.

We conducted a new paleomagnetic investigation of two other Ryugu samples with mass 0.8 mg and 20.8 mg. Data are very consistent among our two samples, but their mass-normalized NRM intensities are 20 to 100 times weaker than the published ones. NRM demagnetization data exhibit a poorly defined low-coercivity component up to ~8 mT, but become completely erratic at higher AF field steps. A similar demagnetization behavior is found after applying anhysteretic remanent magnetizations (ARM) acquired in bias fields up to 10 µT. For ARM bias fields of 20 µT and greater, we can identify a component of the magnetization in the coercivity range 10-50 mT. Although further analyses are being conducted, this favors the idea that the samples experienced magnetic fields $< 17$ µT in intensity, assuming the sample acquired a chemical remanent magnetization. This upper limit is compatible with both (i) the nebula field intensity estimated from other meteorites with similar age of the NRM, and (ii) the absence of field.

We suspect that the samples used by Nakamura, Sato and colleagues may have been contaminated by exposure to strong magnetic fields up to ~20 mT. We will discuss how such a contamination can be identified using measurements that are non-destructive for the NRM. This highlights the need for extreme caution to avoid magnetic contamination during handling of returned extraterrestrial material. Our data show, however, that the samples were not remagnetized *en masse* during sampling on the asteroid, in transit in the spacecraft or during curation preceding any measurements.

We are very grateful to JAXA for the allocation of the Ryugu samples A0154 and C0005.

References

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