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A sample return renaissance

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Missions from various space agencies are going to be busy delivering material from different bodies throughout the upcoming decade, looking forward to the return of samples from Mars.

The return of material from planetary bodies so that it can be studied with advanced laboratory techniques[1] goes back to the race to the Moon during the Cold War. However, the technical challenges involved in sample return have substantially hindered its deployment, especially when it comes to automatic procedures: the crewed Apollo 17 mission gathered up to 110 kg of lunar material, three orders of magnitude more than the best result achieved by robotic retrieval during those years (the 170 g gathered by Luna 24).

In a 2019 Editorial[2], we stressed that sample return was about to see a strong revival in the upcoming years after almost 45 years of only sporadic attempts, and indeed it seems that we are there. The Hayabusa2 mission has attracted a lot of excitement, as it provided a few precious grams of pristine material from a hitherto-unexplored type of body: a carbonaceous asteroid, Ryugu. The images taken from the CAM-H camera show the moments four seconds before and after the second sample collection. Throughout 2022 *Nature Astronomy* published many papers highlighting the discoveries from Ryugu, including the very first look at the samples[3,4]. Now you can find all of them, complemented by other related articles and commentary pieces, in a dedicated Collection. Our intent is to make it a living collection, with upcoming Hayabusa2 sample papers included when published.

Soon, Ryugu will not be the only carbonaceous asteroid that we will have samples from.

After a two-year voyage, NASA's OSIRIS-REx will finally deliver its capsule of material from near-Earth asteroid Bennu on 24 September 2023. OSIRIS-REx will dramatically increase the availability of C-type asteroid particles, as it was so efficient in collecting them that the capsule could not close and briefly leaked the retrieved sample into space. We can be confident that it captured significantly more than the required minimum of 60 g (in comparison, Hayabusa2 brought back 5.4 g of Ryugu grains).

Asteroids are not the only source of extraterrestrial samples. The Chinese mission brought 1,731 g of material back from our traditional target, the Moon — ten times the Luna 24 amount, highlighting the technical improvements in this technology since the 1970s. The numerous studies published from the Chang'e-5 mission demonstrate the range of science that can be performed with planetary samples. The Chang'e-5 samples also complement the Apollo rocks nicely, as they come from a much younger region with different geomorphological and mineralogical characteristics to the Apollo sites. We can expect a ramp-up of sample return activity from the Moon in parallel with the increasing pace of its exploration and the focus on resource utilization, including samples collected by human hand in the second half of the decade: NASA's Artemis I, which successfully flew by the Moon in December 2022[5], got the ball rolling.

On the horizon, there is of course the prospect of sample return from Mars. The idea of having a piece of Mars in our laboratories seemed out of reach for a long time, but finally the plans have been set in motion. At the end of January the Perseverance rover deposited the tenth and last tube of samples on the surface of Mars, the first of three steps in the joint NASA–ESA return mission that should bring the cache of samples to us by the early 2030s. This happens to be around the same timescale as the still mysterious Chinese sample-return mission, Tianwen-3, and a few years after our first sample from the Martian system, specifically from the moon Phobos, will be delivered by the Japanese MMX spacecraft (expected return in 2029). The fact that the Mars sample return mission was given top priority in the last Planetary Decadal Survey[6] shows how focused NASA is on finally getting the prize.

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