

OSIRIS-REx spacecraft successfully returns asteroid sample to Earth

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A sample of the asteroid 101955 Bennu was returned to Earth on Sunday by NASA's Origins, Spectral Interpretation, Resource Identification and Security-Regolith Explorer (OSIRIS-REx) mission. It marks the latest in a series of ambitious "sample return" missions conducted by a number of countries, which have as their goal to collect material from asteroids and other bodies in our Solar System and return them to Earth for careful study.

OSIRIS-REx was launched on September 8, 2016, five years after the project was selected by NASA to be the agency's third mission of its New Frontiers program, beating out a sample return mission to the far side of the moon and a Venus lander. It spent two years cruising to Bennu, including two weeks in February 2017 during which the team used the spacecraft's MapCam instrument to search for near-Earth asteroids.

While no new asteroids were found, the techniques developed were used to avoid potential hazards when OSIRIS-REx arrived at Bennu in December 2018. Throughout the month, the spacecraft was used for a detailed survey of Bennu, which has a diameter of only half a kilometer. The spacecraft then descended from an orbit of 19 kilometers to an orbit of 1 kilometer, beating the previous record set by the Rosetta spacecraft, which orbited comet 67P/Churyumov-Gerasimenko at 7 kilometers.

A year later, NASA announced it had selected its primary and backup landing sites from which to retrieve a sample of the asteroid. Then in April and August of 2020, amid the first and second wave of the ongoing coronavirus pandemic, OSIRIS-REx was used in two rehearsal landings, which took the spacecraft to 65 meters and 40 meters, respectively, above the surface of the asteroid.

The rehearsals were critical. At the time, Bennu was more than 320 million kilometers from Earth, more than

the average distance between Earth and Mars, and two-way communication between OSIRIS-REx and its operators took more than 35 minutes. Given that gap, the entire landing and sample retrieval had to be pre-programmed and executed without direct human intervention. The rehearsals paid off and OSIRIS-REx collected an estimated 250 grams (about 8.8 ounces) of the asteroid as it "tagged" Bennu's surface for five seconds before springing off, using essentially a highly sophisticated pogo stick.

That material is now safely back on Earth and remains ensconced in a capsule containing only nitrogen, to prevent contamination with material from Earth. The samples will ultimately be curated by NASA's Astromaterials Research and Exploration Science directorate (ARES) and at Japan's Extraterrestrial Sample Curation Center.

Moreover, the spacecraft's mission is ongoing. Rather than wastefully end its life in a crash landing into Earth or other body, OSIRIS-REx is now on a trajectory to rendezvous the asteroid 99942 Apophis, a near-Earth asteroid that will make a close pass to Earth on April 13, 2029. It will spend 18 months orbiting the asteroid and is slated to use its thrusters to kick up material from Apophis' surface to study what lies beneath.

Bennu was selected as the target of OSIRIS-REx because it has undergone almost no geological evolution since the formation of the Solar System. It is made up primarily of compounds containing carbon, one of the key elements of organic life, and thought to have existed before the formation of Earth. It is possible that complex carbon-based molecules were collected, including amino acids, which are the building blocks of all known life.

Asteroids and comets are carefully studied largely for these reasons. Unlike Earth, the other planets and even several moons, asteroids are largely unchanged over hundreds of millions and even billions of years. Comets

are similarly preserved when they are not close enough to the Sun to have their tails. Each is a definite piece in the puzzle of the Solar System's formation and provides further insight into how the entire complex of star, planets and lesser bodies, and its living inhabitants, developed.

One of the many other reasons that spacecraft are sent to study asteroids is to compare the *in situ* data to that collected from the Earth. While there are numerous observations of asteroids from telescopes, the distance and atmosphere makes the light reflected far more difficult to interpret. By studying Bennu up close, measurements from OSIRIS-REx can be compared with those from ground-based telescopes and used to better understand similar observations of other asteroids.

Data from OSIRIS-REx was also used to study the Yarkovsky effect, which is a force that acts on small asteroids as a result of uneven thermal emissions from the body. While the effect is very small, it has a definite impact on the orbit of bodies around Bennu's size. This is especially important for asteroids that cross Earth's orbit; the gravitational influence of other bodies on these relatively small objects is well known, but the influence of forces like the Yarkovsky effect is far less so. Understanding this mechanism helps track objects that might be on a collision course with Earth and, if need be, deflect them.

There have been several other sample return missions. The most famous are of course the manned Apollo landings, which brought back several hundred kilograms of rocks and lunar regolith (the Moon's "soil"). Those samples have been intensely studied since they were first brought back in the late 1960s. A renewed effort was launched in 2019 when lunar samples from that era that had been sealed away were opened for study, allowing the more advanced scientific instruments of the modern era to undertake investigations that technology from 50 years ago simply couldn't.

The first robotic sample return mission was in 1970 when the Soviet mission Luna 16 returned 101 grams of lunar soil. The achievement was followed up in 1974 by Luna 20, which returned 55 grams, and in 1976 by Luna 24, which returned 170 grams. While they returned far less lunar material than the Apollo program, the Luna missions paved the way for further robotic sample return missions.

Despite their scientific value, there were no sample return missions in the 1980s. Only one was conducted in the 1990s, when the Soviet-launched Mir space station used an aerogel to capture interplanetary dust in low Earth

orbit. In 2004, the Genesis spacecraft returned particles from the solar wind and in 2006, the Stardust spacecraft returned dust samples from the tails of the comet 81P/Wild.

The modern sample return missions began when the Hayabusa probe from the Japanese Aerospace Exploration Agency (JAXA) brought back a small number of particles from asteroid 25143 Itokawa, despite the failure of the sampling device. Hayabusa was followed by Hayabusa2, which deployed two small rovers on the surface of asteroid 162173 Ryugu and returned a sample of Ryugu to Earth in December 2020. Both missions were the first successful sample returns from an asteroid.

Several future sample return missions are planned. JAXA is slated to launch its MMX mission to Phobos and Deimos, the moons of Mars, in 2024 and return a sample from Phobos that will reach Earth in 2029. China has sample return missions planned for the Moon, Mars and the asteroid Ceres throughout the 2020s and 2030s. Russia has a new Luna-Glob mission which will bring back new samples from the Moon in 2027. And NASA and the European Space Agency are planning on retrieving the samples collected by the Perseverance Mars rover in the late 2020s.

In a rational world, these missions would be universally celebrated. Under capitalism, however, they are seen by the ruling elite as further instances of geopolitical rivalry. NASA Administrator Bill Nelson focused on the fact that the mission was "the first American asteroid sample return in history," as if space exploration does not build on itself in an inherently international process.

Nor was any mention made of the paltry sums spent on the project, about \$1 billion so far, compared to the nearly \$1,000 billion squandered at the Department of Defense every year, including \$30 billion to the Space Force. One can only imagine what will be achieved and discovered when such vast sums are spent for exploration instead of destruction, a future well worth fighting for.



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