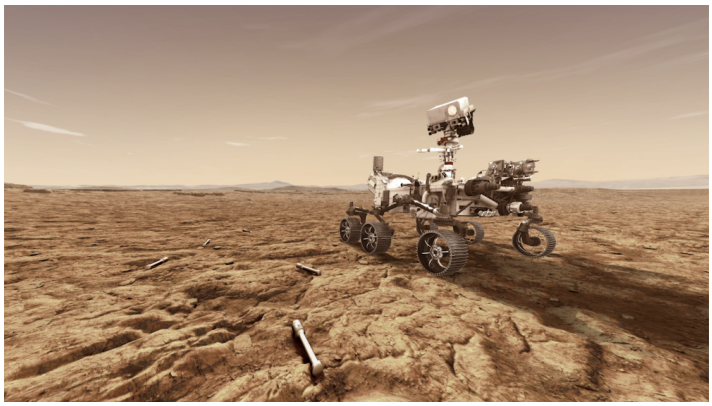
A Rockin' Time for Space Missions

2021 may be the year of the space rock, with scientists combing through new (and old) samples from the Moon and asteroids, while plans for a pick-and-collect mission to Mars get under way.

By **Katherine Wright**

In its first month on Mars, NASA's *Perseverance* rover snapped a dizzying **12,145 images**, and recorded the **first sounds of the red planet**. It also began zapping nearby rocks with lasers, uncovering chemical signatures similar to Earth's volcanic rocks. But at the recent **Lunar and Planetary Society Conference**, where these first results were announced, it was *Perseverance*'s plans for collecting and returning Martian rocks to Earth that was the quiet star of the talks.

And Mars wasn't the only astronomical body whose rocks made a splash at the meeting. The Moon and its geological artifacts featured prominently in missions from the past, present, and future. Apollo, the "grandfather" of lunar missions, will soon offer new data from samples that have lain untouched since they were collected 50 years ago by Apollo astronauts, while China's robotic Chang'e 5 mission returned from the Moon late last year with a fresh batch of lunar samples. And looking ahead, NASA's Artemis mission plans to return rock-gathering astronauts to the Moon within three years.



During its journey over the Martian surface, NASA's *Perseverance* rover will collect several rock and soil samples and store them in sealed tubes, as shown in this illustration. Future missions to Mars will retrieve the tubes and bring them back to Earth.
Credit: NASA/JPL-Caltech

Asteroids are also gold mines for rock collectors. Japan's *Hayabusa2* spacecraft returned to Earth four months ago with just over 5 grams of black dust and gravel-like pieces from the asteroid Ryugu. A significantly larger-mass sample has been collected from the asteroid Bennu by NASA's OSIRIS-REx mission, which is prepping for its last flyover before starting its journey back to Earth.

While rocks provide the common thread through many current and future space missions, each collection and return project is unique. Scientists also have very different questions that they hope to answer with Martian, lunar, and asteroid rock samples. To celebrate the enthusiasm surrounding each of the mission's dirt and stone, here are a few facts that you may—or may not—know about the science of returning samples from each of these rocky bodies.

The Red Planet

NASA has successfully landed five rovers on Mars over the last two decades, but *Perseverance* is the first tasked with collecting rocks for return to Earth. Starting as early as July of this year, the rover will gather up to 30 samples from various locations, using a drill to free rubble from the planet's surface. These

This photo shows the sample tubes being installed in the *Perseverance* rover prior to its July 2020 launch. Scientists took extreme care in keeping these tubes clean, as they are the first things to ever be sent to an alien planet with "return postage." **Credit: NASA/JPL-Caltech**

samples will be deposited at two "collection" sites for later return to Earth.

The return won't be carried out by any equipment aboard *Perseverance*. Instead, NASA and the European Space Agency plan to send several spacecrafts to Mars in 2028 with the goal of bringing the samples home by 2031. This extra step might seem complicated, but it was prohibitively expensive to build the return-journey machinery—essentially a rocket—into *Perseverance*, says Christopher Herd, a geologist at the University of Alberta, Canada, and one of the return sample scientists on the mission. Using a second craft to bring back the rocks also mitigates possible mechanical failure in the rover. "If *Perseverance* stops working, we still have a shot at getting the samples back," he says.

Another consideration for the *Perseverance* team was making sure that the rover and its sample-collection machinery were squeaky clean. Cleanliness is key if scientists are to be sure that any potential signs of life in the samples came from Mars and not from terrestrial contaminants, Herd says. "The collection tubes are probably the cleanest things we have ever sent into space."

Determining whether life existed long ago on Mars is the number one goal for *Perseverance*. Scientists can really only answer that question by bringing Martian rocks back to Earth and subjecting them to the same tests used to find signs of ancient life in terrestrial rocks, Herd says. For him, simply getting the rocks back would be a significant achievement. "Holding Martian rocks is something I've wanted to do since the age of 13," he says.

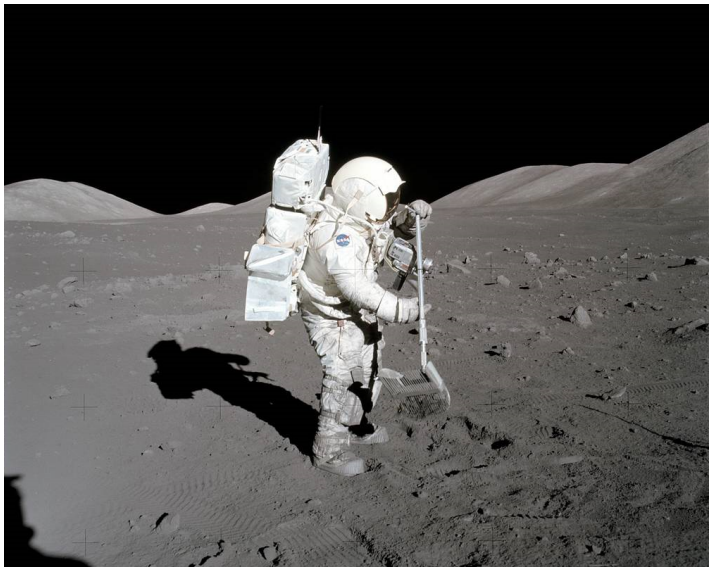
The Moon

The Apollo missions of the 1960s and 70s were the most prolific collectors of space rocks, bringing back 382 kilograms of rock, rubble, and dirt, divided up among 2196 samples. Those samples have now resided on Earth for about five decades, but they haven't all been opened. A few specimen tubes were kept sealed for study at some future date. Many of the scientists now studying lunar rocks weren't even born when the samples came back, says Francis McCubbin, an astromaterials curator at Johnson Space Center, Texas, and the co-lead of the Apollo Next Generation Sample Analysis (ANGSA) program.

As part of ANGSA, researchers are now opening up six samples from the Apollo 15 and Apollo 17 missions that have either been kept frozen or under vacuum since they were collected. They want to learn about the Moon's volatile gases, which they hope the curation techniques have contained, as well as the historic geologic processes that shaped Earth's satellite. The biggest focus, though, is understanding how well the curation techniques worked, as it will inform the design of sample-collection protocols for NASA's upcoming Artemis mission.

Zoe Wilbur, a graduate student at the University of Arizona, is part of the team tasked with evaluating Apollo's freezing technique. Wilbur plans to compare a frozen sample with one from the same rock that has been at room temperature for the last 50 years. She hopes that the frozen sample has new information to share. But she notes that, "even if we find out that there's no difference, that's still a really interesting result."

Wilbur is excited to be part of the effort to send humans back to the Moon and about the secrets they might uncover when they are there. "I didn't think that people would walk on the Moon again in my lifetime," she says. "It's almost surreal."



Astronaut and geologist Harrison Schmitt is shown in this 1972 photograph collecting dust and rock from the Moon's surface with a "lunar rake," one of the tools used for sample collection during the Apollo missions.
Credit: NASA

Ryugu and Bennu

For most rock-collecting missions, the samples are collected by rovers or humans. The *Hayabusa2* mission to Ryugu also deployed rovers—the first ever to touch down on an asteroid—but they weren't used for sample collection. Instead the spacecraft itself captured dust and debris in 2019 during two brief touchdowns on this square-shaped asteroid whose orbit path is close to Earth's orbit.

The OSIRIS-REx rock collection in October of last year also involved a brief touchdown on Bennu, although Ronald Ballouz from the University of Arizona notes that it was more of a collision. "The spacecraft penetrated the surface," he says. The unexpected "softness" of the landing suggests that the asteroid interior is full of voids, according to simulations performed by Ballouz. But, he says, the team won't know for sure until they get the samples back and run some tests.

Another unexpected aspect of Bennu is its rough surface. The OSIRIS-REx team had thought Bennu would be covered in a fine soil-like material, but it is actually really rocky, says Olivier Barnouin, a geophysicist at the Johns Hopkins Applied Physics Laboratory, Maryland, and OSIRIS-REx team member. "It was hard to find a smooth place to land the spacecraft," he says. Luckily the team had equipped the craft with high-resolution cameras that allowed them to find a relatively flat spot to collect their samples. "Asteroids are really cool and each one has unexpected quirks," Barnouin says. "We should keep visiting them."

This video shows a series of 82 images captured on Oct. 20 by a camera aboard OSIRIS-REx as the spacecraft briefly touched down on the asteroid Bennu.
Credit: NASA/Goddard/University of Arizona

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