# Introduction and Background

As part of the Artemis missions, NASA plans to land the first woman and the first person of color on the Moon, using innovative technologies to explore more of the lunar surface than ever before. NASA will collaborate with commercial and international partners to establish sustainable exploration by the end of the decade. Using what we learn from living on and around the Moon will help us take the next giant leap—sending astronauts to Mars.

In April 2020, NASA selected three U.S. companies to develop human landing systems for the Artemis missions: Blue Origin, leading a team that includes Lockheed Martin, Northrop Grumman, and Draper; Dynetics (a Leidos company); and SpaceX. NASA's Artemis missions will reveal new knowledge about the Moon, Earth, and our origins in the solar system. NASA and its partners will be able to fine-tune precision landing technologies and develop new mobility capabilities that allow robots and crew to travel greater distances and explore new regions of the Moon. The Artemis human landing system is a vital part of NASA's deep space exploration plan, along with the Space Launch System (SLS) rocket, the Orion spacecraft, and the Gateway orbiting outpost. After the initial landing, NASA will begin conducting regular surface missions, sending rovers and a habitat to the lunar surface in order to test new power systems and begin preparations for human exploration of Mars.

Illustration of Artemis astronauts on the Moon. (NASA)

## History and Geology of the Moon

When astronauts explored the surface of the Moon from 1969 to 1972, they were doing more than digging up rocks and lunar sediment. The astronauts were getting a glimpse into the past—retrieving clues about the formation of our Earth and Moon, learning about the intensity of early impacts and bombardment from meteorites and the variation of those impacts over time, and even discovering the history of our Sun. Here on Earth, geological activity has made this sort of discovery more difficult. Our planet is so geologically active that most of its early history has been erased by mountain building, weathering, erosion, colliding tectonic plates, and volcanism. In contrast to Earth, the Moon does not experience much geological activity. The lunar plains, valleys, and rocks are preserved essentially as they were originally formed long ago. The Moon is also easier to reach than our closest planets in terms of collecting samples and data about the formation of our solar system. Starting with Apollo 11, astronauts explored the surface of the Moon at six unique landing sites on the Moon's nearside, or Earth-facing side. The Artemis missions plans to send astronauts to the

lunar South Pole region to access persistently shadowed terrain where resources have not been affected in billions of years and can be mined and studied.

Some of the planetary processes that scientists have discovered are differentiation, volcanism, impacts, and accretion. *Differentiation* occurs when planets begin to melt and the materials in them begin to separate due to varying densities. On the Moon, the heaviest materials sink to form cores and the low-density magma rises to form crusts. The magma ocean produced what we see today in the lunar highlands, the light-colored, heavily cratered regions of the Moon. *Volcanism* created the Moon's smooth, dark regions. Scientists have evidence that suggests that for the first 600 million years of the Moon's existence, large asteroids and comets continued to strike the Moon, but details about these *impacts* remain a mystery. During the early formation of the planets and moons of our solar system, smaller asteroids were drawn together by gravity, a process known as *accretion*. The prevailing theory of our Moon's formation is that a planet about the size of Mars collided with the early Earth, knocking a large portion of Earth's material into the void of space. That material accreted together over about a month's time while remaining in orbit around the Earth. Since then, the Moon has continued to slowly drift away from Earth at the rate of 3.78 centimeters (1.48 inches) per year while under constant bombardment by meteorites and comets. It is time to return to the surface of the Moon to learn more about our celestial sister and develop and test the technologies that will allow us to explore deeper into our solar neighborhood. Learn more about the Moon's history in the NASA video "Evolution of the Moon": https://www.youtube.com/watch/UIKmSQqp8wY

## Lunar Surface Activities

The Apollo astronauts were on the lunar surface for just 2 days on average. For future Artemis missions, longer stays on the Moon are expected. Longer duration missions provide more data for human research, more time for scientific work, and more experience for future exploration missions. This is the proving ground that will refine our technologies to live and work in deep space, learn more about planetary processes and evolution, and establish the resources and infrastructure to support further scientific investigations.

Earlier launches to the Moon will be robotic missions to deliver science and technology payloads before the arrival of astronauts. NASA's Volatiles Investigating Polar Exploration Rover, or VIPER, will scout out water ice and attempt to reach some of the most promising ice reserves. This will be the first opportunity to explore the polar craters for volatiles—water ice and other compounds—that are believed to exist there based on evidence from orbiting reconnaissance satellites. A series of launches to the Moon will follow, either for delivery of cargo landers or for astronauts to practice orbiting capabilities and, eventually, landing and launching from the surface.

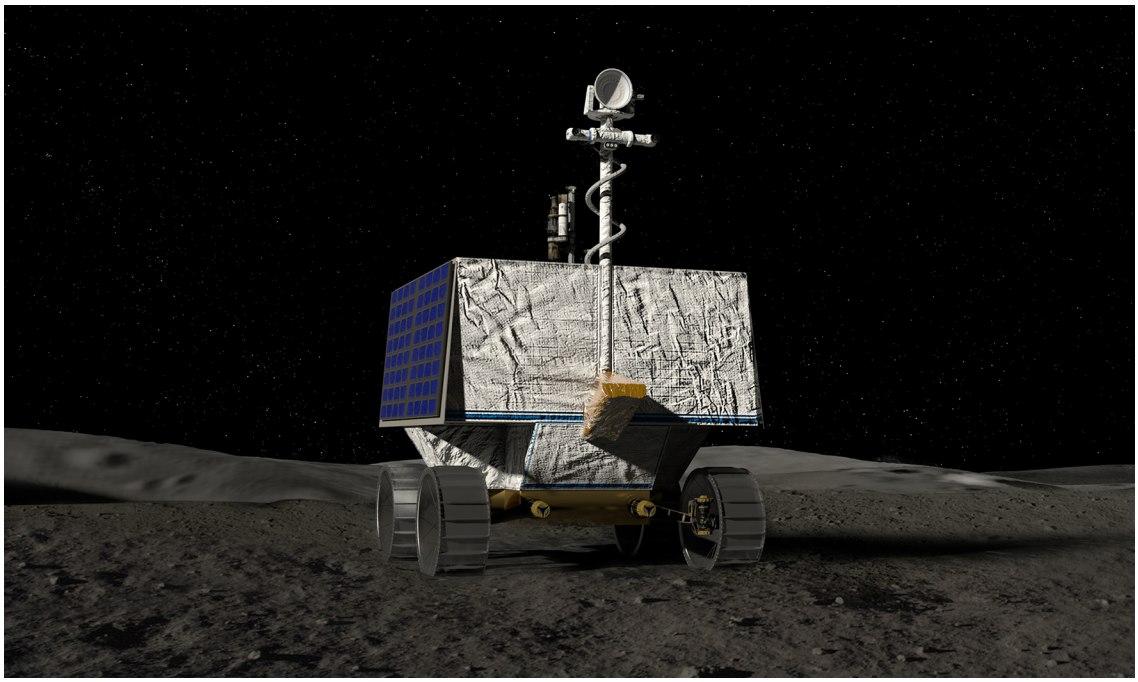

Illustration of NASA's Volatiles Investigating Polar Exploration Rover, or VIPER. (NASA)

## Human Landing System Program

The objective of the Human Landing System program is to deliver humans to the surface of the Moon and return them safely back to lunar orbit. The lander will also carry equipment and supplies that will allow astronauts to spend time on the surface performing various tasks. These lunar landers will work together with the Space Launch System (SLS) rocket, the Orion spacecraft, and the Gateway outpost in lunar orbit to form a lunar architecture for long-term human exploration on and around the Moon.

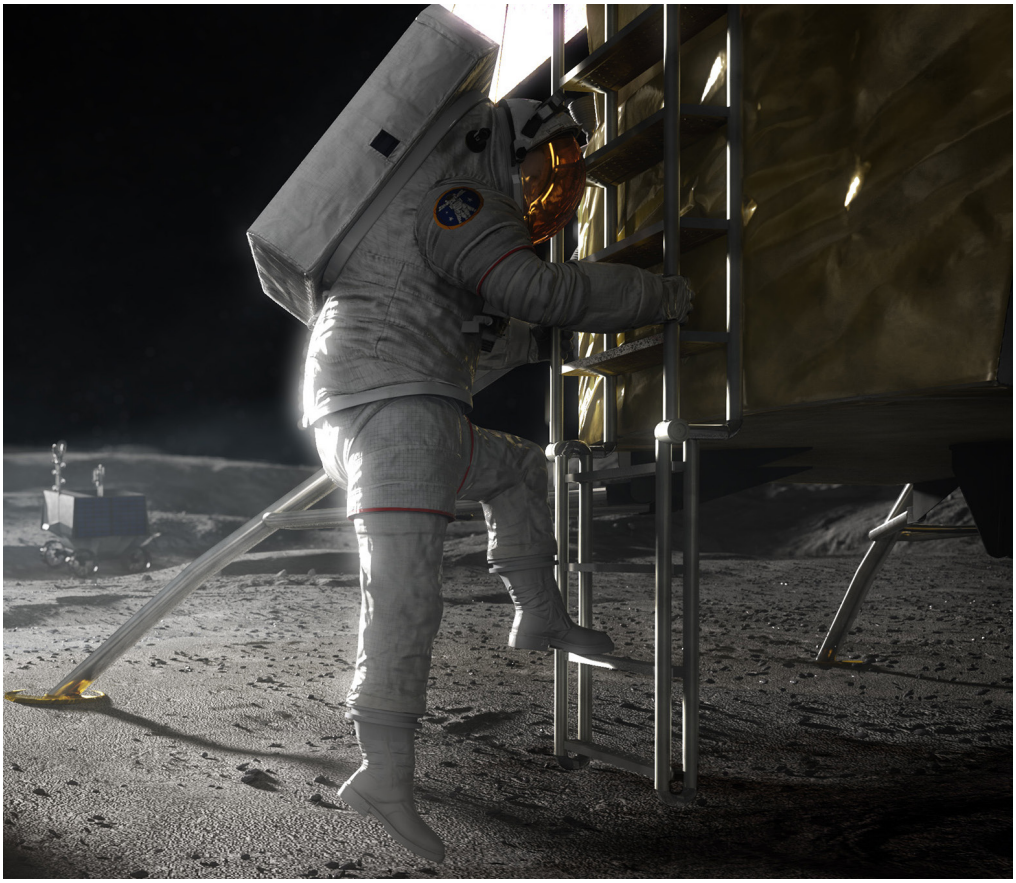

Illustration of Artemis astronaut stepping off lunar lander. (NASA)