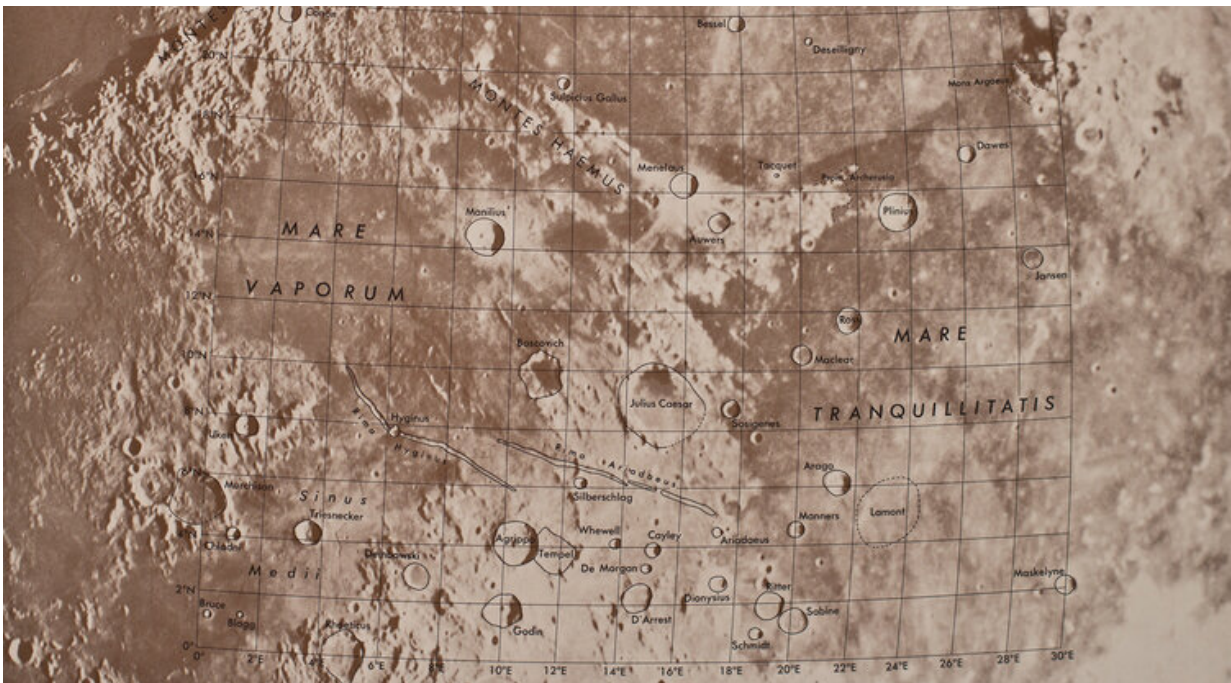


# Maps and images at the start of the space race opened the door for lunar and planetary exploration

June 27 2019, by Mikayla Mace



A page from the Rectified Lunar Atlas. Credit: UA Lunar and Planetary Laboratory

The maps and images created by a small UA team at the start of the space race opened the door for lunar and planetary exploration 50 years ago.

Only a handful people were seriously studying the moon when President John F. Kennedy announced in 1961 that Americans would walk on its surface by the decade's end. Among them was a small group of researchers at the University of Arizona.

The UA team imaged and mapped the [lunar surface](#), which allowed them to understand the moon's geology and NASA to choose landing sites for future robotic and Apollo missions. Gerard Kuiper, the father of modern-day planetary science, led the team and established the UA Lunar and Planetary Laboratory.

"Classic astronomers regarded the moon as an annoyance that lit up the night sky, making it hard to study the faintest stars and galaxies," said William Hartmann, one of Kuiper's first graduate students and co-founder of the Planetary Science Institute, or PSI, in Tucson. Hartmann and PSI co-founder Don Davis, another UA alumnus, also proposed that the moon was born from a giant impact with the Earth. [Their theory](#) still leads thinking today.

"Back then, astronomers were interested only in objects outside our solar system," Hartmann said. "To most 1950s astronomers, the planets did not seem very interesting, and there weren't very useful techniques for studying them."

Moreover, moon maps at the time were drawn by hand, and the names of many features remained unsettled.

Kuiper, already a leader in planetary science by the time he arrived in Tucson in 1960, sought to understand Earth's celestial neighbor and worked for years to create multiple lunar atlases with the best photographs of the moon.

## **The Lunar Atlases**

Kuiper and his team collected the best available telescopic photos of the moon from observatories around the world and used them to produce the first two atlases while working at the University of Chicago's Yerkes Observatory in Wisconsin. The [Photographic Lunar Atlas](#) and the [Orthographic Atlas of the Moon](#), which included a coordinate grid, were published in 1960 and 1961, respectively. Astronomers used these while observing the moon telescopically.

The [Rectified Lunar Atlas](#), published in 1963 by the University of Arizona Press, went a step further. The third atlas allowed humans for the first time to see what features on the moon's edges, called limbs, looked like without distortion.



William Hartmann projected photographic plates of the moon onto a white hemisphere to create the Rectified Lunar Atlas. Credit: UA Lunar and Planetary Laboratory

To accomplish this, Kuiper mounted a 3-foot-wide white hemisphere at the end of a hallway and projected glass plate photographs of the best images of the moon onto it. Hartmann, a first-year graduate student at the time, was tasked with snapping photos of the hemisphere from different angles. The resulting images revealed lunar features as they would appear from the perspective of an astronaut flying overhead.

Four years later, Kuiper produced yet another lunar atlas.

"The 1967 Consolidated Lunar Atlas was the last in the series of Gerard Kuiper," said Steve Larson, who was one of Kuiper's undergraduate research assistants and is now a senior staff scientist at the UA Lunar and Planetary Laboratory, or LPL. Larson established the Catalina Sky Survey and has worked under every LPL director since the lab's inception.

The fourth atlas was comprised of the highest resolution images taken from the ground, most of which were taken using the NASA-funded [61-inch telescope](#) perched atop Mount Bigelow in the Catalina Mountains north of Tucson. The telescope is now managed by the UA's Steward Observatory and bears Kuiper's name.

"That was our main project for the first couple years after the construction of the 61-inch telescope," Larson said. "We were funded by NASA to record high resolution images of the moon, but we also took images of Venus, Mars, Jupiter and Saturn to monitor changes in atmospheres."

Kuiper and his team created the Consolidated Lunar Atlas by carefully focusing the telescope on the moon and systematically snapping thousands of film photos along the moon's terminator, the boundary

between sunlight and darkness. At the terminator, sunlight hits the moon at a low angle, allowing the scientists to capture subtle variations in the lunar topography, Larson said.

But the high contrast and dramatic lighting near the moon's terminator made imaging the lunar surface features tricky. Larson and undergraduate John Fountain laboriously brightened the areas near shadow and dimmed the brighter parts of the surface by hand.

"It was very analog," he said. "I spent the whole summer monsoon season down in the basement dark room; The sun was shining when I went down, and when I came out it's flooding everywhere."

Kuiper and his team inspected, cataloged and graded each of the more than 8,000 film photos to whittle them down to the more than 200 which now comprise the Consolidated Lunar Atlas. It was published by the University of Arizona Press in 1967.





A UA senior staff scientist who worked for Gerard Kuiper as an undergraduate points to the Apollo 11 landing site on photos from the Consolidated Lunar Atlas. The top photo was taken with the sun at a low angle, which reveals more detail than the bottom photo, which was taken with the sun overhead. Credit: Mikayla Mace/UANews

## Landing the Eagle

At the same time, leaders at NASA knew they needed to understand the surface of the moon in detail to choose a landing site. Would the smooth, dark swaths of lunar surface—called maria, which means seas, as the earliest observers thought they were oceans—swallow the astronauts in dust or support them as cooled and solidified oceans of magma?

"When NASA was deciding where to land, they'd be looking at one of these prints. Here's a spot with not a lot of craters that's relatively flat," Larson said as he pointed to the final Apollo 11 landing site, located in the Sea of Tranquility.

There are two main types of terrain on the moon, said LPL professor and planetary science assistant director Shane Byrne.

"Most of the Apollo missions and most of the Surveyor (lander) missions went to one type: the lunar mare, the dark areas of the moon," Byrne said. "It's smoother and safer to land there, and that was the motivation for sending the astronauts there. But most of the moon is covered with the bright areas, the lunar highlands, which are much rougher, much more cratered."

## **Before Men, There Were Robots**

NASA prepared three series of robotic spacecraft to visit the moon ahead of the astronauts: [Ranger](#), Surveyor and Lunar Orbiter.

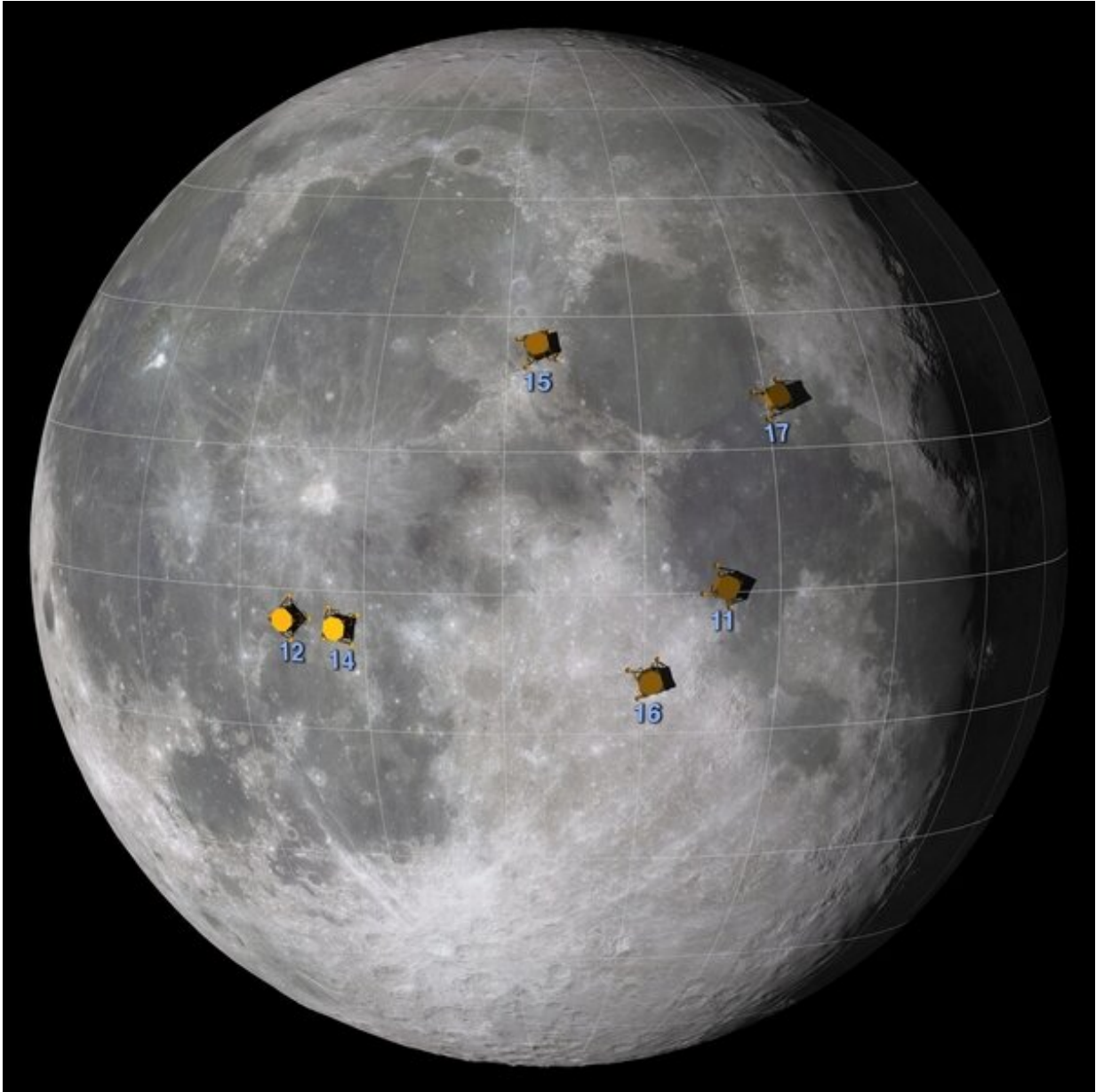
NASA appointed Kuiper as chief experimenter, a position today referred to as principal investigator, on the Ranger missions. Among the team were UA planetary scientist Ewen Whitaker and Eugene Shoemaker, who created the astrogeology branch of the United States Geological Survey in Flagstaff, Arizona.

Ranger 1 launched August 1961 to collect video of increasing detail

before crash-landing on the moon. Future Ranger missions failed until the 1964 launch of Ranger 7, which landed in what Kuiper dubbed Mare Cognitum, the Sea That Has Become Known. Whitaker selected the landing sites for Ranger 6 and 7.

The successful Ranger 7 mission improved the resolution of lunar detail 1,000 times over, Kuiper proclaimed at a press conference shortly after the spacecraft reached the moon.





The Apollo landing sites. Credit: NASA/Goddard Space Flight Center Scientific Visualization Studio

To analyze the photographs, Kuiper partnered with UA professors emeritus Robert Strom of LPL and Spence Titley, of the Department of Geosciences. Titley gave Kuiper's students and NASA's astronauts crash

courses in geology and recommended features the astronauts should photograph from orbit. Titley also worked with the U.S. Geological Survey in 1964 to map the moon using the McMath-Pierce Solar Telescope on Kitt Peak for the Apollo program.

The Ranger missions were followed by Surveyor 1, the first of seven unmanned lunar landers in a program that ran from June 1966 through January 1968. Surveyor 1 reached the surface of the moon on June 2, 1966, and sent back panoramic photos from its travels.

Surveyor's success reassured the astronauts they would not be swallowed by dust. Despite the success of the Surveyor program, NASA had no way of knowing where, exactly, on the moon the spacecraft landed.

NASA published what they thought was the correct landing site in the journal *Science*. But Whitaker noticed a discrepancy, and after poring over images taken by NASA Lunar Orbiter, he published an alternate location for Surveyor 1 in the journal's September issue.

"Whitaker was able to pinpoint the landing area by looking at mountain peaks on the horizon," Larson said.

NASA officials realized their mistake and Whitaker's skills earned him the task of locating four more Surveyor landing sites.

Whitaker again proved his prowess of the lunar surface when he correctly located Apollo 11. The first manned mission didn't hit its intended target because the site was too rocky. The lander carrying the two men cruised for four additional miles, nearly running out of fuel before it touched down. NASA analyzed photos taken from the surface and determined what they believed to be the Apollo 11 landing site. Ewen did his own analysis, which was contrary to NASA's location, and was correct.

NASA then sought to demonstrate a pinpoint landing with Apollo 12 and used Whitaker's location of Surveyor 3 to do so. Whitaker's location was so spot on that the astronauts walked to Surveyor 3.

Since the Apollo missions, the UA has imaged the surface of Mars in great detail using the [High Resolution Imaging Science Experiment](#) aboard the Mars Reconnaissance Orbiter. The UA also led the team that imaged the surface of Saturn's [moon](#) Titan from under the clouds with the Cassini-Huygens probe. The UA is also heading up the OSIRIS-REx sample-return mission to the asteroid Bennu and is currently mapping and imaging the dark surface to choose a collection site.

Provided by University of Arizona

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