Preface

Project Apollo was going to be the final chapter of an exciting celestial mystery novel. Scientists were supposed to take the 842 lb of lunar rocks and soil samples brought back from the Moon and with them piece together the origin, evolution, structure, and composition of the Moon. And voila! All the mysteries of the Moon would be solved.

However, reality doesn't always work that way. Data from Apollo and a flotilla of unmanned Moon orbiters, crashers, and landers have yielded many answers, but much remains unknown.

For example, concentric craters are still not fully understood. These odd craters look like someone placed a donut inside the bowl of a crater. What causes them to have such a strange appearance? Take a look at Hesiodus A near Pitatus in Mare Nubium, which is the classic example. Seventy percent of the known concentric craters have morphologies similar to this. Virtually all concentric craters occur on or near maria. The inner slopes of the main crater are smooth and terrace free, similar to normal craters. Only 57 concentric craters are known to exist.

One lunar scientist speculated that their inner rings were volcanic in origin. Another thought that perhaps an effusive flow of relatively viscous magma from fractures at the edge of the crater's floor built up the inner ring. Still another idea was that they are some sort of wall slump feature within normal impact craters. You'll find the surprising answer to this lunar riddle in Chap. 8.

Plato presents another mystery. The gradual darkening of the floor of this crater as the Sun rises has puzzled observers for centuries. Why should the floor of this crater darken while the surrounding areas brighten? Is it due to physical change, as some have speculated?

Another Plato controversy concerns reports that the dark floor is sometimes obscured by mists or clouds. Some of the observations were made during the last century; Walter Goodacre's

1931 book, called *The Moon*, notes that there are "a number of well-authenticated cases." Descriptions include a "curious luminous milky kind of light," "a fog that cleared as the Sun rose," and a nondescript lack of detail. A nineteenth-century observer found that the floor was covered by numerous points of light, "as if reflected from flocculent clouds lying near the surface." These are just some of the mysteries surrounding Plato. They're all discussed in Chap. 4.

The obscuring mist or cloud appearing on Plato may very well be a lunar transient phenomenon (LTP) of a type that has been reported to occur all over the Moon. LTPs are short-lived changes in brightness in areas on the Moon, appearing as quick bright flashes, with some lasting seconds and some lasting for hours! These changes can also involve changing colors such as flashes of red or violet and some have even been recorded as "darkening." These occurrences also have sometimes been described as a haze rather than flash of light, so it appears any occurrence of light on the Moon's surface can be a LTP.

Some LTPs may be caused by gas escaping from underground cavities. These gaseous events are purported to display a distinctive reddish hue, while others have appeared as white clouds or an indistinct haze. The majority of LTPs appears to be associated with floor-fractured craters, the edges of lunar maria, or in other locations linked by geologists with volcanic activity. However, these sites are some of the most popular observing targets, and this correlation could have an observational bias. You'll find other possible answers to these strange phenomena in Chap. 8.

It's also strange that the Moon has been shown to have a "sodium tail" too faint to be detected by the human eye. Hundreds of thousands of miles long, it was discovered in 1998 by Boston University scientists who were observing the Leonid meteor shower. The Moon is constantly releasing atomic sodium gas from its surface, and solar radiation pressure accelerates the sodium atoms in an anti-sunward direction, forming an elongated tail that points away from the Sun. Although it's difficult to see the tail, it's not impossible. Find out how in Chap. 8.

And here's another mystery. Unlike early tests and studies that indicated the Moon had little or no magnetic field, lunar rocks proved to be strongly magnetized. This was shocking to

scientists, who could not explain where this magnetic field came from. Later on, scientists were able to determine that when rocks solidify from a lava, they capture a record of the magnetic field in their environment. By studying rocks of different ages, scientists were able to reconstruct the history of lunar surface magnetic fields. This analysis revealed that the intensity of the lunar magnetic field was exceptionally strong 3.56 billion years ago, almost identical to the field measured in the rocks brought back from the Moon. But many questions remain about the Moon's magnetic field, such as why it was so intense late into lunar history and how and why it disappeared over time. The answers are in Chap. 9.

In addition to impact events, the Moon is also rocked by "moonquakes," the lunar equivalent of earthquakes. There are four different types of moonquakes. Deep moonquakes occur up to 700 km below the Moon's surface and are a result of tidal stresses caused by the gravitational tug of war between Earth, the Moon, and the Sun. Shallow moonquakes occur at the surface and down to depths less than about 20 or 30 km, and are often due to landslides of rock down steep crater rims. The Moon also suffers from thermal moonquakes, which occur when the freezing crust expands as it returns to sunlight after 2 weeks of lunar night. Meteorite moonquakes can also cause a rumble or vibration of the surface when a meteoroid slams into the surface. You'll be surprised at which one is the strongest type when you read Chap. 6.

Volcanic activity on the Moon was supposed to have died off centuries ago. That's why astronomers were puzzled when they discovered volcanic activity in the D-shaped volcanic Ina caldera with outgassing and sinkage, leaving relatively bright areas of lunar regolith exposed. The region has to be young in terms of lunar features because of the conspicuous lack of impact craters mottling its surface, like elsewhere on the Moon. You'll find possible answers to this enigma in Chap. 4.

The Aristarchus plateau is one of the most geologically diverse places on the Moon—a mysterious raised flat plateau, a giant rille carved by enormous outpourings of lava, fields of explosive volcanic ash, and all surrounded by a massive flood of basalts. Scientists think the crater was created relatively recently, geologically speaking, when a comet or asteroid smashed into the Moon, gouging out a hole in its surface. The bounty of geologic processes

that come together here makes it a high-priority target for future exploration, as explained in Chap. 4.

The "Man in the Moon" was born when cosmic impacts struck the near side of the Moon, the side that faces Earth. These collisions punched holes in the Moon's crust, which later filled with vast lakes of lava that formed the dark areas known as maria, or "seas." In 1959, when the Soviet spacecraft *Luna 3* transmitted the first images of the "dark," or far side, of the Moon, the side facing away from Earth, scientists immediately noticed fewer maria there. This mystery—why no Man in the Moon exists on the Moon's far side—is called the Lunar Farside Highlands Problem. For decades, scientists have been trying to understand why the Earth-facing side of the Moon looks so different from the Moon's far side. Now, they may have an answer to that mystery. See Chap. 10.

The Moon has several bizarre swirl patterns on the surface that look as if visiting aliens took spray paint and left graffiti—"Zord was here." Reiner Gamma is one of the strangest features on the Moon. It is the best-known example of a *lunar swirl* that has baffled planetary geologists for decades. This peculiar pattern looks a *little* like crater rays, but it's curved and lacks a source crater. In fact, there's nothing obviously geological about it. It remains one of the big unanswered questions in lunar science.

The mystery only deepened when orbiting Apollo spacecraft (and later the Lunar Prospector) found strong magnetic fields directly over the swirls—surely an important clue. One theory is that the patchy, localized magnetic field is shunting solar-wind plasma away from the swirls' bright areas and funneling it to the dark lanes that snake through the features. Find out if that's the answer in Chap. 4.

Lunar explorations have revealed that much of the Moon's surface is covered with a glassy glaze, which indicates that the Moon's surface has been scorched by an unknown source of intense heat. As one scientist puts it, the Moon is "paved with glass." One explanation put forward was that an intense solar flare, of awesome proportions, scorched the Moon some 30,000 years or so ago. Scientists have remarked that the glassy glaze is not unlike that created by atomic weapons (the high radioactivity of the Moon should also be considered in light of this theory). Find out more in Chap. 8.

The upper 8 miles of the Moon's crust are surprisingly radioactive. When *Apollo 15* astronauts used thermal equipment, they got unusually high readings, which indicated that the heat flow near the Apennine Mountains was rather hot. The core is not hot at all, but cold. The amount of radioactive materials on the surface is not only "embarrassingly high" but difficult to account for. Where did all this hot radioactive material (uranium, thorium, and potassium) come from? Chapter 9 gives you the answer.

Why does the Moon ring like a hollow sphere when a large object hits it? During the Apollo Moon missions, ascent stages of lunar modules as well as the spent third stages of rockets crashed onto the hard surface of the Moon. Each time, these caused the Moon to "ring like a gong or a bell," according to NASA. On the *Apollo 12* flight, reverberations lasted over an hour. Is the Moon hollow? Find out in Chap. 10.

Today, lunar scientists are quick to acknowledge that there is still much to learn about the Moon. In fact, lunar research is an active and healthy field of study. Researchers continually find new ways to dissect the Apollo samples and to interpret old results. A new generation of ever faster supercomputers makes it possible to simulate a wide range of conditions throughout the Moon's lifetime. But even with new ideas, new tools, and new talent, the Moon continues to hold tight to some of its oldest and most cherished secrets.

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