SPRINGER BRIEFS IN SPACE DEVELOPMENT

Anthony Young

The Apollo Lunar Samples

Collection Analysis and Results

INTERNATIONAL SPACE UNIVERSITY
isu

Springer

SpringerBriefs in Space Development

Series Editor

Joseph N. Pelton Jr., Arlington, USA

More information about this series at http://www.springer.com/series/10058

Anthony Young

The Apollo Lunar Samples

Collection Analysis and Results

INTERNATIONAL SPACE UNIVERSITY

Springer

Anthony Young
Orlando, FL, USA

ISSN 2191-8171 ISSN 2191-818X (electronic)
SpringerBriefs in Space Development
ISBN 978-1-4614-6184-5 ISBN 978-1-4614-6185-2 (eBook)
DOI 10.1007/978-1-4614-6185-2

Library of Congress Control Number: 2017931368

Printed on acid-free paper

This Praxis imprint is published by Springer Nature
The registered company is Springer Science+Business Media LLC
The registered company address is: 233 Spring Street, New York, NY 10013, U.S.A.

This Springer book is published in collaboration with the International Space University. At its central campus in Strasbourg, France, and at various locations around the world, the ISU provides graduate-level training to the future leaders of the global space community. The university offers a two-month Space Studies Program, a five-week Southern Hemisphere Program, a one-year Executive MBA and a one-year Master's program related to space science, space engineering, systems engineering, space policy and law, business and management, and space and society.

These programs give international graduate students and young space professionals the opportunity to learn while solving complex problems in an intercultural environment. Since its founding in 1987, the International Space University has graduated more than 3,000 students from 100 countries, creating an international network of professionals and leaders. ISU faculty and lecturers from around the world have published hundreds of books and articles on space exploration, applications, science, and development.

Preface

Project Apollo was an American geopolitical and technical response to the threat of Soviet Communism in the second half of the twentieth century. Apollo was the third of three human spaceflight programs conducted by the National Aeronautics and Space Administration (NASA). Project Mercury was NASA's first human spaceflight program to prove American capability to orbiting a single astronaut around the Earth; the Soviet Union had already proved that capability with its first cosmonaut Yuri Gagarin in 1961. NASA's Project Gemini followed using a larger capsule for two astronauts, extending their time in Earth orbit for up to two weeks, to prove the ability to rendezvous with another spacecraft. Project Apollo was the lunar landing program meant to beat the Soviets putting men on the surface of the Moon and then returning them safely back to Earth.

Project Apollo was unlike any national effort the United States had conducted in its history. Science was not the imperative of Project Apollo; American technical prowess and the superiority of the capitalistic system were the principal drivers. However, the collective science community in the nation's universities, corporations, and NASA's own research centers provided the impetus behind what the astronauts were to do while on the lunar surface. In the end, the scientific discoveries and the benefits of the multitude of technologies derived from Project Apollo are what are remembered today. America's national prestige was bolstered around the world, and Project Apollo actually created a collective common human bond that transcended borders and languages.

The essence of the Apollo lunar landing missions was sample collection and surface experimentation. However, lunar scientific research preceded the Apollo program and even President John Kennedy's famous address to Congress in 1961. Lunar probes were the essential precursors before astronauts could land and explore the Moon's plains, massifs, and curious rills. These NASA programs were Ranger, Surveyor, and Lunar Orbiter. These programs provided vital information that proved that spacecraft could land there and astronauts could indeed walk on its surface and aid in selecting the most desirable landing sites for exploration.

To achieve the scientific goals of Project Apollo, virtually every piece of hardware had to be designed from a clean sheet of paper. These included the sampling tools and procedure for sample collection and storage and preservation for return to Earth. A Lunar Receiving Laboratory had to be designed and built to examine, test, and publish the findings. Numerous institutions outside of NASA competed for the privilege of conducting research on the lunar samples.

Terrestrial geologic training had to be conducted for the astronauts to know how to properly identify the samples while on the lunar surface. For the first several Apollo landing missions, rudimentary sample collection of loose soil, rocks, and core samples was all there was time for. On Apollo 14, there was an astronaut-pulled tool and sample-carrying cart. However, something far better and more productive was being designed and developed to help the astronauts with their surface tasks and mission.

A separate lunar rover program was begun to give the astronauts a vehicle that would permit them to travel many kilometers from the landing site and expand their scope of exploration, sampling, and photography. In addition, the LRV had a sophisticated tool carrier to secure the tongs, scoop, hammer, drill, and core tubes, as well as sample-carrying and storage areas. All lunar samples were stored in the Lunar Sample Return Container which was then placed inside the lunar module and ultimately transferred to the Command Module for return to Earth.

While the returning Apollo astronauts embarked on tours and speaking engagements, their precious lunar samples were delivered to the Lunar Receiving Laboratory in Houston, Texas, and were sorted, cataloged, and stored for detailed examination. Each sample had a story to tell of the history of the Moon and its formation and even the history of the solar system itself.

Examination of the Apollo lunar samples has continued for many years since the end of the Apollo program. It is with a profound sense of wonder that a scientist with a lifespan of but 80 years can look upon a lunar sample more than four billion years old.

There is a vast body of printed material covering all aspects of the Apollo program. Many peer-reviewed technical papers have been published on the lunar samples. Most of the findings written in these papers are pure science of greatest interest to fellow scientists and researchers. In this book I have striven to present the Apollo lunar samples' story of greatest interest to the lay reader. With regard to the Apollo lunar surface missions, I have confined myself to mission timelines specific to sample collection and voice transcripts supporting that.

Orlando, FL, USA Anthony Young
October 2016

Contents

Chapter 1
Lunar Probes Pave the Way

The Soviet Union dominated the scientific and human spaceflight events of the late 1950s and early 1960s. The United States always seemed to be trying to catch up and surpass the Soviets in their space accomplishments. Eventually, the United States did indeed get behind an agenda to beat Russia in this newest phase of the Cold War. In the early years, however, the Soviet Union basked in its great scientific and human spaceflight achievements.

In January 1959, a massive Russian R-7 rocket lifted off with the first scientific probe to be sent toward the Moon. The first of the Luna probes was intended to impact on the lunar surface. Orbital mechanics were still in their infancy, and Luna 1 missed the Moon by 5,000 km. The second Luna probe impacted near the crater Autolycus. In October of 1959, a third Soviet probe succeeded in orbiting the Moon, and its onboard camera took pictures of the far side. A rocket engine fired to break Luna 3 from the Moon's gravity, and the probe was returned to Earth. The probe's small capsule was recovered, the film developed and the crude images were broadcast around the world. This successful mission said more about the Soviet Union's engineering and scientific capability than it did about the state of the Moon's never-before-seen far side. Other Russian probes followed well into the 1960s.

In December of the same year the Luna program began, 1959, NASA started its Ranger program. NASA's Jet Propulsion Laboratory (JPL) would handle the engineering and manufacture of America's first lunar probe. Ranger could be considered a remote observation probe of the Moon. It embraced several key emerging technologies, including solar power of the probe, flight propulsion and stabilization. A series of Ranger probes would have increasing levels of technology and scientific capability.

In less than 18 months the first Ranger probe was ready and sent to Cape Canaveral Air Force Station in Florida. It was secured inside an Agena upper stage payload fairing to be launched by an Atlas D rocket. The Agena upper stage proved very problematic for the Ranger program. The first Ranger launched in August 1961 and the second launched in November experienced failed Agena stages.

A. Young, *The Apollo Lunar Samples*, SpringerBriefs in Space Development,
DOI 10.1007/978-1-4614-6185-2_1

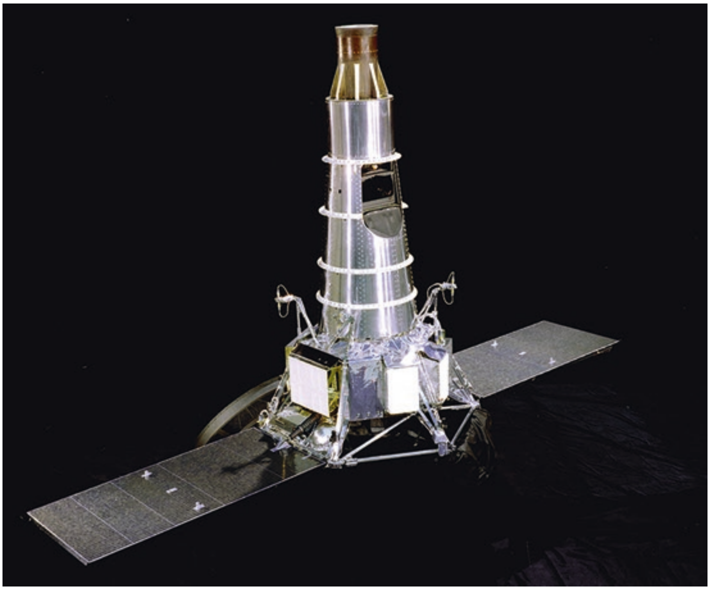

Fig. 1.1 After a series of spacecraft and launch vehicle failures, Ranger 7 was able to return the first images of the lunar surface from a probe. (NASA)

JPL moved forward with construction of its Block II Ranger probes. The third probe, launched in January 1962, missed the Moon. Four months later Ranger 4 was launched; the TV camera failed to function, and it impacted on the Moon without providing images. Ranger 5, launched in October 1962, also missed its target completely. The Ranger team at JPL was discouraged, and some feared the program would be canceled. The team was further demoralized with the failure of the TV camera on Ranger 6, in which no images were recorded during its approach to Mare Tranquilitatis.

Finally, with Ranger 7, there was success. Launched in July 1964, Ranger 7 had six functioning TV cameras, and JPL engineers were thrilled to see high resolution images on their monitors as the probe approached the Moon. Its target was Mare Nubium, near the crater Copernicus. Image resolution was so good, in fact, that scientists could discern boulders on the lunar surface. This fact undermined the theory that the surface of the Moon was comprised of one to several meters of dust, which would make a landing there impossible. This added impetus to the Surveyor project probes that would soon soft-land on the surface.

Ranger 8 was launched in February 1965 and was successfully sent on a trajectory that would impact in Mare Tranquillitatis, which would become famous as the landing site of Apollo 11. The TV cameras performed to perfection, and the images contributed to understanding of the formation of the lava flows that made up the mare, as well as the ejecta from the craters within the mare basin. Ranger 9, the last probe of the project, launched in March of that year, was targeted for the massive

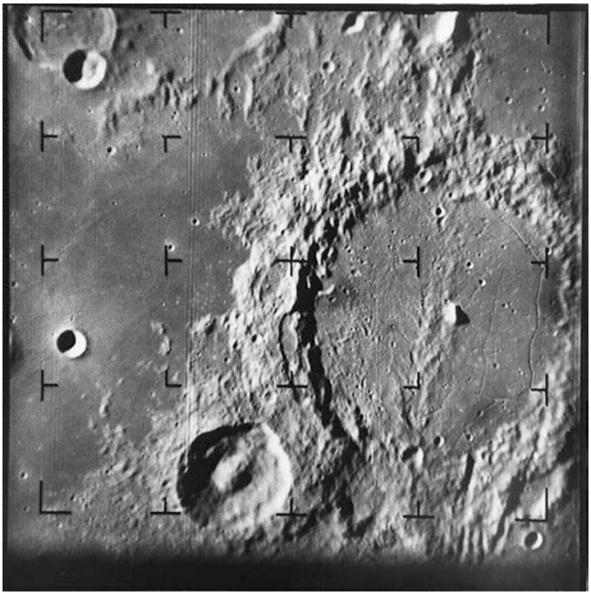

Fig. 1.2 Ranger 9 photographed Alphonsus Crater in the Mare Nubium basin. (NASA)

crater Alphonsus. It sent back nearly 6,000 images. In total, Rangers 7, 8 and 9 returned over 17,000 images of the lunar surface, having resolution that significantly increased knowledge of lunar surface feature creation and characteristics.

The Brilliant Machines: The Surveyor Soft Landers

NASA initiated another lunar probe program long before President John Kennedy made his historic speech before Congress in May 1961. As such, the Surveyor program was fortuitous in ultimately providing information about the Moon and its surface that would prove invaluable for the Apollo program. NASA again approached JPL in the spring of 1960 to initiate and manage the development of a lunar soft-landing probe. It was conceived as strictly a scientific probe, but was later adopted in support of Apollo.

JPL conducted its first studies on mission objectives, design constraints and feasibility shortly after getting the NASA directive. It was given the name Surveyor. Evaluating several aerospace firms to perform design development and construction of Surveyor, JPL selected the Hughes Aircraft Company in Los Angeles. However, the Surveyor program did not get off to a good start. For one thing, it was hampered by the need for the development of a more powerful upper stage to get the Surveyor craft to the Moon. The projected weight of Surveyor precluded the use of the Agena upper stage. The new upper stage was the Centaur. The Atlas-Centaur was actually