C. APOLLO MISSIONS PROGRESS

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INTRODUCTORY REMARKS: THE APOLLO 14 MISSION

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Abstract. To set the context of our current exploration of the Moon, it is well to recall: Apollo 11 landed near the equator and was capable of affording the astronauts only a few hours on the lunar surface; Apollo 12 checked out pin-point landing which then permitted going to more difficult, non-equatorial sites; in Apollo 14 enlarged propellant tanks permitted some 42 kg of samples to be brought back. Three more Apollo missions follow Apollo 14. The Apollo missions, complemented by unmanned missions to the various planets, form a program to explore the solar system.

Captain Scherer will elaborate on the significant increase in Apollo capability in the last three missions. Of note are the lunar heat flow experiments, the lunar surface gravimeter, and, for Apollo 15, the laser ranging retroreflector which will be three times the area of and four times as efficient as retroreflectors in the previous Apollo missions. In the lunar orbital equipment will be the sub-satellite with instruments for measuring various physical properties of the Moon and its environment. Also noteworthy is the lunar sounder, for Apollo 17, which will use radar for probing a large fraction of the lunar surface to considerable depth.

Hardware changes will allow the astronauts to remain on the lunar surface for up to 66 hrs – an increase of 100%; thus the landed scientific payload may be doubled to approximately 550 kg. Increased range and efficiency of surface operations will result from improved suit mobility, an improved life support system, and a Lunar Roving Vehicle capable of up to 90 km traverses. Changes in the Command and Service Modules will allow for up to 16 days total flight duration.

We will again welcome proposals for analysis of the new samples, but now that the initial exploratory work has been done we intend to be far less duplicative in choosing proposals to support. We are particularly pleased with the growing attention being given by the scientific societies to the results of lunar research.

In the last talk of this series, Mr. Burke will describe some of the future possibilities that have been studied for exploration of the Moon and planets. We will particularly welcome suggestions as to how to improve the value of future missions.

My remarks are intended to be introductory to the more detailed presentations to follow. After my remarks, Captain Lee Scherer, Director, Apollo Lunar Exploration Office, NASA, will discuss the Apollo 14 mission and some of the results. Peter Armitage, Manager, Lunar Receiving Laboratory, NASA Manned Spacecraft Center, will then give some of the results on the examination of the Apollo 14 rocks by the Preliminary Evaluation Team. Then Lee Scherer will return to discuss the remaining Apollo missions. After that, J. D. Burke, Manager, Advanced Technical Studies, Jet Propulsion Laboratory, will peer into the future beyond any currently approved projects or missions.

To set the context of our current exploration of the Moon, it is well to recall a few facts about the earlier missions. Apollo 11 landed on Mare Tranquillitatis near the equator, and was capable of only a limited stay affording the astronauts only a few hours on the lunar surface. Apollo 12, in landing on Oceanus Procellarum, checked out pin-point landing, the success of which then permitted going to more difficult, non-mare, non-equatorial sites on later flights. Also, during the Apollo 12 mission it was observed that the consumables carried by the portable life support system would permit longer extravehicular activities (EVA's) than original appropriately conservative estimates had planned.

Urey and Runcorn (eds.), The Moon, 75–80.

TABLE I

Assignment of approved lunar surface experiments

	Experiment or instrument	Principal investigator	Apollo 11	12	13	14	15	16	17
	Lunar geology investigation	Shoemaker/USGS	A	A					
		Swan/USGS			X	A	A		
		Muehlberger/U. of Texas						A	A
	Laser ranging retro-reflector	Alley/U. of Md.	A						
		Faller/Wesleyan, Mass.				A	A		
	Cosmic ray detector	Fleischer/GE.	A					A	
		Walker/Wash. U. at St. Louis							
		Price/UCLA							
	Lunar surface close-up stereo photo	Gold/Cornell	A	A	X				
	Portable magnetometer	Dyal/ARC				A		A	
	Lunar gravity traverse	Talwani/Columbia							A
	Soil mechanics	Mitchell/U. of Cal., Berkeley				A	A	A	A
	Far UV camera spectroscope	Carruthers/NRL						A	
	Surface electrical properties	Simmons/MSC							A
	Solar wind composition	Geiss/Berne Univ.	A	A	X	A			
	Lunar passive seismology	Latham/Columbia	A	A	X	A	A	A	[a]
	Lunar active seismology	Kovach/Stanford				A		A	
	Lunar tri-axis magnetometer	Dyal/ARC		A			A	A	
	Medium energy solar wind	Snyder/JPL		A			A		
	Suprathermal ion detector	Freeman/Rice		A		A	A		
ALSEP	Lunar heat flow (with drill)	Langseth/Columbia			X		A	A	A
	Cold cathode ionization gauge	Johnson/U. of Texas (Dallas)		A	X	A	A		
	Lunar ejecta and meteorites	Berg/GSFC							A
	Lunar seismic profiling	Kovach/Stanford							A
	Lunar atmos. composition	Hoffman/U. of Texas (Dallas)							A
	Lunar surface gravimeter	Weber/U. of Maryland							A[a]
	Charged particle-lunar environment	O'Brien/U. of Sidney, Australia			X	A			

A – Assigned
X – Aborted
[a] Lunar passive seismology may be substituted for lunar surface gravimeter

TABLE II

Assignment of approved lunar orbital, in-flight, and pre- and post-flight experiments

Experiment or instrument	Principal investigator	Apollo 13	14	15	16	17
Gamma-ray spectrometer	Arnold/U. of Sal. SD			A	A	
X-Ray fluorescence	Adler/GSFC			A	A	
Alpha particle spectrometer	Gorenstein/Am. Sci. and Eng.			A	A	
S-band transponder (CSM/LM)	Sjogren/JPL	X	A	A	A	A
Mass spectrometer	Hoffman/U. of Texas (Dallas)			A	A	
Far UV spectrometer	Fastie/Johns Hopkins					A
Bistatic radar	Howard/Stanford	X	A	A		
IR scanning radiometer	Low/Rice					A
Apollo window meteoroid	Cour-Palis/MSC			A		
UV Photography – Earth and Moon	Owen/IITRI			A	A	
Gegenschein from lunar orbit	Dunkelman/GSFC			A		
Lunar sounder	Brown/JPL Ward/U. of Utah					A
Bone mineral measurement	Vogel/USPHS San Fran.			A	A	A
Total body gamma spectrometry	Benson/MSC			A*	A*	A*
Subsatellite:						
S-band transponder	Sjogren/JPL			A		A
Particle shadows/boundary layer	Anderson/U. of Cal., Berkeley			A		A
Subsatellite magnetometer	Coleman/UCLA			A		A

X – Aborted
A – Assigned
A*– Assigned pending elimination of quarantine requirements

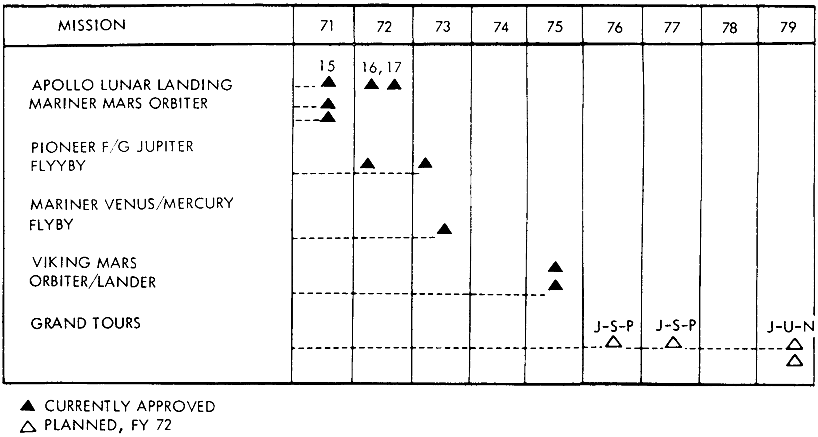

Fig. 1. Lunar and planetary missions. The currently approved missions to the Moon and the planets are indicated by the solid triangles. New missions included in the FY 1972 budget request are indicated by open triangles.

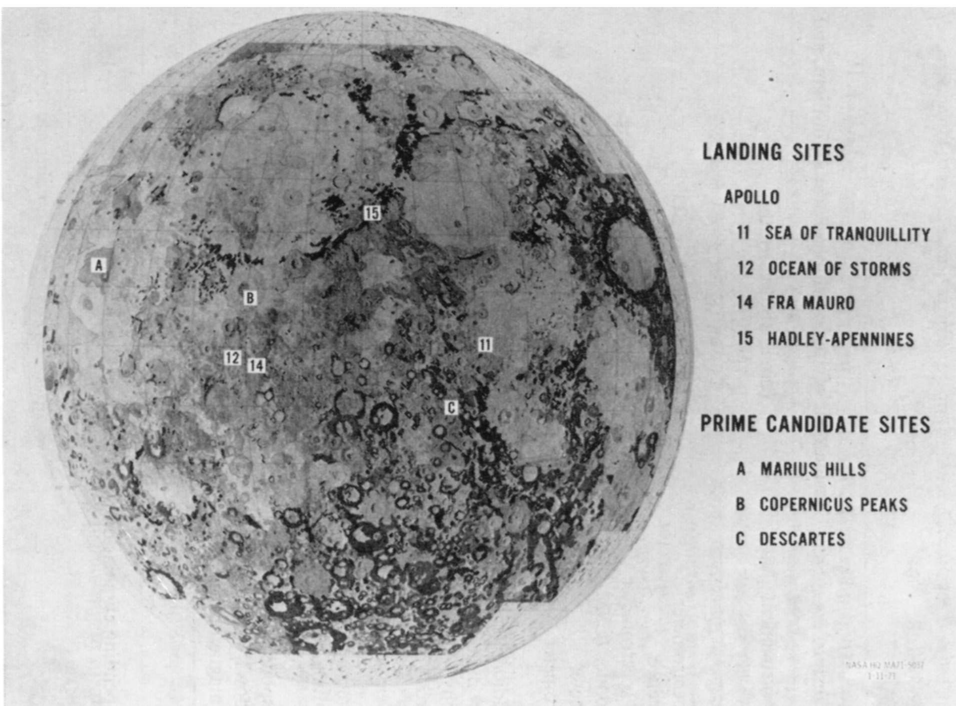

Fig. 2. Geologic map of the Moon with landing sites. Shown are the landing areas for Apollo missions that have been accomplished and candidate sites for the remainder of the Apollo flights. Some of the candidate sites for future missions are: Marius Hills, Copernicus, Hadley/Apennines, and Descartes (NASA Hq MA 71-5037).

Thus, in Apollo 14, which has just been completed, returning safely to Earth on 9 February 1971, more EVA time was achieved. In addition, enlarged propellant tanks permitted a larger payload, and some 42 kg of psamles were brought back.

The completion of the Apollo 14 mission leaves three more Apollo missions to the Moon as shown in Figure 1. The window for Apollo 15 runs from 7–26 July 1971;

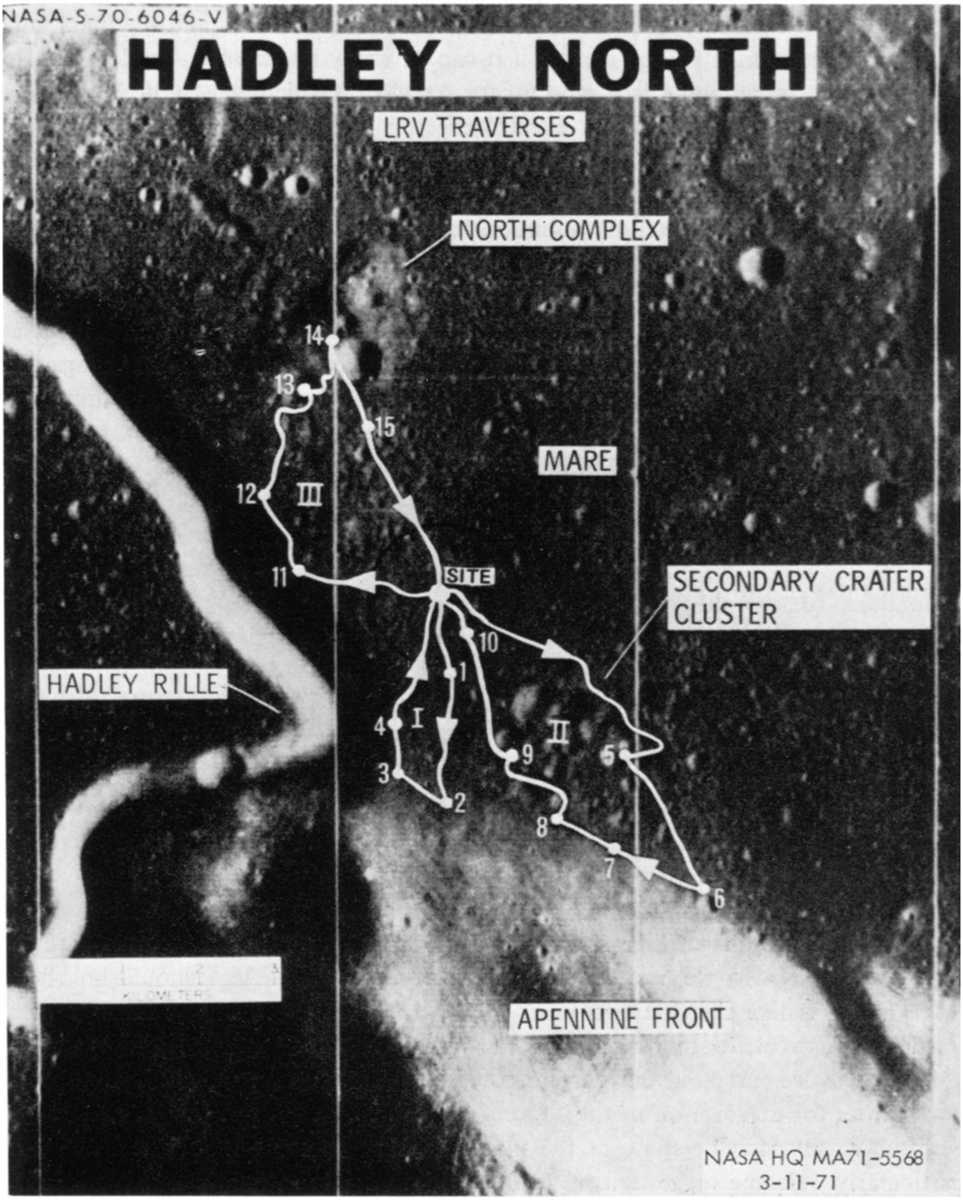

Fig. 3. **Hadley/Apennines. The chosen lunar landing site** for Apollo 15 (NASA Hq MA 71-5568).

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Apollo 16 and 17 are scheduled for 1972. As may be seen from Figure 1, the Apollo missions form part of a program to explore the solar system, being complemented by a number of unmanned missions to the various planets.

As Captain Scherer will elaborate in his second talk, there will be a significant increase in Apollo capability in the last three missions. The instruments to be carried or experiments planned are shown in Tables I and II. Of particular note are the lunar heat flow experiments, in which it is planned to drill three meters into the lunar surface and insert thermocouples for lunar heat flow measurements, and the lunar surface gravimeter which will be carried if it can be ready in time for Apollo 17. Also of note is the laser ranging retroreflector for Apollo 15, which will be three times the area of and four times as efficient as retroreflectors in the previous Apollo missions. Of particular interest in the lunar orbital equipment will be the subsatellite which will carry instruments for measuring various physical properties of the Moon and its environment. Also the lunar sounder, for Apollo 17, which will use radar for probing a large fraction of the lunar surface to considerable depth, is worthy of note.

Changes in hardware will allow the astronauts to remain on the lunar surface for up to 66 hr – an increase of 100%; furthermore, these changes will allow the landed scientific payload to be doubled to approximately 550 kg. Increased range and efficiency of surface operations will result from improved suit mobility, an improved life support system, and a Lunar Roving Vehicle capable of up to 90 km traverses. Changes in the Command and Service Modules will allow for up to 16 days total flight duration.

Candidate landing sites for future missions are shown in Figure 2. We are planning to target Apollo 15 for an area in the vicinity of the Hadley Rille and the Apennine Mountains, some of the features of which can be seen on the Lunar Orbiter photo of Figure 3. Sites for Apollos 16 and 17, however, are yet to be determined.

All three of these missions will, of course, bring back additional lunar samples. We are open to suggestions as to what the astronauts should especially look for, particularly those that investigations of previous samples indicate will be especially illuminating. We will again welcome proposals for analysis of the new samples, but now that the initial exploratory work has been done with the samples from Apollos 11, 12, and 14, we intend to be much more selective, and far less duplicative, in choosing proposals to support.

We are particularly pleased with the growing attention being given by the scientific societies to the results of lunar research, as in this series of meetings sponsored by the I.A.U. In NASA we have raised the question whether NASA should hold any more meetings like the first two lunar symposia in Houston, or should now look to the various societies to sponsor and organize future sessions.

Finally, as we carry out our current program, we are continually studying future possibilities for exploration of the Moon and planets. In the last talk of this series, Mr Burke will describe some of the possibilities that have been studied. We will particularly welcome suggestions as to how to improve the value of future missions.