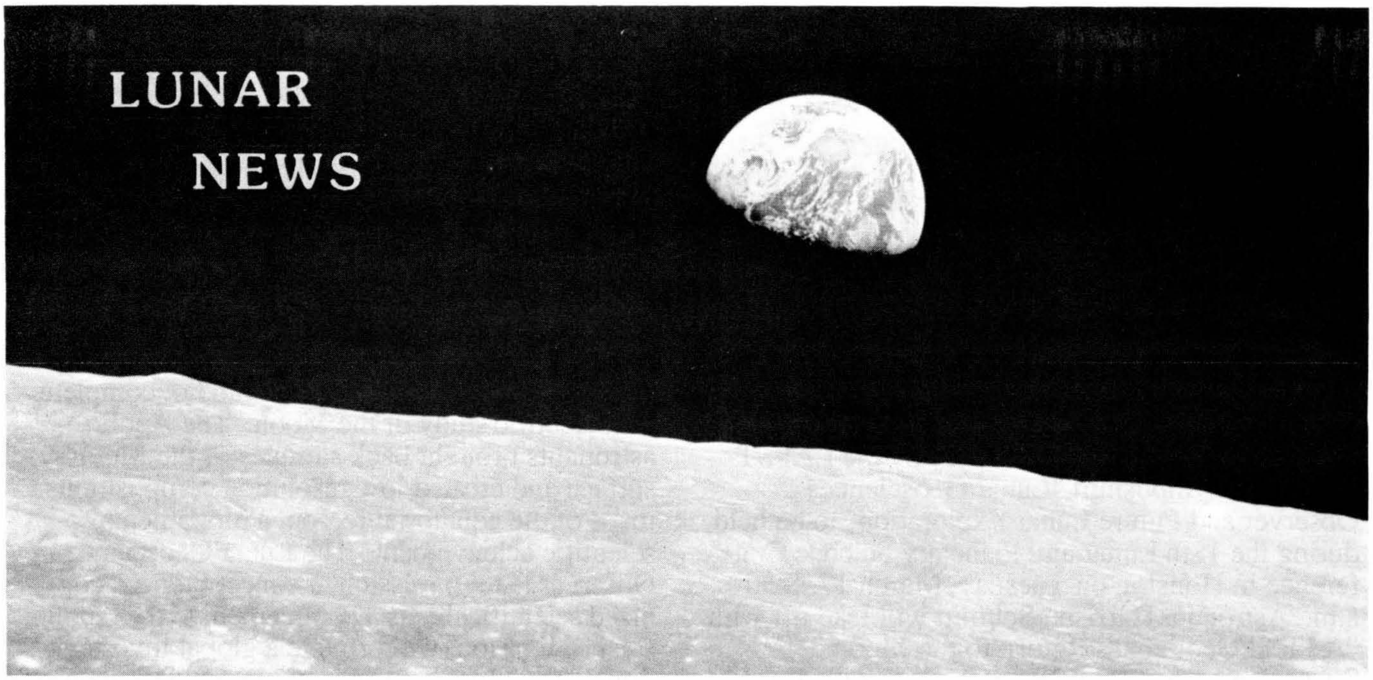

NEW REPORT ON LUNAR GEOSCIENCE NOW AVAILABLE

Paul Spudis
U.S.G.S., Flagstaff

A new NASA Special Publication, "The Status and Future of Lunar Geoscience" (SP-484) by the Lunar Geoscience Working Group is now available from the U.S. Government Printing Office. The 54-page booklet is profusely illustrated with over 25 black/white and color illustrations.

The report both reviews our current knowledge of the geologic history of and processes operating on the Moon and discusses research directions in lunar science that are likely to be productive in the future. Among the topics of current understanding that are discussed are surface and geologic processes, the crust, mantle, and core of the Moon, and global properties, including lunar origin. The future of lunar geoscience section reviews topics that may be profitably studied with existing and easily obtainable new data, potential new unmanned missions including the Lunar Geoscience Observer, a global geophysical net and sample returners, and ultimately the establishment of a permanent human presence on the Moon, including surface sorties, extended traverses and a lunar base.

This document could serve as an introduction to lunar geoscience for graduate students and planetary scientists in other disciplines as well as a general review of our current knowledge of the Moon. An extensive bibliography provides access to the widely scattered lunar literature in a number of specific subdisciplines and related topics.

LUNAR NEWS NO. 48 SPRING 1987

CONTENTS:

LUNAR GEOSCIENCES OBSERVER AND FUTURE LUNAR EXPLORATION

Jeff Taylor
University of New Mexico

What major unsolved problems remain in lunar science? What is the next step in our exploration of the Moon? How does it contribute to solving those problems? What is the likely progression in lunar exploration?

These are the questions addressed by the LAPST-sponsored symposium "Lunar Geosciences Observer and Future Lunar Exploration" to be held during the 18th Lunar and Planetary Science Conference in Houston on Tuesday, March 17, 8:30 a.m. Astronaut Harrison Schmitt will lead off with "A Field Geologist's Return to the Moon." F. M. Sturms and other scientists will discuss the Lunar Geosciences Observer mission and instruments. Noted lunar scientists (M. J. Drake, G. J. Taylor, L. L. Hood, and others) will focus on unsolved problems in lunar science and the contributions of LGO to their solution. L. A. Haskin and K. O. Fairchild will look further into the future and consider resources and science experiments which might be involved in a permanent lunar habitation. Join us for a morning of reflection and speculation.

Topics will include: A Field Geologist's Return to the Moon; Lunar Geoscience Observer Mission Overview; Lunar Geoscience Orbiter and the Origin of the Moon; The Lunar Geoscience Observer's Role in Unraveling the Magmatic Evolution of the Moon; Surface Processes; Contributions of an LGO Mission to the Solution of Lunar Geophysical Issues; Toward Geochemical Prospecting for Lunar Ores; The Use of Basin Ejecta to Determine Lunar Crustal Structure and Composition: Current Models and LGO Contributions; Stratigraphy and Evolution of the Lunar Highland Crust: A Sampling of Vertical and Regional Heterogeneities; Design and Engineering of Lunar Science Experiments: The Importance of Getting an Early Start; Coupled Neutron/Gamma-Ray Spectroscopy from Lunar Orbit; and Laser Altimetry in Planetary Geology. Poster presentation will include LGO Mission and Science Summary and Lunar Geoscience Observer Spacecraft.

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LGO - THE U.S. RETURNS TO THE MOON

R.A. Wallace
Jet Propulsion Laboratory

Introduction:

It's been a long time since Apollo 17 left the Moon, some 14 years. Although highly successful in every way, the Apollo program did not complete the scientific study of the Moon. The Apollo astronauts brought back samples of the Moon's surface and created low resolution composition maps of the equatorial region, a monumental scientific achievement. The Lunar Geoscience Observer (LGO) mission, a concept long recognized scientifically as a complement to the Apollo science mission, will provide a global investigation of the Moon's surface composition, topography, and gravitational/magnetic fields. Coupled with results from the Apollo mission, the LGO mission expects to answer a couple of popular and intriguing questions about our nearest neighbor in space - what's the Moon made of, and how did it get there? Some of a long list of questions we hope to answer with the LGO mission are:

- What is the global mineral and elemental composition?
- Does the Moon have a metallic core?
- Is there water at the poles?
- What is the bulk composition of the Moon, what constraints does this put on the Moon's origin?
- What does the evolution of the Moon have to tell us about the evolution of other planets?

Mission Perspective:

The LGO mission is being planned as the second in the series of Planetary Observer missions sponsored by NASA's Planetary Exploration Program. The Planetary Observer missions will allow investigations of focused, high priority scientific objectives at planetary targets, utilizing low-cost spacecraft derived from Earth orbiters. The Mars Observer mission, managed by Jet Propulsion Laboratory (JPL), is the first in the Planetary Observer series with launch in August 1990; RCA is building the Mars Observer spacecraft. The LGO mission is currently in the advanced mission definition phase. An LGO Project New Start is being suggested for Fiscal Year 1989.

The LGO mission concept was selected by the NASA Headquarters Solar System Exploration Management Committee (SSEMC) in February 1986 as the next Planetary Observer mission after the Mars Observer. Some of the favorable mission qualities guiding the SSEMC in its recommendation for a Lunar mission are:

1. Excellent science return, building on previous missions to the Moon and establishing a ground truth basis for comparative planetology.
2. Most like the Mars Observer mission in its science and flight operations - low altitude circular mapping orbit.
3. Monthly launch opportunities.
4. Very short flight to target with one year standard mission.
5. Launch vehicle selection flexibility (low launch energy requirements).
6. Use of an Earth orbiter spacecraft design at Earth distance from the Sun.
7. Telecommunication ease and flexibility with the existing telecommunication ground system.

Science Objectives and Payload:

The primary scientific objectives of the LGO mission are:

1. To map the global, regional, and local geochemical composition of the surface of the Moon.
2. To determine the internal geophysical structure of the Moon on a global scale.
3. To survey the Moon's surface for locations of useful resources, including frozen volatiles at the poles, and safe sites for a lunar base.

The strawman science instrument payload defined by the 1986 LGO Science Workshop consists of:

- Visual and infrared mapping spectrometer (VIMS)
- Gamma-ray spectrometer (GRS)
- X-ray spectrometer (XRS)
- Radar altimeter (Alt)
- Magnetometer (Mag)
- Electron reflectometer (ER)
- High resolution solid state imager (HRSSI)
- Geodesic imager (GSSI)
- Microwave radiometer (MRAD)
- Thermal infrared mapping spectrometer (TIMS)
- Spacecraft gravity system (SGS)

Four of these instruments provide the capability to map the surface geochemical composition: the XRS and GRS for elements, and the VIMS and TIMS for minerals. The Mars Observer Thermal Emission Spectrometer (TES) is considered an acceptable alternate for the LGO recommended TIMS. An imaging capability is required to place the geochemical data in a geological context and to provide for geodesic control. The altimeter and a doppler-tracking gravity experiment are key geophysical requirements for extrapolating surface geochemical results throughout the whole lunar crust. Likewise, the magnetometer and electron reflectometer are required to determine the Moon's internal core structure, the MRAD to map surface heat flow and determine bulk uranium content, and an SGS to measure farside gravity.

In comparing the above instruments with the payload selected for Mars Observer it appears that all of the instrument capabilities except the XRS, MRAD, ER, and SGS can be met with the instruments selected for the Mars Observer mission. A derivation of the Mars Observer camera could be used with suitable changes in focal length and other adjustments. The XRS can be combined with the GRS and share some common electronics. The MRAD and ER would have to be added, but could replace the Mars Observer pressure modulated radiometer.

"Lunar News" is produced three times a year by the Planetary Materials Branch of the Solar System Exploration Division, Johnson Space Center of the National Aeronautics and Space Administration. "Lunar News" is intended to be a forum for discussion of facts and opinions regarding lunar sample study, Lunar Geochemical Orbiter and Lunar Base activities. It is sent free to a mailing list of more than 700 individuals; to be included on the mailing list, write to the address below. Your contributions to "Lunar News" on topics relating to the study, exploration and utilization of the Moon and comments about "Lunar News" and material appearing in it should be sent to:

Doug Blanchard, Lunar Sample Curator
Code SN2, NASA JSC
Houston, TX 77058

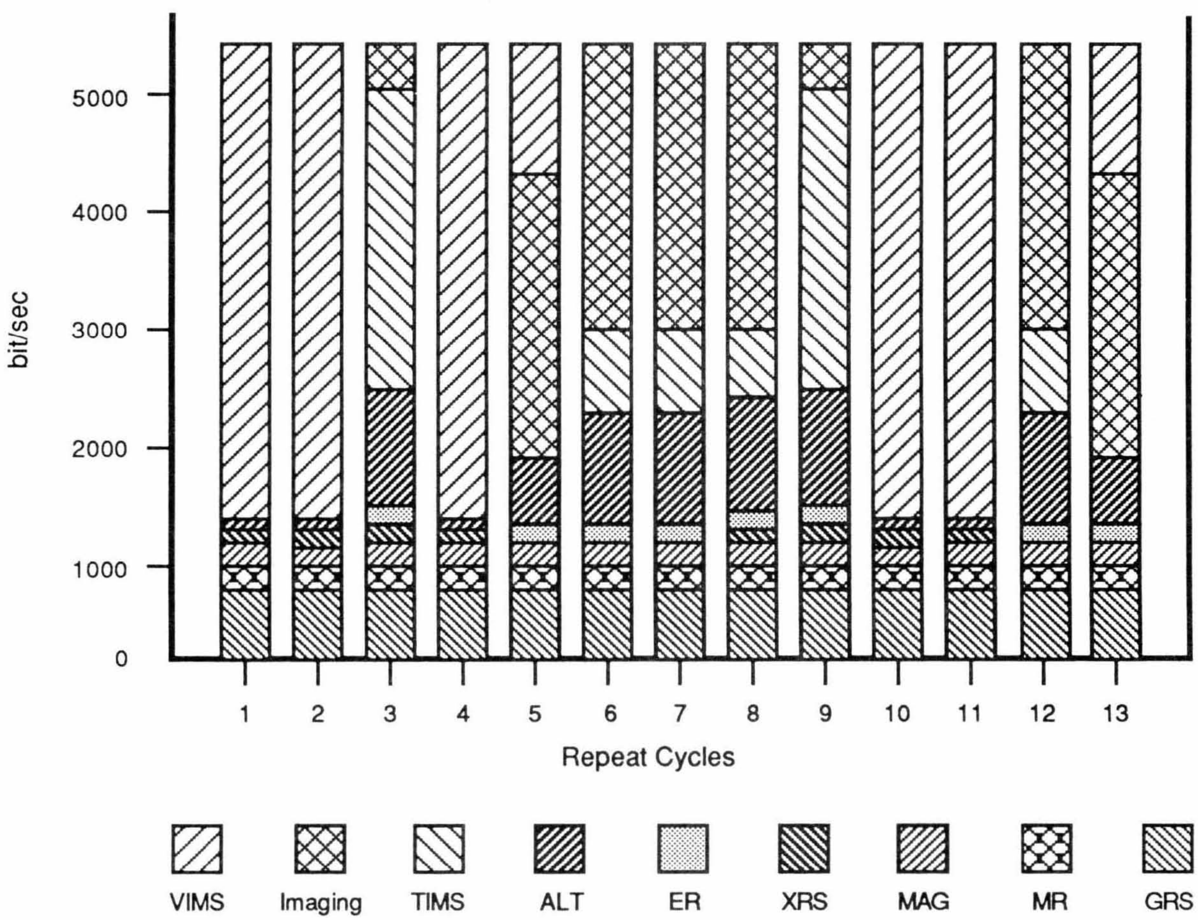
Mission Operations:

The LGO mission operations will resemble the Mars Observer mission operations more than any other Planetary Observer mission candidate. Both are low altitude polar orbiters with repetitive/continuous science operations and global mapping coverage objectives. Both have an intial gravity-field determination phase followed by the main mission of global science acquisition. The initial LGO phase to establish an effective gravity model is currently estimated to last about 30 to 45 days.

The strawman strategy for the first LGO operations phase is to use the Spacecraft Gravity System (SGS) in association with the radar altimeter to determine the lunar gravity field to the level of accuracy required for the subsequent mapping mission. The system incorporates an antenna on the spacecraft with an associated 8 GHz transmitter/receiver and one or more passive corner reflectors which are separated from the spacecraft by about 100 to 200 km in the same orbit. The spacecraft tracks the corner reflector, and the Doppler tracking data are recorded and sent to the ground for processing. The number of reflectors required could be as many as three while the length of time to achieve a sufficiently precise lunar gravity field model may be as long as 45 days. There is the possibility of using other spacecraft for relay - including those launched by other countries.

The last LGO science return strategy was designed before the selection of the Mars Observer spacecraft and science in 1986. The 1985 LGO Science Workshop did provide recommendations to the JPL Planetary Observer Planning Team, and a strawman data allocation was generated for each of the 13 cycles (about one year of mission time) of lunar coverage. As would be expected, this allocation is driven by the VIMS and imaging instruments. Although the 1985 strawman allocation is

1985 STRAWMAN DATA ALLOCATION



based on a 1985 hypothesized spacecraft with a six kbps record rate, it does indicate the quality of science possible with the LGO mission.

The above data allocation permits one VIMS global map, two XRS global maps, and a geodesy network from six cycles of two frames per orbit (potentially a 4 deg. by 4 deg. network).

From the above one can see that the LGO operations will be exciting. An important characteristic of the LGO mission is that so much can be achieved with relatively modest expense, particularly so if the Mars Observer system (a second spacecraft and the existing ground system) can be used with minimal modifications.

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SPACE RESOURCES

David Vaniman
Los Alamos National Laboratory

On January 28-30 a workshop on In-Situ Resources Utilization was held in Orlando, Florida. The workshop was sponsored by NASA, the Large Scale Programs Institute (Austin, Texas), Los Alamos National Laboratory, and the Jet Propulsion Laboratory. Participants in the workshop were evenly divided between people with strong backgrounds and perhaps vested interests in the space program, and people from the private sector with experience and knowledge important to space development but without previous participation. The purpose of the workshop was to explore the means by which the established space development community might grow by the active participation of private industries other than the established aerospace companies.

For the first two days, participants were divided into five working groups. The first four working groups (prospecting, mining and surface transportation; materials processing; life support and services; and construction, assembly, and robotics) addressed the major components of systems for using lunar, Martian, and asteroidal resources. The moons of Mars, Phobos, and Deimos were considered separately from the free-orbiting asteroids. The fifth working group concentrated on innovative ventures and the need to keep space development open to new materials, procedures, and concepts.

The final day of the workshop was spent in a plenary session which allowed all of the working groups to compare their findings. Detailed discussions of resource availability, energy requirements, products, and markets with lists of major concerns and unknowns will be published later. However, two major conclusions were reached by all working groups. First, an integrated systems evaluation is needed for the use of space resources. The system components of materials availability, power requirements, and processing procedures need to be integrated. Proof is also needed of procedure practicality and of the utility of the products made. Moreover, the use of by-products and recycling of waste must be maximized. Second, NASA should develop a stable long-term program that will encourage participation by the private sector. For successful space exploration and for the health of the nation, the malaise of short-sighted goals must be cured.

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THE JOY OF CATALOGING

Graham Ryder
Lunar and Planetary Institute

Any kind of analysis of lunar samples requires knowing what appropriate samples there are, and what analyses have already been done on them. For the potential analyst, the most efficient way to acquire this information would be to have documents that list lunar samples, classify them, and describe previous work on them. Such documents have been produced and continue to be produced by the Planetary Materials Branch at JSC. They have not been produced as a continuous, logical series. Instead they have been produced for varied purposes, have been organized in varied formats, and have had differing levels of detail and inclusiveness.

As a reflection of their scope, such documents have different names such as Handbooks, Catalogs, Information Catalogs, and Guidebooks; some have no distinct name at all. All documents of this type go out of date in some aspects almost as soon as they are produced. Although many of these have been called catalogs, that is a somewhat arbitrary term, which does however reflect the normal internal numerical organization of the samples. For the level of inclusiveness of some of them, catalog is perhaps a misleading, almost derogatory, term. Compendium does not fit the bill either, so catalog is retained as a general term here. A list of those produced is available from the Planetary Materials Branch.

The original publicly available documents (as opposed to curatorial processing records) were called Information Catalogs. Produced a few months after each mission following preliminary examination, they listed the samples and their masses, and gave brief descriptions and photographs of their macroscopic characteristics; some petrographic and chemical characteristics were available in rare cases. Naturally these catalogs were never intended to provide accurate classifications and descriptions of the samples in anything much more than their masses, sample locations, and general appearance. Subsequent information research on samples has not consistently tracked back into the curatorial records, such as computer-filed generic and split listings. Varied cataloging updates have been made, such as Apollo 14 Rock Samples (Carlson et al. 1978), Handbook of Lunar Soils (Morris et al. 1983), and the Catalog of Apollo 15 Rocks (Ryder, 1985). Most of these updates have been mission and general sample type (i.e., rock or regolith) oriented. Most have not attempted to be completely comprehensive in description or referencing.

Catalogs have a planned obsolescence: they are intended to spur further research by making it easier to see what remains to be known about samples. As the same time they provide an encyclopedia for simply learning about the collection and the Moon; for many samples, much of the work which will ever be done on them has been done, and was done before 1980. So catalogs have at least a bifaceted importance, and while they may become out of date for some samples, they will retain their overall usefulness for a long period. There is a further importance from the actual production of a catalog; those producing it look in detail at sample suites as a whole, in many cases for the first time. For the Catalog of Apollo 15 Rocks, for instance, it was necessary for me to find and read (and attempt to understand) all references to the rocks, including their sampling locations and geological context; inspect the curatorial documentation on sample processing, dissection, and allocation; and inspect samples both macroscopically and microscopically. Thus I was able to relate analyses to each other in a way which most analysts had never been able to do and which was not possible from published literature alone. This understanding of the relationships among various analyses is fundamentally useful for complex samples such as highlands breccias, but is also helpful even for homogeneous samples such as mare basalts.

There are several gaps in the cataloging effort, which is made as circumstances (i.e., time, personnel) permit. There has never been an update of the Apollo 12 Information Catalog, nor of the Apollo 17 Information Catalog. Both of these are deemed desirable efforts. Last year, LAPST concluded that the highest priority lay with a comprehensive catalog of the highlands rocks from Apollo 17. Therefore I am now working on compiling a catalog of rocks (i.e., individually numbered rock and rake samples) from the Apollo 17 highlands stations. However, a companion volume on rocks from the mare stations is also desirable. Given the simpler nature of the rocks in the mare sites, such an effort relies much less on the curatorial facility records than the highlands catalog, and someone at another institution could produce the catalog with some time spent in Houston. Volunteers are encouraged. While compiling references for the highlands rocks, I am finding it efficient to compile those for the mare stations too (especially as so many papers include data for both mare and highlands rocks). On completion this reference compilation could be made available to anyone willing to catalog the rocks from the mare stations. A volunteer to catalog the Apollo 12 rocks, or rocks and regoliths, is also encouraged. The Apollo 12 collection is much smaller than Apollo 17 mare collection, and would be commensurably easier to catalog. Catalogs which have been produced have been used as direct data sources, and referred to many times. Therefore it is important that they be both reliable and comprehensive; a cataloger must be dedicated to producing it. In return, he will get a very detailed knowledge of the sample suite involved and the nature of the lunar sample collection and its curation as a whole. The insight gained will be useful to the cataloger in formulating future research for himself, creating a synthesis useful to others, and providing ready access to sample information for a generation to come.

In compiling other catalogs it has become obvious that useful unpublished data resides in the archives of PI's. It would be very useful if PI's who have such data for Apollo 17 rock samples (mare or highlands) which is not intended to be or would not be easy to publish could send it to me (Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058). It will be included in the catalog(s) and given proper credit.

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CURATOR'S COMMENTS

Doug Blanchard
John Dietrich
NASA Johnson Space Center

Lunar Sample Allocations:

The Lunar and Planetary Sample Team (LAPST) reviewed 12 requests for lunar samples at the October 22-23 meeting held at the Lunar and Planetary Institute. LAPST allocated 98 samples (weighing 60.1 grams) and 11 thin sections to nine investigators. Between the June and October, the Curator allocated 7 samples (weighing 1.6 grams) and 44 thin sections to four investigators.

Lunar breccias and their included clasts continue as a major topic for study. Two breccia consortium leaders requested additional samples from lunar breccias. Another has expanded her consortium to include Rb-Sr and Sm-Nd internal isochron work for a large clast in 15459. Another has requested 24 polished thin sections of Apollo 16 breccias to support his ongoing study of the lunar regolith.

Two requests support isotopic studies. Studies include ^{138}La-^{138}Ce analyses in minerals separated from three lunar samples and Rb-Sr and Sm-Nd isochron analyses of two lunar basalts.

Several recommended allocations support studies of the interaction between solar particles and the lunar surface materials. Noble gasses implanted by the solar wind will be studied by step-wise etching of metallic particles in the 100-200 micrometer fraction of a lunar soil. In another laboratory, hydrogen abundances in lunar soils will be studied by analyzing samples from 18 core segments. Samples from near the surface of lunar rock 74275 will be analysed for ^{10}Be.

A new study using facilities at the Brookhaven National Synchrotron Light Source generated a request for thin sections mounted on silica slides. The characteristics of feldspar crystals in the thin sections using the synchrotron x-ray fluorescence (SXRF) instrument.

Other recommended allocations support a variety of studies. Requests included chips of five lunar rocks for the non-destructive, room-temperature measurement of magnetic properties as part of a continuing effort to define the behavior of the lunar magnetic field through time, samples for measuring the reflectance spectra of several mineral separates to refine data for the upcoming Lunar Materials book, five additional thin sections to support the search for datable lunar zircons, and samples for germanium analysis in twelve lunar basalts.

LAPST recommended denial of three requests.

Dissection of Lunar Core 79001/2:

The dissection of lunar core 79001/2 continues in the pristine sample laboratory in the Planetary Materials Branch. The first half (lunar top) of the double drive tube, 79002, has been totally dissected. The second half (lunar bottom), 79001, will be completely dissected by the end of April 1987. Thin sections from 79002 are complete and available for allocation. Thin sections from 79001 will be complete by mid summer 1987.

The dissection of 79002 is documented on the three diagrams which follow. The ferromagnetic resonance (FMR) data for this core, indicating the relative degree of surface exposure, was reported in the last edition of LUNAR NEWS. 79002 was dissected in three separate 0.5 cm deep passes using dissection intervals of 0.5 cm. All splits are identified, including sieved (at 1mm) and unsieved samples and large or special particles. The distinctive dark/light boundary which was discovered in this core is noted in the diagrams betweeen 8.5 and 10.5 cm.

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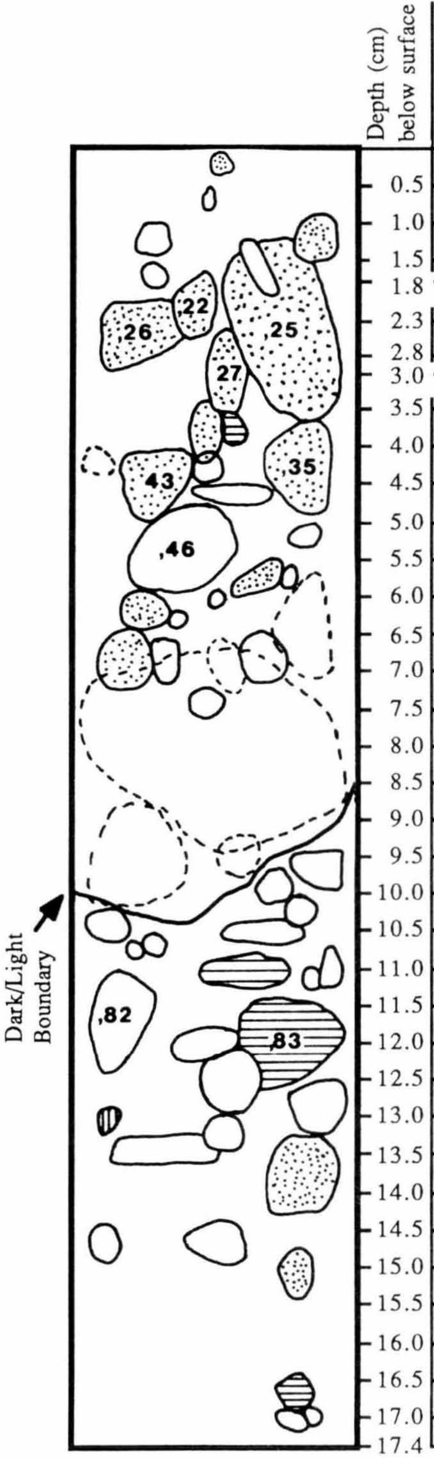
DRIVE TUBE 79002 (First Dissection)



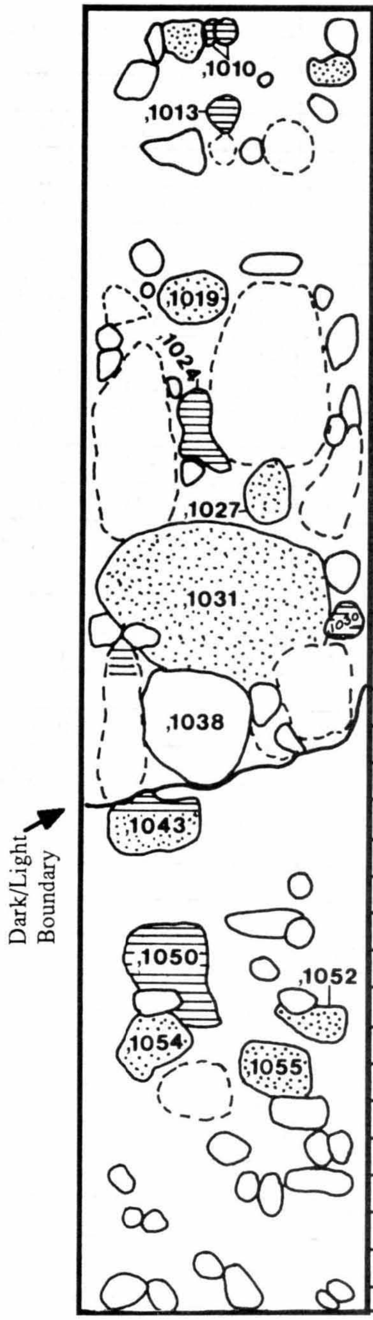
<1mm Fraction Sample No.	<1mm Fraction Sample Wt.	>1mm Fraction Sample No.	>1mm Fraction Sample Wt.	Special Samples No.	Special Samples Wt.	Special Samples Type
12	1.348	13	0.142			
14	1.562	15	0.124			
16	1.396	17	0.358			
18	0.916	19	0.167			
20	1.101	21	0.058	22	0.169	soil bx
23	1.221	24	0.096	25	2.266	soil bx
29	0.675	30	0.107	26	0.614	soil bx
31	1.018	32	0.213	27	0.210	soil bx
33	1.136	34	0.67	35	0.751	soil bx
36	1.127	37	0.185	43	1.189	soil bx
39	0.618	40	0.309			
41	0.839	42	0.305	46	0.969	soil bx
44	0.79	45	0.401			
47	1.354	48	1.20			
49	0.749	50	0.471			
51	1.03	52	0.496			
53	0.228	54	0.051			
55/57D	.142/.181	56/58D	.022/.017			
59L/61D	.222/.291	60L/62D	.021/.02			
63L/65D	.555/.429	64L/66D	.141/.155			
67L	1.376	68L	0.314	69	0.164	unsieved dk.
70L	1.103	71L	0.24			
72L	1.442	73L	0.402	74D/75D	.752/.141	9.8-11.3 cm
76	1.827	77	0.486			
78	1.93	79	0.305	82	0.449	basalt?
80	1.954	81	0.363	83	0.866	glass?
84	1.961	85	0.372			
86	2.195	87	0.968			
88	1.781	89	0.485			
90	1.967	91	0.253			
92	1.697	93	0.525			
94	1.882	95	0.523			
96	2.481	97	0.393			
98	1.619	99	0.275			
100	1.326	101	0.372			
102	1.814	103	0.513			

Type not identified — Glass or glassy fragment — Basalt

Soil breccia — White fragments or Lt gray bx — Bx, more coherent than soil bx

------ Fragment left in place — L = Light — D = Dark

DRIVE TUBE 79002 (Second Dissection)



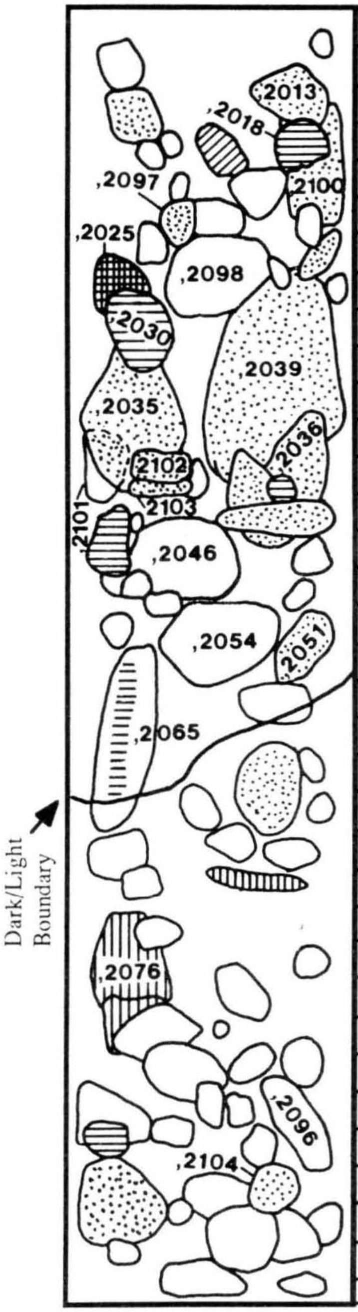
Depth (cm) below surface	Unsieved Sample No.	Unsieved Sample Wt.	Special Samples No.	Special Samples Wt.	Special Samples Type
0.5	1009	3.017	1010	.031	Glass
1.0	1011	1.835			
1.5	1012	1.977	1013	0.064	Glass
2.0	1014	2.462			
2.5	1015	2.113			
3.0	1016	1.684			
3.5	1017	2.904			
4.0	1018	2.306	1019	0.395	
4.5	1020	1.489			
5.0	1021	1.324			
5.5	1022	1.078	1024	0.387	Glass
6.0	1023	1.107			
6.5	1025	1.198	1027	0.482	Soil bx
7.0	1026	1.791			
7.5	1028	1.512			
8.0	1029	1.112	1030	0.191	Glass ball
8.5	1033	1.843	1031	11.041	Bx
9.0	1034	1.731			
9.5	1035	1.847	1038	3.458	Ba?
10.0	1036L/1037D	1.803/.657			
10.5	1039D/1040L	.686/2.019			
11.0	1041L/1042D	1.857/.665	1043	1.153	Bx with glass
11.5	1045	3.083			
12.0	1046	2.71			
12.5	1047	3.213			
13.0	1048	3.09	1050	0.768	Glass
13.5	1049	2.58	1052	0.204	Bx
14.0	1051	2.019	1054	0.305	Bx
14.5	1053	2.456	1055	0.666	Bx
15.0	1056	3.821			
15.5	1057	2.999			
16.0	1058	2.828			
16.5	1059	3.388			
17.0	1060	2.25			
17.4	1061	3.81			

- Type not identified
- Glass or glassy fragment
- Basalt
- Soil breccia
- White fragments or Lt gray bx
- Bx, more coherent than soil bx
- ------ Fragment left in place

L = Light

D = Dark

DRIVE TUBE 79002 (Third Dissection)



Depth (cm) below surface	<1 mm Fraction Sample No.	Wt.	>1 mm Fraction Sample No.	Wt.	Special Samples No.	Wt.	Type
0.5	2009	2.808	2010	0.263			
1.0	2011	1.554	2012	0.199	2013	0.676	Soil bx
1.5	2014	2.252	2015	0.469			
2.0	2016	2.58	2017	0.751	2018	0.203	Glass ball
2.5	2019	0.194	2020	0.339	2100	0.887	Soil bx
3.0	2021	2.404	2022	0.495	2097	0.417	Soil bx
3.5	2023	2.012	2024	0.459	2098	2.669	Basalt?
4.0	2026	1.679	2027	0.508	2025	1.468	Bx, lt. gray
4.5	2028	1.023	2029	0.304	2030	0.862	Glass w/metal. luster
5.0	2031	0.619	2032	0.222	2039	9.689	Soil bx
5.5	2033	0.581	2034	0.275	2035	4.882	Soil bx
6.0	2037	0.734	2038	0.107	2036	2.852	Soil bx
6.5	2040	1.666	2041	1.308	2101	0.574	Soil bx
7.0	2042	1.496	2043	1.054	2101-2103 - underneath 2035		
7.5	2044	1.305	2045	0.901	2046	1.115	?Fg. w/glass
8.0	2047	1.018	2048	0.525			
8.5	2049	1.474	2050	0.487	2051	1.26	Soil bx
9.0	2052	1.007	2053	0.318	2054	3.677	Fg. w/glass
9.5	2055	1.939	2056	0.302			
10.0	2057L/2059D	1.76/0.54	2058L/2060D	0.24/.094	Act. interval 2059/2060 = 1cm (9.5-10.5)		
10.5	2063L	1.351	2064L	0.233	2065	3.377	Fg. w/glass
11.0	2066L	3.276	2067L	1.016			
11.5	2068	1.971	2069	0.369			
12.0	2070	3.368	2071	0.467			
12.5	2072	3.352	2073	0.584			
13.0	2074	2.511	2075	0.297	2076	1.241	Lt. gray rock
13.5	2077	3.291	2078	0.726			
14.0	2080	2.48	2081	0.48			
14.5	2082	2.574	2083	0.579			
15.0	2084	3.292	2085	0.897	2096	0.584	Dark, platy (?)
15.5	2086	3.101	2087	0.646			
16.0	2088	2.66	2089	0.741	2104	0.504	Lt. gray soil bx
16.5	2090	2.202	2091	1.141			
17.0	2092	1.777	2093	0.626			
17.4	2094	2.114	2095	0.801			

Type not identified
Soil breccia
------ Fragment left in place
Glass or glassy fragment
White fragments or Lt gray bx
L = Light
Basalt
Bx, more coherent than soil bx
D = Dark