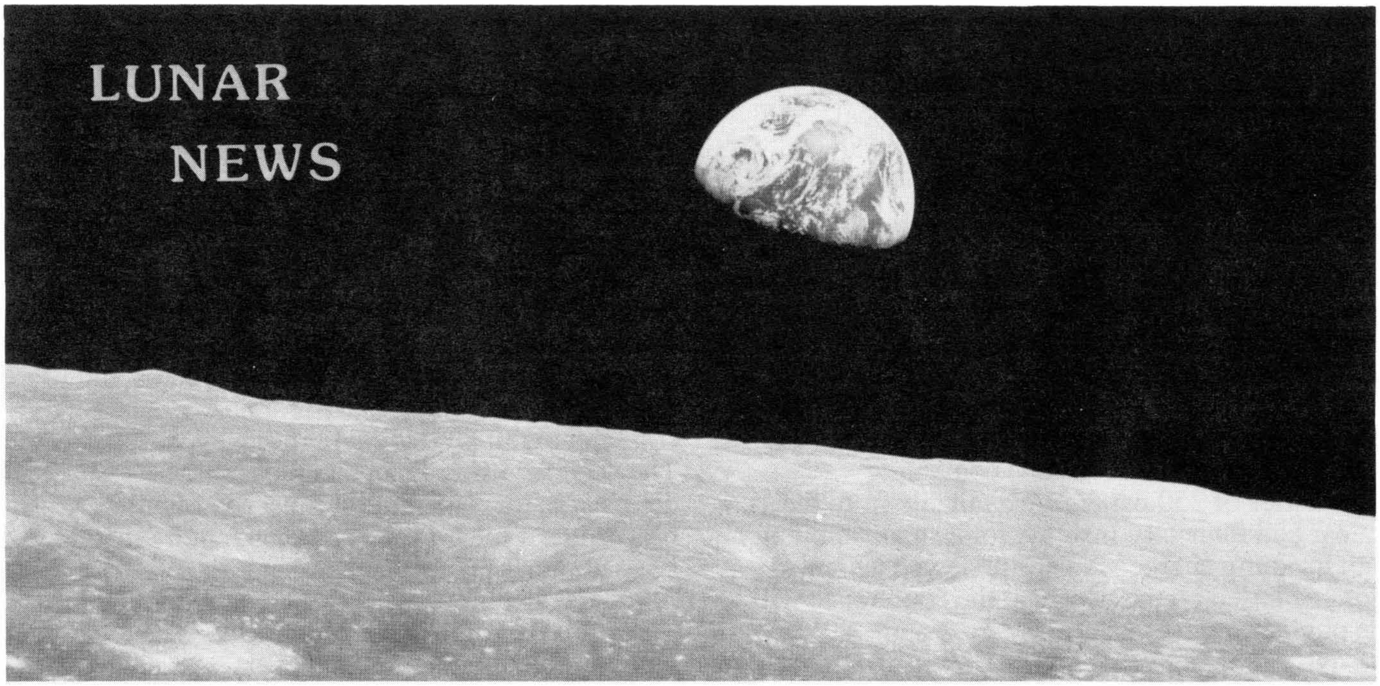

LUNAR BASES AND SPACE ACTIVITIES

Wendell Mendell

The Second Symposium on Lunar Bases and Space Activities of the 21st Century was held April 5-7, 1988, at the Westin Galleria Hotel in Houston, Texas. Approximately 550 attendees heard more than 200 papers delivered on subjects ranging from engineering analyses of space transportation networks and planetary surface outposts to legal, sociological, and public policy discussions related to space program initiatives over the next few decades. Scientists proposed experiments suited for a manned lunar space base; designers suggested architectural concepts and construction techniques for planetary surface habitats; and bioengineers reviewed the essential elements of biologically based, regenerative life support systems.

Participation was double that of the first lunar base symposium held at the National Academy of Sciences in Washington, D.C., in 1984. Attendees and presenters included many participants from NASA Headquarters and the NASA field centers. This symposium was the first large meeting to focus on the theme of human exploration of the solar system as it is being developed in NASA's new Office of Exploration.

Featured speakers included Dale Myers, NASA Deputy Administrator; John Aaron, NASA Assistant Administrator for Exploration; Aaron Cohen, Director of the NASA Johnson Space Center; Hans Mark, former NASA Deputy Administrator; and Harrison Schmitt, Apollo astronaut and former U.S. senator. Attendees came from 34 states and the District of Columbia, as well as several foreign countries. A session on International Questions was chaired by Dr. Herman Koelle of the Technical University of Berlin, who

LUNAR NEWS NO. 51 SUMMER 1988

CONTENTS:

heads up an International Lunar Base Committee within the International Academy of Astronautics. The featured luncheon speaker was Dr. V.V. Shevchenko of the Sternberg Astronomical Institute at the University of Moscow, who reflected on considerations for site selection for a lunar base.

The symposium was cosponsored by NASA Johnson Space Center, the American Institute of Aeronautics and Astronautics, the Lunar and Planetary Institute, the American Geophysical Union, the American Nuclear Society, the Space Studies Institute, and the National Space Society. Copies of the abstract volume containing summaries of 250 papers are available from the Lunar and Planetary Institute for a small shipping and handling charge. A peer-reviewed technical volume based on the papers at the conference will be published next year.

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CURATORIAL POLICY ON UTILIZATION OF LUNAR MATERIALS FOR APPLIED AND ENGINEERING STUDIES

Doug Blanchard
Lunar Sample Curator

NASA and the Planetary Materials and Geochemistry Program encourage research on extraterrestrial materials for a variety of scientific studies. Study of these materials for applied and engineering uses is also encouraged. NASA has established procedures to ensure that all approved investigators can have access to the sample collection regardless of their source of funding. Responsibility for access to and security of lunar materials remains with NASA-JSC, specifically with the Lunar Sample Curator. The Lunar and Planetary Sample Team (LAPST) advises NASA and the Lunar Sample Curator on the appropriateness of allocations of lunar materials for various purposes.

The primary purpose of this policy is to insure the continuation of stringent safeguards against ill-advised use of lunar samples. All applicants for lunar samples must respect this concern and tailor their requests accordingly. By most industrial standards, there is very little lunar material available for direct testing. Large-scale tests using lunar samples generally are not feasible. Most large-scale tests can be performed using simulated lunar materials. The Curator can provide references for preparation of several types of simulated samples and can in some cases provide such simulants.

Requests for lunar samples must address the following items: 1) Tests and processes to be done shall be clearly described. The procedures will use the absolute minimum mass of lunar samples consistent with producing high-quality results; 2) The need for using lunar samples must be demonstrated. The request must specify those properties of lunar samples which require that they be used rather than simulated lunar materials; and 3) Independent reviewers should be recommended for evaluation of the proposed study. The requestor should recommend peers who are expert in the proposed field of research. However, the Curator reserves the right to choose other reviewers.

This information should be sent to the Lunar Sample Curator for review. Samples will not be granted until the actual procedures to be used have been tested using appropriate simulants. These tests must address the reproducibility of results using minimum amounts of sample, the measures taken to prevent waste or loss of sample, and precautions taken to handle samples in a clean environment.

Test results will be reviewed. The Curator and LAPST will allocate samples that have been previously used if at all possible. Special justification must be provided by the requestor if pristine samples are required.

Upon approval of the request the Curator will initiate a formal agreement with the institution of the Principal Investigator which will include a plan to provide security for the lunar samples. The results of the research will be made available through publication in the open literature or, in special cases, in a report to the Lunar Sample Curator.

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LUNAR SOIL SIMULANT SURVEY

Jim Blacic
Los Alamos National Laboratory

LAPST is beginning to receive increasing numbers of requests for lunar materials to be used in destructive tests for research on lunar resource processing, plant growth, etc., and these requests are likely to grow as the Lunar Base planning advances and Pathfinder gets underway. LAPST policy is to insist that simulants be used to the greatest extent possible before any allocations of lunar materials are made for these purposes. The problem is: what simulants should be used, who should certify their properties, and where can they be obtained at a reasonable price or how can I make my own?

LAPST would like to solicit input from all of you potential simulant makers and users out there. Please consider the following specific questions:

- Are you producing a lunar simulant for your own use or to sell to others? If so, what properties are you simulating, what quantity of material are you producing, how are you making the simulant, and how are you measuring or certifying the simulated properties?

- What property or combination of properties needs to be simulated for the research you are contemplating? How much simulant do you anticipate needing?

- For some uses, the quantity of simulant needed will always be too large to ever consider using lunar materials (e.g., architectural displays, vehicle traction tests, pilot-scale chemical processing plants). For such specific uses, should LAPST or some other "official" body certify simulants or their recipes?

Please return your comments to:

LAPST
c/o Lunar Sample Curator
SN2/NASA Johnson Space Center
Houston, TX 77058

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LUNAR SAMPLE ACTIVITY

The Lunar and Planetary Sample Team (LAPST) reviewed 25 requests for lunar samples at its June 7-8 meeting at the Lunar and Planetary Institute. LAPST recommended allocating 117 samples (weighing 48.2 grams) and 114 thin sections to 17 investigators for scientific study and 5 samples (weighing 5.0 grams) to an investigator for a lunar resources study. After careful review LAPST recommended denial of one request; the experiment plan was judged to be inadequate.

At its November meeting, LAPST will review requests received by November 10, 1988.

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"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

MOON IN TRANSITION: APOLLO 14 AND EXTREME LUNAR DIFFERENTIATION

Jeff Taylor
University of New Mexico

Paul Warren
UCLA

LAPST is organizing a workshop that will focus on the transition from the earliest (magma ocean?) lunar differentiation to subsequent magmatic activity, including the production of ancient (4.3 Gy) mare basalts. This period of lunar history involved the formation of highly evolved materials, such as granites and KREEP. The workshop will also focus on Apollo 14 samples and the Apollo 14 site, as this site contains an extensive suite of evolved materials. Concentrations of thorium and uranium in Apollo 14 soil samples are roughly 15 times greater than the average crustal compositions estimated from orbital gamma-ray data. Most Apollo 14 samples are greatly enriched in all incompatible elements, with incompatible element ratios generally conforming to the distinctive pattern of KREEP. Other evolved rock types such as granite, very high potassium (VHK) basalt, and alkali anorthosite are also common among the few "pristine" lithic fragments (those not affected by impact-mixing) for Apollo 14. In many respects the record of lunar igneous activity is more extensive among the diverse clasts found in Apollo 14 breccias than among samples from any other mission. Many important unanswered questions about the Apollo 14 crust can be addressed by further sample studies and by up-to-date interpretative syntheses of sample-studies results.

The Apollo 14 landing site was chosen primarily to sample the Fra Mauro Formation, which was believed to be a deposit of ejecta from the Imbrium basin. Most Apollo 14 rocks are polymict impact breccias, and their ages have often been assumed to date the Imbrium impact. But many workers argue that, although the Fra Mauro Formation was certainly sculpted by Imbrium ejecta, most of its material is of local provenance. What proportion of the Fra Mauro Formation is Imbrium ejecta? In particular, did the abundant KREEP at the Apollo 14 site come from Imbrium? Orbital spectrometry data indicate that the global distribution of KREEP is highly asymmetrical (concentrated in the central-western near-side; mare basalts follow a roughly similar distribution). Is this pattern significant? If so, what caused it? What is the relationship (if any) between KREEP and the magma ocean? Pristine KREEP is rare or absent among the Apollo 14 lithic fragments. What was the Apollo 14 KREEP component like in pristine form, before it was mixed into the polymict breccias? Why is pristine KREEP now so rare?

The Apollo 14 lithic fragments include many high-Al mare basalts, including the distinctive VHK basalts and the oldest (3 b.y.) basalt known from the Moon. High-Al basalts are also abundant among the soil particles from Luna 16, and small pieces are occasionally found among Apollo 12 and Apollo 16 samples. What is the origin of high-Al basalt in general, and VHK basalt in particular? What is the volumetric abundance of pre-4.0 b.y. mare basalt in the Moon's crust? What other mare basalt types may be found among the Apollo 14 lithic fragments? What role did assimilation and fractional crystallization play in the evolution of these basalts? What was the nature of the material assimilated?

A suite of plutonic lithologies from Apollo 14 is distinctive and has not yet been thoroughly studied. Small lunar granite fragments are relatively abundant among Apollo 14 and some Apollo 17 samples. How did these highly evolved rocks form? Are they related to KREEP? Was liquid immiscibility involved? Apollo 14 troctolites tend to have higher incompatible element contents than their counterparts from elsewhere on the Moon. Are these magnesian cumulates somehow related to KREEP? How old are they? Alkali anorthosites seem to far outnumber ferroan anorthosites among Apollo 14 lithic fragments. How and when did alkali anorthosites form? Why are ferroan anorthosites and plutonic norites rare from Apollo 14? Are any of the Apollo 14 lithologies direct products of the magma ocean?

Convenors of the workshop are Paul Warren (UCLA) and Jeff Taylor (University of New Mexico). The workshop will be held November 14-16, 1988, at the Lunar and Planetary Institute. More information is available from Pam Jones at the LPI (713-486-2150).

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DISSECTION OF LUNAR CORE 15009 COMPLETED

Carol Schwarz

Dissection of 15009, a single drive tube collected on the Apennine Front at Station 6, has been completed. The core was dissected in three longitudinal layers 1 cm thick at a time in 0.5 cm increments starting at the top and continuing through the length (29.3 cm) of the core. In the first and third passes the soil from each 0.5 cm increment was sieved at 1 mm, separating it into coarse and fine particles. The coarse particles were examined via binocular microscope, classified (as much as possible) and photographed. All samples are now available for study. Thin sections of the entire length of the core are being prepared at this time and will be available soon.

The following units were identified based on compositional changes observed during dissection and obvious color changes after the peel was taken:

DEPTH	SUMMARY OF LITHIC COMPONENTS (>1 mm Particles)
0-5 cm	(Color - light gray) Soil breccias and soil clods most abundant and occur in all size ranges; glass and glass-splashed breccias next most abundant along with a few agglutinates and minor amounts of anorthosite, basalt and unknowns.
5-12 cm	(Color - slightly darker, 10 YR 5/1) Coherent breccias most abundant along with increasing amounts of glass (including agglutinates) and breccias with glass. Soil clods are rare. Also present are basalts, a few unidentifiable coherent fragments, and some glassy-matrix breccias.
12.5-14.5 cm	(Color - lighter gray, similar to 0-5 cm depth) Soil breccias still dominate and occurrence of clods is increasing. No agglutinates occur, but glass and breccias with glass are present along with some anorthosite, basalts, and glassy-matrix breccias.
15-18 cm	(Color - lighter gray, 10 YR 6/1) Soil breccias dominant with some friable soil clods; glass and glass-splashed breccias occur with minor amounts of anorthosite, basalt, and unknowns.
18-29.3 cm	(Color - lighter gray, 10 YR 6/1) Soil breccias and soil clods dominate; clods start out small but increase in size starting at 26 cm. Glass and glass-splashed breccias occur with very minor amounts of agglutinates, anorthosites, basalts, and glassy-matrix breccias. A number of small white fragments were observed between 16.5 and 28.5 cm.

The dissection of 15009 is documented on the three diagrams which follow. Exposure data (I_s/FeO) and FeO data provided by Dr. Richard Morris are shown on the final two diagrams.

Carol Schwarz was the dissection processor for this core. Illustrations were prepared by Claudine Robb.

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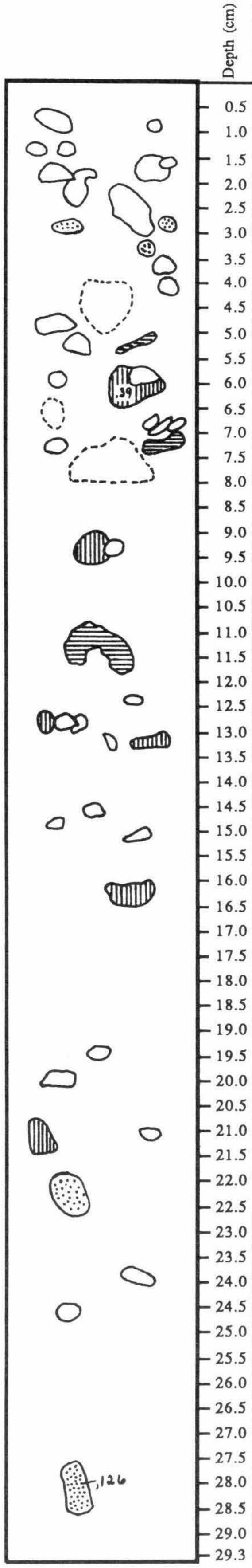
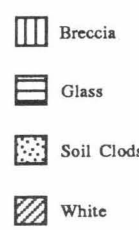
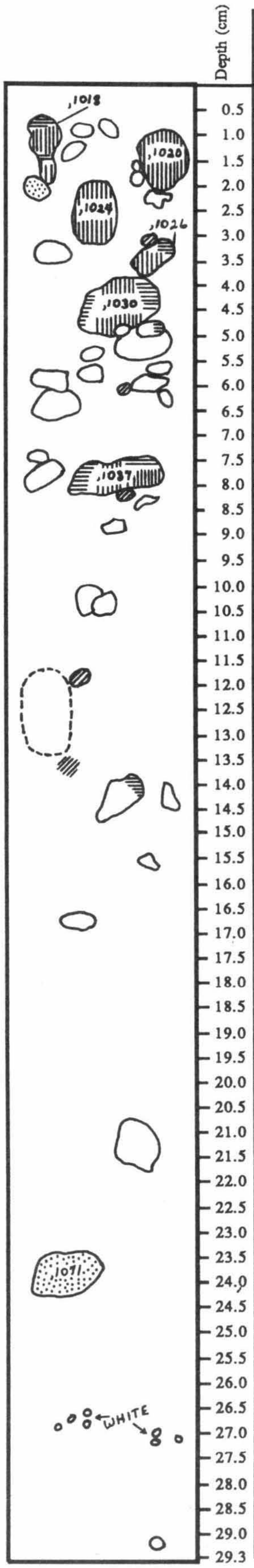
DRIVE TUBE 15009 (First Dissection)



<1 mm Fraction Sample		>1 mm Fraction Sample		Special Samples		
No.	Wt.	No.	Wt.	No.	Wt.	Type
11	.339	12	.035			
13	.480	14	.246			
15	.745	16	.120			
17	.687	18	.559			
19	.683	20	.703			
21	.837	22	.204			
23	1.073	24	.153			
25	.835	26	.159			
27	.669	28	.142			
29	1.015	30	.177			
31	1.033	32	.249			
33	1.162	34	.254	39	0.34	Breccia?
35	.841	36	.099			
37	1.088	38	.225			
40	1.123	41	.235			
42	.427	43	.082			
44	1.444	45	.103			
46	1.330	47	.055			
48	1.326	49	.580			
50	1.748	51	.044			
52	1.555	53	.018			
54	1.335	55	.034			
56	1.693	57	.407			
58	1.760	59	.081			
60	1.661	61	.149			
62	1.610	63	.531			
64	1.826	65	.149			
66	1.487	67	.108			
68	1.618	69	.120			
70	1.710	71	.128			
72	1.720	73	.133			
74	1.970	75	.056			
76	1.873	77	.269			
78	2.009	79	.168			
80	2.018	81	.067			
82	1.836	83	.095			
84	2.072	85	.060			
86	1.620	87	.050			
88	1.849	89	.155			
90	2.137	91	.185			
92	1.942	93	.053			
94	2.028	95	.045			
96	2.028	97	.296			
98	1.983	99	.073			
100	1.505	101	.137			
102	2.162	103	.326			
104	1.730	105	.079			
106	2.017	107	.106			
108	2.011	109	.175			
110	1.905	111	.187			
112	2.166	113	.135			
114	1.669	115	.174			
116	2.184	117	.126			
118	1.823	119	.158			
120	1.816	121	.245			
122	1.653	123	.108	126	0.383	Soil clod
124	1.832	125	.087			
127	1.649	128	.160			
129	1.447	130	.163			



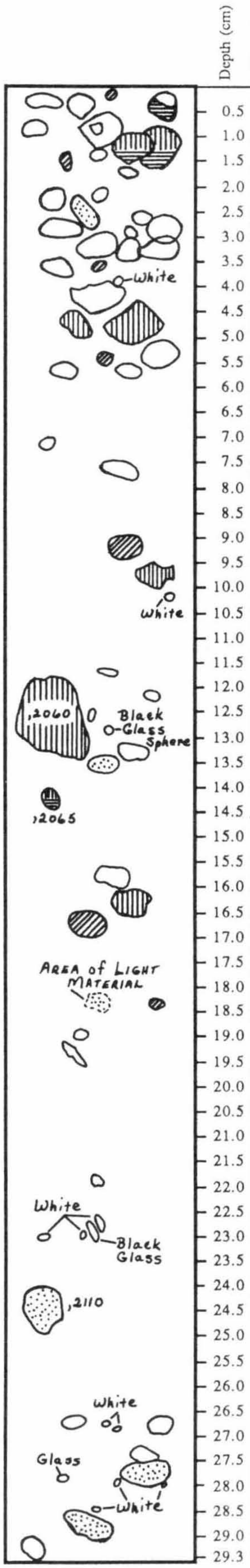
DRIVE TUBE 15009 (Second Dissection)



Unsieved Sample		>1 mm Fraction Sample		Special Samples		
No.	Wt.	No.	Wt.	No.	Wt.	Type
1015	2.150					
1016	1.813					
1017	1.942			1018	0.559	S. Bx w/glass
1019	2.120			1020	0.525	S. Bx
1022	1.834					
1023	2.345			1024	0.540	S. Bx
1025	2.698			1026	0.380	S. Bx w/glass
1027	2.405					
1028	2.526			1030	1.581	S. Bx w/glass
1029	2.201					
1031	2.808					
1032	2.997					
1033	2.834					
1034	2.703					
1035	2.537					
1036	2.043			1037	2.836	S. Bx w/glass
1039	2.753					
1040	2.713					
1041	2.762					
1042	2.192					
1043	2.602					
1044	2.846					
1045	3.177					
1046	2.865					
1047	2.398					
1048	2.427					
1049	2.489					
1050	2.714					
1051	2.501					
1052	2.595					
1053	2.563					
1054	2.885					
1055	2.475					
1056	3.019					
1057	3.023					
1058	2.307					
1059	3.499					
1060	2.571					
1061	2.613					
1062	2.930					
1063	2.989					
1064	2.455					
1065	2.817					
1066	3.053					
1067	3.254					
1068	2.665					
1069	3.190					
1070	2.485			1071	0.479	Soil Clod
1072	3.001					
1073	2.883					
1074	3.026					
1075	3.149					
1076	3.189					
1077	3.118					
1078	3.284					
1079	3.101					
1080	2.776					
1081	2.510					
1082	2.442					

Breccia
Glass
Soil Clods
White

DRIVE TUBE 15009 (Third Dissection)



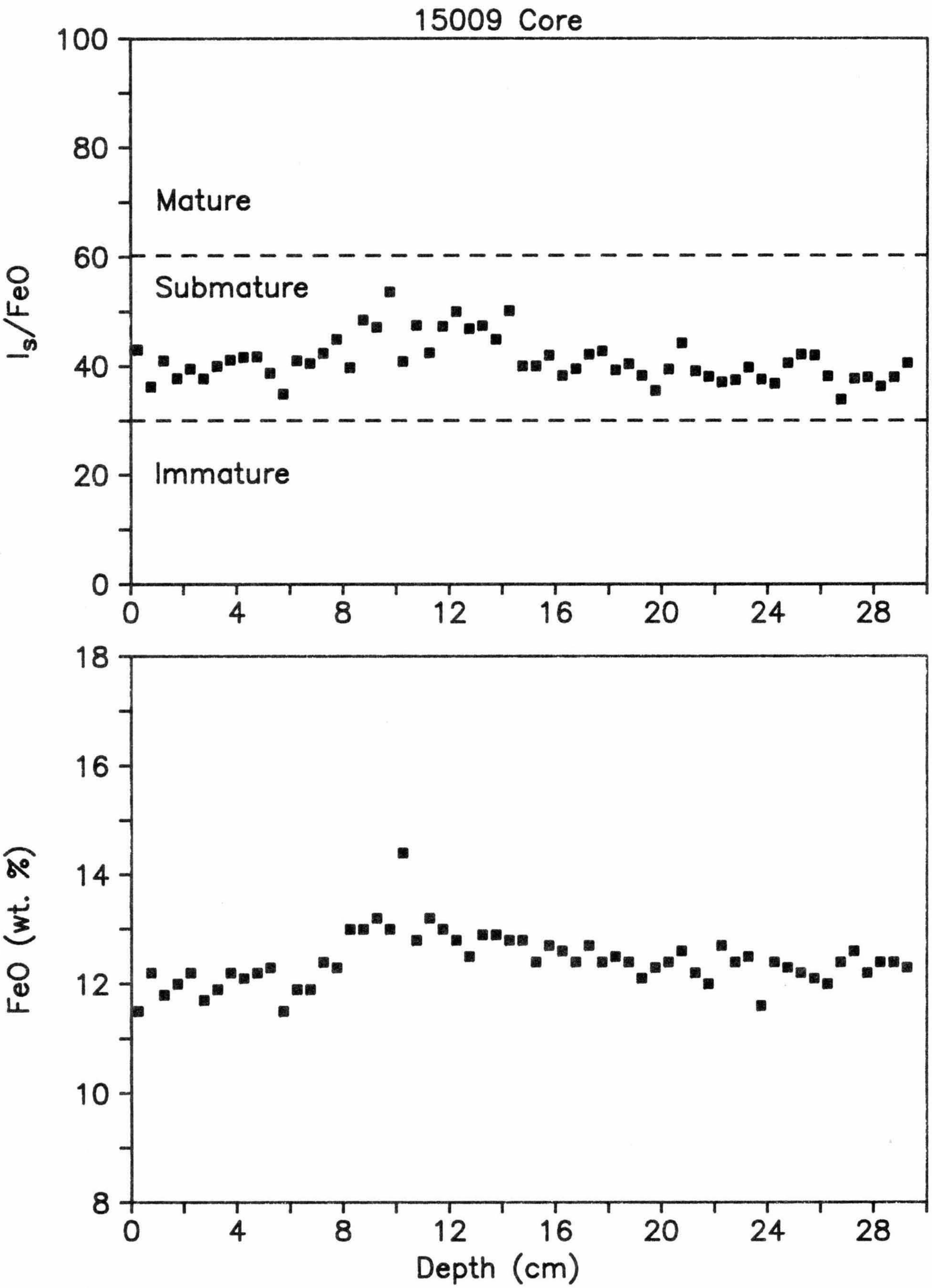
<1 mm Fraction Sample		>1 mm Fraction Sample		Special Samples		
No.	Wt.	No.	Wt.	No.	Wt.	Type
2006	2.272	2007	0.698			
2008	2.293	2009	1.044			
2010	2.147	2011	0.760			
2012	1.591	2013	0.341			
2014	2.150	2015	0.707			
2016	1.985	2017	0.393			
2018	2.244	2019	0.676			
2020	2.455	2021	0.368			
2022	2.091	2023	0.284			
2024	2.245	2025	0.612			
2026	1.986	2027	0.275			
2028	2.623	2029	0.257			
2030	2.067	2031	0.132			
2032	2.626	2033	0.091			
2034	2.660	2035	0.079			
2036	2.053	2037	0.129			
2038	2.538	2039	0.051			
2040	2.926	2041	0.093			
2042	3.134	2043	0.195			
2044	2.873	2045	0.118			
2046	2.815	2047	0.075			
2048	2.375	2049	0.058			
2050	2.946	2051	0.075			
2052	2.901	2053	0.156			
2054	1.864	2055	0.066	2060	2.605	S. Breccia
2056	2.442	2057	0.099			
2058	2.739	2059	0.309			
2061	2.737	2062	0.228			
2063	2.269	2064	0.120	2065	0.537	Bx w/Glass
2066	3.157	2067	0.092			
2068	2.358	2069	0.112			
2070	3.104	2071	0.408			
2072	2.828	2073	0.161			
2074	3.178	2075	0.179			
2076	2.458	2077	0.051			
2078	2.678	2079	0.157			
2080	2.868	2081	0.049			
2082	2.987	2083	0.052			
2084	2.996	2085	0.094			
2086	3.146	2087	0.137			
2088	2.822	2089	0.038			
2090	3.055	2091	0.154			
2092	2.812	2093	0.072			
2094	2.787	2095	0.198			
2096	2.634	2097	0.268			
2098	2.870	2099	0.145			
2100	2.914	2101	0.183			
2102	2.609	2103	0.167			
2104	2.726	2105	0.216			
2106	2.096	2107	0.287	2110	1.238	S. Clod
2108	2.725	2109	0.137			
2111	3.204	2112	0.235			
2113	2.526	2114	0.359			
2115	2.996	2116	0.354			
2117	3.273	2118	0.422			
2119	3.143	2120	0.400			
2121	2.687	2122	0.237			
2123	2.509	2124	0.607			
2125	2.112	2126	0.145			

Breccia

Glass

Soil Clods

White


15009 Core
Is/FeO
100
80
60
40
20
0
Mature
Submature
Immature
FeO (wt. %)
18
16
14
12
10
8
0
4
8
12
16
20
24
28
Depth (cm)

NASA-JSC