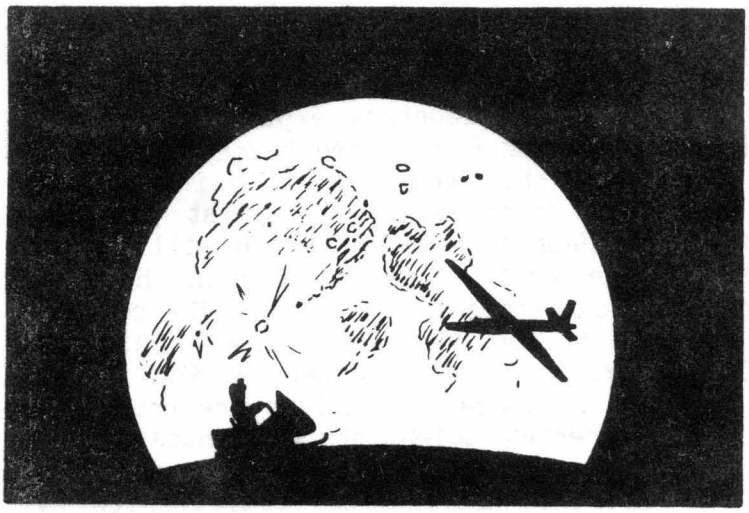

LUNAR SAMPLE NEWSLETTER

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NEXT LAPST MEETING IS JUNE 10-12, 1983

The Lunar and Planetary Sample Team (LAPST) met at the Lunar and Planetary Institute March 11-13, 1983. LAPST reviewed nine requests for lunar samples and recommended allocation of 62 samples with a total weight of 174 grams. The team also endorsed the allocation of two samples and 37 thin sections with total weight of 0.67 gram recommended by the Curator in response to seven lunar sample requests between the November 1982 and March 1983 meetings.

Studies of the regolith generated requests for the largest number of samples. Four requests demonstrated the continuing interest in the highlands initiative. Six samples of soil from five Apollo sites were requested for studies related to the utilization of lunar materials. The samples will be analyzed to determine the total hydrogen content and the distribution of hydrogen among the size and mineral fractions of the samples.

Other requests supported studies of:

- Spectral Properties of Lunar Glass
- Minor Phases in Older Moon Rocks
- Remnant Magnetism

The JSC Public Affairs Office requested allocation of an Apollo 11 sample for long-term display at the Neil A. Armstrong Air and Space Museum.

LAPST will meet again June 10-12, 1983. We welcome your requests anytime; allocations to fill some requests can be made between LAPST meetings (see present policy in this newsletter). We especially encourage you to submit your requests well ahead of the LAPST meeting.

Solar System Exploration Committee - Core Program

The Solar System Exploration Committee recently has provided NASA management with a recommendation for a core planetary exploration program through the end of the 20th century. This program, while it does not accomplish many of the investigations proposed in previous NASA planetary exploration plans, fits a series of sound science missions into the constrained budget which the program now faces. Early indications are that the plan is being viewed favorably by the executive and legistative branches. The highest priority mission in the SSEC plan, the Venus Radar Mapping mission, which will obtain global 1 km resolution radar imagery of the surface, is included in the NASA budget for fiscal year (FY) 1984 recently submitted to Congress. The concept of a planetary observer program, a series of low cost inner planet missions utilizing commercial earth orbital spacecraft, is recommended by SSEC for a new start in the FY 1985 budget. The fate of these initiatives are uncertain at this time; the active support of interested scientists continues to be necessary if a viable planetary exploration program is to be maintained. The Division of Planetary Sciences of the American Astronomical Society, led by Clark Chapman, has been very active in assembling information for public dissemination on the SSEC core program and is happy to provide information. We have additional copies of the Executive Summary, which provides an excellent overview and a useful tool for explaining the rationale for the SSEC recommendations. If you have not received one or need more for distribution, please let us know.

The Apollo experience and meteorite analysis have demonstrated the powerful contributions of sample studies to planetary science. Unfortunately, sample return missions could not be included in the core program, due to the high cost of such missions in the near future. However, a strong recommendation of the SSEC report is to augment the research and analysis program, which can allow the continued study of samples in hand and can help develop the means of sample acquisition and analysis for sample return missions, should they prove feasible as augmentations to the core program. To prepare for that possibility, the SSEC will provide this year an additional report on larger "Viking-class" missions that could be flown in an augmented core program. Such missions could include Mars, comet or asteroid sample returns. In addition, the SSEC will explore the questions of lunar and asteroidal resources and future manned activities as they could affect planetary exploration in the next 15 years.

LPI Workshop On

Past and Present Solar Radiation: The Record in Meteoritic and Lunar Regolith Material

This workshop will be held September 3-4, 1983, in Mainz, Germany, prior to the 46th Annual Meeting of the Meteoritical Society (scheduled for September 6, 1983).

Informal discussions and presentations will address the following topics:

1. trapped solar gases, tracks and micrometeorite pits in regolith mineral grains;
2. how and to what extent have records of incident radiation been altered in various types of grains;
3. implications of the data for the flux and compositional history of solar particle emission;
4. the special role of regolith breccias and the challenge of dating their times of compaction; and
5. direction and organization of future research.

Those interested in participating in the workshop should contact Pamela Jones, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058.

Topical Conference on the Origin of the Moon

A major unsolved problem in planetary science is the origin of the Moon. Although several new models for lunar origin have been proposed since the return of Apollo and Luna samples, there has never been a conference devoted exclusively to this fascinating topic. LAPST intends to organize a Topical Conference, sponsored by the Lunar and Planetary Institute, that will concentrate solely on how the Moon may have formed. The conference will be convened by G.J. Taylor and Roger Philips.

Tentative plans envisage that the conference will be organized in two parts. One part will emphasize constraints that lunar and other planetary research have placed on models for the Moon's origin. This will include an assessment of how firm the constraints are. The second part of the conference will focus on models for lunar origin. Discussions will likely center on how well the models satisfy the constraints and on how we might test the models.

Goals of the conference are to assess our present understanding of the lunar (and hence planet) formation and to reveal where our knowledge is too meager. The conference should lead to research designed to test specific models and help in planning new planetary exploration missions.

The conference will be held in late Spring or in the Fall, 1984. We will try to hold it immediately preceding a major conference sponsored by a professional organization. An organizing committee will be chosen during the next few months.

Policy on Lunar Sample Access and Curatorial Allocations

LAPST has reviewed sample access policy and rules for curatorial allocations. These are their recommendations.

Sample Access Policy

All lunar sample access for research will be covered by a Lunar Sample Access Agreement between the Principal Investigator and NASA Johnson Space Center. This agreement must be approved initially, renewed annually, and can be closed by either party to the agreement.

Conditions for Approval

1. PI recommended for access by LPRP or NSF, or;
2. PI recommended for temporary access by LAPST until next LPRP review;
3. and Planetary Materials Discipline Scientist approval.

Conditions for Continuation

1. Recommendation of the LPRP or NSF based on yearly progress report and request for renewal;
2. and Planetary Materials Discipline Scientist approval.

Closure

1. Voluntary, or;
2. failure to request renewal, or;
3. recommendation of LPRP, LAPST, NSF, or Curator;
4. and discretion and concurrence of the Planetary Materials Discipline Scientist.

Curatorial Allocations

Curatorial allocations are allocations made at the discretion of the curator without an explicit prior recommendation from LAPST.

The necessary conditions for any allocation to an investigator are:

1. The investigator has been approved for access to the samples (see CONDITIONS FOR APPROVAL section).
2. The investigator has a valid security plan on file.

Curator may allocate:

1. Any thin section unless specifically designated as a restricted sample.
2. Return samples with the following conditions:
   ---less than 10 grams per sample
   ---clearly within the scope of the approved proposal.
3. Pristine samples with the following conditions:
   ---less than 0.1 gram per sample
   ---non-restricted samples
   ---consistent with the 80% rule
   ---clearly within the scope of the approved proposal.

Samples which are consortium samples will be handled according to the consortium guidelines adopted at the November 1982 LAPST meeting. (See Lunar Sample Newsletter #37, February 1983.)

LAPST will recommend:

1. Returned samples >10 grams;
2. pristine samples >0.1 gram;
3. samples where there is any question as to scope of proposed work;
4. Samples requested by anyone not previously approved for sample access.

Some Curatorial Data on Lunar Soils

Judy Allton (Northrop) has recently assessed our reserves of lunar regolith as a part of our preparations for supporting lunar materials utilization activities. Soils have been broken into four compositional and two maturity categories.

The following tables summarize the status of this collection. More specific data are given for returned uncontaminated soils which we consider prime candidates for allocation for utilization studies. The returned, uncontaminated soils have not been heated or contaminated and still retain their original grain size distribution below 1mm.

RETURNED, UNCONTAMINATED LUNAR SAMPLES

Soil Type	Weight Available	
All Soil*	783.210g	
Total Mare	318.188g	
High Ti Mare		186.592g
Low Ti Mare		131.596g
Highlands	72.966g	
KREEP	342.953g	
Mature	538.011g	
Immature	22.658g	

*This weight is not the sum of the soil type weights given in this table since the "mature" and "immature" groupings include some soils which are also classified as other types.

CLASSIFICATION OF SELECTED SAMPLES BY SOIL TYPE

SAMPLE	HIGH Ti MARE	LOW Ti MARE	HIGHLAND	KREEP	MATURE	IMMATURE
10084	X				X	
12001		X				
12003		X				
12023		X			X	
14003				X	X	
14141				X		X
14163				X		
14240				X		
14259				X	X	
15013		X			X	
15021		X			X	
15041		X			X	
15071		X				
15221					X	
15271					X	
15301		X				
15471		X				
15601		X				X
60601			X		X	
62241			X		X	
64501			X		X	
70011	X					
71501	X					
72501	X				X	
72701	X				X	
78421					X	
78461					X	

76501, a submature, non-mare soil is also available

RETURNED, UNCONTAMINATED LUNAR SAMPLES

10084, 24	6.773g
, 27	10.581g
, 67	5.207g
, 83	5.012g
, 93	8.386g
, 94	10.436g
, 135	6.770g
, 152	9.772g
, 155	10.622g
, 157	10.000g
, 158	10.037g
, 534	7.072g
, 627	17.928g
,1050	6.572g
,1225	8.000g
,1226	7.000g
,1540	5.161g
,1561	(4.802g)
12001, 35	5.001g
12003, 3	15.601g
12023, 1	8.254g
14003, 56	5.000g
, 96	199.980g
14161, 50	9.700g
14163, 58	8.778g
, 59	19.661g
, 61	5.480g
, 64	6.552g
, 127	19.299g
, 158	5.128g
, 168	6.112g
, 229	9.980g
, 230	9.980g
, 231	9.980g
14240, 1	7.085g
14259, 137	5.427g
, 511	14.811g
15013, 6	5.829g
15021, 81	5.100g
, 82	5.031g
, 83	5.027g
15041, 21	5.103g
15071, 3	5.000g
15221, 23	5.000g
15271, 44	10.094g
, 45	9.009g
15301, 20	39.960g
, 43	(5.752g)
15471, 108	12.980g
15601, 24	5.000g
, 43	7.958g
60601, 20	30.000g
, 31	30.030g
62241, 21	5.936g
64501, 8	7.000g
70011, 37	5.212g
71501, 35	(20 g)
72501, 80	6.239g
72701, 20	5.010g
76501, 17	5.000g
78421, 37	10.000g
78461, 6	10.000g

STATUS OF THE TEN LARGEST SOIL SAMPLES TAKEN ON THE MOON

About 52.0 kg of soil were collected on the moon. Of this, 82% remains in the pristine lunar collection.

SOIL SAMPLE	ORIGINAL WEIGHT	% PRISTINE REMAINING
14163	4444.0g	94%
10084	3830.0g	61%
14259	2352.1g	81%
12001	2216.0g	71%
74220	1171.0g	90%
12070	1102.0g	80%
14003	947.9g	60%
75081	932.4g	78%
15301	810.2g	78%
15601	802.0g	82%

SUGGESTED REFERENCES

Heiken,G.: Petrology of Lunar Soils. Reviews of Geophysics and Space Physics, vol. 14, no. 4, 1975, pp. 567-587.

Morris, R.V.: The surface exposure (maturity) of lunar soils: Some concepts and Is/FeO compilation. Proceedings of the 9th Lunar and Planetary Science Conference, 1978, pp.2287-2297.

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Phinney, W.C.; Criswell, D.; Drexler, E.; and Garmirian, J.: Lunar Resources and Their Utilization in Space-based Manufacturing from Extraterrestrial Materials. AIAA Progress in Astronautics and Aeronautics Series, vol. 57, K. O'Neill, ed., AIAA, New York, 1977, pp. 97-123.

REFERENCE SUITE OF REGOLITH BRECCIA SAMPLES

In connection with the Regolith Breccia Initiative, a limited suite of regolith breccias has been compiled. It includes ten regolith breccias from each mission, except Apollo 12, for which all (three) breccias are included. This is not intended to be a truly representational suite but rather an extensive sampling.

Regolith breccias are simply defined as containing some regolith component(s). However, even when thin sections are available, a breccia's heterogeneity can be so extreme that unequivocal identification is simply not possible. Bottom line: the following list is our best shot. An effort was made to include a range of petrologic types, solar-wind-bearing breccias, highlands and mare samples, and regolith breccias from as many geomorphological units as possible. Limitations that restricted achieving the ideal suite include the non-random distribution of regolith breccias; deliberate and unintentional sampling biases of the astronauts; including samples of a reasonable mass; and the difficulty in determining which samples in the collection are and which are not, regolith breccias.

Petrographic descriptions are presented after the listing of the sample suite. In a month, The Regolith Breccia Workbook will be published which will provide more information about each sample, including rock and thin section photos, and references. We hope the newsletter and the workbook will provide enough information to be able to formulate sample requests for the June LAPST meeting, and include regolith-oriented research in their proposals this summer.

Regolith Breccia Reference Suite

Apollo 11	Apollo 12	Apollo 14	Apollo 15	Apollo 16	Apollo 17
10009	12010	14042	15015	60016	70019
10018	12034	14047	15086	60019	70175
10019	12073	14049	15205	60255	70295
10021		14055	15265	60275	74115
10046		14255	15295	61135	74246
10048		14301	15306	61175	76565
10060		14307	15465	61195	78546
10065		14313	15505	61295	79035
10068		14315	15558	66035	79135
10073		14318	15565	66075	79175

10009

Petrography: This is a moderately compact soil breccia composed of lithic, mineral and glass fragments embedded in a fragmental matrix of glass and mineral fragments. Porosity is low. The grain size distribution is seriate. The overall color is dark brown to black. No large accretionary structures were observed in the matrix. Fabric is generally chaotic. Glasses include rare agglutinates, but numerous spheres. There is a range in color of glass spheres and fragments from clear, to yellow, to brownish. Fine- and medium-grained basalt clasts are present. Ilmenite occurs in clasts and as mineral fragments in the matrix, less abundant than plagioclase and mafics, but more abundant than sulfides and metal.

10018

Petrography: This is a very porous breccia in thin section with a matrix composed of glass and fragmental grains. There is a seriate grain size distribution and a generally chaotic fabric. Some of the matrix appears glassy and although it has an overall brown color, there are zones or areas of lighter and darker matrix. These are sometimes associated with accretionary structures in the matrix and around some of the larger clasts. Agglutinates occur in the matrix and as clasts. Glass spheres exhibit a range in color from clear to yellow to dark red-brown. The glasses are generally clast-poor to clast-free. There is also fragmental glass as clasts and in the matrix. The major mineral fragments (from high to lower abundance) are pyroxene, plagioclase and ilmenite. Basalt clasts are present: medium grained, porphrytic, and/or shocked. No sets of cracks or fractures are present that offset grains or clasts. There are crushed fragments and some that show undalatory extinction.

10019

Petrography: According to Phinney et al. (1976), this breccia's matrix contains less than 10% pore space. They defined the matrix as <10 um particles and glass patches, and based on SEM petrography, found the sample to be 40-45% matrix by volume, with 35% of the matrix being glassy.

Based on standard petrography, the matrix appears subcompact (not very porous) and ranges from glassy, to welded-appearing, to fragmental in texture. The overall color is brown-black, but there are areas of lighter and darker matrix.

Agglutinates are relatively abundant as clasts and in the matrix. Glass spheres are present, whole and broken, and there are abundant glass fragments. A metal-sulfide sphere is present in 10019,63. This sample is not highly shocked, but there are crushed, recrystallized plagioclase fragments and undulatory extinction among the silicate mineral grains. Ilmenite is common and occurs in the matrix. The major lithic clasts are coarse- and fined-grained mare basalts and a few dark matrix breccias.

10021

Petrography: This sample is quite similar to 10019 in thin section. The matrix is brown-black and does not appear to be very porous. Its matrix texture is variable, ranging from fragmental, to welded, to glassy and vesicular in appearance.

Several large accretionary structures were observed in the matrix. Agglutinates are relatively abundant in the matrix and as clasts. They range from colorless to schlieren- and clast-rich. Spheres are common and range from colorless to pale to bright yellow; most are whole, some are broken; and they are generally clast-poor to clast-free. Some glass fragments contain skeletal crystals. Approximately 20% of the breccia is glass or glassy clasts; 20% is mineral clasts (pyroxene, plagioclase, ilmenite, olivine, sulfides and metal, listed in decreasing order), and 20% is lithic clasts of basalts (medium- to fine-grained, unshocked to aphanitic) and a few glassy matrix breccias. Some mineral grains exhibit reaction rims with the matrix, crushed internal structure and undulatory extinction.

10046

Petrography: This is a porous matrix sample with about 25% porosity in the matrix according to Phinney et al. (1976). In thin section the matrix displays a range in texture from fragmental to welded. The matrix components display a seriate grain size distribution and many appear to be glassy. The overall color is brown-black, but there are lighter and darker areas. Accretionary structures occur in the matrix. There are also abundant agglutinates and agglutinitic droplets, both as clasts and in the matrix. Ropy glass (Fruland et al., 1976) may also be present. Glass sphere fragments occur as clasts in the matrix. Mineral clasts appear to be more abundant than lithic clasts: mafics > plagioclase >> ilmenite > sulfides >> metal. There are coarse and fine-grained basalt clasts displaying a range in shock features, and rare, shocked plagioclase-rich (highlands?) clasts.

10048

Petrography: The sample is brown-black in thin section and appears to have a fragmental to welded texture. Porosity ranges from moderate to low. Phinney et al. (1976) define matrix for this sample as "glassy patches up to about 20um and sub-angular grains <10um." They report 40-45% of the breccia to be matrix with a 50-60% glass content and a 10-20% porosity. Simon & Papike (pers. comm.), defining matrix as <20um particles and including pore space, found ~50% by volume to be matrix.

There is a wide range in the type and occurrence of glass from agglutinates to clear and devitrified spheres and fragments, although the latter are not abundant. Clasts of mare basalts are relatively abundant, along with a small highlands component (plagioclase-rich fragments). Among the mineral fragments: mafics > plagioclase > ilmenite >sulfides > metals.

10060

Petrography: This is a very porous, fragmental breccia with a seriate grain size distribution. The matrix is brown-black in color, with a chaotic fabric. According to Phinney et al. (1976) the sample is moderately friable and the matrix contains about 35% pore space. Matrix, defined by this group as grains less than 10um, comprises 30-35% by volume of the rock. McGee et al. (1979), defining the matrix as the <39um material, determined matrix to be about 55% by volume. There is little discernable glass in the matrix, and the grains tend to be angular to sub-angular with a trace of shattered grains (Phinney et al., 1976). There are definitely accretionary structures present, similar to those described in McKay and Morrison (1971).

There are numerous agglutinates, both as clasts and in the matrix, and glass spheres, more broken than whole. There may be multiple-generation agglutinitic particles present.

Most of the clasts are basalt clasts, with perhaps a very small highlands component. Mineral fragments observed, in decreasing order, are mafics, plagioclase, ilmenite, sulfides, and metal.

10065

Petrography: The sample in thin section displays a porous to welded, fragmental to glassy texture with a seriate grain size distribution. The color is overall brown-black, with zones of darker and lighter matrix. There are excellent examples of accretionary structures in the matrix. Phinney et al. (1976), define matrix as glass plus <10 um grains. They report the sample as being moderately coherent, with a 10% matrix porosity and a 30% glass content. Total matrix is about 40-45% of the sample's volume. The glass texture (viewed with the SEM) appeared to be film-like or patchy, and the authors considered glass to be a sintering agent. The rest of the matrix was fragmental. Simon and Papike (pers. comm.) defined matrix as <20um, and found it to be about 49.3% by volume.

Agglutinates occur both as clasts and in the matrix. Spheres and glass fragments are present. The impression is that shattered and broken glass fragments are more abundant than whole or intact glass particles. The lithic clasts are primarily basaltic, with a few rounded crushed plagioclase-rich clasts. The minerals present, in decreasing order, are mafics, plagioclase, ilmenite, sulfides and metal.

10068

Petrography: This sample is a classic soil breccia. The matrix is quite porous with a seriate grain size distribution and a largely fragmental texture, but welded-appearing in some areas. The matrix is dark-brown to black in color, and contains accretionary structures.

There are abundant classic agglutinates, as individual clasts, and in the fine-grained matrix; some appear intact, others are broken. Glass spheres display a range in color (clear, pale yellow/green, bright yellow), and a range in texture. Some are whole, others are shattered or broken. Glassy fragments are typically clast-laden.

Mineral clasts are generally angular to subangular in outline. The major mineral clasts in order of decreasing abundance are: mafics, plagioclase and ilmenite, with minor sulfides and rare metal. Lithic clasts are nearly all mare basalts. They range from what appear to be small porphrytic vitrophyric clasts, to fine- and coarse-grained basalts.

10073

Petrography: The sample in thin section appears to be a very porous, fragmental to glassy matrix breccia with a seriate grain size distribution. There are areas of higher porosity that appear to coincide with the darker matrix areas and accretionary structures. The overall color is brown-black, although there are definitely areas of lighter and darker matrix. Agglutinates are abundant, generally appear to be clast-rich, and occur both as discrete clasts and in the fine-grained matrix. There are stringers of glass. Spherules are present but not abundant, and display a wide range of color and texture; some with quench textures.

Mineral clasts are abundant and in decreasing order are: mafics, plagioclase and ilmenite (not abundant), and minor sulfide and metal grains.

Lithic clasts are primarily mare basalts with a range in texture from vitrophyric(?), to fine-grained, to medium-grained. A few dark, fine-grained breccia fragments may be present.

12010

Petrography: The sample in thin section is composed essentially of two lithologies: a range of large igneous clasts and matrix. The brown-black matrix is relatively porous, and fragmental in texture with a seriate grain size distribution. The matrix fabric is chaotic.

Rare agglutinate-like fragments were observed. Whole and broken glass spheres are present, ranging in color from clear, to pale yellow, brown and orange-brown. Some glass is clast-rich and vesicular. The matrix contains mineral clasts and fragments of mafics (pyroxene, olivine), plagioclase, ilmenite, metal and sulfides.

The light-colored lithic clasts are typically porphrytic basalt clasts with angular to sub-rounded outlines. Fewer porphrytic vitrophyres are present. The lithic clasts are fractured, contain crushed mineral grains and (diaplectic) glass. The clasts make up roughly half of the thin sections viewed, which may not be very representative of the sample as a whole.

Wide variations in compositions have been reported for this sample (e.g. Goles et al., 1971; Compston et al., 1971). Petrographic control is required because the rock is so heterogeneous. Kirsten et al. (1971) report dramatic differences in solar wind gases between (gas-rich) matrix material and the igneous clasts, as well as some variation among the clasts.

12034

Petrography: The three macroscopic lithologies may correlate with three gradations in matrix color and porosity observed in thin section. The matrix ranges from dark brown-black to light brown in color. Changes in porosity follow changes in color: the black glassy matrix is vesicular; brown areas are porous and fragmental in texture with a seriate grain size distribution; the light brown matrix areas are compact, have little pore space and appear annealed. On the small scale of a thin section, the three matrix lithologies give the appearance of intruding each other plastically. Clasts display preferred orientation.

Glass occurs in a variety of forms. There are no obvious agglutinates, but dark matrix breccias are common as clasts. There is a thin vesicular coating along one (probably exterior) side, and there are vesicular glass veins within the breccia. There are numerous large and small brown, quench-textured glassy clasts. Some of these are clast-laden, some are vesicular. These glassy clasts are similar to Apollo 12 KREEP ropy glasses (Meyer et al., 1971). This "ropy glass" type of clast occurs in all three matrix lithologies.

Lithic clasts are not abundant. The basalt clasts observed were either ophitic or vitrophyric. Cataclastic anorthosite clasts are also present. Mineral clasts include plagioclase and mafics with the plagioclase most common.

Phinney et al. (1976) provide the following description, based on SEM petrography for 12034,37. Defining matrix as the <20um material, they report about 40-50% matrix by volume. Porosity, which included vugs up to about 30um, ranged from 15-20%. The sample appears to be coherent. About 50% of the matrix is glass: either "blobby or occurring as devitrified glass patches from 10-100um across with inclusions." Devitrification was found to be greater in the center of the glass patches. A few shattered appearing grains displayed partly annealed cracks.

12073

Petrography: This is a relatively typical regolith breccia. The matrix is porous with fragmental texture and seriate grain size distribution. The overall color is dark brown. There are accretionary structures in the matrix, but in general, the fabric appears chaotic. Agglutinitic glass is present, but no large intact examples were observed. There is a wide range in color and texture of glass: spheres (rare), ropy-appearing glass, and glass shards (angular to subrounded), are all present. There is much brown glass and lesser amounts of colorless, pale yellow or light to bright orange glass. Most glass is clast-laden and displays flow texture. Some glass has a quench texture. Black glassy areas may either be microcrystalline or have a high opaque content.

The major lithic clasts are basaltic. Shock features such as wavy extinction, shattered grains and thetamorphic glass were observed. Mineral clasts, in order of decreasing abundance, are: pyroxene, plagioclase, olivine, ilmenite and other opaques.

14042

Petrography: This is a highly porous, glassy to fragmental matrix breccia. The matrix has a seriate grain size distribution and is brown in color. Some structures appear accretionary, but the fabric is basically chaotic. There are few sizeable clasts. Agglutinates occur but, are generally small and part of the matrix. There are glass spheres and fragments, ranging from colorless to yellow to dark brown (cryptocrystalline). Pyroxene and plagioclase are the most common mineral clasts, a few display shock features such as fracturing and undulatory extinction. There is little ilmenite and metal in this sample. Basalt clasts with a range in shock damage are the most common lithic clasts.

Phinney et al. (1976), using SEM techniques, found the matrix to be relatively porous (about 35%). The volume of matrix (grains <10um) in the area of study (14042,12) was found to be 30-35%. The matrix contains some shattered grains, but filaments were also observed and the sample had a sintered texture. Chao et al. (1972) classified 14042 as an unshocked, porous regolith microbreccia.

14047

Petrography: Thin section 14047,53 displays a complex matrix texture in which dark-brown, porous matrix interfingers with brown annealed-appearing matrix. Accretionary structures are present in the matrix.

Agglutinates occur generally as agglutinitic glass in the matrix. Small, whole or broken spheres are present, ranging from colorless, to yellow and red. Some display a quench texture or skeletal mafic crystals. Irregular glass fragments are generally clast-laden, and range in color from clear, yellow (most common), and red-brown.

A few shocked, granular-porphrytic mare basalt clasts and breccia clasts are apparent in thin section. Mineral clasts include mafics and plagioclase. Opaque abundance is very low, in decreasing order: ilmenite, metal, troilite and chromian spinel (Carlson and Walton, 1978).

The matrix texture ranges from fragmental to glassy. Phinney et al. (1976), who studied the matrix of 14047,4 with the SEM, defined matrix as the <10um grains and glass patches that are "blobby, vesicular and 1-20 um in diameter." Their sample contained 40-45% matrix with a porosity of <10%. Simonds et al. (1977) reported that the sample was made up of 85.5% matrix defined as particles <39um. Chao et al. (1972) call 14047 an unshocked, porous regolith microbreccia.

14049

Petrography: This breccia has a highly porous, glassy to fragmental matrix with a seriate grain size distribution. The overall thin section color is brown. There are accretionary structures present, but the overall fabric is chaotic.

Agglutinates are present as clasts as well as in the matrix, and are vesicular, clast-laden, and range from light to dark brown in color (some appear greenish). Ropy glass may be present; spheres, whole and broken, some with a quench texture, are present. Glass fragments occur as clasts and in the matrix. Lithic fragments include breccia clasts and rare basaltic (shocked) clasts. Major mineral clasts are: plagioclase and mafics, with rare ilmenite and metal.

This is one of the most friable Apollo 14 samples, and it contains the highest agglutinate content of those breccias studied by Simonds et al. (1977). Chao et al., (1972) classify it the same as 14042 and 14047, an unshocked, porous regolith breccia.

14055

Petrography: The sample is highly porous in thin section with a seriate grain size distribution and a fragmental to glassy-appearing matrix. There are accretionary structures present, and some subtle color variations suggestive of a breccia-in-breccia structure. Shock fractures were observed. The overall color is brown. Agglutinitic glass appears in the matrix, but there were no obvious agglutinates as clasts. Glass spheres and fragments are present as clasts and in the matrix. The glass fragments range in color from clear to greyish, yellowish and brownish, and are usually clast-bearing.

There are some shocked granulitic clasts and a few dark matrix breccia clasts. Mineral fragments are few, but include plagioclase and mafics. Opaques are rare. Chao et al. (1972) classify it as an unshocked, porous regolith breccia.

14255

Petrography: In thin section, the matrix has a glassy to fragmental texture with a seriate grain size distribution. The overall color is brown. The matrix ranges from porous, to non-porous in glassy-appearing areas. There is a subtle alignment of grains and this impression is reinforced by a set of apparent shock cracks with parallel to subparallel alignment.

Agglutinates and a few glass spheres are present, mainly in the matrix. Glass fragments occur both as clasts and in the matrix. Colorless, angular glass is probably maskelynite. Clast-laden brown and yellow glass is common (ropy glass?). Quench-textured glass is also present.

There are no large lithic clasts. There are small clasts of crushed-appearing, or shock-melted basaltic material. There are also mineral fragments: plagioclase, mafics, minor ilmenite and metal.

14301

Petrography: In thin section the matrix texture ranges from angular fragments to rounded, and from porous to compact (welded-appearing), with a seriate grain size distribution. The overall color is grey to grey-brown. There may be some subtle layering present (coarse on the thin section scale), and there are accretionary structures in the matrix and around clasts. Shock cracks are present.

Agglutinates were not observed, but glassy particles resembling ropy glasses are present. Glass spheres range from colorless to yellow; and from whole to broken, some with clasts and others with quench textures. Glass fragments display a similar range in color and texture; clear fragments may be maskelynite; some clast-containing glass clasts display internal flow structure.

The most common lithic clasts are shocked, crushed and/or recrystallized-appearing basalts; breccia clasts are also present. Mineral clasts, in decreasing abundance, are plagioclase, mafics, ilmenite and metal. Spinel was observed in the matrix of 14301,9. Matrix, defined as <39um, is only 46% by volume according to Simonds et al. (1977). 14301 is classified as a porous, unshocked regolith breccia by Chao et al. (1972).

14307

Petrography: This is an unusual-appearing regolith breccia in thin section. The matrix texture appears glassy and annealed, with a seriate grain size distribution, and an overall brown color. There are accretionary structures in the matrix; and also discernable layers or zones in some thin sections. Most of the matrix is dark brown in thin section, but some areas are slightly lighter in color. One or two sets of (shock) fractures may be present. Simonds et al. (1977) report 65% matrix by volume, which is on the low side for a regolith breccia.

In 14307,9 a glass-coating is present, and vesicular glass surrounds interior breccia clasts and rounded, shocked igneous clasts in which the plagioclase has been maskelynitized. Simmonds et al., (1977) report a 1% agglutinate content. There is a range in glass spheres (colorless, pale to bright yellow, reddish; whole and broken, clast-free to clast-laden); and there are abundant glass fragments (most are yellowish and contain schlieren).

There are abundant coarse- and fine-grained and porphrytic igneous clasts; most show signs of shock. 14307,40 displays offset along a fracture. In the same section, half of a coarse-grained basaltic clast has re-crystallized into the fine-grained, porphyritic equivalent. Lithic clasts of plagioclase and mafics only, and of plagioclase, mafics and opaques are present. One clast is rounded and appears to be composed of an opaque (ilmenite) surrounding plagioclase crystallites. Many clasts are breccia clasts and some display breccia-within-breccia texture. Mineral clasts observed include: plagioclase, mafics, ilmenite, sulfide, metal and spinel. Chao et al. (1972) classify 14307 as a shocked regolith breccia.

This sample contains KREEP with a modal age of 4.4 by (Berdot et al., 1972; and Nyquist et al., 1972). Berdot et al., (1972) note that the dark matrix of 14307 contains large absolute amount of excess ^{40}Ar ($^{40}Ar/^{36}Ar$ = 4.8).

14313

Petrography: The sample has a porous, fragmental matrix with a seriate grain size distribution and is brown overall in color. Accretionary structures are present in thin section, but in general the fabric is chaotic. There may be some small matrix agglutinates, and 14313,56 contains ropy-like glasses. Glass is common as spheres and as fragments (clasts and matrix). The glass ranges from clear to light yellow to light brown; some is clast-laden with flow bands. Other glasses have reaction rims against the matrix or display a quench texture. Lithic clasts range from basaltic clasts to granulitic anorthositic clasts. Breccia clasts are the most common type and are grey and fine-grained. Mineral clasts are: plagioclase (much more abundant than the rest), mafics, with rare ilmenite, and metal. Chao et al. (1972) classify 14313 as a compact, nonporous regolith breccia.

14315

Petrography: In thin section the matrix is compact with a low porosity. It has a glassy texture and is dark brown in color with a seriate grain size distribution. There is a high clast to matrix ratio (66% matrix by volume according to Simonds et al, 1977) for a regolith breccia. The clasts are rounded and display a subparallel alignment. There are shock cracks present, but they display no preferred alignment on the thin section scale.

The round clasts are either glass spheres or mechanically-abraded igneous clasts. Accretionary structures are present. No agglutinates were observed. The glassy spheres and fragments range in color from clear to brown, and display quench or cryptocrystalline textures; some are whole, others are broken.

Lithic clasts include breccias and igneous clasts. There are some breccia-in-breccia structures and numerous crystalline matrix breccias. Igneous clasts observed include granulitic mare basalts, feldspathic basalts and highly shocked clasts with a low opaque content. Plagioclase is the major mineral clast, followed by mafics and ilmenite, metal, sulfide and spinel. Chao et al. (1972) classify 14315 as a spherule-rich, transported microbreccia.

14318

Petrography: The matrix appears to be glassy with little pore space. Some breccia clasts are porous, however. There is a high clast-to-matrix ratio (only 42% matrix by volume according to Simonds et al. 1977), and a seriate grain size distribution. The matrix appears medium to light brown in color, and the overall color of the sample in thin section is grey-brown. The numerous rounded clasts show subparallel alignment, and at least one parallel fracture system was observed on the thin section scale. The glass shows accretionary structure and the larger clasts display a breccia-in-breccia texture.

No agglutinates were observed. Whole and broken glass spheres are present (clear, yellow, red-brown). More abundant are glass fragments with the same range in color. Some are clast- and schlieren-rich.

Lithic fragments display a wide range in texture. Most appear igneous: crystalline matrix breccias, granulitic and shocked mare and feldspathic basalts; the rest are breccia fragments.

Mineral fragments tend to be shocked, fractured, and/or broken, and include plagioclase, mafics, minor ilmenite, metal and sulfide.

15015

Petrography: In thin section the matrix is glassy, vesicular, and dark-brown to black in color. It is composed of glass, mineral and lithic fragments with a seriate grain size distribution. Although there are no identifiable agglutinates, accretionary structures occur around clasts, and glassy vesicular veins intrude the matrix. There appears to be an alignment of clasts in at least one direction.

Colorless, pale green, yellow, and brown glass spheres and fragments are present. Some glass clasts display reaction rims with the matrix and quench textures. Ropy glass fragments and maskelynite may be present.

Lithic clasts include basalt clasts with a range in texture (ophitic, coarse- and fine-grained), and rare breccia clasts.

Mineral clasts are common and include: mafics, plagioclase, ilmenite and sulfides.

15086

Petrography: 15086 is a typical Apollo 15 soil breccia, with a very porous fragmental matrix texture and a seriate grain size distribution. The fabric is chaotic, with no obvious clast alignment, no discernable accretionary patterns, and no observed fracture systems.

Agglutinates are present in the matrix, but are not abundant. Glass particles include green spheres and shards; orange-brown sphere-bearing clasts (these may be clast-laden and/or quench-textured); yellow glass, rare bright orange fragments, and patches of irregular, schlieren-bearing glass.

In addition to the glass clasts, there are basalt clasts and mineral clasts of mafics, plagioclase, ilmenite, metal and rare sulfide.

15205

Petrography: The matrix ranges from fragmental to glassy and annealed-appearing. It is subcompact (not very porous) with a seriate grain size distribution. The matrix fragments and pore space show a preferred orientation in one direction. There are accretionary structures in the matrix and a shock fracture pattern in two directions. The overall color is brown.

No agglutinates were observed, but there are abundant glass spheres, ellipsoids and angular fragments. Color ranges from colorless, pale green, brownish, and (rare) orange. One large orange-brown clast contains spheres and displays a quench texture. There are also greenish and brownish glass veins which display cloudy to quench textures.

Lithic clasts are predominantly basaltic to gabbroic, with rare breccia clasts. Mineral clasts include plagioclase, mafics and ilmenite, minor sulfide and rare metal. The ilmenite is relatively abundant in the matrix.

15265

Petrography: The sample has a moderately porous matrix, a fragmental texture and a seriate grain size distribution. (There are areas in the matrix that give the impression of bimodality.) There are accretionary structures in the matrix and around clasts. Overall the fabric is chaotic, with no obvious alignments or shock fractures.

Agglutinitic glass may be present. Glass spheres and fragments range from clear, pale green, yellow, orange to red brown in color; from unfractured to shattered, with and without quench textures and clasts.

Lithic clasts include aphanitic matrix breccias and basalts. The basalts range from intergranular to intersertal and variolitic in texture. Vitrophyric porphrytic textures were also observed. Mineral clasts include plagioclase, mafics and ilmenite. The opaque content is very low.

15295

Petrography: The sample has a brown, glassy-textured matrix with low porosity. The general fabric is chaotic, but there are accretionary structures around some clasts, and some local alignments of matrix grains. There are two sets of shock fractures, roughly perpendicular to each other.

No agglutinates were observed. There are numerous glass spheres and clasts with quite a range in size, color and texture: large and small; whole and broken; colorless, brown, yellow, orange-brown, and orange (rare); most are fractured; some are clast-laden or quench-textured. Maskelynite is probably present. One large brown clast appears to be a shock-melted basalt. It contains relict mafic and plagioclase crystals, but has a largely quench texture.

Lithic clasts range from basaltic to large (shocked) ANT fragments. There are a few small breccia clasts. Mineral clasts include mafics, pyroxene and opaques. Ilmenite is not abundant.

15306

Petrography: The breccia has a subcompact, fragmental to glassy-textured matrix, with a seriate grain size distribution. Porosity is low, fabric is chaotic; a few accretionary patterns were observed in the matrix, as well as a few shock fractures.

Agglutinates are present, and possibly ropy glasses. There are numerous green glass spheres and fragments (very pale green in thin section). Yellow, rare orange, and brown glass (clast-rich or quench-textured) is also present. Glass is the most common type of clast.

Lithic clasts are not common and are either ANT suite igneous or anorthositic cataclastic fragments. Mineral clasts are abundant: plagioclase (and maskelynite), mafics and minor opaques (ilmenite, metal and sulfides).

15465

Petrography: This is a complex regolith breccia with several lithologies present in thin section (which may or may not be representative of the rock as a whole). The matrix is fragmental to glassy and ranges from porous to subcompact. The fabric is basically chaotic, but there are breccia-within-breccia structures. No distinct accretionary structures were observed. The overall color is brown-grey.

Agglutinates are present but not common and range from very dark to light brown, vesicular and clast-laden. The most common glasses are green glass spheres and shards, but there are also rarer yellow, red and brown spheres and shards. Some of these are quench-textured. Large parts of this section (,28) are similar to the green glass clods.

Lithic clasts include ANT suite fragments, some are crushed, others are partly melted or partly recrystallized. There are a few highly shocked fine-grained anorthositic clasts, and a few dark matrix breccia clasts. Mineral fragments include plagioclase, mafics, and rare ilmenite and metal.

15505

Petrography: The matrix has low porosity, a glassy-appearing annealed texture, and a seriate grain size distribution. The texture is chaotic in general, with some accretionary structures observed. There are pronounced parallel fractures. The overall color is dark brown.

Agglutinates were not observed, although there is a fair amount of glass. Some brownish-greenish clast-rich glasses maybe shocked agglutinates (agglutinitic glass that has lost its vesicularity from shock compression). Glass is present as whole and broken spheres and shards. The colors range from colorless, brown, red-brown to rare bright orange-red, and the texture ranges from inclusion-free to quench-textured to clast-laden.

The major lithic clasts are basalts and rare breccia clasts.

Mineral fragments include pyroxene and plagioclase; ilmenite with lesser amounts of metal appears to be relatively evenly distributed throughout the thin section viewed.

15558

Petrography: The breccia has a porous matrix in which the fragments range from angular to subangular to rounded and have a seriate grain size distribution. The fabric is chaotic. The matrix is grey-brown and the overall thin section color is brown.

Agglutinates are present along with abundant glass spheres and fragments. Some of the glass is clear, but most is either quench-textured or clast-laden. Color ranges from colorless to pale green to brown and red-brown. Lithic clasts include a range in basalt textures (vitrophyric, porphrytic, shocked, coarse-grained) and a few small breccia clasts.

Mineral clasts include mafics, plagioclase (some as maskelynite), ilmenite, metal and sulfides. A relatively high opaque content suggests a mare origin.

15565

Petrography: The sample contains a porous, fragmental matrix of angular to rounded grains with a seriate grain size distribution. The matrix color is grey-brown; overall color is brown. The general texture is chaotic with some accretionary structures in the matrix and shock cracks.

Agglutinates are not abundant and there may be rare ropy glasses (in 15565,48). Spheres, broken and intact, are abundant, and range from clear to dark brown. There are numerous very pale green glass spheres and rare orange glass fragments. Some glass is clast-laden and/or quench-textured. There are numerous glass fragments in the matrix and as clasts.

Lithic clasts are mainly basaltic, but there are a few breccia clasts. A fine-grained grey clast in 15565,84 contains a large pink spinel which suggests a highland component occurs in the breccia.

Minerals include mafics, plagioclase (some as partly-devitrified maskelynite) and opaques (ilmenite, metal, sulfides).

60016

Petrography: The matrix of this rock is relatively porous, fragmental and has a seriate grain size distribution. The texture is chaotic; no preferred orientations were observed.

Rare agglutinates are present; also glass spheres and fragments some with quench textures. There are numerous rounded, brown, clast-laden and/or relict grain-containing glass fragments. Rounded dark matrix (glassy) breccias, with relict clasts are also present.

The major lithic clasts are crushed anorthosite, granoblastic clasts, coarse- and fine-grained poikilitic impact melts, noritic clasts and a few breccia clasts. Mineral clasts include abundant plagioclase, pyroxene, olivine, and rare spinel, sulfides and metal. Rusty-appearing spots are present (Ryder and Norman, 1980). Metal is more abundant than either spinel or sulfide.

60019

Petrography: The matrix of this breccia is compact and only slightly porous because of vesicular glassy areas. The grain size distribution is seriate. The matrix ranges in color from brown to black with glassy swirls and glassy accretionary structures around some clasts. There are glass-lined cracks and veins in the matrix. The overall color in thin section is grey-brown.

No agglutinates or spheres were observed, but glassy clasts and patches, usually clast-laden or with a quench-texture are present.

Lithic clasts are poikilitic impact-derived melts, most with opaques. Mineral clasts include plagioclase and mafic minerals; metal and sulfide occur together; there is minor ilmenite.

60255

Petrography: The sample is compact and has a cryptocrystalline to glassy matrix. Depending upon which thin section is viewed, a dark brown and a lighter-colored matrix are both present. There is a definite orientation of clasts, or fabric, observed on both the macro- and microscopic scale.

No agglutinates were observed. Glass spheres and fragments occur and range from colorless to yellow, brown and orange in color. Some are quench-textured.

Lithic clasts include granoblastic and basaltic clasts, gabbroic clasts, and rare olivine vitrophyres. Mineral fragments include plagioclase, pyroxene, metal, sulfides and ilmenite, in decreasing order of abundance.

60255 contains abundant trapped solar wind gases and a cosmogenic component; it may or may not contain excess fission Xe (Bernatowicz et al., 1978).

60275

Petrography: The matrix of this sample is a welded-appearing brown glass. There is a seriate clast population. Although there are clear and brown quench-textured glass clasts present, no agglutinates and only rare spheres were observed.

Lithic clasts include poikilitic and basaltic melt fragments; crushed anorthosites and feldspathic granulites. Mineral fragments include plagioclase, mafics, and very minor opaques.

61135

Petrography: The matrix texture is fragmental with some glass, and it has a seriate grain size distribution. Although the rock itself is friable, the sample in thin section is not porous and is subcompact. The color is light grey. The thin sections viewed displayed no pronounced orientation or fabric. Accretionary structures do occur around some clasts.

Agglutinates are uncommon, range from light to dark brown, and tend to be clast-laden and devitrified. Clear to brown glass spheres and fragments are present; ropy glass may be present in the matrix.

Mineral fragments observed include abundant plagioclase, less common mafics and opaques. clasts. Most lithic clasts are anorthositic or noritic, with breccia clasts also being present, and markedly rounded.

61175

Petrography: The sample is a classic fragmental soil breccia. It has an extremely porous, fragmental, light grey matrix and there is no apparent fabric or accretionary structures. There are abundant agglutinates, which tend to be fragmental, and other glassy components include glass spheres and shards, and ropy glasses.

Mineral clasts include plagioclase, mafics, minor ilmenite, rare metal, sulfide, and spinel. Lithic clasts include basalt melt rocks, coarse- and fine-grained ANT's and cataclastic anorthosites.

61195

Petrography: The sample in thin section is compact and has a glassy, welded-appearing matrix. It is light brown in color. Two or possibly three fracture sets are present.

No agglutinates were observed. Glass spheres and fragments are common. A brown glass coating and glassy veins are vesicular and contain clasts.

Lithic clasts include granoblastic and cataclastic anorthosite and noritic material, impact melts with a range in texture and plagioclase vitrophyres. Clasts range from angular to rounded, most show signs of shock and melting. Mineral clasts include plagioclase, pyroxene, olivine, minor metal and sulfide, and rare ilmenite.

61295

Petrography: The sample in thin section displays a very porous, fragmental matrix, with a seriate grain size distribution. The color is light grey brown. There are no obvious preferred lineations or fabric. Some clasts do appear to be surrounded by accretionary structures.

Glass types include agglutinates, spheres, shards and possibly some ropy glasses. Colors range from clear, to pale green, brown and orange.

Mineral fragments include abundant plagioclase and mafic minerals, with minor amounts of ilmenite, metal and sulfides.

Lithic fragments include feldspathic basalts and granulites, melt rock clasts and aphanitic matrix breccia clasts.

66035

Petrography: The sample appears to have low porosity in thin section. It is fragmental to glassy in appearance with a seriate grain size distribution. Color is medium grey-brown. Overall texture is chaotic, but accretionary structures surround some large clasts.

Agglutinates were not observed. Glass spheres, brown clast-rich glass and possibly ropy glass fragments are present.

Mineral clasts include plagioclase, pyroxene, olivine and minor ilmenite, metal and sulfides. Lithic clasts include light and dark clasts: the two large clasts are a noritic anorthosite and a norite; melt rock types, and breccia clasts display a range in texture.

66075

Petrography: In thin section the sample is not very porous and has a fragmental to glassy matrix. Grain size distribution is seriate. Matrix fabric is chaotic. Overall color is light grey brown.

Glass particles observed include possible agglutinates, ropy glass, spheres, and brown glass.

Mineral clasts include: plagioclase, olivine, pyroxene, spinel, sulfide and metal.

Lithic clasts are mostly impact melt rock types ranging in texture from glassy to aphanitic breccias, vitrophyres, poikilitic breccias and basalt melt rocks. Granoblastic ANT rock clasts are also present.

70019

Petrography: The sample in thin section exhibits a very porous, fragmental, dark grey brown matrix with a seriate grain size distribution. There is a vesicular glass coating, glass veins and glassy patches (the latter are still quite porous). A chaotic fabric and fracture patterns are present in thin section.

Agglutinitic glass is present, along with glass spheres and fragments with a range in color and texture from orange, black, and pale green to colorless.

Mineral clasts include plagioclase, pyroxene, olivine, relatively abundant ilmenite, and minor metal and sulfides. Mare basalt clasts are the most abundant lithic clasts.

70175

Petrography: This unusual breccia is orange- and black-glass-rich. It is reminiscent of the Apollo 15 green glass clods. The matrix is compact, with very low porosity, and appears to be composed of orange and black glass spheres and shards; mineral fragments (mafic and plagioclase clasts are identifiable), and a black aphanitic lithology. The matrix color is basic black, the overall thin section color is red-black. There are two or possibly three sets of shock fractures.

There are no recognizable agglutinates. In addition to the orange and black spheres and shards, there are veins and clasts of clast-rich yellow-orange glass.

Ilmenite is present but is very fine-grained and skeletal.

70295

Petrography: The matrix is fragmental, compact and essentially non-porous. Matrix grains range from angular to rounded and have a seriate size distribution. There are no obvious accretionary structures and no fracture systems were observed.

The glass component includes some agglutinitic glass and clast-laden glass. Orange is the dominant glass color. There are some black glass spheres and shards. Colorless clast-free fragments may be maskelynite.

The major lithic clasts are mare basalts, some are shocked and rounded or abraded in appearance. There may be some recrystallized ANT suite lithologies, and a few small aphanitic matrix breccias are present.

Plagioclase, mafics and ilmenite are the most abundant mineral clasts; minor metal and sulfides are present.

74115

Petrography: This breccia has an extremely porous, fragmental-textured matrix with a seriate grain size distribution. Although the matrix contains some glassy areas, it is composed primarily of angular grains and shards. Accretionary structures are present but the general fabric is chaotic. The matrix and overall color is light to medium grey.

Agglutinates are present as well as a few orange and black glass spheres. Other glass includes colorless spheres and fragments, clast-rich brown glass and brown quench-textured glass. There are both (rare) mare basaltic and highland's affinity lithic clasts present, but neither are abundant. There are numerous dark matrix (aphanitic) and glassy matrix breccia clasts. Most, but not all the lithic clasts give the impression of being rounded rather than angular. Mineral clasts include plagioclase, mafics, minor ilmenite and metal.

74246

Petrography: The two thin sections viewed were dominated by an igneous clast containing (very approximately) 55% plagioclase, 20% pyroxene, 10% olivine and 15% ilmenite. The breccia portion was polymict with a dark grey, compact, fragmental-textured matrix. Fabric was chaotic; there were no discernable accretionary structures or shock fractures. No agglutinates were observed. Orange and brown glass spheres and fragments are present as clasts. There are small clasts of shocked and unshocked igneous material. Mineral clasts include plagioclase, pyroxene, olivine, ilmenite and minor metal.

76565

Petrography: The sample in thin section has a subcompact, relatively non-porous, glassy to fragmental matrix with a seriate grain size distribution. There is a range in porosity, although it is never high. Overall fabric is chaotic; color is dark brown. Accretionary structures were not observed. Fractures are short and randomly-oriented.

Agglutinitic glass may be present: there are light brown vesicular clast-bearing glass clasts. A large angular orange-glass clast, a few small orange spheres and shards are present. Some spheres have quench textures and there are irregular glass patches, usually containing mineral clasts.

Lithic clasts include highland's-affinity feldspathic clasts and a few mare (ilmenite-rich) basalt clasts. There are aphanitic clasts, either highly shocked basalts or breccias. Mineral clasts include plagioclase, mafics, some ilmenite and minor metal and sulfide.

78546

Petrography: The matrix of this sample is compact and non-porous with a glassy to fragmental texture. The grain size distribution is seriate, and the overall color is brown-black. There were no cracks or fracture sets observed. Accretionary structures may be present in the generally chaotic matrix. At least one clast appeared to be wrapped by fragment-laden glass.

Agglutinates are present along with orange and black glass spheres and colorless spheres (large in size compared to orange spheres). Glass fragments and shards, and schlieren-rich clasts are also present.

Lithic clasts include shocked mare basalts with ilmenite and recrystal-lized-appearing feldspathic rocks. Mineral clasts include plagioclase, mafics, ilmenite and rare metal.

79035

Petrography: The matrix of this breccia is highly porous with a fragmental texture and seriate grain size distribution. The color is dark brown-black. The matrix and clast fragments range from angular to rounded. Fabric is generally chaotic. A few large clasts appear surrounded by accretionary structures.

Agglutinates are relatively numerous, as are orange and black spheres and shards. Clear to clast-laden glass spheres and shards are also present. Some glass is probably maskelynite and some display quench textures.

There is a range in texture among the lithic clasts, which include mare basalts, breccias and anorthosites. Mineral clasts include plagioclase, pyroxene, olivine, ilmenite and minor opaques.

79135

Petrography: The matrix of this breccia ranges from fragmental to glassy in texture, is moderately porous, has a seriate grain size distribution and is brown-black in color. The fabric is chaotic. No obvious accretionary structures were observed.

Agglutinitic and/or ropy glass is present along with dark brown, red and clast-rich glass clasts. Colorless, orange and black glass spheres and shards are also present. Brown, quench-textured glass was observed.

Lithic clasts include mare basalts, norites, anorthosites, and breccias. Mineral clasts include plagioclase, pyroxene, abundant ilmenite and minor metals and sulfides.

79175

Petrography: The matrix is very compact, fragmental to glassy and non-porous. The color is black and the grain size distribution is seriate. Clasts of matrix are bonded together by yellow vesicular glass. Accretionary structures are present. Within the matrix there are numerous red, pale yellow, orange, brown and even clear vesicular glass clasts, much of which is schlieren-rich and swirly. Some of these clasts may be agglutinates.

Most of the glass is clast-rich. A few spheres are present. Lithic clasts include orange glass clasts, mare basalt clasts with a range in texture, shocked and/or melted feldspathic clasts, and probable breccia clasts.

Mineral clasts include mafics, plagioclase, abundant ilmenite and minor metals and sulfides.