

LUNAR SAMPLE ALLOCATION GUIDEBOOK

Astromaterials Acquisition and Curation Office
Astromaterials Research and Exploration Science Directorate

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National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
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1.0 INTRODUCTION

1.1 Purpose

The Lunar Sample Allocation Guidebook is a reference source for lunar sample investigators and prospective investigators, and includes descriptions of specific procedures and requirements, as well as Lunar Curatorial and other facilities available to support lunar sample investigators.

1.2 Overview of the Apollo Lunar Sample Collection

The Apollo missions to the Moon included six piloted landings in 1969-72 that returned to Earth a total of 382 kilograms (842 pounds) of geologic samples consisting of 2,196 separate specimens. Table 1 summarizes the original collection on a mission-by-mission basis. Recognizing that the scientific value of the samples can be maximized only by intensive study of the materials, NASA continuously has made available subsamples of lunar material to qualified investigators. Results of those studies have been published by teams of investigators, as well as by individual investigators, in the open scientific literature. An authoritative digest of those findings can be found in *Lunar Sourcebook: A User's Guide to the Moon* (G. Heiken, D. Vaniman, and B. M. French, Eds.; Cambridge University Press, 736 pp.; 1991; ISBN 0-521-33444-6) and the *New Views of the Moon* (B. Jolliff, M. Wieczorek, C. Shearer, and C. Neal, Eds.; Mineralogical Society of America Reviews in Mineralogy & Geochemistry, Vol. 60, 772 pp.; 2006; ISBN 0-939-95072-3). Although samples have been provided to thousands of different research projects, conservation of the sample collection has assured that substantial amounts of pristine sample material remain available for continuing and future studies.

Table 1. Summary of Apollo lunar sample collection returned from the Moon.

| Mission | Rocks | | Core samples | | Regolith Fines | | Mission Total | |
|---------|-------|------------|--------------|----------|----------------|-----------|---------------|------------|
| | No | Mass(g) | No | Mass(g) | No | Mass(g) | No | Mass(g) |
| AP 11 | 50 | 9685.717 | 2 | 98.2 | 16 | 11770.625 | 68 | 21554.542 |
| AP 12 | 49 | 27682.04 | 4 | 427.1 | 16 | 6242.4 | 69 | 34351.54 |
| AP 14 | 151 | 28629.81 | 6 | 377.59 | 70 | 13277.31 | 227 | 42284.71 |
| AP15 | 267 | 58578.16 | 11 | 4645.0 | 179 | 140887.4 | 457 | 77310.56 |
| AP16 | 544 | 70069.321 | 16 | 7050.7 | 282 | 18594.43 | 842 | 95714.451 |
| AP17 | 335 | 73712.513 | 17 | 7337.28 | 398 | 29468.421 | 750 | 110518.214 |
| TOT. | 11396 | 268357.561 | 56 | 19935.87 | 961 | 93440.586 | 2413 | 381734.017 |

2.0 ACCESS TO LUNAR SAMPLES

NASA policies define lunar samples as a limited national resource and future heritage, and require that samples be released only for approved applications in research, education, and public display. To meet that responsibility, NASA carefully screens all sample requests with most of the review process delegated to the Curation Analysis and Planning Team for Extraterrestrial Materials (CAPTEM) and the Lunar Sample Curator. All individuals requesting a lunar sample should follow the steps given below for the appropriate category of sample.

2.1 Research samples

NASA provides lunar rock, regolith, and core samples for both destructive and non-destructive analysis in pursuit of new scientific knowledge. Requests are considered for both basic studies in planetary science and applied studies in lunar materials beneficiation, resource utilization, and human spaceflight.

2.1.1 The sample investigator must demonstrate favorable scientific peer review of the proposed work involving lunar samples.

The required peer review can be demonstrated in any one of three ways: (1) a formal research proposal recommended by any NASA funding program for planetary or program science within the past three years; (2) a formal research proposal recommended and funded by any government or non profit funding agency, foreign or domestic; or (3) submittal of a proposal for the research supported by reprints of scientific articles pertaining directly to the specific research methods to be applied to the samples (step 2.1.2), and published in peer-reviewed professional journals.

New investigators not familiar with lunar materials should consult *Lunar Sourcebook: A User's Guide to the Moon* (G. Heiken, D. Vaniman, and B. M. French, Eds.; Cambridge University Press, 736 pp.; 1991) and the *New Views of the Moon* (B. Jolliff, M. Wieczorek, C. Shearer, and C. Neal, Eds.; Mineralogical Society of America Reviews in Mineralogy & Geochemistry, Vol. 60, 772 pp.; 2006). See also www.lpi.usra.edu.

2.1.2 The investigator submits a written request specifying the numbers, types and quantities of lunar samples needed as well as the planned use of the samples.

For planetary science studies, the sample request proposal should be submitted directly to the Lunar Sample Curator at the follow address:

Gary E. Lofgren
Lunar Sample Curator
Mail Code KT
NASA Johnson Space Center
2101 NASA Parkway
Houston, Texas 77058-3696
USA
Office: 281-483-6187
Fax: 281-483-5347
E-Mail: gary.e.lofgren@nasa.gov

The sample request must present the scientific or technological justification, the scientific or technological methods, and the scientific or technological benefits. The request will be considered favorably if preliminary work has been completed on terrestrial, meteoritic, or lunar simulant materials using proposed peer-reviewed methods. Requests determined to be sufficiently mature to warrant consideration for use of lunar materials will be forwarded to CAPTEM by the Lunar Sample Curator.

For new investigators, tangible evidence of favorable peer review (step 2.1.1) should be attached to the sample request proposal together with appropriate résumés. Investigators proposing the application of new analytical methodologies (not previously applied to lunar

samples) should submit test data obtained for simulated lunar materials including meteoritic and carefully selected terrestrial materials.

The Curation Web site contains a summary of the requirements for lunar sample requests:

<http://curator.jsc.nasa.gov/>

2.1.3 The Lunar Sample Curator will research the availability of the requested samples and decide whether the request can be processed without further action or if the request is to be reviewed by CAPTEM.

Outside review is prescribed for all new investigators and for most established investigators except where returned (previously used) samples are being requested. For outside review, the Lunar Sample Curator forwards the original request, with background information, to CAPTEM, a standing committee of scientists (with rotating membership) who advise NASA on the care and use of lunar samples. CAPTEM checks for favorable peer review (step 2.1.1) and appropriate sample selection (step 2.1.2).

2.1.4 Given CAPTEM endorsement and concurrence by NASA Headquarters, the Lunar Sample Curator will prepare a Lunar Sample Loan Agreement for signature by the investigator's institution.

The agreement delineates the responsibilities of the new investigator and requires a security plan that prescribes precautions to minimize prospects for theft or unauthorized use of lunar samples. A PI's privilege for retention and use of lunar samples is contingent upon continued compliance with the Lunar Sample Loan Agreement. The PI will remain in good standing by fulfilling the following obligations: (1) maintenance of, and adherence to, the lunar sample loan agreement and security plan; (2) timely cooperation with annual lunar sample inventory; and (3) timely cooperation with sample recalls.

2.1.5 Upon receipt of the properly executed loan agreement, the Lunar Sample Curator prepares the authorized samples and sends them to the investigator.

Quantities less than 10 grams can be sent directly by U. S. registered mail to domestic investigators. Shipments to foreign investigators are sent by an international courier service, e.g. FedEx. *Quantities larger than 10 grams will usually be hand-carried by the investigator or a designated representative; exceptions to this requirement will be considered by the Lunar Sample Curator.*

2.1.6 Continuation as a Lunar Sample PI.

A PI's privilege for retention and use of lunar samples is contingent upon continued good standing in the Lunar Sample Program. The PI will remain in good standing by fulfilling the following obligations: (1) maintenance of, and adherence to, the lunar sample loan agreement and security plan; (2) timely cooperation with annual lunar sample inventory; and (3) timely cooperation with sample recalls.

2.2 Public Display Samples

NASA provides for a limited number of rock samples to be used for either short-term or long-term displays at museums, planetariums, expositions, or professional events that are open to the public. Requests for such display samples are administratively handled by the JSC Public

Affairs Office (PAO). Requestors located in the United States should apply in writing to the following address:

Mr. Louis Parker
Exhibits Manager
Mail Code AP161
Office of Public Affairs
NASA Johnson Space Center
2101 NASA Parkway
Houston, TX 77058-3696
USA
Email: louis.a.parker@nasa.gov
Office: 281-483-8622
Fax: 281-483-4876

For both domestic and foreign requestors, Mr. Parker will pass along the request to CAPTEM, via the Lunar Sample Curator, for advice on available samples and the suitability of the request. He will then advise successful applicants regarding provisions for receipt, display, and return of the samples. All loans will be preceded by a signed loan agreement executed between NASA and the requestor's organization. Mr. Parker will coordinate the preparation of new display samples with the Lunar Sample Curator.

The Curation Web site contains a summary of the requirements for lunar sample display requests:

<http://curator.jsc.nasa.gov/>

2.3 Educational Thin Sections Packages

NASA prepared polished thin sections of representative lunar rocks on rectangular 1 x 2-inch glass slides, with special safety frames, that are suitable for use in college and university courses in petrology and microscopic petrography for advanced geology students. Each set of 12 slides is accompanied by a sample disk of representative lunar rocks and soils, embedded in rugged acrylic disks suitable for classroom use and teaching materials. The typical loan period is two weeks. The This Section Package is sent 10 days in advance by registered mail. Each requestor must apply in writing, on college or university letterhead, to the following address:

Mary Drake
Education Sample Curator
Mail Code KT
NASA/Johnson Space Center
2101 NASA Parkway
Houston, TX 77058-3696
Email: mary.k.drake@nasa.gov
USA
Office: 281-483-3154
Fax: 281-483-5347

For each approved user, the Curation Office will prepare a loan agreement to be executed between NASA and the requestor's institution prior to shipment of the thin section package.

3.0 LUNAR SAMPLE ACCOUNTABILITY AND SECURITY

Lunar samples are the property of the United States Government, and it is NASA's policy that lunar sample materials will be used only for authorized purposes. It is therefore essential that rigorous accountability and security procedures be followed by all persons who have access to lunar materials. The elements of these procedures, described in the next sections, are (1) lunar sample loan agreement, (2) lunar sample security agreement, (3) PI accounting procedures for lunar samples, and (4) annual lunar sample inventory.

A program is in place for spot checks, by the Lunar sample curator, the JSC Security Division, and the International Relations Division of NASA Headquarters, for investigator adherence to procedures described in this guidebook, adherence to the provisions of security plans, and adherence to the requirement for annual sample inventories.

3.1 Lunar Sample Loan Agreements

A current loan agreement is a condition for the receipt and use of lunar research samples and lunar educational samples. These legally binding agreements specify the conditions for the loan of lunar samples, including security measures for safeguarding the samples, the return of loaned samples to NASA and, for research samples, an annual inventory of samples in the PI's possession. Appendix A1, *Domestic Lunar Sample Loan Agreement* and Appendix A2, *International Lunar Sample Loan Agreement* are examples of a loan agreement for research on lunar samples. Appendix B, *Lunar Petrographic Thin Section Package Loan Agreement*, is an example of a loan agreement for educational samples. Typically, research samples are loaned for a period of one, two, or three years. Educational samples are loaned for a standard period of two weeks, unless other time periods are justified by the requestor and approved by the Lunar Sample Curator who may seek guidance from CAPTEM in this decision.

3.2 Lunar Sample Security

A lunar sample PI is responsible for the control and safeguarding of all lunar samples consigned to his/her custody. In the event a sample is missing, lost, or cannot be accounted for, the PI must immediately report it to the local law enforcement agency and to the Lunar Sample Curator. A delay in reporting could seriously impede efforts to locate and recover the sample.

To ensure that appropriate procedures and safeguards are carried out in the PI's laboratory, and at the laboratories of his/her co-investigators if different from his/her own, a sample security plan is required. For research samples, the security plan is an attachment to the loan agreement as shown in Appendix A1, *Lunar Sample Loan Agreement* or A2, *International Lunar Sample Loan Agreement*. For educational samples, the security plan is incorporated in the loan agreement as shown in Appendix B, *Lunar Petrographic Thin Section Package Loan Agreement*.

It is recognized that security plans may differ somewhat between investigators, but every plan must incorporate the elements of security outlined in the *Lunar Sample Loan Agreement*. Changes in security plans are considered to be changes in scope of a contractual agreement, and must be submitted in writing to the Lunar Sample Curator for approval. The elements of an appropriate security plan include maintenance of an inventory log, keeping lunar samples under continual supervision, keeping lunar samples under the control of the PI and/or his designate. In

no case may the lunar samples be stored with money, precious stones or minerals, classified material, or any other item that is considered to be of high theft value.

3.3 Lunar Sample Accountability

Lunar sample investigators are expected to maintain complete records of the use of lunar samples in their possession. The samples become the PI's responsibility when delivery of the samples from NASA has been accepted, and that responsibility ends only when (1) the samples have been returned to NASA in the manner authorized, and (2) all sample material has been accounted for. The following sections specify requirements of sample accountability which must be met by a lunar sample PI.

3.3.1 Sample Transfer Documentation for Research and Educational Samples

All sample transfers between the Lunar Sample Curator and PIs must be documented. By signing the Sample Assignment Form (Appendix C), the recipient investigator becomes accountable for the sample. A PI may delegate authority to another person to receive samples in his/her name. Such a delegation of authority must be in writing and a copy must be on file with the Lunar Curator. A delegation of authority does not relieve the PI of responsibility for samples received by the delegated alternate or Co-Investigator.

Research samples transmitted by the Lunar Curator are accompanied by a *Lunar Sample Assignment* form, an example of which is shown as Appendix C. Educational samples transmitted by the Lunar Curator are accompanied by a *Lunar Petrographic Thin Section Package Sample Assignment* form, an example of which is shown as Appendix D. Upon receipt of samples, the appropriate form must be signed by the PI and returned to the Lunar Sample Curator.

Sample transfers are generally not permitted between or among PIs. The permanent transfer of samples to another PI should be completed by returning the samples to JSC. Samples will be reissued to the new PI. If a portion of an allocated sample is to be transferred to a new PI the sample is to be returned to JSC with an F-75 (Appendix G) documenting the splitting of the original sample. The returned sample will be given a new number and allocated to the new PI. In rare instances it is prudent to make a direct PI to PI transfer. This should only be done with the approval of the Lunar Curator and an F-75 documenting the splitting of the original sample should be sent to the Lunar Curator.

3.3.2 Sample Return Documentation for Research and Educational Samples

All lunar samples and residues remaining at the completion of experiments or investigations are to be returned to the Lunar Sample Curator. Upon the receipt of the samples and sample accountability and history documentation (section 3.3.3) from an investigator, the database will be updated and the Lunar Curator will issue a *Lunar Sample Return Receipt* (Appendix E) for research samples, and a *Lunar Petrographic Thin Section Package Sample Receipt* (Appendix F) for educational samples.

3.3.3 Sample Accountability and History Documentation for Research Samples

A summary of sample accountability information and a brief history of sample treatment must be returned to the Lunar Curator whenever sample materials are returned. *Lunar Curatorial Form F-75, Return Sample Accountability & History* (Appendix G), has been designed to simplify the accounting for allocated sample mass and the handling history of the lunar material while in the investigator's possession.

The sample history should be presented on *Lunar Curatorial Form F-75* as brief narrative describing actions that could have degraded the sample (e.g., processed in air, washed in acetone, crushed, sieved, etc.). Accurate documentation permits reallocation of samples not compromised by tests and handling, to other investigators for research.

Instructions for completing *Lunar Curatorial Form F-75* and for the packaging and mailing of samples to the Lunar Sample Curator will be provided to every investigator. An example of these instructions is shown as Appendix H. An electronic version of the F-75, the continuation sheet F-75c, and the instructions can be downloaded - <http://curator.jsc.nasa.gov/>.

3.4 Lunar Sample Inventory for Research samples

Annually, the Lunar Sample Curator will provide each PI with a complete inventory listing of samples in the investigator's possession for which the investigator is accountable. The PI is expected to review and verify the listing of current sample holdings to ensure (1) that all samples are appropriately listed, and (2) that all sample weights are correct. If the weight of a sample has changed as a result of destructive analysis, this fact must be documented and a F-75 submitted to change the accountable weight of the sample. The annual inventory must be supervised by the Principal Investigator and witnessed by a security official or other official of the investigator's institution. The verified inventory listing is to be promptly returned to the Lunar Sample Curator.

Where samples are in the possession of a Co-Investigator at the time of the annual inventory, the PI may authorize (in writing) the Co-Investigator to conduct the inventory and account for those samples in the possession of the Co-Investigator. That properly witnessed verification must be provided to the PI who will transmit it to the Lunar Sample Curator as part of the total inventory verification. In no case will the verification of sample inventory by any person other than a PI or an authorized Co-Investigator be accepted by the Lunar Sample Curator.

4.0 Sample allocations

Samples, including thin sections, are allocated to PIs on the recommendation of CAPTEM. Sample requests are reviewed by CAPTEM and approval is based on the premise that the PI is attempting to solve some specific lunar science or comparative planetology problem or an engineering study critical to future robotic or human missions. CAPTEM will usually respond directly to the PI requests, but on occasion may suggest alternative science strategies or samples based on its experience with lunar samples. The PI is not obligated to accept the recommendations in which case the PI and CAPTEM may need to negotiate a final allocation plan. Allocation plans are reviewed and approved by the Associate Administrator of the Science Mission Directorate at NASA Headquarters.

4.1 Sample Requests

It is essential that sample requests include a scientific discussion of the specific problem(s) that will be pursued in the sample studies and how the requested sample bear on the problem(s). Samples may be requested at any time. CAPTEM meets twice per year; one meeting is usually associated with the Lunar and Planetary Science Conference in March and the other usually occurs some time during October. Some requests will be evaluated between meetings. These requests include those from existing PIs requesting samples for previously approved projects, requests for thin sections only, requests for returned lunar samples. As a

general guideline, no lunar sample will be allocated that reduces the remaining pristine sample below 50% by weight. Exceptions are granted based on the importance of the scientific problems being studied.

4.1.1 Thin Sections

Thin section requests will be completed immediately to approved investigators with current Lunar Sample Loan Agreements, if the material is available. Requests for specific thin sections can be made, but general requests can be filled more promptly. If 1” round sections are required for the study that fact should be specified. A library of lunar thin sections is maintained and PIs can come to the Curation Facility to examine thin sections. Foreign visitors need to request access well in advance of their visit (2-3 months) to allow for badging security checks. We will request the necessary information once we receive the request. The PI can receive an immediate allocation of library thin sections for a period of 6 months. A long-term allocation of thin sections usually requires the fabrication of a new thin section.

Thin section studies are predicated on the assumption that the thin section will not be damaged in any way. Polished surfaces may be immersed in oil for microscopic observation, may be carbon coated for electron microprobe analysis, and may be gently cleaned and repolished in the course of these operations. Studies that require severe degradation of the surface such as ion microprobe or laser ablation inductively coupled plasma mass spectrometry analysis require permission of the Lunar Sample Curator.

4.1.2 Guidelines for Allocating Lunar Samples for Resource, Engineering, and Life Science Studies

Studies of resource utilization, engineering, and life science applications using lunar samples are encouraged. Lunar samples are, however, a scarce and precious national resource, and limited amounts of material are available for any type of study. Requests for samples must demonstrate knowledge of the lunar collection and be consistent with NASA policies concerning the heritage value of lunar samples.

All processes, procedures, and expected technical outcomes of the proposed tests must be described clearly in the sample request. The request must document the expertise of the team involved in the experiments. NASA funding for the proposed tests may be considered as evidence of expertise but is not a pre-requisite for receiving an allocation of lunar samples.

Prior tests using appropriate simulants are expected and must be documented. The request should identify specific properties of lunar material that make simulants unsuitable for the proposed tests. It is the responsibility of the requestor to obtain appropriate lunar simulants that have been characterized in the open literature, or provide to the Lunar Sample Curator all relevant and necessary information regarding physical or chemical properties of simulants prepared in-house.

The request must demonstrate efforts to downsize the scale of the tests for use of lunar material. Further, the proposers must verify that the request is for the minimum mass of lunar material that will yield useful results.

Test results on extraterrestrial materials are expected to be made available in the open scientific or technical literature. There is no propriety claim on data derived from tests on extraterrestrial materials allocated by NASA.

5.0 SAMPLE USE GUIDELINES

5.1 Numbering of Samples

Permanent numbers for samples are assigned by the Lunar Sample Curator's staff. Samples returned by investigators may be assigned new numbers when they are re-inventoried upon return to JSC. Investigators are required to identify all daughter samples by an unambiguous numbering system and account for them in their sample history. This numbering scheme must be explicitly written and available for inspection by NASA when security and inventory spot checks are conducted.

The Lunar Sample Curator's staff maintains sample records in a computer database. The computer programs accept the Lunar Sample Curator's numbering scheme, and no other. This numbering scheme is organized in such a manner that each individually separate sample is assigned a double number, the parts separated by a comma (e.g., 14026,34). The two parts are defined as the generic and specific numbers, (also parent, daughter) respectively.

The generic number has been assigned by the Lunar Curator. All samples from the same mission begin with an identical code, as shown in the following table.

| <u>Mission</u> | <u>Number</u> |
|----------------|---------------|
| Apollo 11 | 10XXX |
| Apollo 12 | 12XXX |
| Apollo 14 | 14XXX |
| Apollo 15 | 15XXX |
| Apollo 16 | 6XXXX |
| Apollo 17 | 7XXXX |
| Luna 16 | 21XXX |
| Luna 20 | 22XXX |
| Luna 24 | 24XXX |

Each generic number represents a single rock or soil sample. Some samples are homogeneous; others exhibit a high degree of variability.

On later missions (i.e., Apollo 15 and subsequent), numbering gives an indication of the type of sample represented, such as unsieved soil, sieve fractions, or rocks. Further, for these missions, sample numbers close to one another often indicate that the samples were collected at the same or adjacent lunar sites. These codes are explained fully in the lunar sample catalogs developed for each mission.

The specific number refers to an individual fraction of the whole, and numbers are assigned consecutively by the Lunar Curatorial staff as they are generated and entered in the Lunar Curatorial database.

5.2 Disposing of Samples Other Than by Return to Lunar Sample Curator

The process of analysis, or other operation involving lunar samples, may render them unrecognizable as lunar samples (note: loss of sample labels does not count as rendering samples as unrecognizable). The Lunar Sample Curator may authorize disposal other than by return. With respect to such a disposal, the PI is to inform the Lunar Curator of (a) the identity of the subject lunar sample(s) or lunar sample material(s), (b) the pertinent facts supporting the request for disposal rather than return, (c) a plan for the disposal of the subject material, and (d) submission of the requisite forms detailing the method of destruction, the sample number and type, and the mass involved.

The Lunar Sample Curator must approve all plans to destroy lunar samples in lieu of return to Curation Office. CAPTEM may be consulted for specific cases, if necessary.

5.2.1 Criteria for Samples that may be Destroyed in Lieu of Return to Lunar Curator

a. Sample destruction and disposal must take place by one of the accepted methods for destruction listed below.

b. In every case, destruction and disposal of the samples must be documented as described below.

5.2.2 Acceptable Methods for Lunar Sample Destruction

a. Dissolve the samples completely in acid.

b. Dilute the lunar material in and thoroughly mix with similar terrestrial material such that the lunar sample makes up <30% of the final, homogeneous mixture.

c. other methods may be approved after discussions between the PI and the Lunar Sample Curator (and CAPTEM if requested by the Lunar Sample Curator).

5.2.3 Documentation of Sample Destruction

The sample history form (F-75) will be used to document what samples are destroyed. Documentation must include:

a. The identity of the sample, including if it is a split of an originally allocated sample.

b. The weight of the sample that was destroyed (the split weight if appropriate, or the original weight if the entire sample has been destroyed).

c. The method of destruction.

d. The method of disposal.

5.2.4 Disposal of Containers, Trash, etc.

Disposable material of small value which comes in contact with lunar samples, such as containers, tools, paper, gloves, etc., should be treated as lunar material. Since lunar dust adheres to most surfaces, these items have potential collector item value. The PI should provide a disposal plan similar to that in section 5.2 or return all items to the Lunar Sample Curator for disposal. Under no circumstances are such items to be handled in a less secure manner than lunar samples themselves.

5.3 Acceptable Methods for Handling Extensively Subdivided Lunar Samples that do not Meet the Criteria for Destruction

Many lunar samples have been extensively subdivided, but do not meet the criteria for destruction discussed above. Nominally each split requires a separate sample history form (F-75). Completion of these largely duplicate forms is a large drain on PI and Curation resources. In some cases, this task may present an impediment to the return of samples. In most cases these samples are of limited value to other scientists. Whether there is value in the sample splits will be determined by consultation and discussion of the nature of the samples between the PI and the Lunar Sample Curator.

5.3.1 For Splits Determined Not to Have Significant Scientific Value

The splits can be recombined in a single vial and a gross weight determined. The gross weight of the recombined sample and the amount of sample lost to attrition can then be entered on the sample history form, F-75.

5.3.2 For Samples That Do Have Scientific Value

The splits will be returned as individually contained samples. A single F-75 will describe the process by which the samples were processed and any contamination information. An attachment should list weights of individual samples and describe further individual processing.

5.4 Sample Transfers

Samples that weigh 10 grams or less may be transferred by registered mail between locations in the United States. All samples weighing more than 10 grams are usually hand carried. Because of the ever changing conditions for air travel, exceptions to this requirement will be considered by the Lunar Sample Curator. Specific procedures follow for various cases encountered.

5.4.1 Transfers by Mail from the Lunar Sample Curator to Domestic Investigators

Samples transferred from the Lunar Sample Curator to a PI are addressed to “(PI name) RESTRICTED DELIVERY.” The RESTRICTED DELIVERY provision allows the PI to authorize someone else to pick up samples at the post office by depositing a letter of authorization at his local post office.

Registered mail will be held by a post office for ten days. If an investigator, who is expecting samples, will not be available to pick up mail for a longer period and has not designated an alternate to pick up RESTRICTED DELIVERY mail, the investigator should notify the Lunar Sample Curator so that samples will not be mailed.

5.4.2 Transfers by Courier from the Lunar Sample Curator to U.S. Investigators

If the aggregate sample weighs more than 10 grams, the Lunar Sample Curator will attempt to arrange courier service for the sample, but will generally contact the PI for assistance. A PI may request delivery of a sample to self or a designated courier at the Lunar Sample Curator's office at the JSC. A letter of authorization is required to identify a courier who is not a PI. The letter must contain the signature of both the PI and the courier. Because of the ever changing conditions for air travel, exceptions to this requirement will be considered by the Lunar Sample Curator. Specific procedures follow for various cases encountered.

If requested with adequate prior notification, the Lunar Sample Curator's staff will identify the package containing lunar samples for airline officials and will provide identifying documents for the courier's protection. It is recommended that PIs arrange for a similar letter from their own institution which will serve to identify a courier returning samples to JSC. Such a letter will prove valuable in expediting airport security check. An example of a letter provided by the Lunar Sample Curator is shown as Appendix I. Hand-carried samples must remain in the possession of the courier at all times. The courier's home institution should be advised of scheduled departure and arrival times and any changes or delays in order to prevent an overdue delivery going unnoticed. Most samples can be carried to the final destination in a few hours. In the event the courier must stop overnight, care must be taken to protect the samples. During an overnight stay, arrangements should be made to store the samples as safely as possible. Options include a hotel safe or at a local police station. It is recommended that a simple hand receipt be obtained if such storage is necessary. Every situation is different and the courier must use discretion to choose in their estimation the most prudent method of overnight storage. If such storage cannot be secured, the samples must be kept in courier's possession at all times. These caveats do not include lunar display, education, or education thin section samples.

5.4.3 Transfers from the Curation Office to Foreign Investigators

Samples for foreign investigators are shipped by an International Courier Service (e.g., FedEx) if the samples weigh 10 grams or less. On the inside package a label will be attached that indicates the foreign investigator's name and address. If the samples weigh more than 10 grams they will be hand carried as per domestic investigators, see above.

5.4.4 Transfers from Domestic and Foreign Investigators to the Curation Office

A PI should notify the Lunar Sample Curator by letter, phone, email, or FAX when a package of lunar samples has been sent for return to JSC. Samples are to be returned to the Lunar Sample Curator in containers that do not degrade the samples further than the experiments to which they have been subjected. Two layers of protection, such as a sample vial within a plastic bag, should be provided at a minimum. If requirements appear to be special, the Lunar Sample Curator should be contacted. The Lunar Sample Curator can also provide cleaned containers on request. One month should be allowed for delivery.

Packages containing no more than 10 grams of lunar materials may be mailed. They should be sent by REGISTERED MAIL "RETURN RECEIPT REQUESTED" to the following address:

REGISTERED MAIL
NASA Johnson Space Center
Attn: KT/Dr. Gary E. Lofgren
2101 NASA Parkway
Houston, Texas 77058

Samples returned by foreign investigators should be sent by international courier service (e.g., FedEx).

NASA Johnson Space Center
Attn: KT/Dr. Gary E. Lofgren
Bldg. 31, Room 248D
2101 NASA Parkway
Houston, Texas 77058
USA
281-483-6187

Packages containing more than 10 grams of lunar materials should not be mailed or sent by international courier service and must be hand carried, see 5.4 above.

The U.S. Government acts as a self-insurer, therefore investigators should not obtain postal insurance for lunar samples transmitted by U.S. mail service.

5.4.5 Transfer of Radioactive Materials

To transfer lunar samples to an irradiation facility in accordance with the provisions of section 5.4, the PI must obtain a security plan from the irradiation facility that describes the safeguarding of the samples upon arrival at the facility, storage prior to and after irradiation, and the procedures to be used for return of the samples to the PI. At a minimum, the plan must include all of the provisions of a *Lunar Sample Loan Agreement Security Plan* (Appendix A), and the following for shipment of the samples from the facility to the PI:

- a. Irradiated materials, packaged in accordance with the requirements of the Interstate Commerce Commission, will be sent from the irradiation facility to the PI via a commercial carrier who provides a means of controlling the movement of the container within and between terminals, whether by signature or armed guard service.
- b. The Bill of Lading will **not** identify the shipment as lunar samples.
- c. The PI will be notified of the expected time of arrival of each shipment.
- d. The Lunar Sample Curator will be notified immediately in the event a shipment is lost, and details of the loss will be confirmed in writing.
- e. The shipments will be subject to inspection by NASA on a spot-check basis.
- f. A written statement will be submitted to the Lunar Sample Curator by the responsible irradiation facility personnel, through the PI, that the procedures outlined in section 5.4 of this guidebook are being observed.

6.0 PROCESSING, PACKAGING, AND REMOTE STORAGE OF LUNAR SAMPLES

The conditions under which lunar samples are processed, stored, and packaged, as well as the capabilities of the Lunar Sample Curator's office to provide special samples to PIs, are described in the following paragraphs.

6.1 Lunar Sample Processing

6.1.1 Pristine Lunar Samples

Most lunar material is stored and processed in a dry nitrogen atmosphere in stainless steel glove boxes. The only materials allowed inside the cabinets, in the form of tools and containers, are stainless steel, aluminum, polyethylene vials, Teflon, and Viton A. The cabinets are equipped for binocular microscopy and photography to support descriptive studies.

Sub-samples are obtained by scooping or splitting samples of fines, and by chipping or sawing rocks. All of these operations are carried out within glove cabinets that contain dry nitrogen. No cooling agent is used in sawing operations. There are no facilities to sieve samples of fines other than the routine splits of <1mm, 1-2mm, 2-4mm, and 4-10mm. Samples can be shaped only with straight saw cuts; there is no capability of preparing circular disks. The success of rock sawing varies from rock to rock. Pieces as small as 1 mm thick can be cut from hard rocks, but it may be impossible to cut a slice thinner than 1 cm for incoherent/friable rocks. Requests for special sample configurations will be considered in association with review of sample requests. Contaminants from sawing are the materials of the blades: diamonds set in stainless steel for the band saws, and diamonds set in copper wire for the wire saws.

PI's are invited to examine rocks in nitrogen cabinets at the Lunar Curatorial Facility. Access to the collection must be requested in writing with justification, and is subject to scheduling by the Lunar Sample Curator. Foreign visitors need to request access well in advance of their visit (2-3 months) to allow for badging security checks. We will request the necessary information once the request is received. In general, technicians working in the Lunar Curatorial Facility will provide actual manipulation of the samples, and can support a variety of photographic requests. Requests to remove material from any sample must be approved in advance as described in Section 2.1.

6.1.2 Other Lunar Samples

A small quantity of sample material is stored in a helium atmosphere and has never been exposed to other gases since initial handling in the Lunar Sample Curatorial Facility. Two Apollo 16 and 17 core tubes are being maintained under vacuum in unopened condition.

Many samples returned by PIs, and a few other special samples, have been exposed to air and can be studied on laminar-flow clean benches. Requests for such inspections should be made in writing to the Lunar Sample Curator, with a statement of the scope, of the reasons for and the requirements of the proposed work. The Lunar Sample Curator will schedule visits to the facility as time and personnel allow. Special samples that fall into this category are coarse-fines (limited amounts of 1-2 mm fines that are available for the selection of specific types of material), and core tube peels (impregnated strips from core tubes, available for binocular microscope study).

6.2 Lunar Sample Packaging

Packaging of lunar samples is designed to provide the maximum protection of samples consistent with the amount of sample and the experiment to be performed. Samples are transmitted to investigators in containers of Teflon, aluminum, stainless steel, or polyethylene with protective layers that usually maintain the sample in nitrogen. Special packaging requirements can be designed to meet the requirements of lunar sample investigators as long as

those requirements do not call for materials other than stainless steel, Teflon, aluminum, polyethylene, or Viton to be introduced into the cabinets.

6.3 Remote Sample Storage

Approximately 14 percent by weight of the lunar sample collection is stored in a vault at White Sands Test Facility near Las Cruces, New Mexico. The collection includes representatives of each lithology recognized during preliminary examination, pieces from most of the large lunar rocks, sub-samples from many lunar soils, and an unopened core segment. Samples in remote storage are generally unavailable for scientific study (see also Section 7.3).

7.0 LUNAR CURATORIAL FACILITIES

7.1 Lunar Sample Curatorial Facility

The Lunar Sample Curatorial Facility and the Sample Information and Control Center are located in a specially designed building constructed to provide secure storage for the Apollo lunar sample collection and to protect the collection from contamination during storage and processing for transfer to laboratories for analysis. The building was designed to protect the lunar samples from theft, damage by natural hazards such as tornadoes and hurricanes, and contamination that would affect the interpretation of geochemical tests. Specially designed vaults with thick, reinforced concrete walls provide secure storage for the samples. The vault doors remain closed except for removal or storage of samples. All pipes and openings into the vaults close automatically if there is any disturbance in the building, such as fire or intrusion. Two vaults are used, one to store samples that have not been out of the sample laboratories and the other for samples that have been returned by investigators after analysis. In that way, "pristine" samples can never become mixed with "used" samples. The elevation of the vault floor is above the level of the highest expected storm surge at this location. All materials used in constructing the building (such as floor coverings, walls, plumbing, light fixtures, and paint) and equipping the laboratories were selected because they contain the lowest concentrations of critical elements such as lead, gold, and the rare earth elements.

Adjacent to the sample processing laboratory is a special experiment room for tests and measurements on particularly large or rare lunar specimens. Visiting scientists working with these specimens can take advantage of the facility's unique environmental controls, as well as the assistance of people experienced in the care of lunar materials.

A number of measures are taken to control airborne particles in the vaults and laboratories. The air is circulated through special filters to remove suspended particles and to maintain Class 10,000 or better conditions. The pressure of the filtered air in the lunar sample areas is kept slightly higher than the outside air pressure to keep unfiltered air from leaking into the laboratories. Persons entering the area wear nylon coveralls, shoe covers, caps, and gloves to reduce contamination by particles from clothing, shoes, hair, and skin.

Lunar samples are stored and processed in cabinets filled with positive pressure of dry nitrogen gas (<10 ppm water and oxygen) to prevent any reaction of the samples with the oxygen and water vapor in the Earth's atmosphere. An automatic monitoring system samples the gas in each cabinet once an hour to determine the oxygen and water content, and activates visual and audible alarms if either gas exceeds the preset limit.

