LUNAR SAMPLES: APOLLO COLLECTION TOOLS, CURATION HANDLING, SURVEYOR III AND SOVIET LUNA SAMPLES. J. H. Allton, Mail Code KT, NASA Johnson Space Center, Houston, TX, USA, 77058, judith.h.allton@nasa.gov.

TRENDS IN APOLLO SAMPLES COLLECTED AND IN SAMPLE USAGE:

The 6 Apollo missions that landed on the lunar surface returned 2196 samples comprised of 382 kg. The 58 samples weighing 21.5 kg collected on Apollo 11 expanded to 741 samples weighing 110.5 kg by the time of Apollo 17. The main goal on Apollo 11 was to obtain some material and return it safely to Earth. As we gained experience, the sampling tools and a more specific sampling strategy evolved [1]. This trend is shown graphically in Figs. 1 & 2.

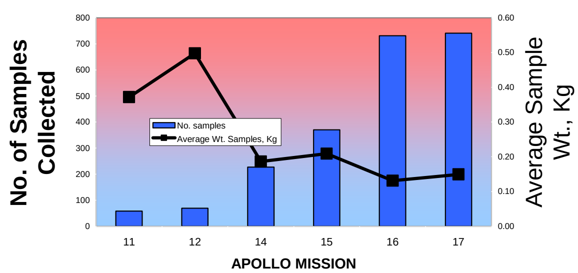


Fig. 1. Numbers of samples, average sample wt. by mission

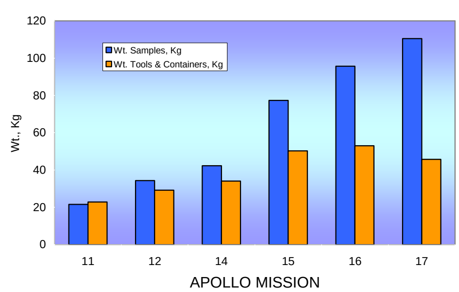


Fig. 2. Wt. of samples vs wt. of tools by mission.

A summary of the sample types returned is shown in Table 1. By year 1989, some statistics on allocation by sample type were compiled [2]. The "scientific interest index" is based on the assumption that the more allocations per gram of sample, the higher the scientific interest. It is basically a reflection of the amount of diversity within a given sample type.

Table 1. Distribution of Sample Types Returned

Sample Type	% by number	% by weight
ROCK	30	66
RAKE	32	8
SOIL	22	21
SOIL FRAGMENTS	14	1
SOIL CORE	3	5

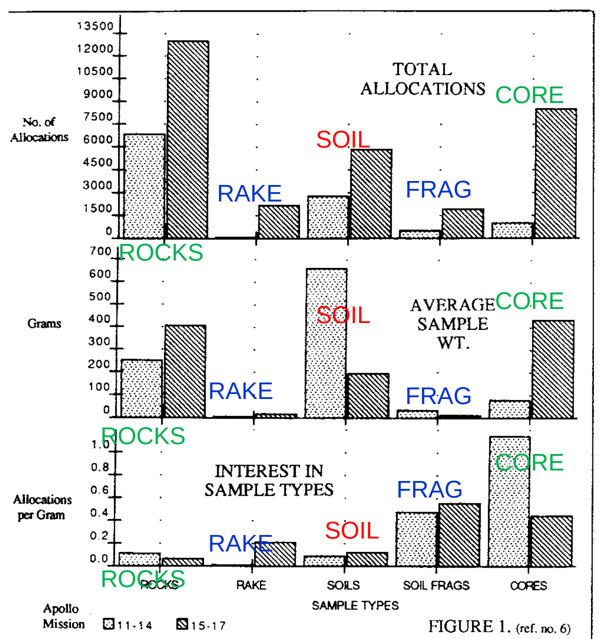
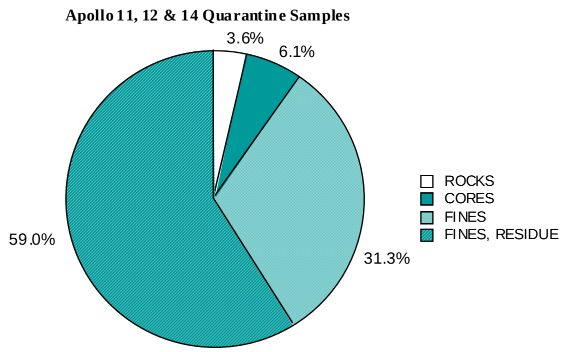


Fig. 3. Allocation statistics – a proxy for "interest".

Early Lunar Receiving Laboratory (LRL): Samples were also set aside for biohazard testing. The samples set aside and used for biohazard testing were representative, as opposed to diverse. They tended to be larger and be comprised of less scientifically valuable material, such as dust and debris in the bottom of sample containers.



Sources of Organic Contaminants [3]:~

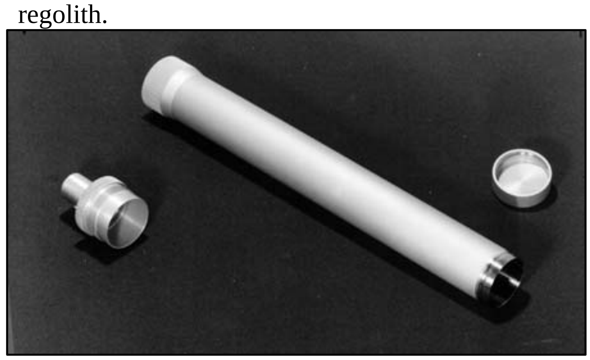
1.Surface contamination of lunar-bound rock box
2.Surface contamination of collection tools
3.Descent engine exhaust products
4.Lunar module outgassing
5.Spacesuit leakage
6.Particulates abraded from suits, etc
7.Venting of LM fuel, oxidizer, cabin and waste systems
8.Venting of spacesuit backpack
9.Exposure to LRL vacuum and nitrogen chambers
10.Surface contamination of sample processing tools
11.Surface contamination of containers sent to PIs

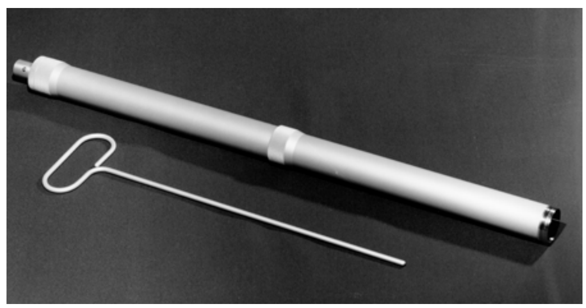
EVOLUTION OF APOLLO SAMPLE COLLECTING TOOLS:

CORE TUBES

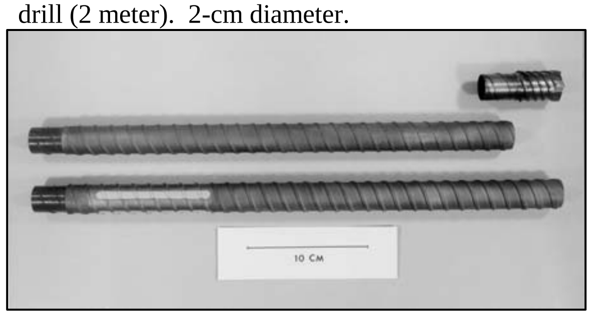
Drive tubes (Apollo 11-14): 2-cm diameter, thick-walled

Drive tubes (Apollo 15-17): 4-cm diameter, thin-walled. The tubes were widened and made with thinner walls to facilitate penetration into the dense lunar regolith.



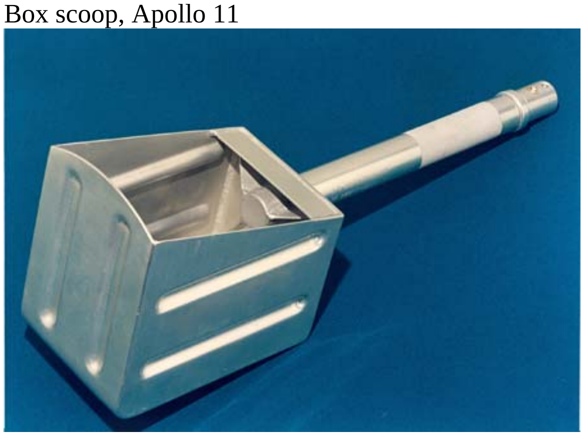


Drill core (Apollo 15-17): Rotary, percussive deep drill (2 meter). 2-cm diameter.



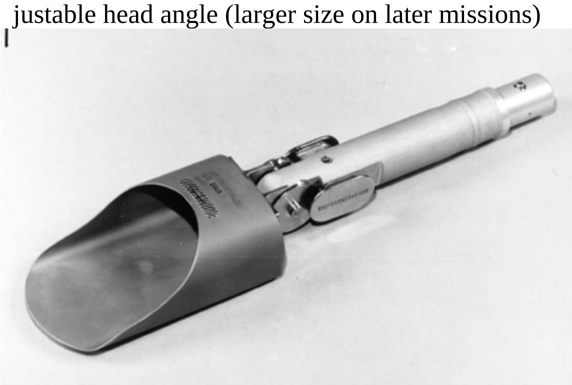
SCOOPS

Box scoop, Apollo 11



Scoop, Apollo 12, 14.

Scoop shape for Apollo 15-17. This scoop has an adjustable head angle (larger size on later missions)



Trenching tool, Apollo 14

TONGS

Tongs, smaller early version. Used for picking up small rocks.

Tongs, larger version used on Apollo 15-17.

RAKE

Rake (Apollo 15-17). Statistical sampling of many small, diverse rocks.

HAMMER

Hammer, early version

Hammer with extension handle

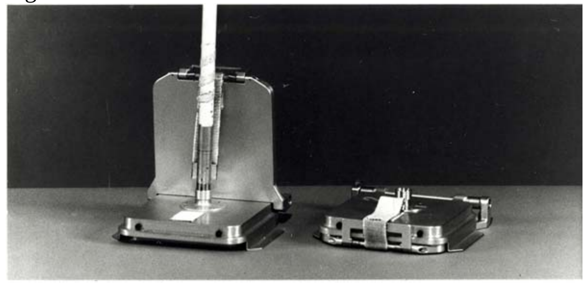
Hammer, later version. Larger head near shaft for pounding core tubes.

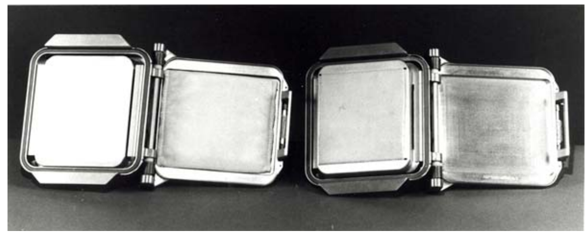
CONTINGENCY SAMPLER

Used to collect sample immediately upon landing (Apollo 11

SURFACE SAMPLER

Two devices to sample only the top 100 µm and top 1 mm of regolith.



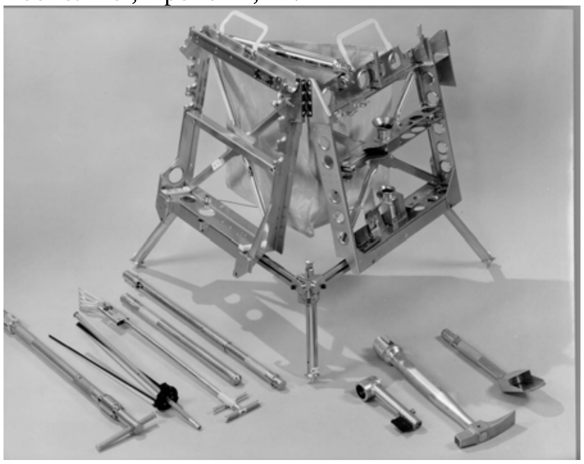


Lens-scriber-brush.

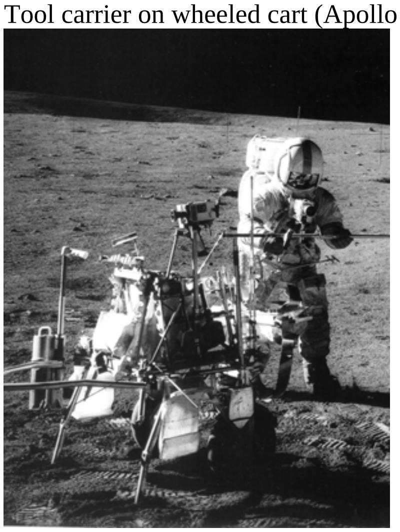
Rarely used.

TOOL CARRIERS

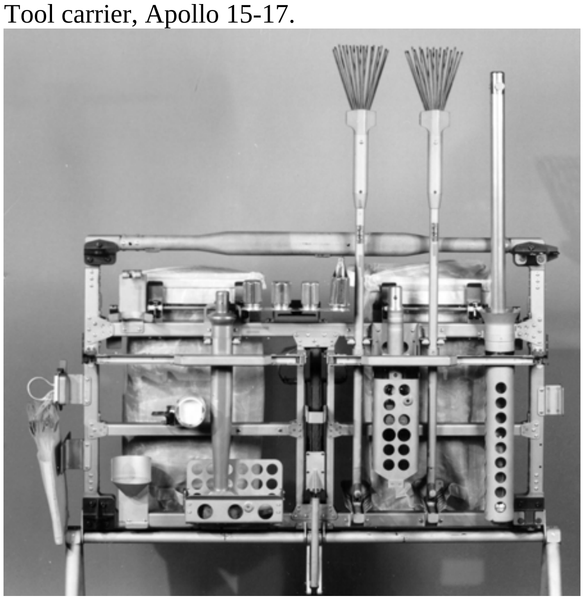
Tool carrier, Apollo 12, 14.



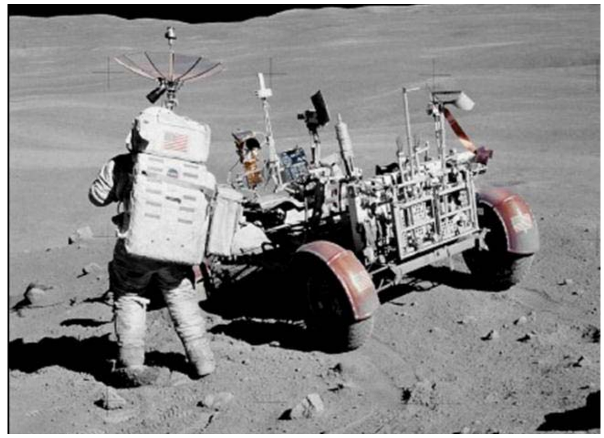
Tool carrier on wheeled cart (Apollo 14).



Tool carrier, Apollo 15-17.



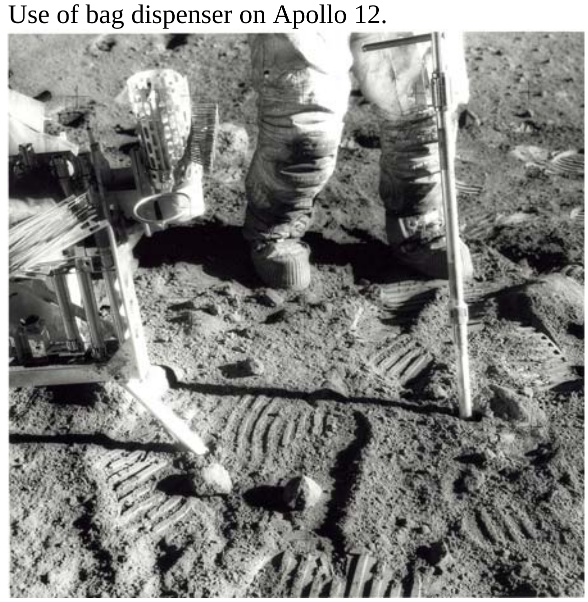
Tool carrier mounted on rear of rover.



INDIVIDUAL SAMPLE BAGS

Individual sample bags and dispenser (Apollo 12-14).

Use of bag dispenser on Apollo 12.



Bag dispenser, Apollo 15-17.

GAS-TIGHT CANS

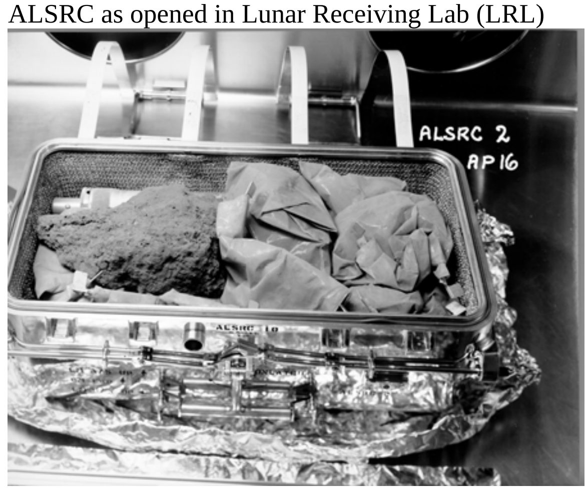
SESC – Special Environment Sample Container. Stainless steel knife edge into indium metal alloy seal.

GASC – Gas Analysis Sample Container (smaller version of SESC).

ROCK BOXES AND BAGS

ALSRC (Apollo Lunar Sample Return Container) All missions. Packed for launch.

ALSRC as opened in Lunar Receiving Lab (LRL)



SCB (Sample Collection Bag) packed for launch.

CURATION OF SAMPLES

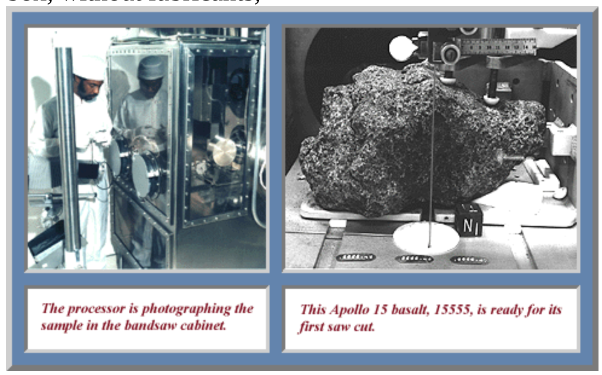
Purpose:
- Sample preservation
  - Keeping pristine condition
  - Reserving a portion for future studies
  - Keep samples secure
- Sample characterization
  - To enable wise allocation
  - Not to extract science results
  - Publish availability
- Sample subdivision

Storage & handling environment:
- Pure, dry nitrogen
- Cleanroom
- Vault storage (hurricane-proof)
- Restricted materials – only ss, aluminum, teflon may touch the samples

Pristine Sample Lab, Johnson Space Center

Pristine nitrogen glovebox

Bandsawing a lunar rock inside of a nitrogen glovebox, without lubricants,

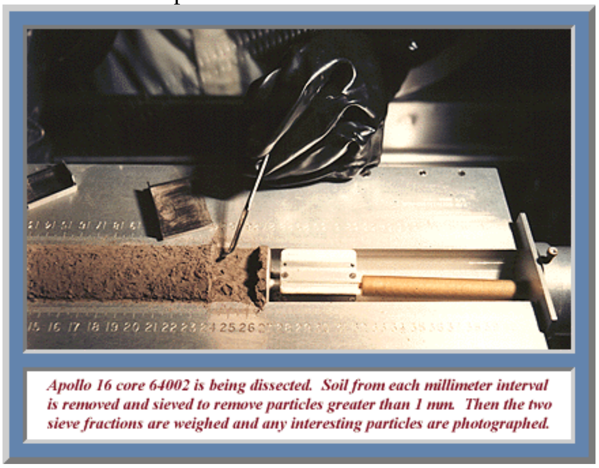


Subdivision:
ROCKS – chipping, sawing
SOILS – sieving, scooping
CORES – dissection (subdivision by depth, particle size)

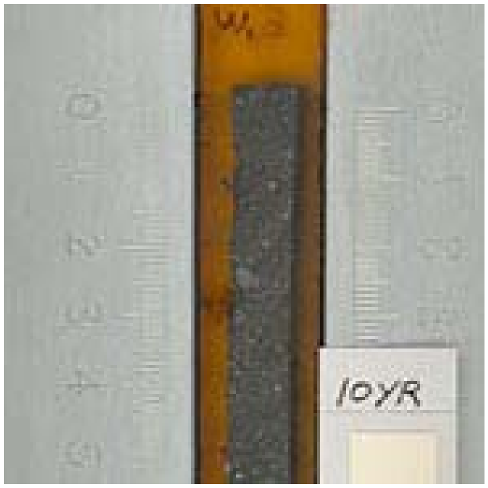
Special Sample Preparation:
- Thin sections – 30 µm thick slices of epoxy-impregnated rock or soil or soil core section that allow petrographic analysis and electron beam analysis
- For CORES – peeling away a thin layer to preserve original stratigraphy

Pre-opening core tube x-ray

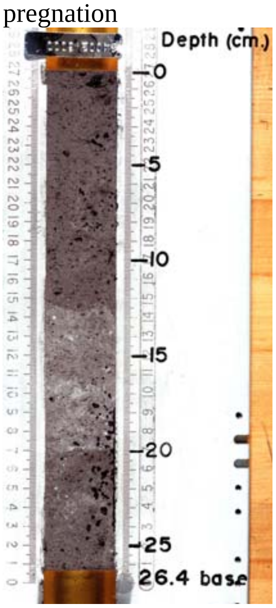
Dissecting a lunar soil core to provide samples for each half-cm depth.



Epoxy impregnated core ready to be made into thin sections.



Post-dissection peeled surface ready for epoxy impregnation



DESIGN LESSONS LEARNED FROM APOLLO

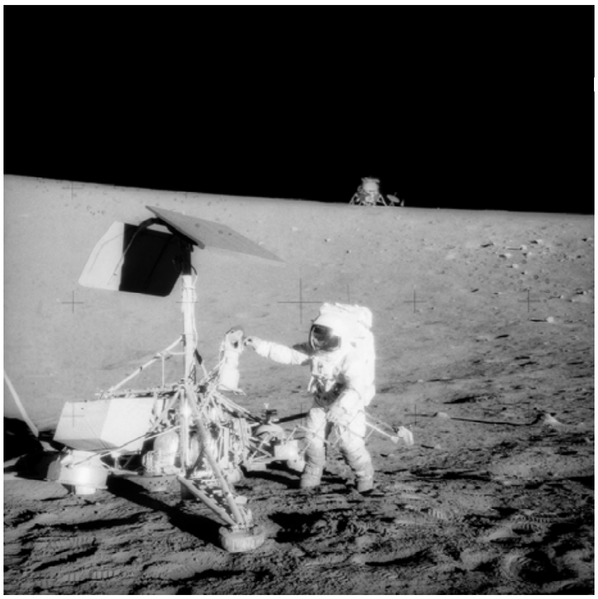
- Containers need to be openable
- Tools need to be usable in a spacesuit
- Seals need to cope with dust
- Tools and containers need to be made from chemically acceptable materials
- Oversee the process as well as the materials

LESSONS FROM GENESIS

Surface finish matters
Oversee the process as well as the materials

SURVEYOR III

Surveyor III landed on the Moon in April 1967. Portions were retrieved by Apollo 12 astronauts in November 1969, furnishing, for detailed study, an array of materials exposed to the lunar environment for over two years. The astronauts cut off and returned the video camera, the soil scoop and a portion of polished aluminum strut. [4]



LUNA 16, 20, 24

The Soviets robotically acquired and returned to Earth soil cores from the Moon, using an innovation drilling method in which the core was coiled into a small package for Earth return. Luna 16 returned 6 kg of material in September 1970. Luna 20 returned 6 kg in 1972 and Luna 24 returned 6 kg in 1976. [An image of the Luna coring vehicle will be shown in the class session. Image credit the Ft. Worth Museum of Science and History Association.] [5]

LUNOKHOD ROVERS

Lunokhod 1 sucessfully achieved a soft landing in 1970 and roved 10 km on the lunar surface for 11 months collecting data. Lunokhod 2 roved 37 km in 4 months of 1973. [An image of the Lunokhod vehicle will be shown in the class session. Image credit the Ft. Worth Museum of Science and History Association.] [5]

References:

[1] Allton J. H. (1989) *Catalog of Apollo Lunar Surface Geological Sampling Tools and Containers*. JSC 23454, Houston, TX 77058.

[2] Allton J. H. and C. B. Dardano (1988) How sucessful were the lunar sampling tools?: Implications for sampling Mars. In *Workshop on Mars Sample Return Science*, LPI Tech. Report 88-07 Houston TX 77058, pp. 30-31.

[3] Simoneit B. and D. Flory (1970) Apollo 11, 12 and 13 Organic Monitoring History. A U. Calif. Berkeley report to NASA.

[4] ______(1972) *Analysis of Surveyor 3 material and photographs returned by Apollo 12*. NASA SP-284.

[5] Miller J. (1991) *Soviet Space*. Ft. Worth Museum of Science and History Association.