Caldwell

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY REPORT

ON

SNAP LINE OPERATIONS

DURING

APOLLO 15 MISSION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

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Introduction

Processing of a portion of the lunar samples returned by Apollo 15 was successfully performed in the Sterile Nitrogen Atmosphere Processing (SNAP) Line during the period August 9, 1971 to January 14, 1972. This report presents the history of the samples processed in the SNAP Line as well as a discussion of the environmental data gathered from instrumentation installed and operated by BRN Sample Processing Laboratory personnel. Events of special interest are also discussed briefly.

This was the first mission in which there was not a quarantine requirement for the crew nor the lunar samples. As a result, several major changes in operations occurred.

1. The SNAP Line was not sterilized. This significantly reduced certain contaminants in the cabinets which result from sterilization. Also cabinet cleaning procedures were improved, providing an overall improvement in cabinet cleanliness.

2. The SNAP Line was operated at +1 inch water gage pressure (relative to the room) as opposed to -1 inch water gage pressure used for Apollo 14 sample processing. This mode of operation increased the protection of the lunar samples from atmospheric contamination due to potential leaks in the cabinets or gloves. Previously the importance of isolation of personnel from possible lunar pathogens was of greater importance.

HISTORY OF OPERATIONS

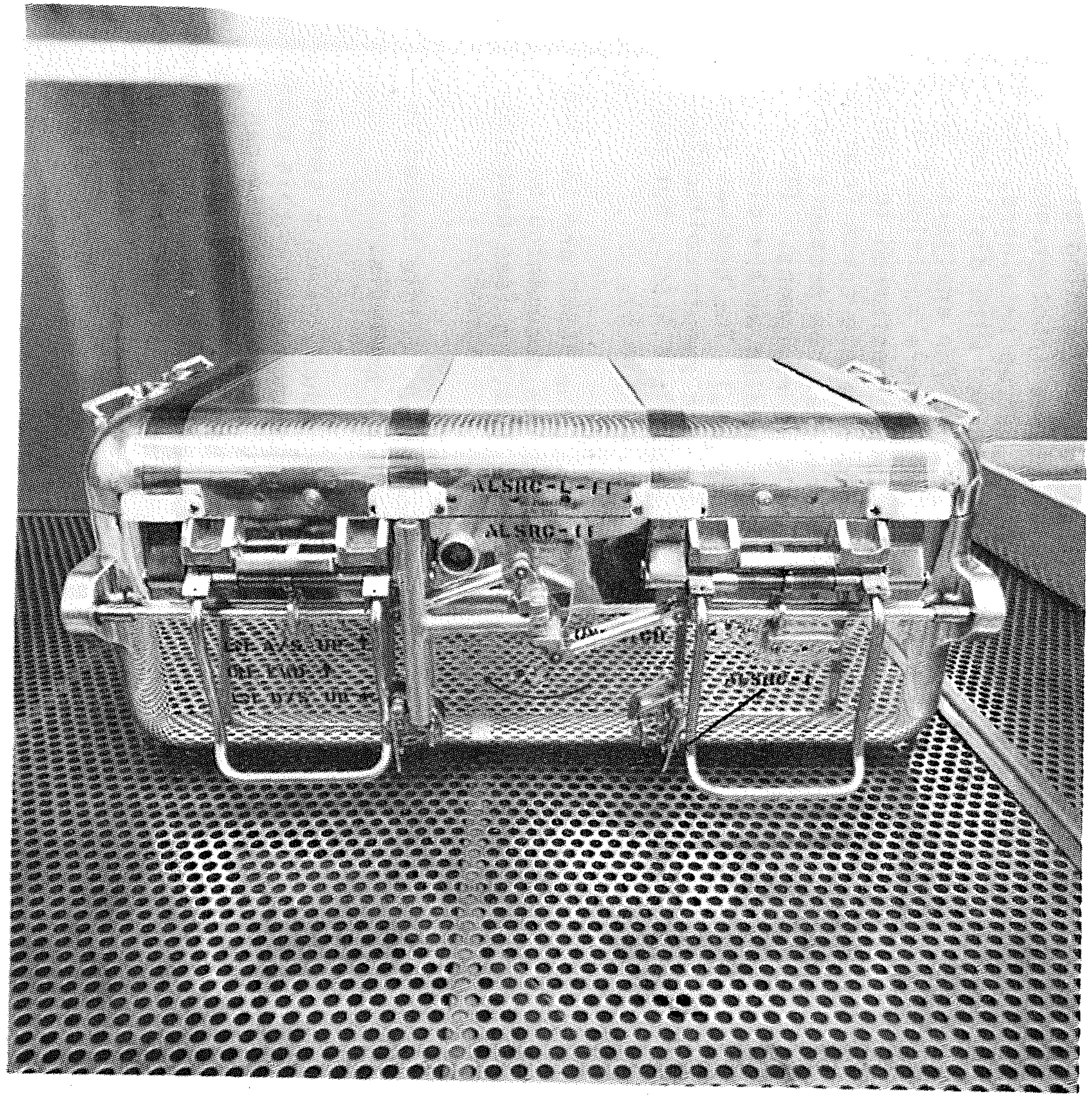
The first samples received in the SNAP Line were in Apollo Lunar Sample Return Container (ALSRC) (serial number 1011). They were received by the Area Test Director (ATD) for the SNAP Line on August 9, 1972. The ALSRC was placed on a laminar flow (class 100) clean bench for an internal pressure check and external precleaning. The pressure was determined to be 39μ using an integral thermocouple pressure gage. Detailed photographs were taken of the ALSRC as received. One strap latch retaining clip was not functioning properly and was only partially closed (photographs S-71-43295 and S-71-43291 pp 4 and 5). The hinge, strap retainers, and temperature sensors were removed, the ALSRC was flushed with distilled water and alcohol and the flush samples were retained for analysis. The ALSRC was then transferred into SNAP Line Cabinet 2 where additional drying was accomplished using a GN_2 hose. It was then transferred to Cabinet 4 where the gas analysis port was punctured and a gas sample taken from inside the box for analysis. At that time, the internal box pressure was determined to be 32μ as measured by the gas analysis equipment. (This slight discrepancy in measurements from pressure reading at the clean bench is within the accuracy limits of the two gages.) The box was then opened and upon inspection it was determined that the sample collection bag (SCB) was partially obstructing the seal area of the ALSRC, but not sufficiently to preclude a seal (photograph S-71-43336 p 6).

The SCB and organic monitor were then removed from the ALSRC and the SCB unpacked. Items removed from the SCB included eleven documented bags and two core tubes, for a total sample weight of 8014.9 g (see genealogy, Figure 1 p 17 and Table 1, p 19).

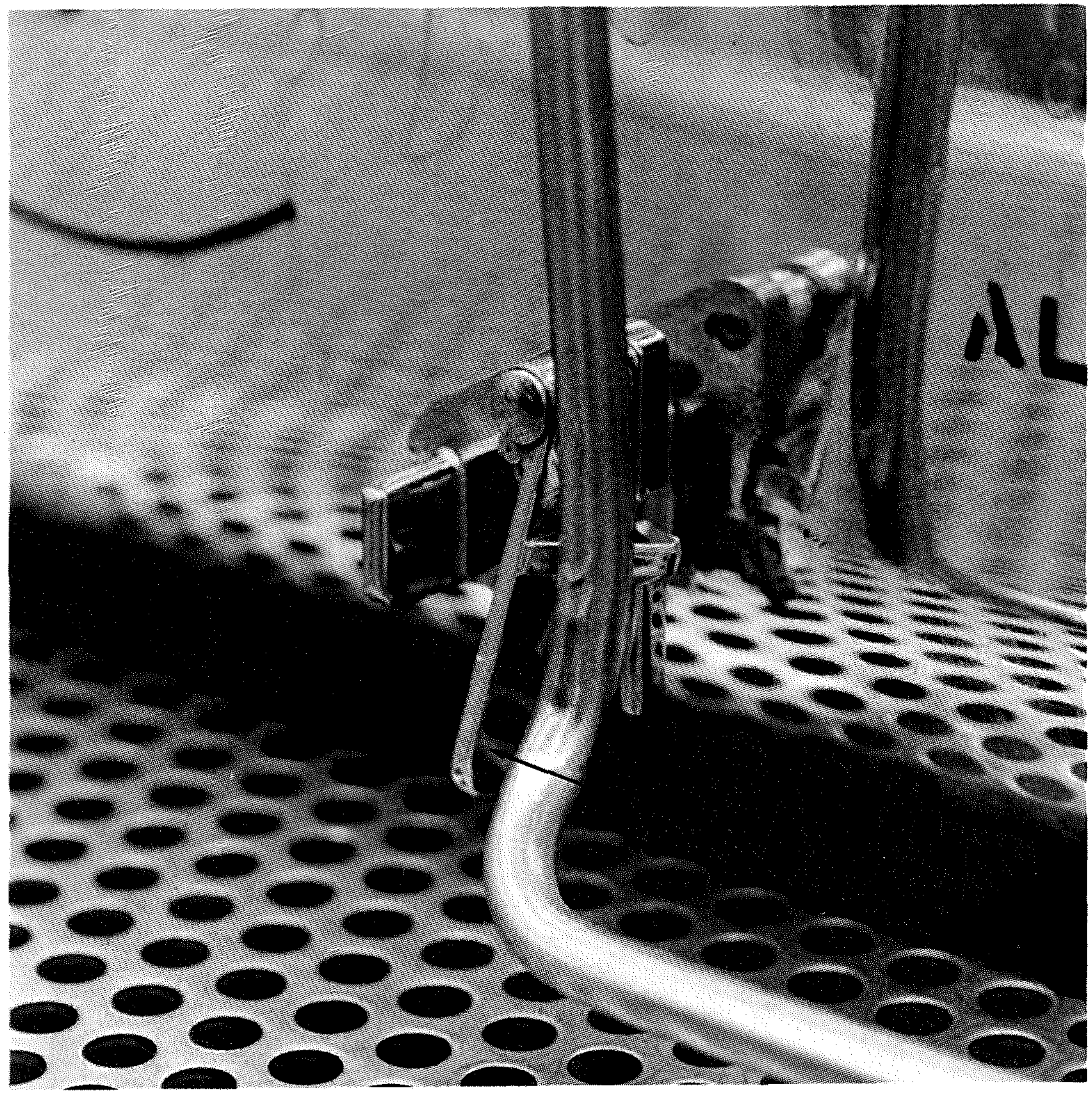
The core tubes were immediately weighed, photographed, triple bagged in Teflon and transferred out to Grant Heiken for X-ray analysis.

The remainder of the samples were weighed, photographed, given a sample number and canned. The documented bags were not opened during this phase of the operation, the objective being to identify and individually can the samples as quickly as possible. Documented bags were given temporary sample numbers during inventory as a means of identification without using the numbers in the previsously assigned groups for rocks and fines. These temporary sample numbers were kept active after the individual documented bags were opened and inventoried and now identify the empty documented bags. This phase of processing was completed by August 16, 1971.

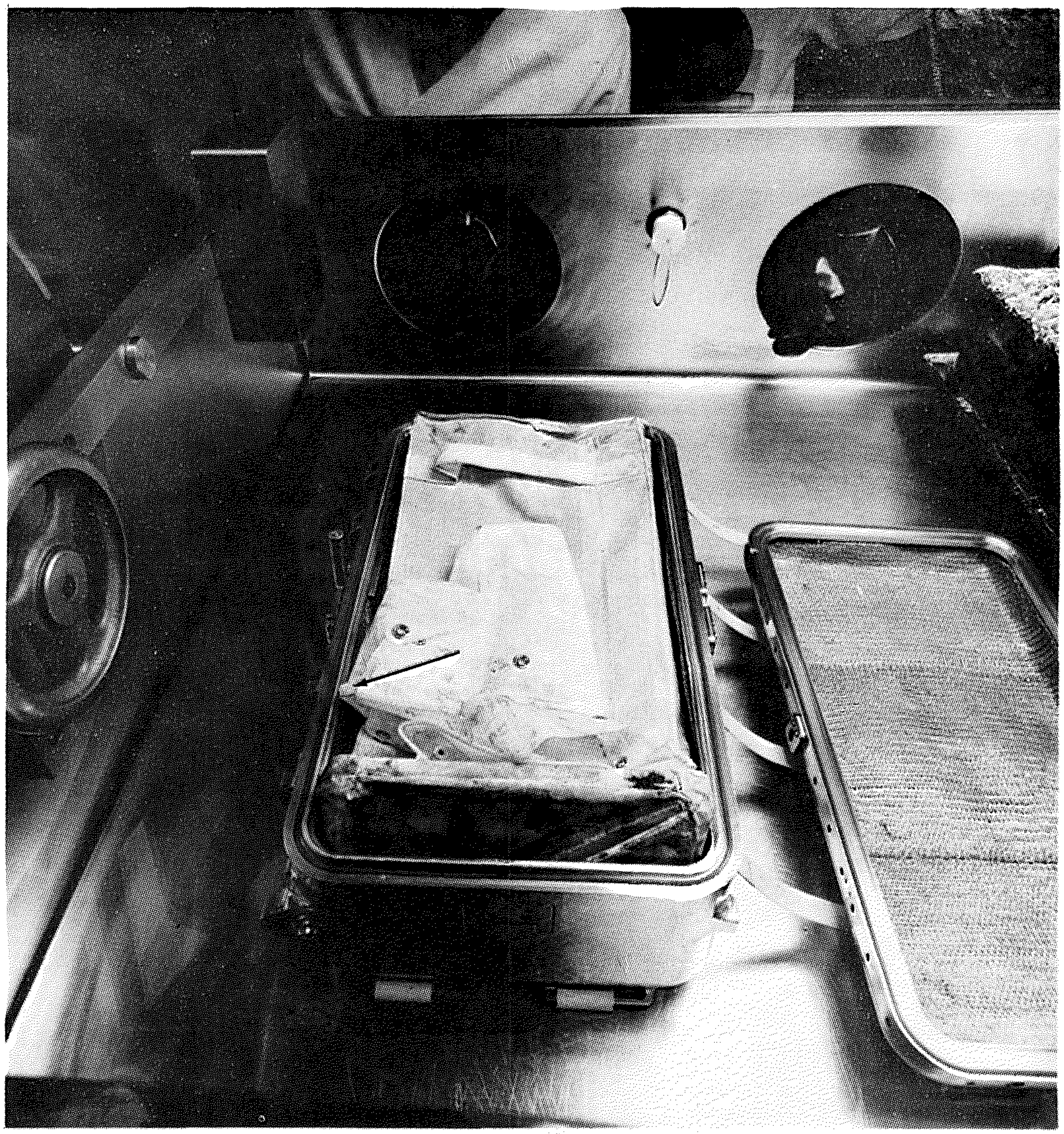
ALSRC 2 (serial number 1012) was received on the same day (February 9, 1971) as ALSRC 1. It was also placed on the laminar flow clean bench. The Apollo crew were not able to seal the box by closing the strap latching system. In fact, upon inspection it was noted that the strap latch handles were severely bent in attempts to properly latch the system (photographs S-71-43278, S-71-43281, pp 7 and 8).



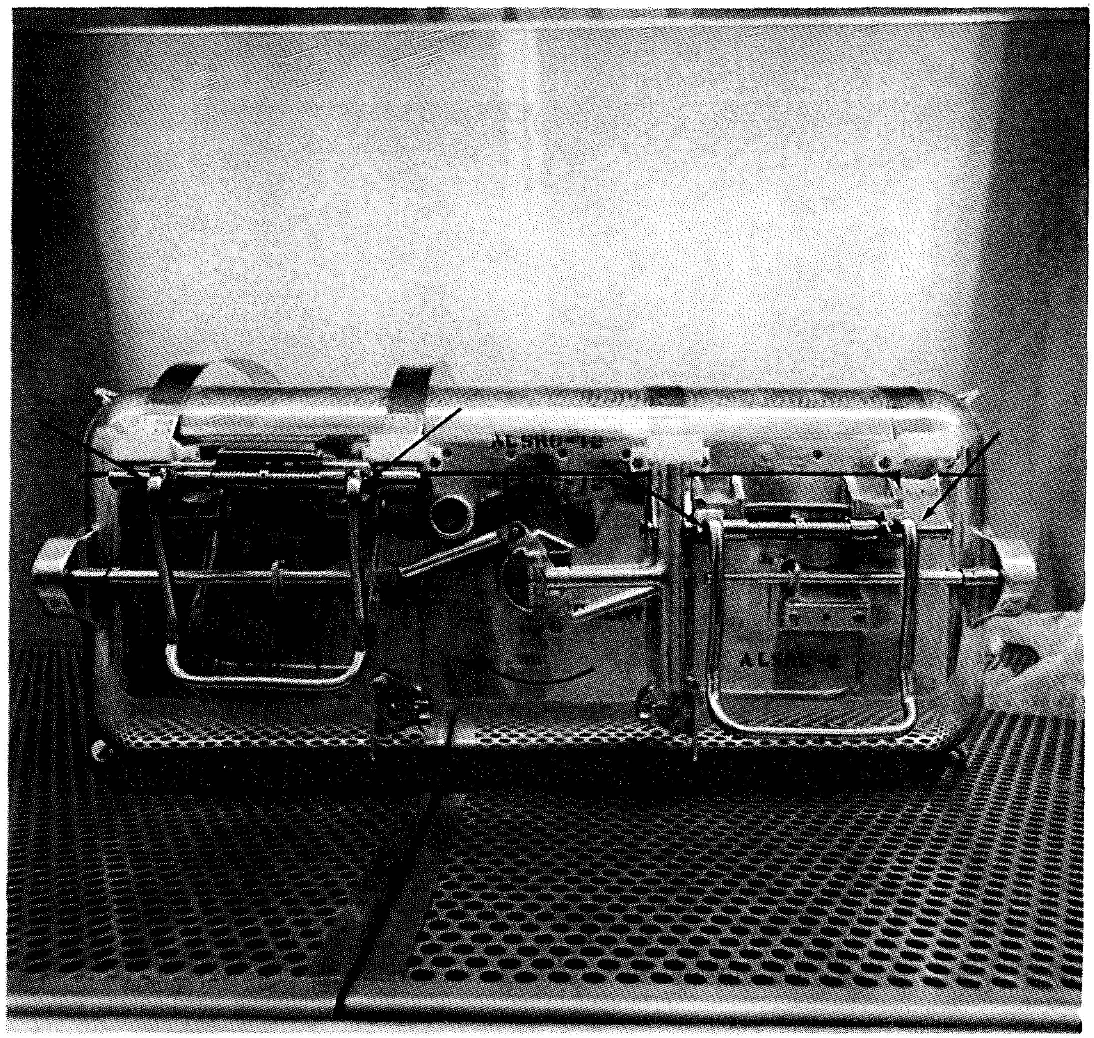
Photograph S-71-43295. - Showing Partially Closed Strap Latch Retaining Clip.



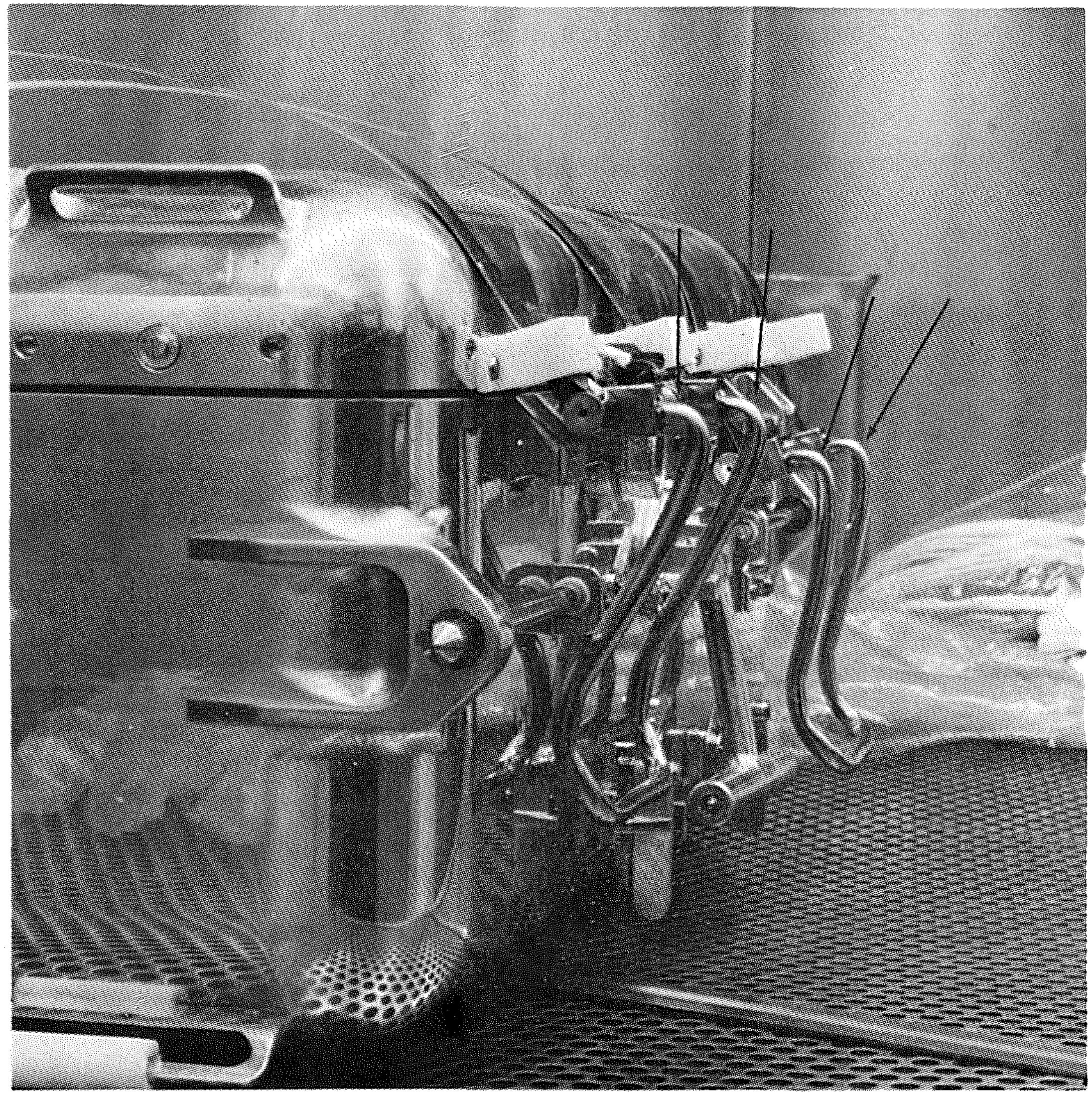
Photograph S-71-43291. - Closeup view of partially closed strap latch retaining clip.



Photograph S-71-43336. - Partial obstruction to seal area of ALSRC 1011.



Photograph S-71-43278. - Bent strap latch handles.



Photograph S-71-43281. - Close up of bent strap latch handles.

Some obstruction of the seal area on the ALSRC was apparent. Therefore, the water and alcohol wash cycles were deleted for fear of contaminating the lunar samples and the ALSRC was transferred directly to the SNAP Line and placed in cabinet 2. The box was then opened and inspected. The inspection revealed that a large portion of the seal area on the front of the box was obstructed by a portion of the SCB and in fact no seal could have occurred under these conditions (photographs S-71-43340, S-71-43343, pp 10 and 11).

The SCB and organic monitor were removed from the box and stored in cabinet 3 while processing was in progress on ALSRC 1. On August 16, 1971, processing began on the SCB 5. The samples removed from the SCB included one core tube, two special environment sample containers (SESC), ten documented bags and one undocumented rock for a total of 9293.25 g of lunar sample (see genealogy, Figure 2, p 21, and Table 2, p 23).

The core tubes were processed as those from ALSRC 1 and the SESC were weighed, photographed, partially disassembled and stored in sealed containers. The containers were evacuated to approximately 35μ for storage.

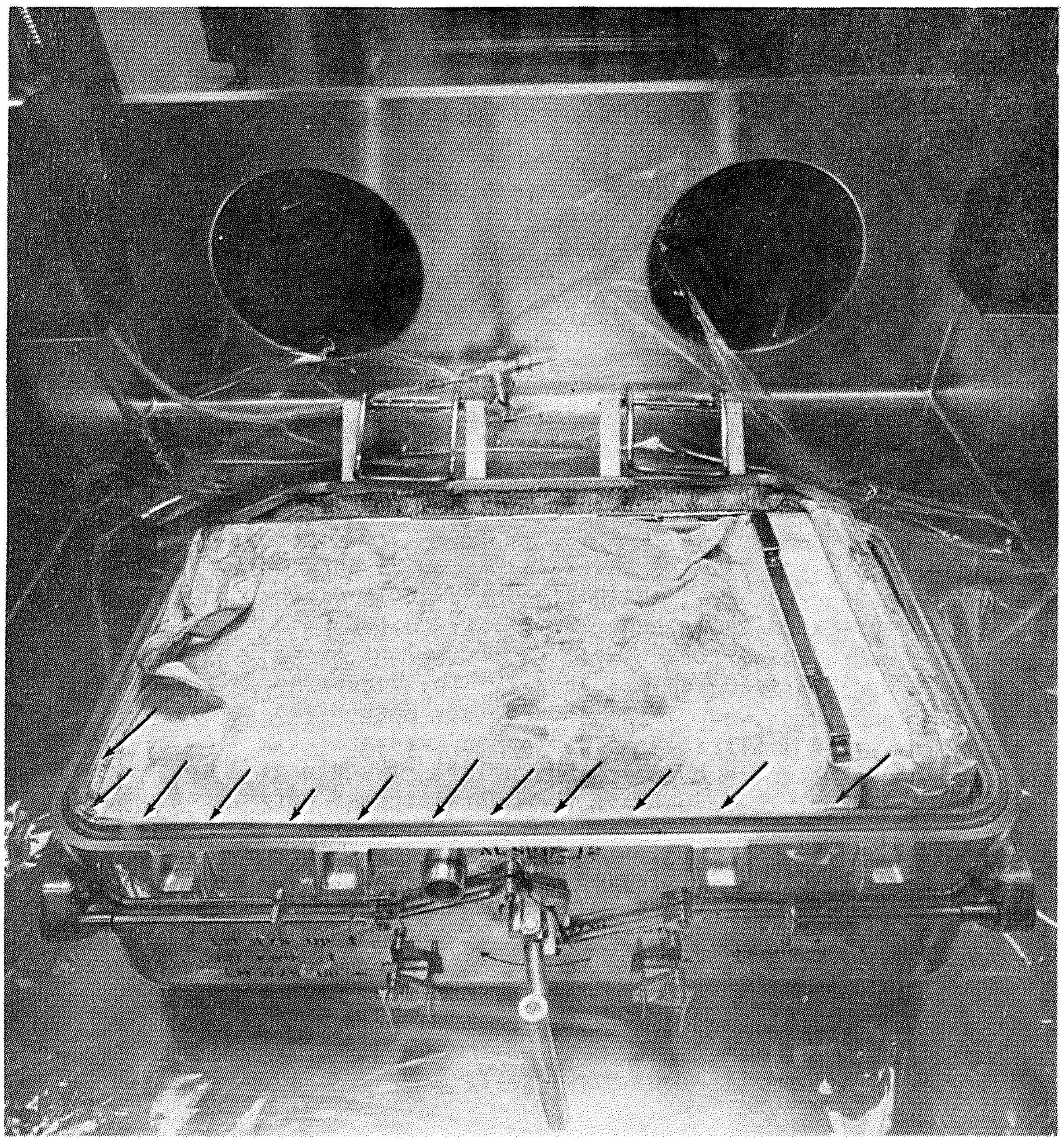
The documented bags were also processed as before with this phase of processing of ALSRC 2 completed on August 28, 1971.

On August 19, 1971, SCB 7 was transferred from the Curator to the SNAP Line and stored in cabinet 3 until ALSRC 2 processing in cabinet 4 was completed. On August 23, 1971, SCB 7 was unpacked revealing two core tubes, one SESC, and seven documented bags for a total sample weight of 8429.3 g (see genealogy, Figure 3, p 25, and Table 3, p 27). The core tubes were processed as those from ALSRC 1. Upon inspection it was determined that the SESC had not sealed. The lid retaining cable had inadvertently been tangled in the seal area (photograph S-71-44785 p 12). Therefore, the SESC was placed in the storage container but the container was not evacuated for storage.

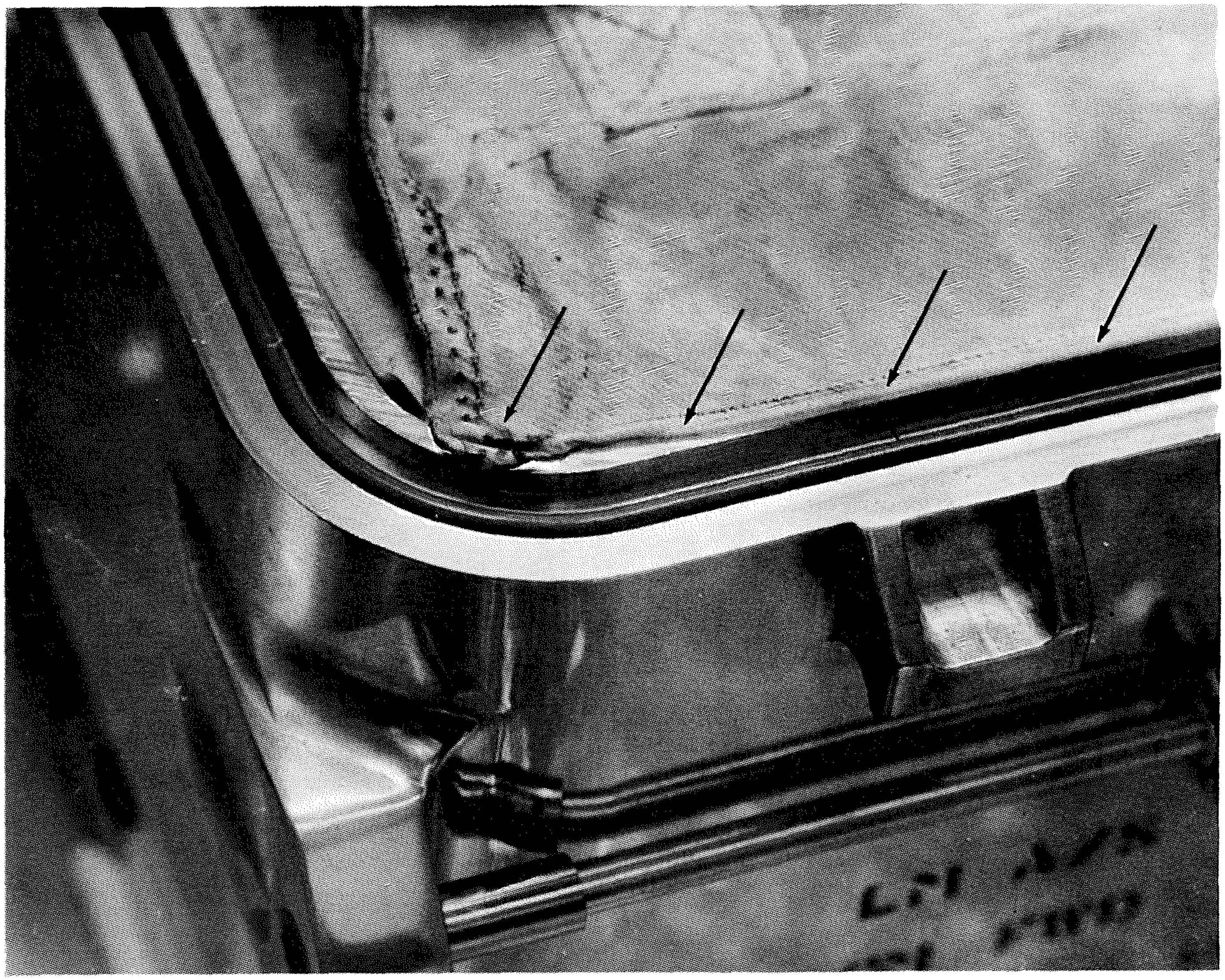
The initial processing of samples from SCB 7 was completed by August 27, 1971.

Operations then centered around rock processing. The remaining processing on each rock in the SNAP Line included:

1. Record photography and weighing
2. Dusting
3. Reweighing
4. Orthogonal photography
5. Sample description (PET)
6. Stereo photography



Photograph S-71-43340. - Obstruction of ALSRC 1012 seal area by portion of SCB.



Photograph S-71-43343. - Closeup of obstruction of ALSRC 1012 seal area by portion of SCB.

Photograph S-71-44786. - Lid retaining cable tangled in SESC seal area.

7. Rock modeling

8. Field Geology

9. Preliminary rock chipping

The only item needing clarification is Field Geology, which included photography and rock orientation relative to its position and location on the lunar surface.

The above operations were written into the operating procedures which were used on each sample. Many samples were modeled and used in the Field Geology experiment; all, however, were photographed and described. Packaging and transfer of Radiation Counting Laboratory (RCL) samples and samples for other laboratories continued on an almost dialy basis as they had from the beginning of sample processing operations.

Fines samples were processed so that an unseived reserve sample was taken and the remainder of each sample was seived into fractions <1 mm, 1-2 mm, 2-4 mm and 4-10 mm. All samples larger than 10 mm were processed as rocks.

Three types of special samples were also processed using specifically designed procedures:

1. The organic monitors (one from each ALSRC) were placed in bolt-top containers and transferred out for analysis.

2. The clod samples (documented bags 170 and 273) were given special processing to preserve the very fragile material. Numerous small clods (remainders of a large clod) were inventoried and stored. No further processing was performed on these samples.

3. The rake samples (walnuts in documented bags 282 and 186) were grouped as to type by bag and then processed as rocks.

Processing the samples from ALSRC 1 and 2 and SCB 7 to this stage of completion was performed by October 1, 1971. Further processing in the SNAP Line continued for approximately 12 weeks. This phase of operations was oriented toward processing allocations of fines samples for shipment to principal investigators (PI), and chipping rocks to provide PI allocations.

The majority of the rock chipping required to fill allocations and preparation of Apollo 15 fines allocations for release to the Curator was performed in the SNAP Line. Some rocks sawed in the Sample Processing Laboratory (SPL) were subsequently transferred to the SNAP Line for additional chipping. These samples were also packaged for release to PI by the Curator.

All remaining samples not to be allocated were packaged for storage in the curatorial storage vault. The samples were subsequently transferred to the Curator together with all the data logs and records on sample processing from the laboratory. The last of the samples were removed from the SNAP Line by January 14, 1972.

SAMPLE NUMBER ASSIGNMENT

Sample numbers used to identify the Apollo 15 samples were partially predetermined in that the following sequence was used in most cases:

Sample No.	Type Sample
15XY0,0	Fines reserve
15XY1,0	<1 mm fines
15XY2,0	1-2 mm fines
15XY3,0	2-4 mm fines
15XY4,0	4-10 mm fines
15XY5,0 to 15XY9,0	Rocks

This numbering sequence was used for each documented bag. The Science Advisor controlled the number assignment.

Exceptions to the general rule were primarily in the assignment of numbers to special samples: SESC, core tubes, organic monitors, and rake samples. An example is one rake sample where the numbers 15611 through 15689 were used without regard to the previous rule.

SAMPLE GENEALOGY

Because returned sample containers were inventoried one at a time in the SNAP Line, it was possible to construct a genealogy for each basic container (ALSRC 1, ALSRC 2, and SCB 7), identifying its components, and identifying the parents and daughters of all splits made during sample processing.

Figures 1, 2, and 3 present the genealogies of ALSRC 1, ALSRC 2, and SCB 7 respectively. The weight notation in each sample block is the weight of that sample alone. The weight for the SESC, core tubes, etc., represents only the weight of the lunar material in these containers. Even the SCB weight does not include the weight of any bags or containers.

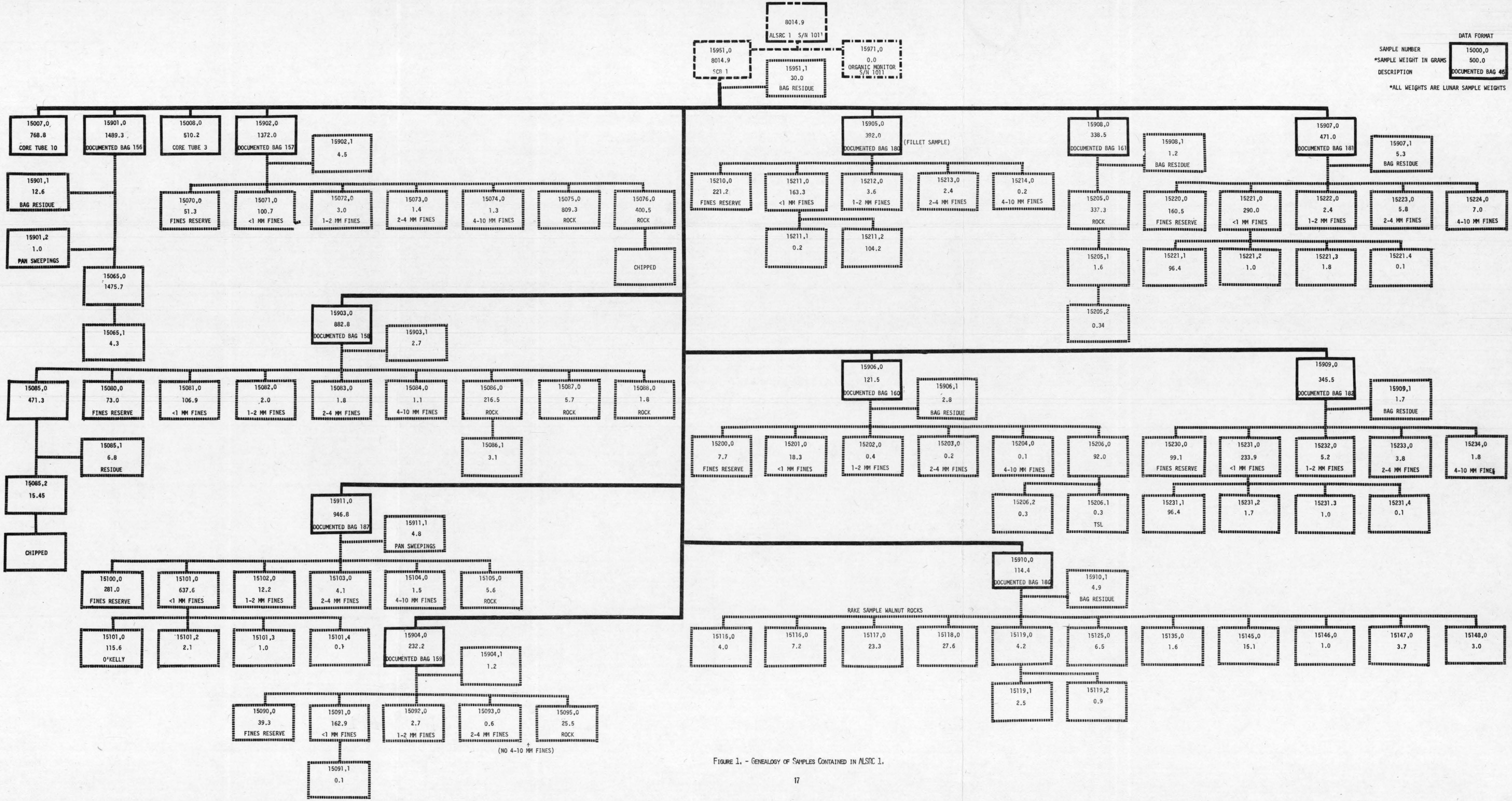


FIGURE 1. - GENEALOGY OF SAMPLES CONTAINED IN ALSRC 1.

TABLE 1. - ALSRC 1 (S/N 1011) CONTENTS

Item	Sample No.
SCB 1	
Organic Monitor S/N 1011	
Sample Containers	
Core Tube 10	15007,0
Core Tube 03	15008,0
Documented Bag 157	15902,0
Documented Bag 158	15903,0
Documented Bag 159	15904,0
Documented Bag 160	15906,0
Documented Bag 161	15908,0
Documented Bag 180	15905,0
Documented Bag 181	15907,0
Documented Bag 182	15909,0
Documented Bag 186	15910,0
Documented Bag 187	15911,0
Documented Bag 156	15901,0

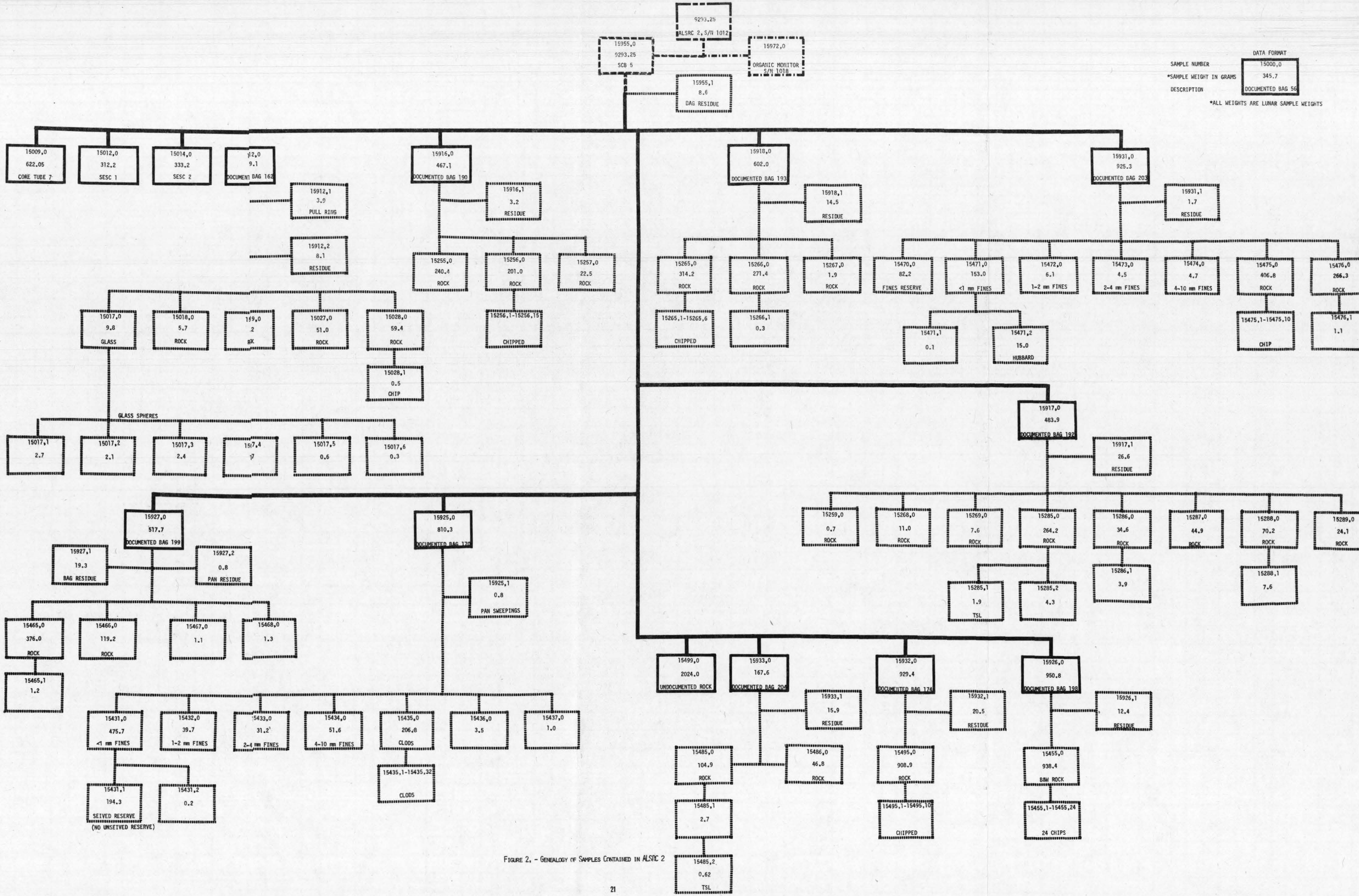


FIGURE 2. - GENEALOGY OF SAMPLES CONTAINED IN ALSRC 2

TABLE 2. - ALSRC 2 (S/N 1012) CONTENTS

Item	Sample No.
SCB 5	
Organic Monitor, S/N 1018	
Sample Containers	
Core Tube 07	15009,0
SESC 1	15012,0
SESC 2	15014,0
Documented Bag 162	15912,0
Documented Bag 170	15925,0
Documented Bag 174	15932,0
Documented Bag 190	15916,0
Documented Bag 192	15917,0
Documented Bag 193	15918,0
Documented Bag 198	15926,0
Documented Bag 199	15927,0
Documented Bag 203	15931,0
Documented Bag 204	15933,0
Undocumented Rock	15499,0

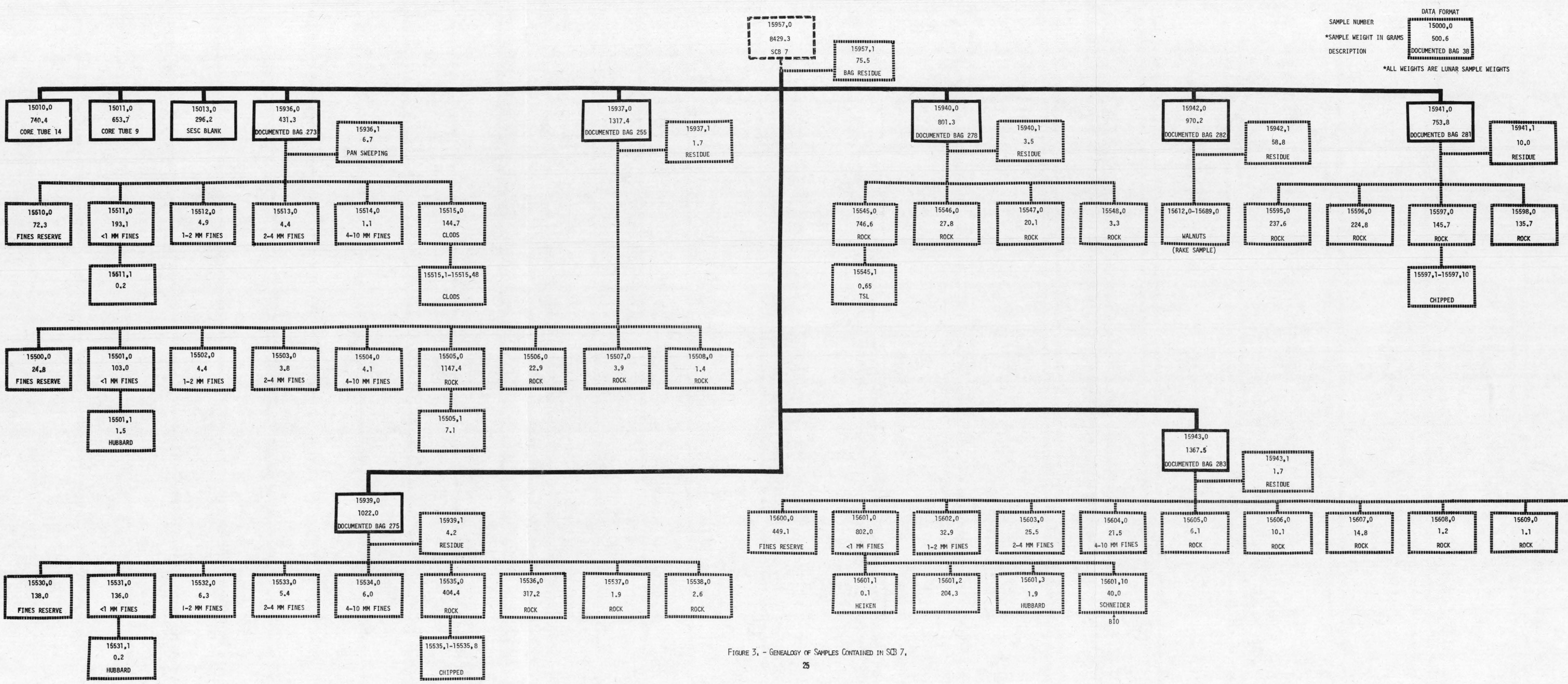


FIGURE 3. - GENEALOGY OF SAMPLES CONTAINED IN SCB 7.

TABLE 3. - SCB 7 CONTENTS

Item	Sample No.
Core Tube 14	15010,0
Core Tube 09	15011,0
SESC - Blank	15013,0
Documented Bag 255	15937,0
Documented Bag 273	15936,0
Documented Bag 275	15939,0
Documented Bag 278	15940,0
Documented Bag 281	15941,0
Documented Bag 282	15942,0
Documented Bag 283	15943,0

SNAP LINE OPERATION

The physical operation of the SNAP Line included monitoring and control of:

1. Electrical supply to:
   a. Ainsworth balances
   b. Heat sealers
   c. moisture monitor
   d. oxygen analyzer
   e. recorders
   f. cabinet lighting
2. Gaseous nitrogen flow to all cabinets
3. Vacuum system valving
4. Operation of the moisture monitor system
5. Operation of the oxygen analyzer and recorder.

The only significant event occurring in the environmental control system involved operation of the vacuum dusting fixture in conjunction with Cabinet 1 transfers.

Operation of the vacuum line in Cabinet 4 overpowered the normal GN_2 flow to the cabinet and caused readmission of gasses to the cabinet from the exhaust header. This caused a rise in the oxygen level in the cabinet especially when the exhaust header was contaminated with high percentages of oxygen during transfer through Cabinet 1 to and from the laboratory. The problem was discovered early in the processing phase and was corrected by increasing the normal flow of GN_2 to the cabinet during operation of the vacuum lines on the dusting fixture.

On September 9, 1971, a hurricane alert for this area was put in effect. The SNAP Line was secured for the night by placing it under static pressure rather than the constant flow of GN_2 to safeguard the sample in case of loss of GN_2 or electrical power. The next day the system was reactivated and was back in normal operation after several hours with no abnormal conditions. During the static phase of operation, the moisture level indicated in the cabinets rose to approximately 200 ppm. During normal operations in the cabinets (during mission operation), the average moisture levels varied from 5 - 15 ppm in the various cabinets and the average oxygen levels varied from 3 - 10 ppm.

GENERAL

Access to the laboratory was much easier due to the lack of restrictions imposed by quarantine; therefore, many tours, by personnel who were not previously qualified to enter the laboratory during mission operation periods, were allowed. These tours included mostly NASA dignitaries and visiting scientists. Other visits by political dignitaries were conducted through the viewing room and on some of the tours special displays of lunar samples were arranged.

The Public Affairs Office coordinated interviews and filming of operations by outside organizations such as National Geographics and Life magazines, a live TV broadcast on NBC, and other filmed and taped interviews.

Numerous visits were made by the Apollo 15 crew to view lunar sample displays and comment on them and in general on the lunar exploration. The Apollo 16 and 17 crew members were also provided many opportunities to view samples throughout the processing phase of operations.

Some slight interference with operations did occur as a result of the numerous tours, interviews, and displays required; however, most personnel involved benefitted from the exercise.

APPENDIX A. - SNAP LINE PREMISSION PREPARATIONS

The SNAP Line had been used for Apollo 14 sample processing under quarantine conditions and was prepared for Apollo 15 mssion operations in approximately three months. Preparations included systems repair, modifications, cabinet cleaning, tool loading, procedures simulation, and training.

Repairs included replacement of leaky valves and gaskets. Several windows were changed from Lexan to glass for improved visibility (dusting operations in Cabinet 4 coated the Lexan with a fine layer of dust which was held in place by static electricity). A late decision was made to change all the windows; however, due to schedule restrictions only the windows in Cabinet 4, 5, 5A (one side), and 9 (one side) were changed to glass. Due to a shortage of Viton gasket material, neoprene was used to seal these windows which later proved to be a problem during cabinet cleaning. The final flush of the cabinets with Freon caused some of the neoprene material to dissolve in the Freon which was highly undesirable.

Cabinet cleaning was performed in accordance with new cleaning procedures requiring much higher levels of cleanliness. The procedure essentially conformed to MSC 03243 "Cleaning Procedures for Contamination Control, CP-1", and required three weeks of extensive effort to complete. All aspects of cleaning were accomplished and the cabinets were ultimately much cleaner than for Apollo 14.

A particulate test was performed after cleaning to determine airborne particulate levels, size, and type of particulate remaining on the cabinets. The following are exerpts from a report by NASA-MSC-WSTF entitled "SNAP Cabinet Line Particle Contamination Report", January 1972.

> Background
>
> On July 1, 1971, and August 10, 1971, samples of particulate material were collected from Cabinet 4, 5, and 9 of the Sterile Nitrogen Atmosphere Processing (SNAP) Line at the Lunar Receiving Laboratory.
>
> The samples were transported to the WSTF laboratories for processing and analysis. The collected particulate samples were sized and counted, analyzed for chemical content, photographed and classified.
>
> Sample Procedure - "Fallout" Samples
>
> Squares of aluminum foil (6"x6") were cleaned and individually bagged in Teflon following the procedures specified in CP-7 of "Lunar Receiving Laboratory Cleaning Procedures for Contamination Control,"MSC 03243, dated October 1, 1970. In addition, the foils were cleaned until no particles greater than 5 microns were detected in rinse samples of the foil surfaces.

The bagged foils were introduced into Cabinet 4, 5, and 9, removed from the Teflon bags and allowed to remain in the cabinet for 14 hours to collect "fallout" particulate. The cabinet atmosphere was agitated for several minutes by use of a hand-held Teflon "fan" in order to disperse the particulate on the cabinet surfaces. The foils were then folded, rebagged in Teflon and sealed.

Count and Size Data Summary

After examination using the electron microprobe, the samples were transferred to a Class 100 clean room for sizing and counting. The following summarizes the data obtained by cabinet and sample number:

Cabinet 4

Size Range (microns) and Count Data

Sample Number	10-25	25-50	50-100	100-175	greater than 175
3	97	37	1	0	0
4	106	35	5	2	0
5	52	24	9	0	0
9	159	43	5	1	1
10	106	25	3	0	0
11	55	31	0	0	0

Cabinet 5

Sample Number	10-25	25-50	50-100	100-175	greater than 175
19	93	13	1	0	0
22	168	21	8	1	1
29	74	15	1	0	1

Cabinet 9

Sample Number	10-25	25-50	50-100	100-175	greater than 175
31	66	24	0	0	1
35	55	29	1	1	1
38	165	19	2	1	2

Procedures Used to Determine the Relative Abundance of the Elements in a Particle

Particles were scanned for elements from atomic number 5 and higher using a Norelco electron microprobe (with scanning electron microscope capability) equipped with lithium fluoride, mica and LSD crystals. A flow proportional counter was used. The peak heights of the two-theta scans were compared to standards to obtain an estimate of relative abundance.

The standards prepared and their forms are tabulated below:

Element	Form	Element	Form
Zn	Metallic Zn	Al	6061T6
C	Graphite	Na	NaF
Cu	Copper Wire	F	NaF
Ni	Metallic Ni	Cl	NaCl
Cr	Metallic Cr	Ca	$CaSO_4$ (briquette of anhydrous powder)
Si	Si		
Mg	Metallic Mg	S	$CaSO_4$ (briquette of anhydrous powder)
Fe	Iron Rod		
Ti	Ti6Al4V	O	$CaSO_4$ (briquette of anhydrous powder)
		K	KCl

Percent of Particles in Each Sample Containing Aluminum, Carbon, Iron or Silicon as the Major Element

During the microprobe examination of the silver membranes for particles, one can view the particles both visually (light microscope attachment to the probe) and electronically (secondary backscatter image on a cathode ray tube).

The particles were then classified on the basis of major element found in each particle. The percent of the particles in a given sample containing silicon, for example, as the major element were then calculated from the tabulated data and relative abundance results. The percent of particles containing the major elements are listed below.

Percent of the Particles Containing the Major Elements Indicated

Sample Number	Carbon	Iron	Silicon	Aluminum	Miscellaneous
1	0	41	13	35	10
3	27	13	35	22	2
4	4	8	54	31	5
5	7	12	29	52	0
9	41	5	4	34	17
19	7	3	51	12	26
22	5	0	64	31	0
29	54	3	40	1	2
31	67	0	7	23	2
35	33	15	29	12	11
38	19	3	57	10	10

The basic philosophy of processing lunar samples includes the supposition that exposing the material to the least number of different types of material will result in less contamination of the sample with unknown and undesirable materials. Therefore, the cabinet materials and tools are restricted to Teflon, Viton, stainless steel, aluminum. Use of other materials when necessary requires approval of the Contamination Control Committee. Some of the exceptions are:

1. Neoprene gloves (cabinet)

2. Parts of balances

3. Heat sealers