



Briefing Topic:

Geologic Tools for the Moon

Review of Apollo

David A. Kring

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Hammer



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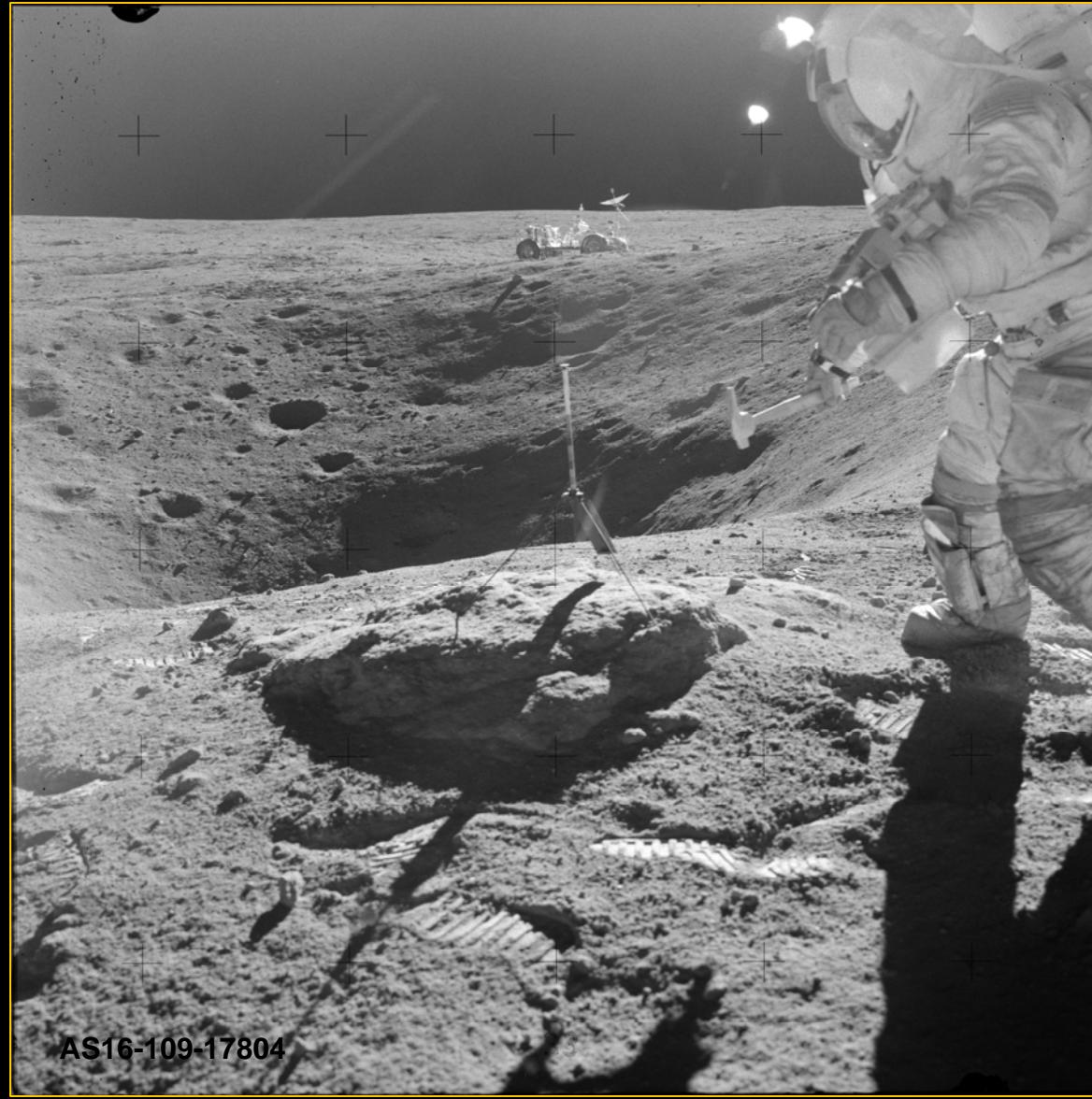
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Hammer

- Two sizes of hammers were used on Apollo
 - Apollo 11 and 12
 - 860 g (1.9 lb)
 - 41 cm hammer length
 - 16 cm head length
 - Apollo 14, 15, 16, & 17
 - 1300 g (2.9 lb)
 - 39 cm hammer length
 - 16 cm head length
- Small improvements were made to these basic configurations with each mission



Hammer

- This is a view of the 1300 g hammer used on Apollo 16



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Tongs



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Tongs

- Because crew were unable to bend over or squat to pick up samples in their space suits, tongs were required to pick up rock samples (<10 cm in size)
- Apollo 11, 12, and 14 utilized 67 cm long tongs with an aluminum handle and 1/8-inch diameter tongs
 - 140 g
 - 67 cm long
 - 10 cm wide T-handle
- These tongs hung on the space suits

Tongs

- Apollo 15, 16, and 17 used a longer set of tongs (32-inch tongs) with an aluminum handle and 1/8-inch steel tongs
 - 230 g
 - 80 cm long
 - 12 cm wide T-handle
- Tongs were stored on the large tool carrier on the LRV





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Scoops

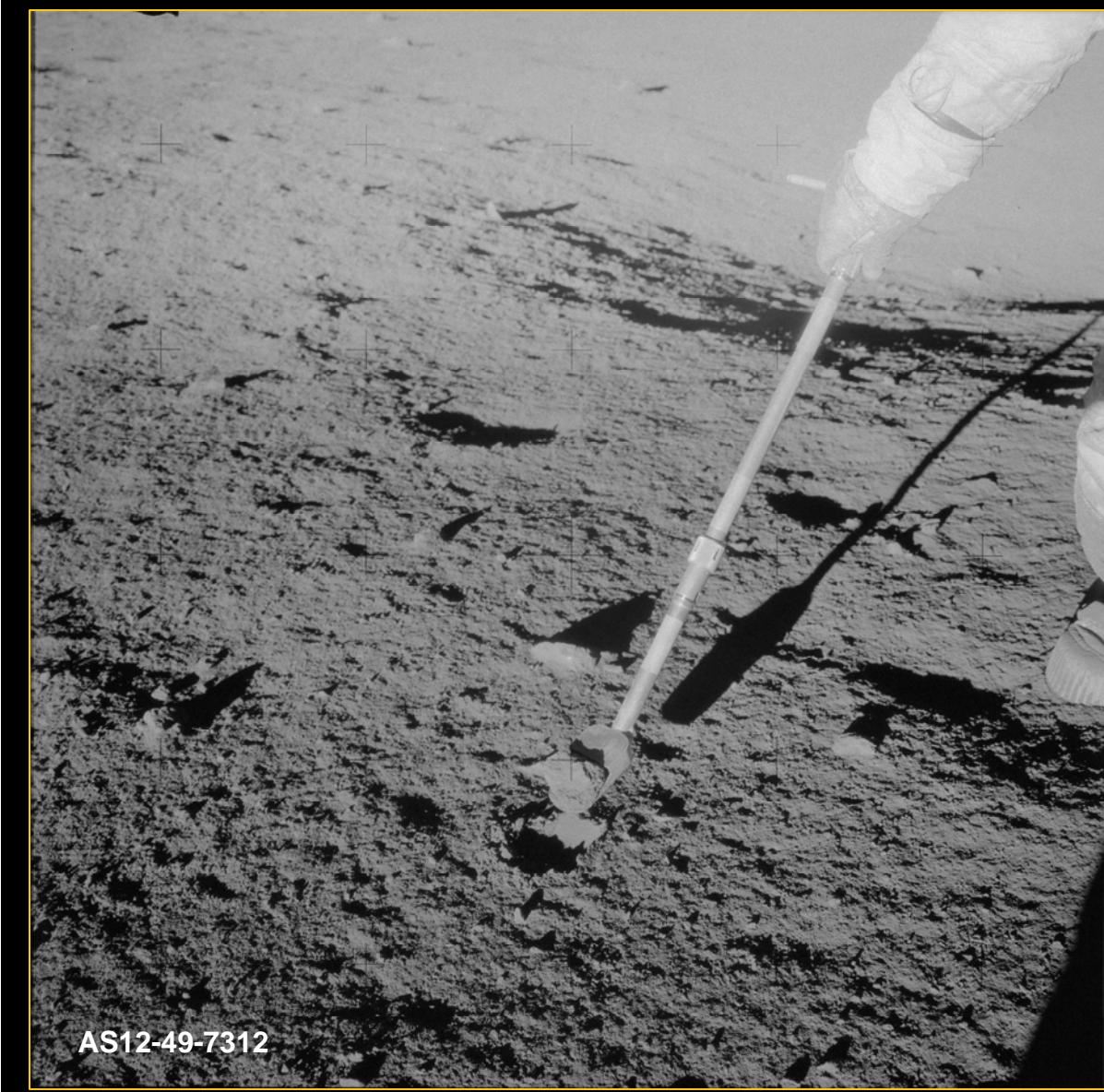


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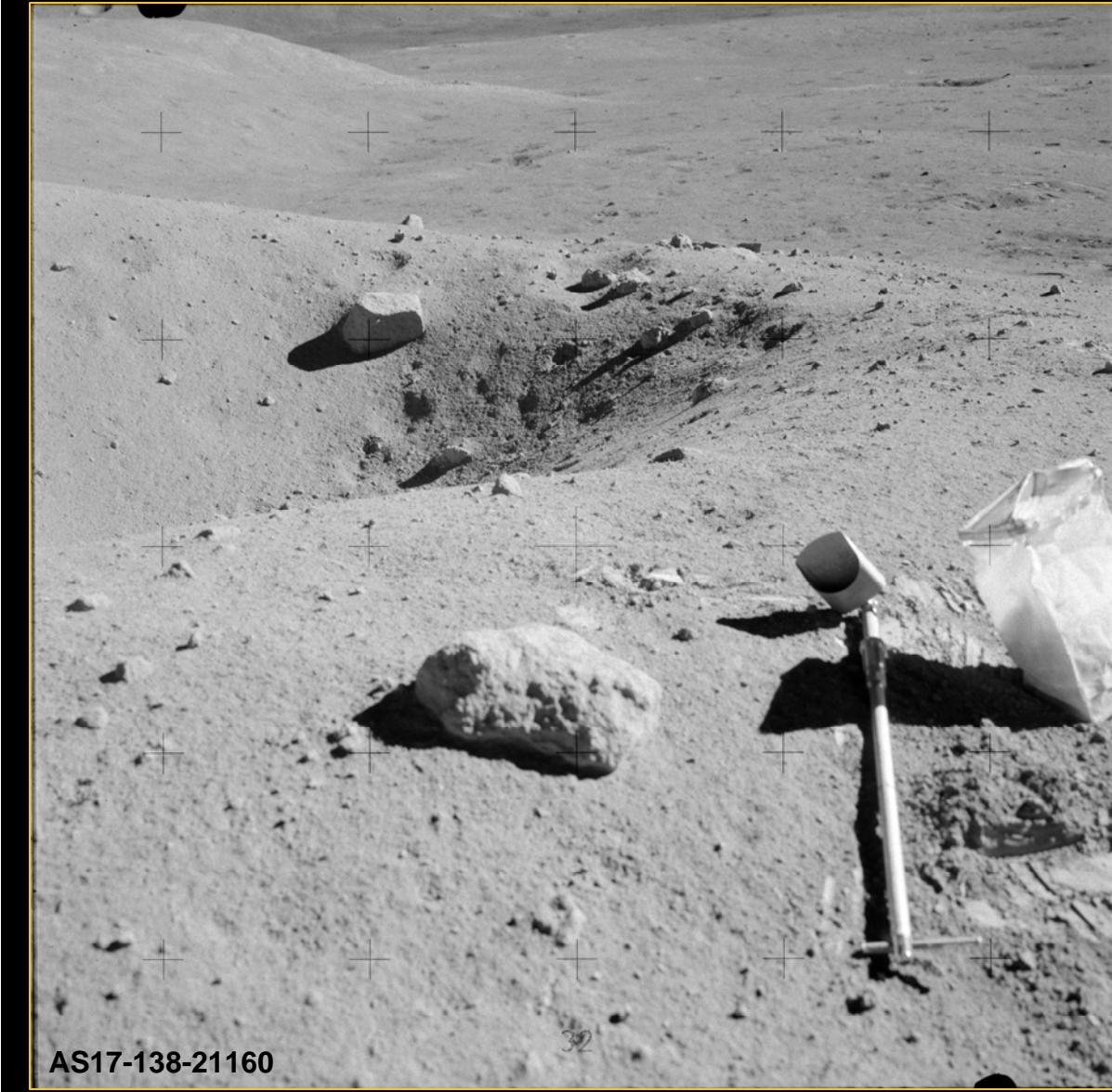
Small Scoop

- Small, non-adjustable scoops (shown here) were part of the small tool carriers on Apollo 12 & 14
 - 163 g
 - 34 cm long
 - 6.6 cm wide pan
 - 3 cm pan height
- A small, adjustable-angle scoop was used on Apollo 15 and was stored on the LRV's large tool carrier
- Later missions used larger, adjustable-angle scoops



Large Scoop

- Large, adjustable-angle scoops were used on Apollo 16 & 17
 - 590 g
 - 35.44 cm long
 - 11.4 cm wide pan
 - 5.1 cm pan height
 - 15.2 cm pan length
- The scoops were designed so that crew could sample material by either pushing or pulling them through the regolith



Large Scoop

- Large, adjustable-angle scoop with its pan adjusted to its maximum tilt at Station 3 (Apollo 17) where crew sampled material around a 12 m crater in a light-albedo unit that may represent a landslide from the South Massif
- The pans were made of stainless steel. The pans of the small, non-adjustable scoops of Apollo 12 & 14 were made of aluminum and had a stainless steel edge



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Rake



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Rake

- Used to collect pebbles (>1 cm diameter) from regolith
- Used on Apollo 15, 16, & 17
 - 1500 g
 - 29.4 cm basket length & width
 - 10.4 cm backset height
 - 22.3 cm handle length
 - 1 cm tine separation
- The basket sidewalls were constructed of aluminum and the tines were 1/16-inch stainless steel wire

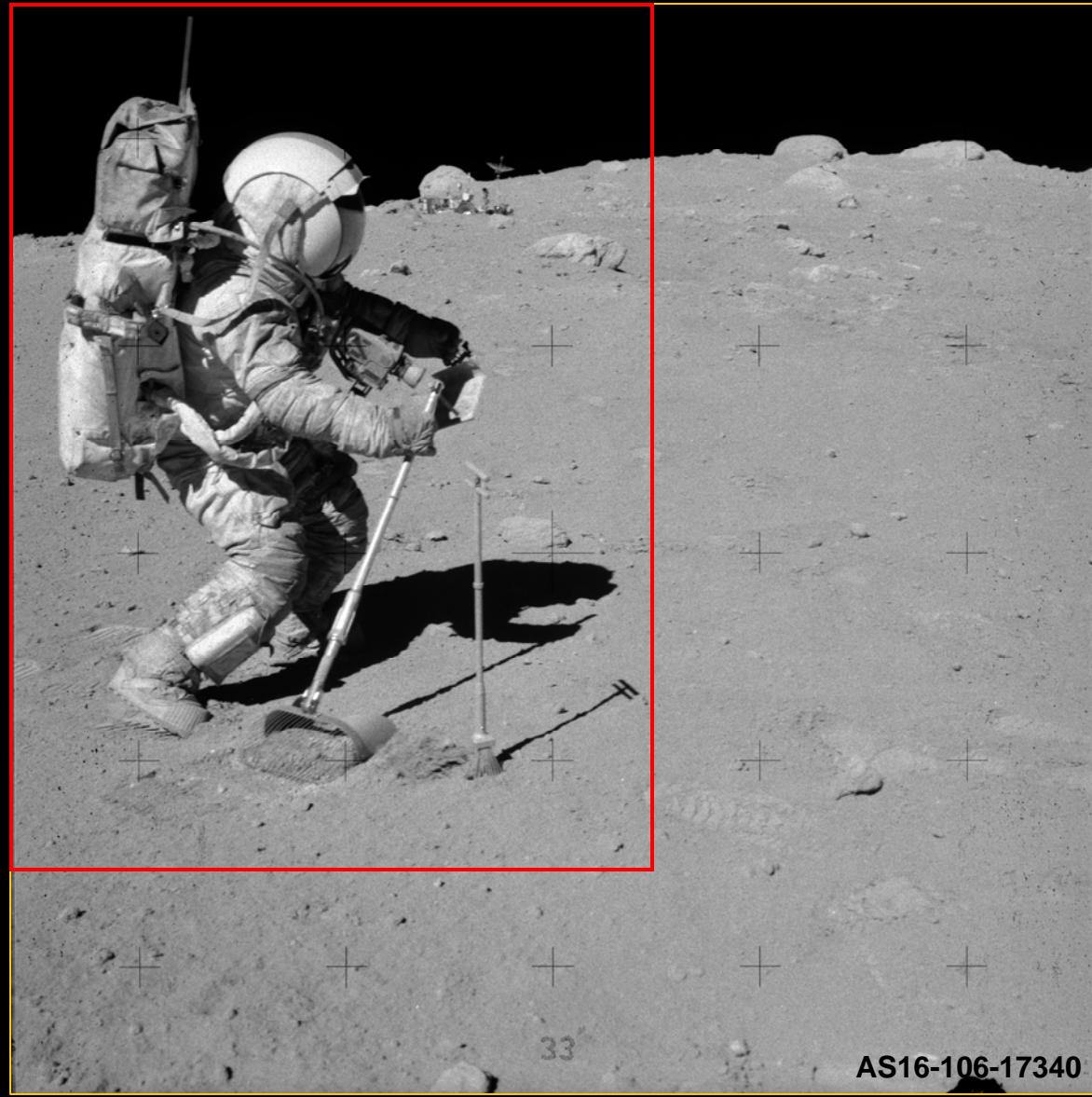


Rake

- Drawing the rake across the body from back-right to front-left

33

AS16-106-17340



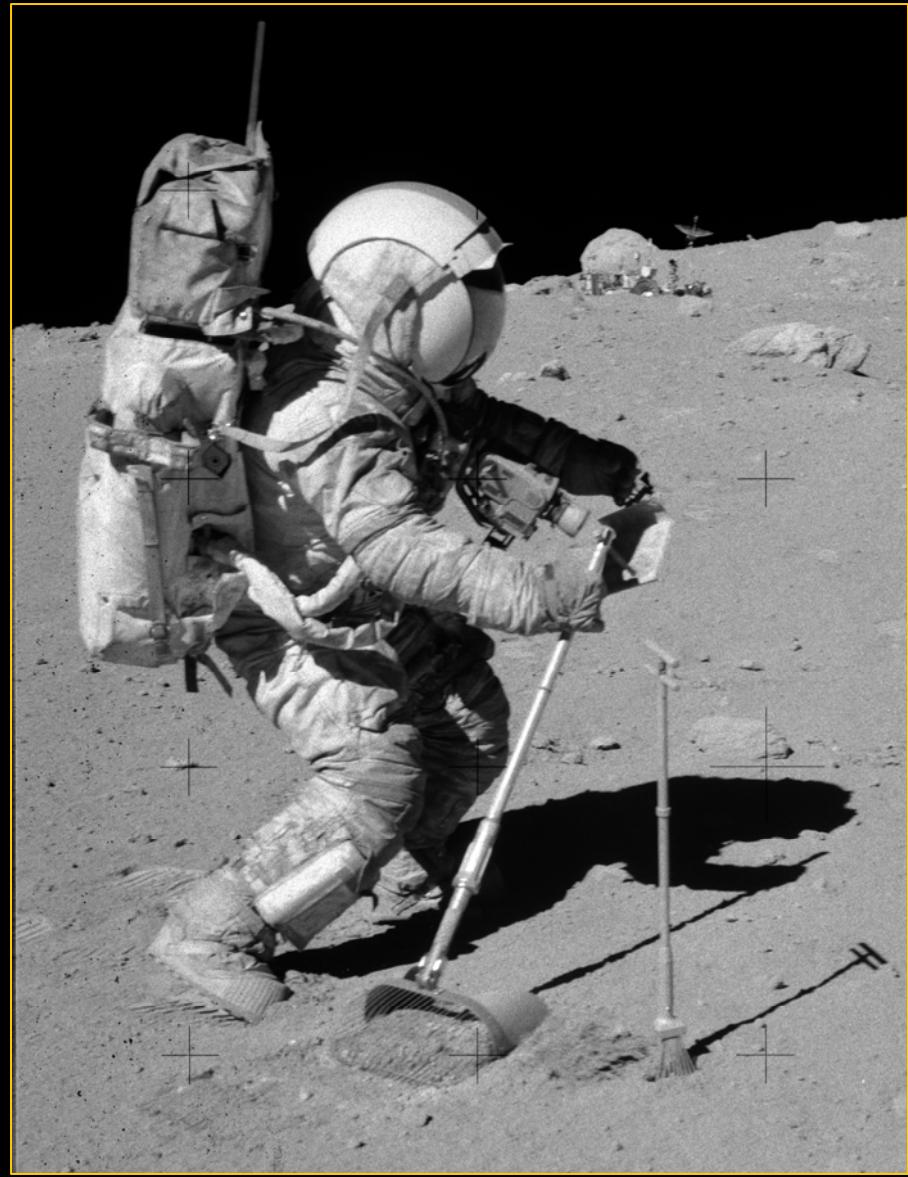
Rake

- Drawing the rake across the body from back-right to front-left



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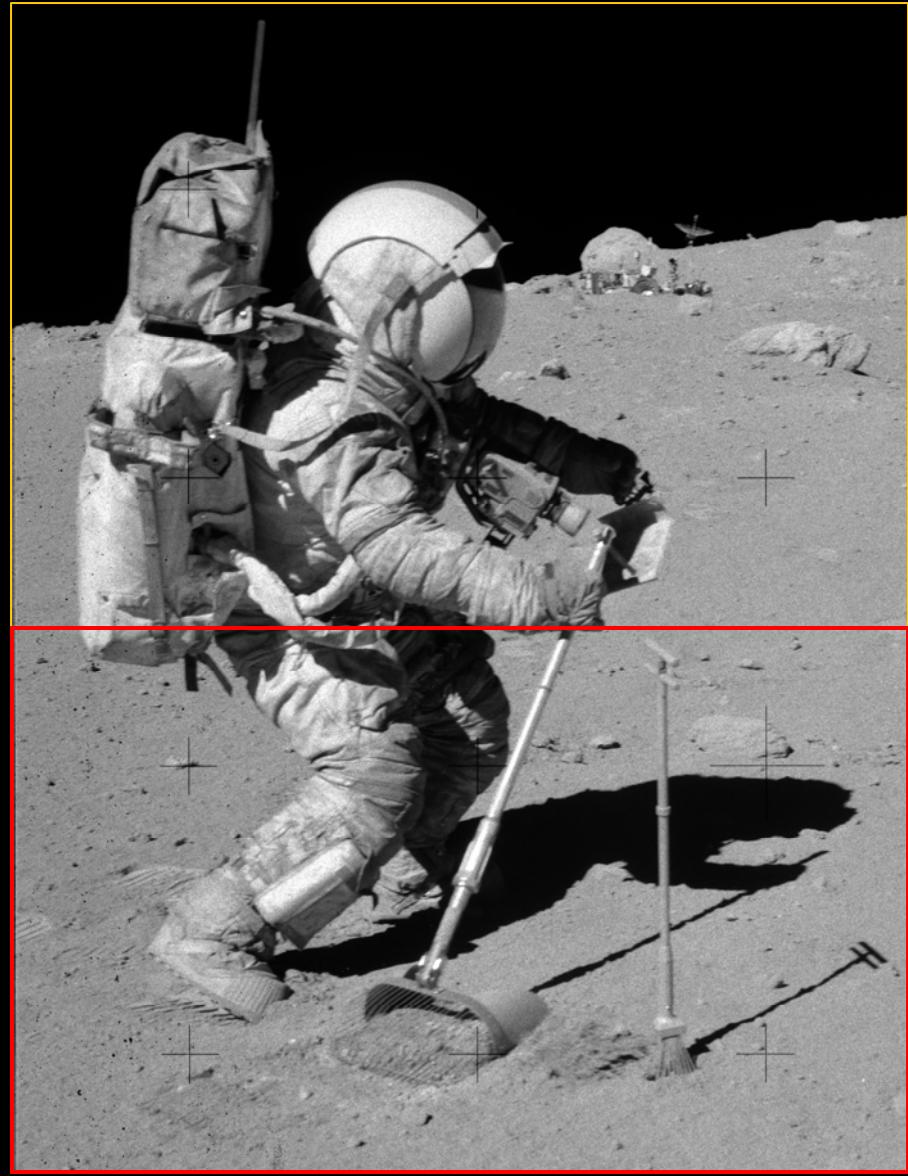


Detail of AS16-106-17340



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Rake

- Second example of its operation
- Sweeping the rake from front left to back right; or rotating the rake after sweeping in other direction

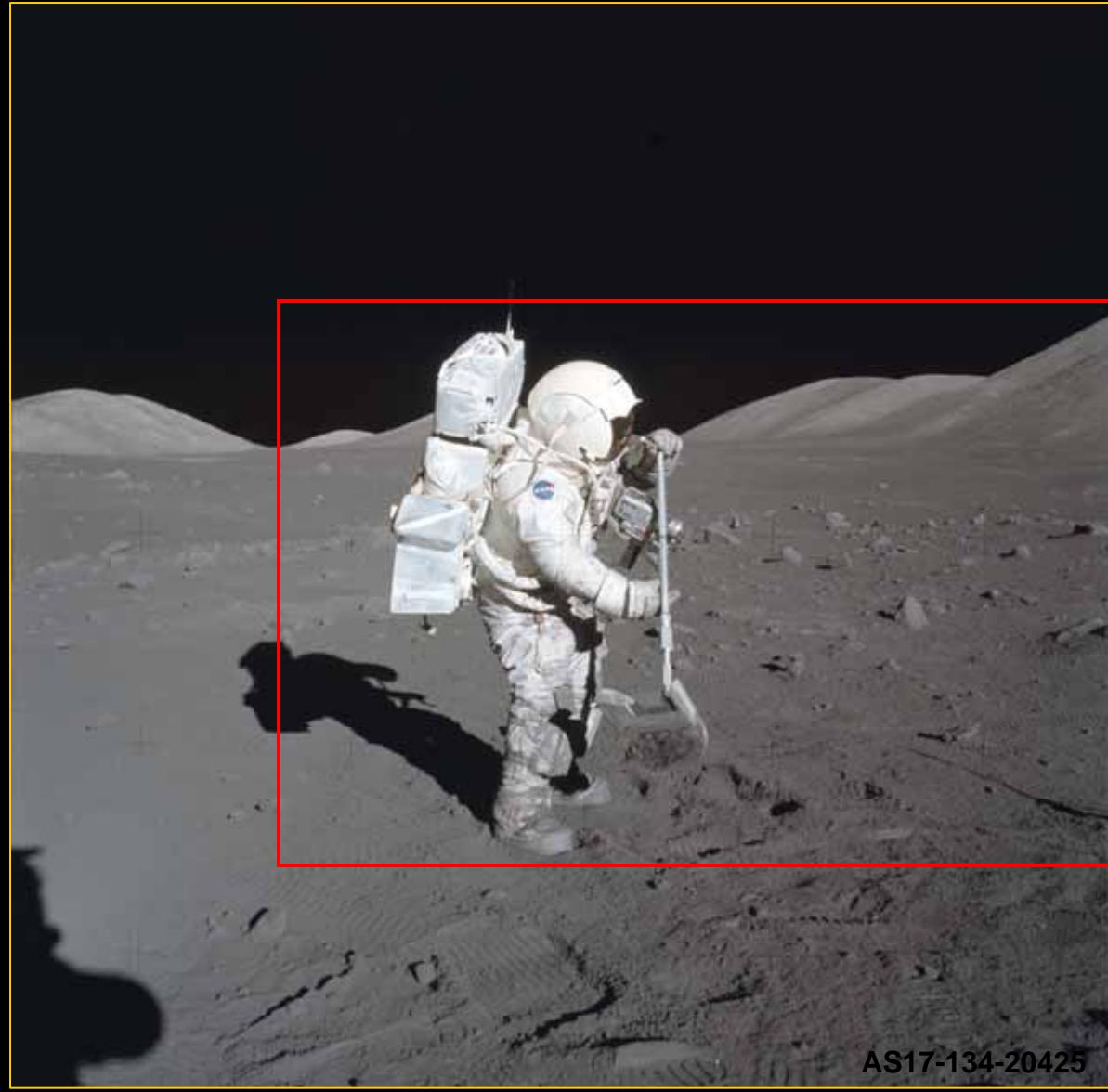


AS17-134-20425



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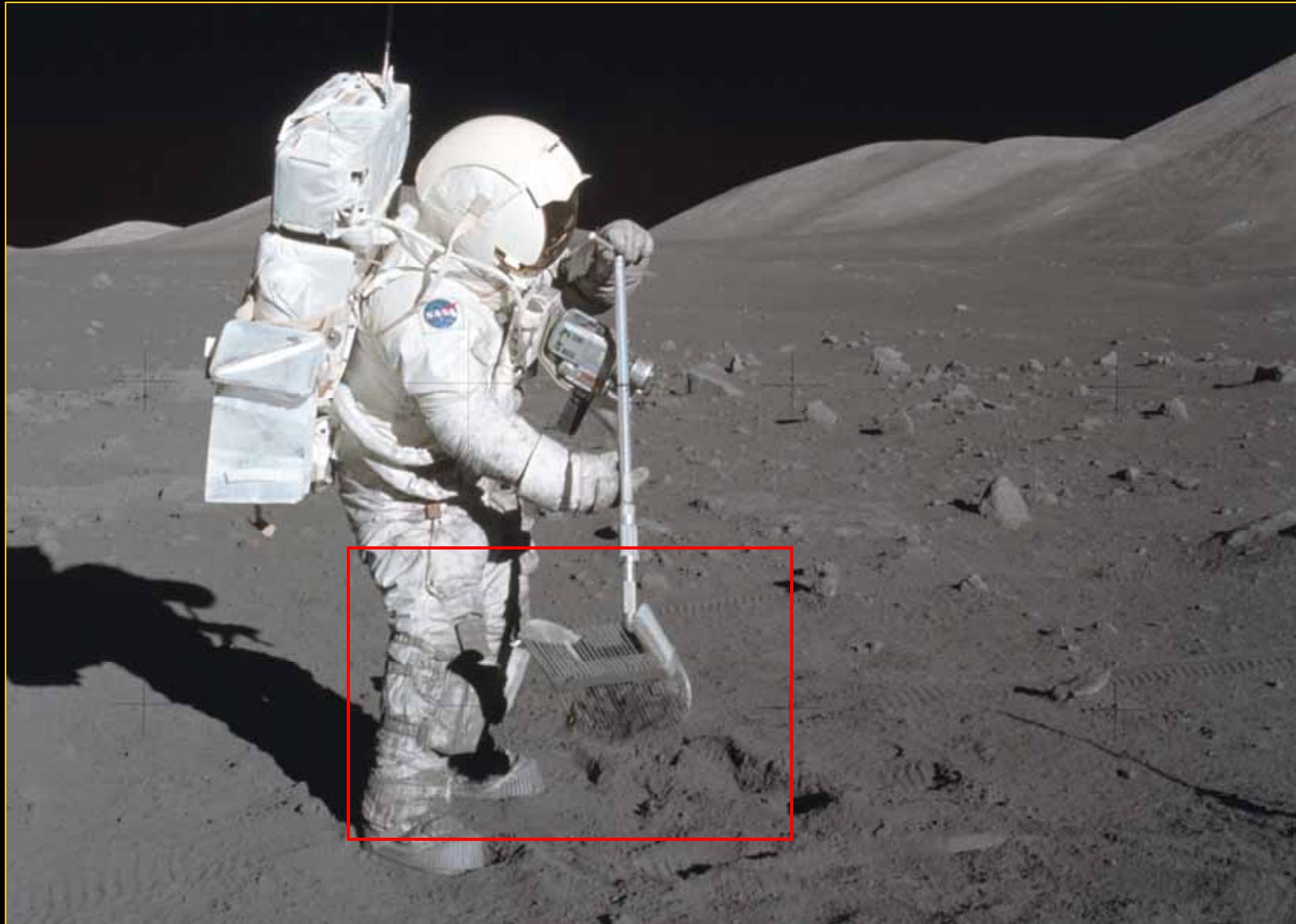
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Rocks
are trapped
within rake

Detail of AS17-134-20425



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AS17-134-20426

Rake

- Astronaut continues to lift the rake, displacing additional fines and isolating pebbles and cobbles



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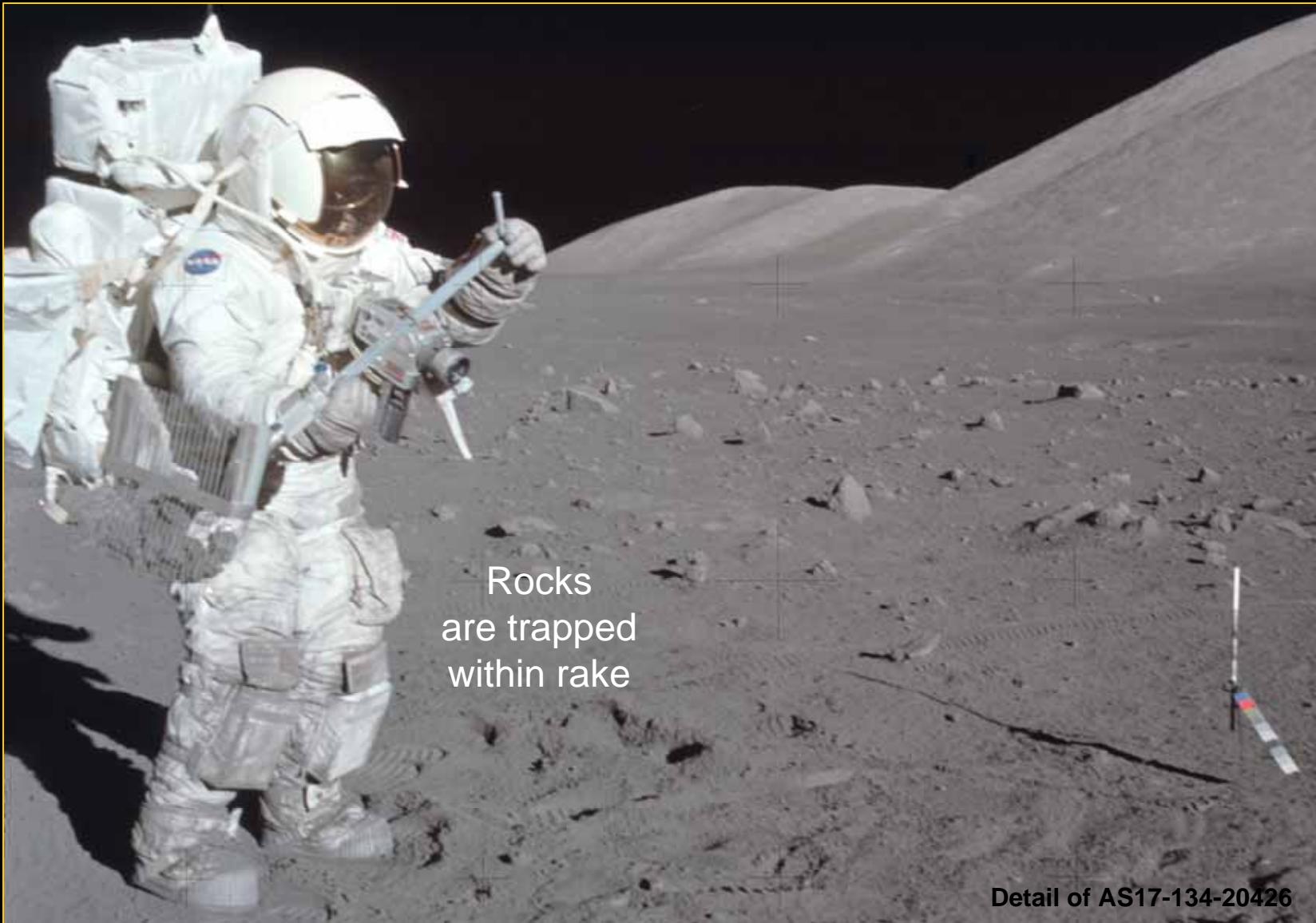


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Core Tubes & Drive Tubes



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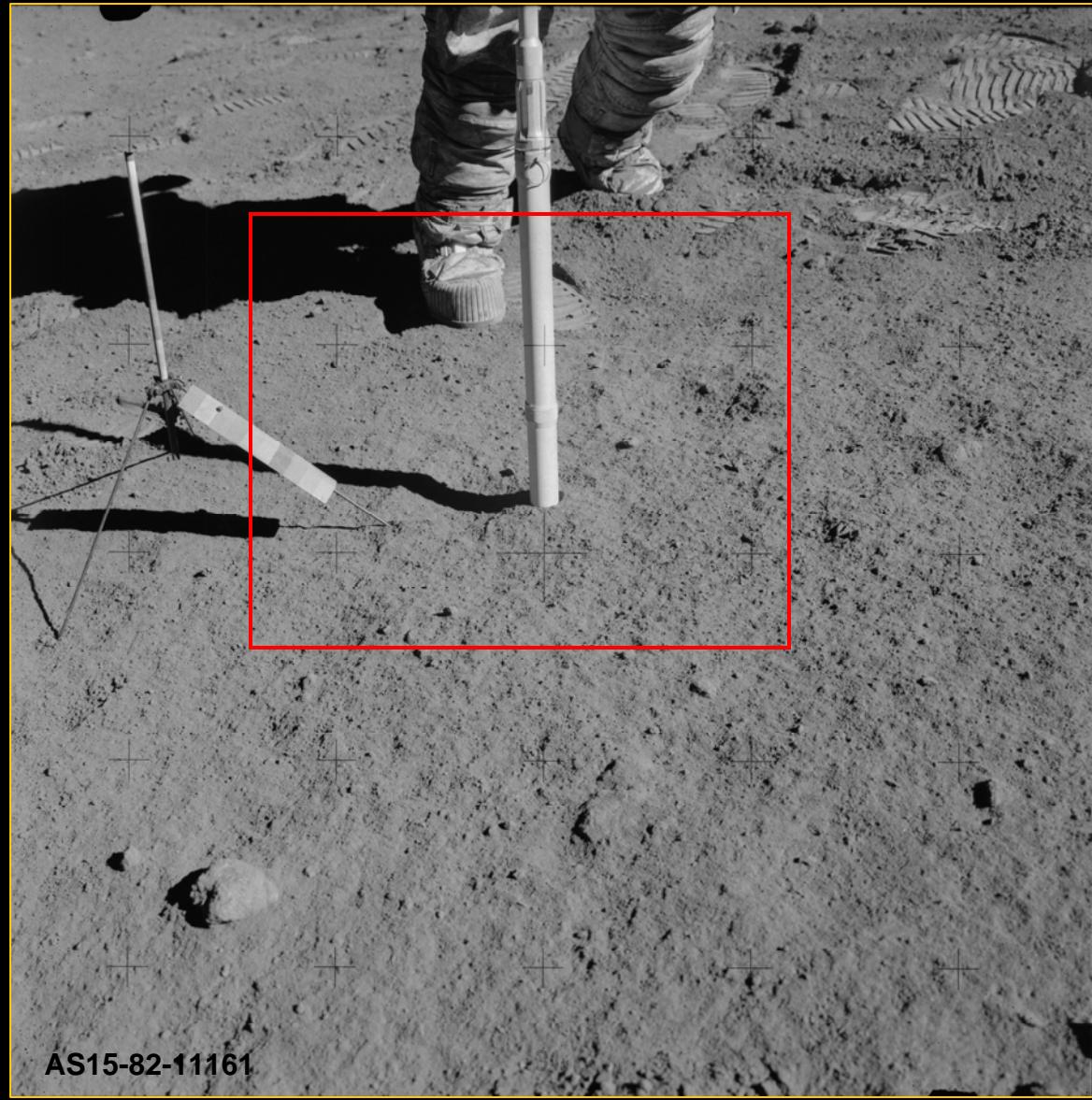
Core Tube

- On the Apollo 11, 12, & 14 missions, a thick-walled, small-diameter core tube was used to sample soil columns
 - 2-cm diameter
 - 327 g (assembled)
 - 39.9 cm length
 - 2.8 cm outside dia.
 - 100 cm³ capacity
- A funnel-shaped bit (A11) was changed to a tapered bit (A12, A14), because the lunar soil is dense
- Tube was driven into the soil with a hammer



Drive Tube

- On the Apollo 15, 16, & 17 missions, the core tube was replaced with a thinner-walled, larger-diameter drive tube
 - 4-cm diameter
 - 300 g tube w/o cap
 - 110 g caps & dispenser
 - 90 g ram tool
 - 42 cm length
 - 4.4 cm outside diameter
 - 470 cm³ capacity
- Crew pushed and/or hammered the drive tube into regolith



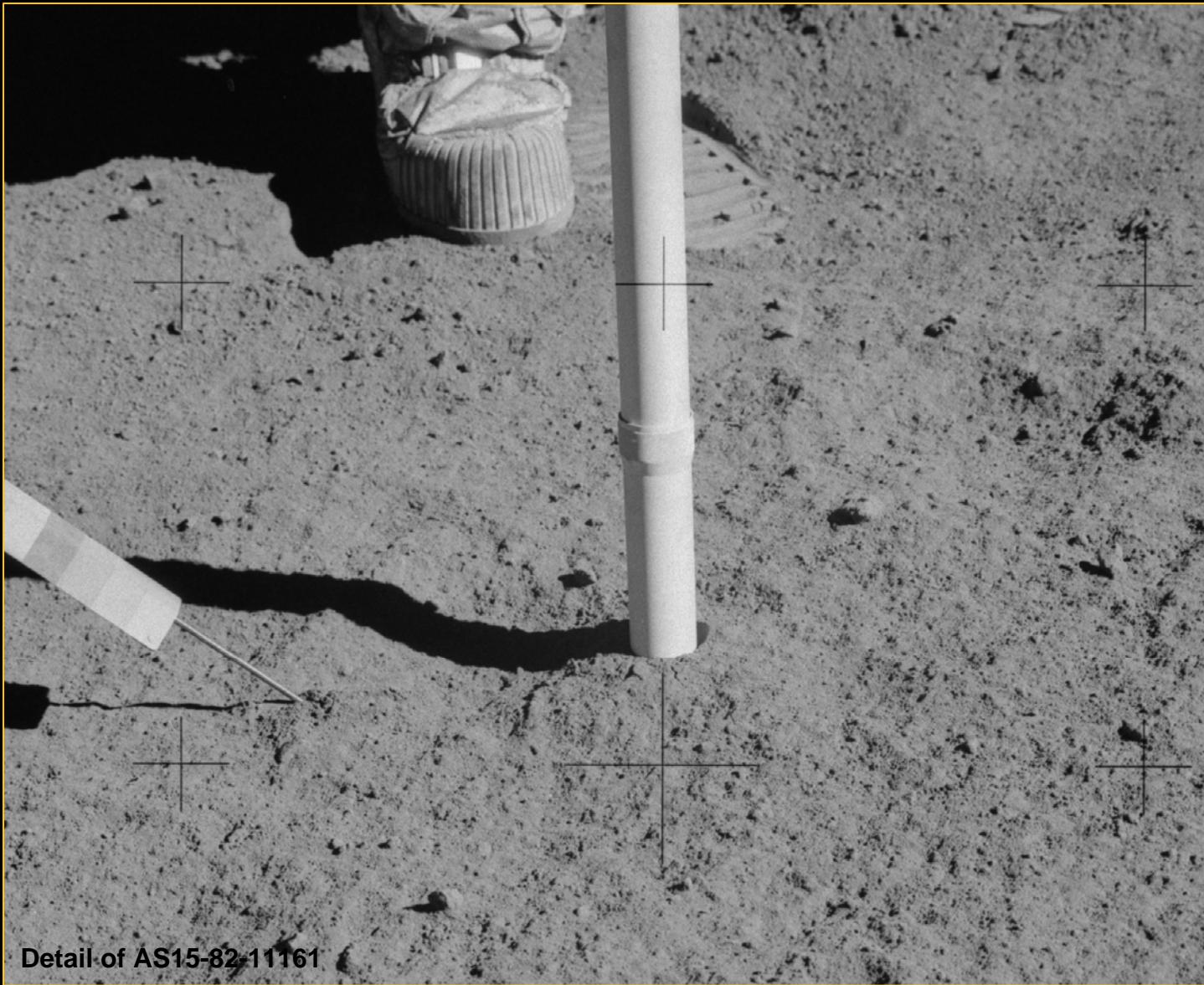
Drive Tube

- Pushing and/or hammering drive tube into regolith



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Drive Tube

- Hole where core was extracted



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Extension Handle

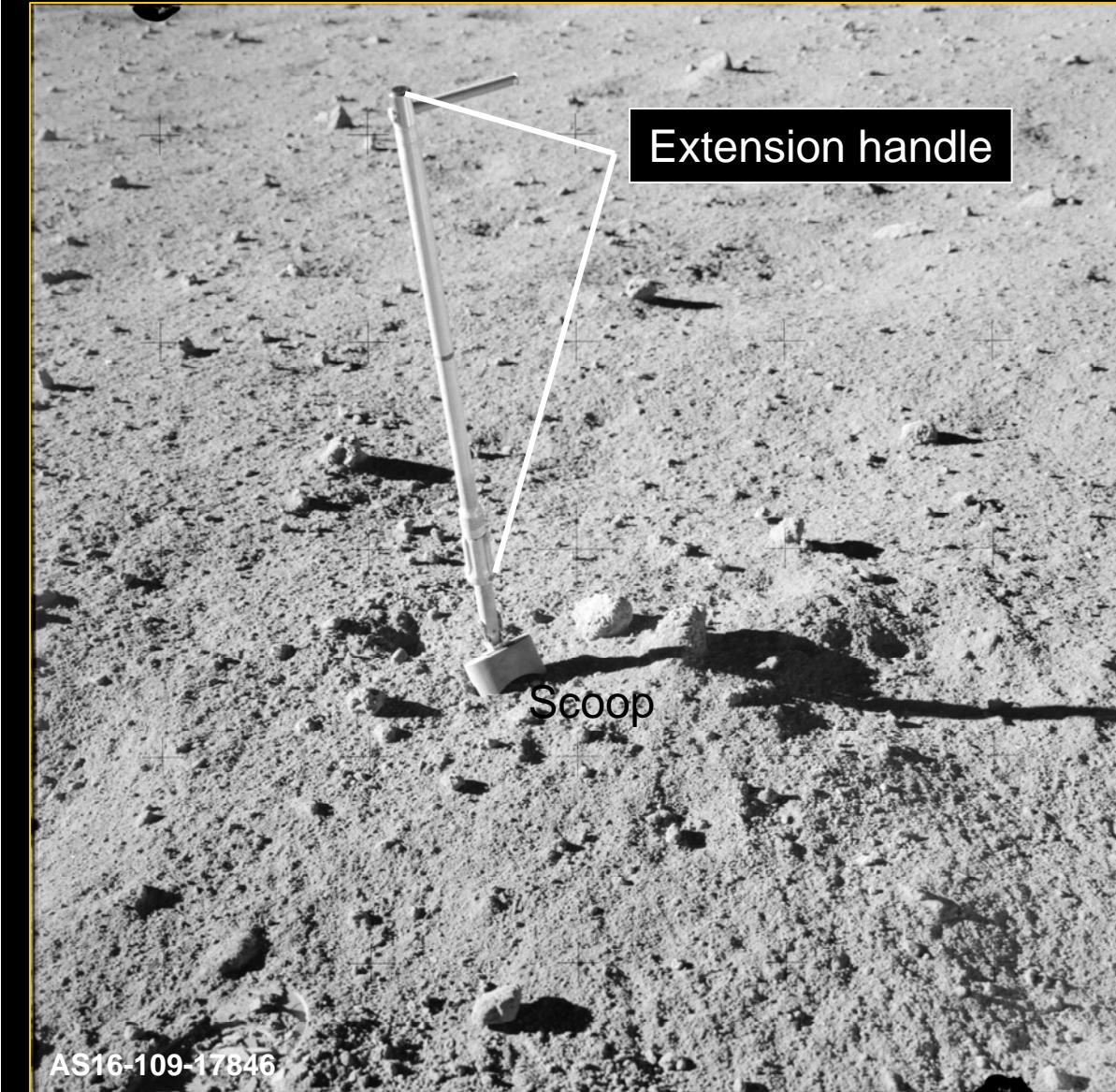


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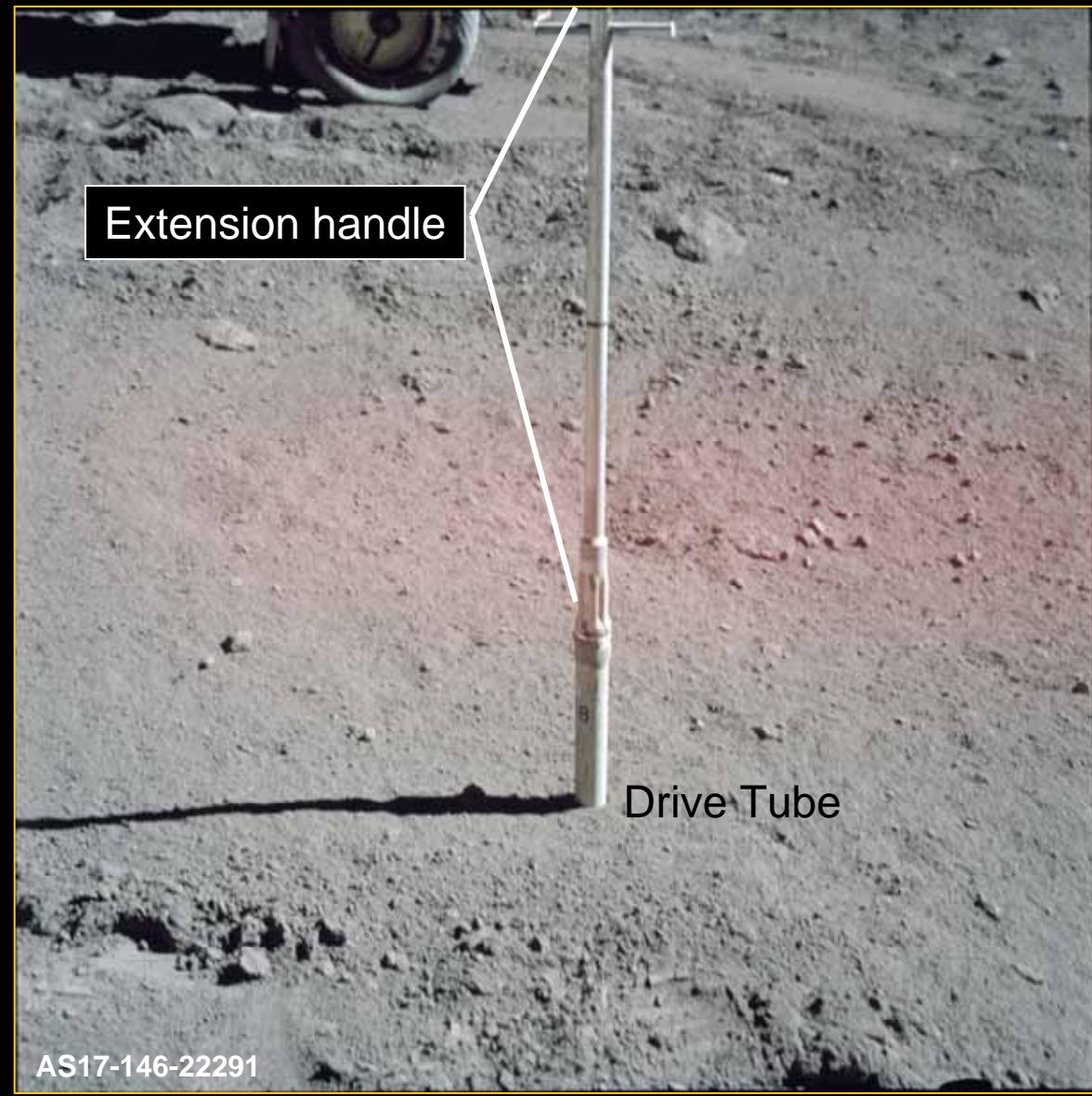
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Extension Handle

- Designed to save mission mass
- A single handle was used with a scoop, hammer, rake, core tube, and drive tube
- Shorter Extension Handle
 - 590 g
 - 61 cm long
 - 15.5 cm wide with T-handle
- The Shorter Extension Handle was used on the Apollo 11 and 12 missions



Extension Handle

- The T-handle and shaft were made of aluminum allow and the top that was pounded by the hammer was reinforced with stainless steel
- Longer Extension Handle (shown here and on preceding slide)
 - 770 g (A14)
 - 820 g (A15-17)
 - 76 cm long
 - 15.5 cm wide with T-handle



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Drill

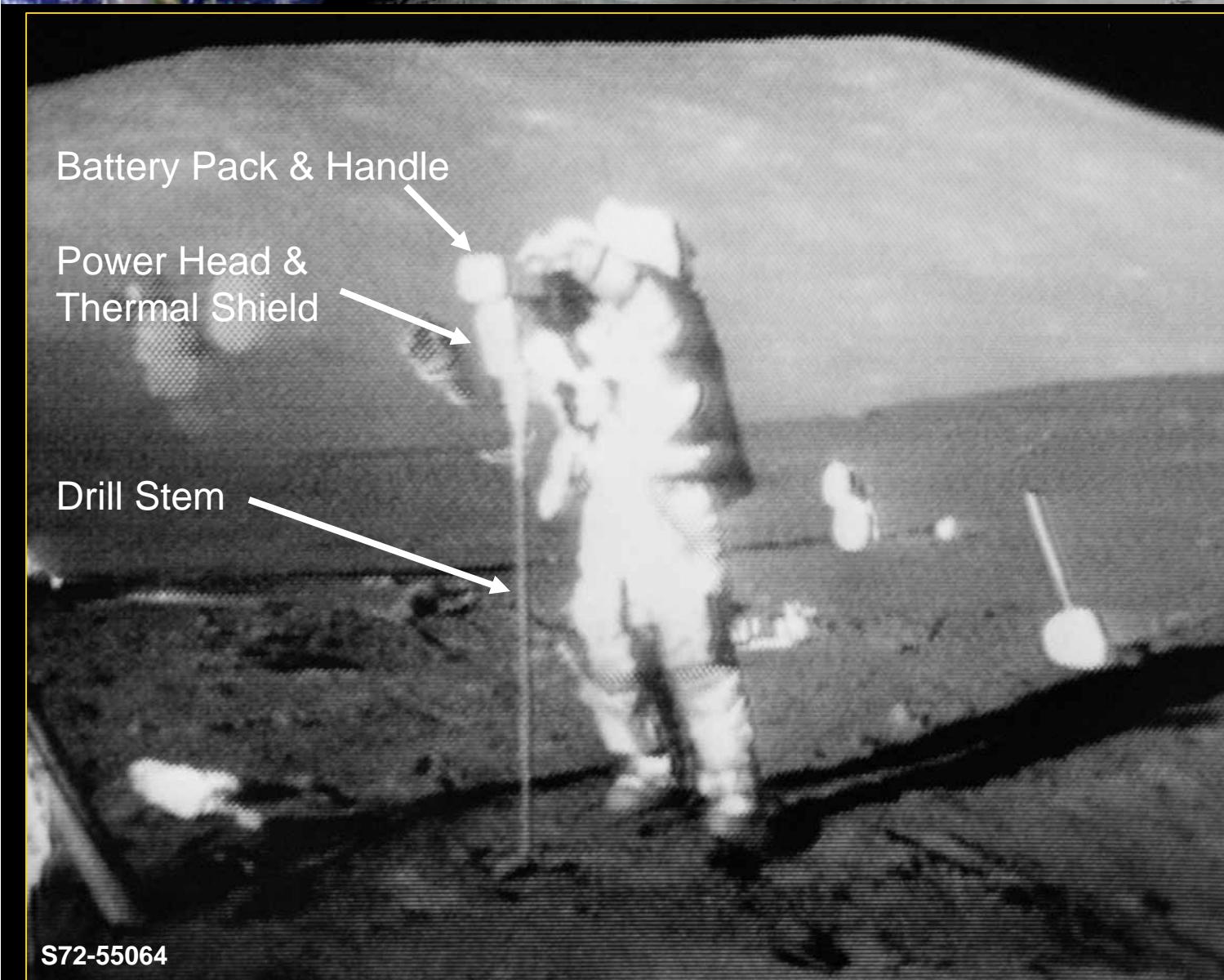


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Drill

- The Apollo Lunar Surface Drill (ALSD) was a rotary-percussive drill that could retrieve a 3 m-long core of regolith
- Apollo 15 & 16 produced six core stem tubes and Apollo 17 produced eight core stem tubes



Gnomon & Sample Photography



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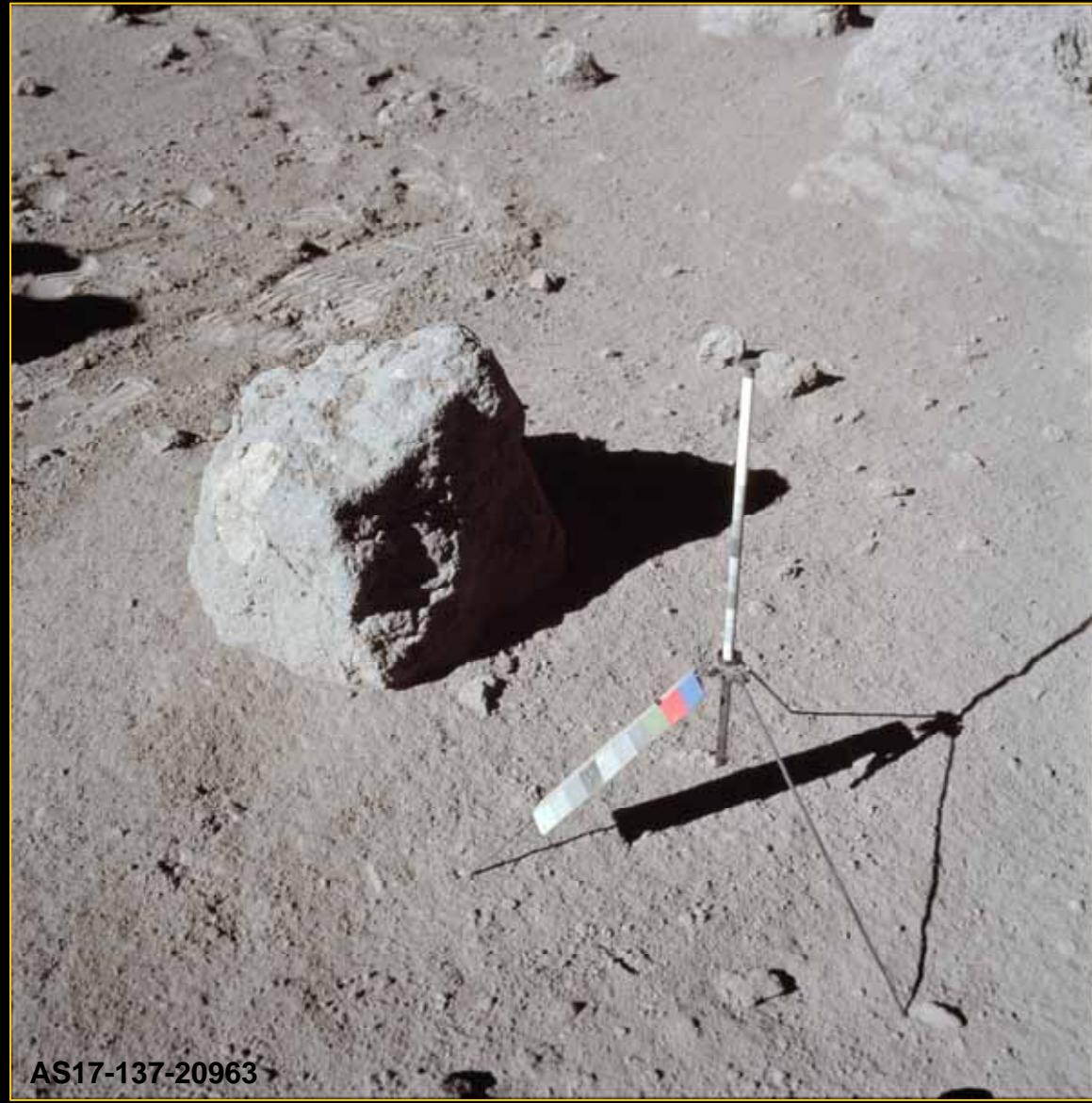
Gnomon

- The gnomon had a gimbled stadia rod to document vertical orientations
- The cast shadow documented the sun angle
- The rod length and painted scale provided a reference for the sizes of nearby rocks and other objects
- A gray and color scale provided a reference for rock and soil colors



Gnomon

- The device was modified as the missions evolved, but was generally:
 - 270 g
 - 53 cm long (stowed)
 - 62 cm high (deployed)
- This device was not used in 2009 simulations of future lunar missions; it is hoped that digital imaging and other techniques will remove the need for this cumbersome device



AS17-137-20963

Sample Photography

- Place gnomon facing sun
- Photograph sample context (with wide-enough view to include LRV or feature on horizon)
- Photograph sample with sun behind camera
- Take two steps sideways & photograph to make a stereo pair
- Photograph sample at 90° to original sample photo
- Collect sample
- Photograph area without sample to confirm which rock was collected



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Documented Sample Bags

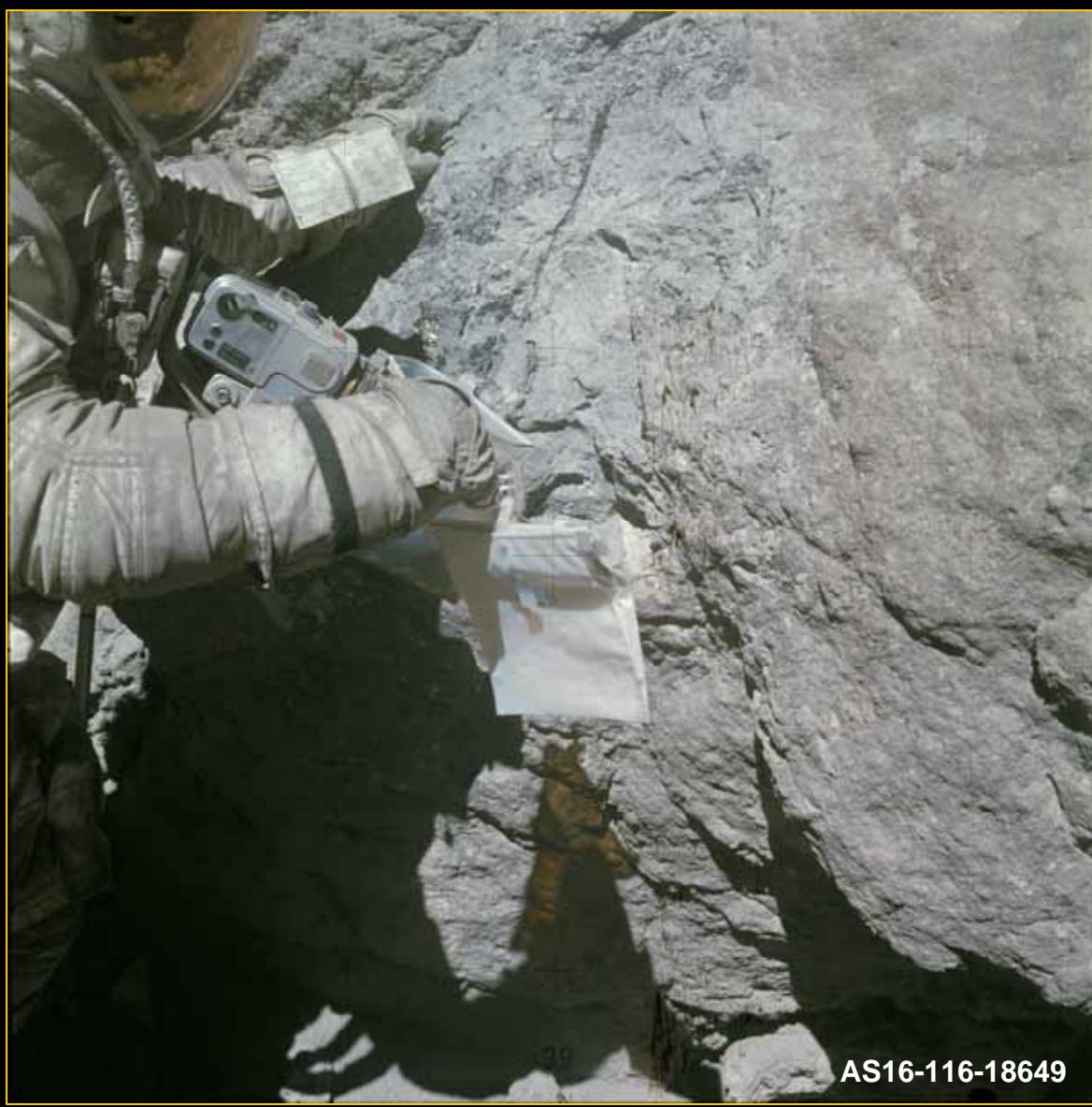


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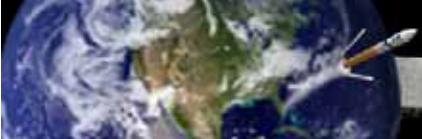
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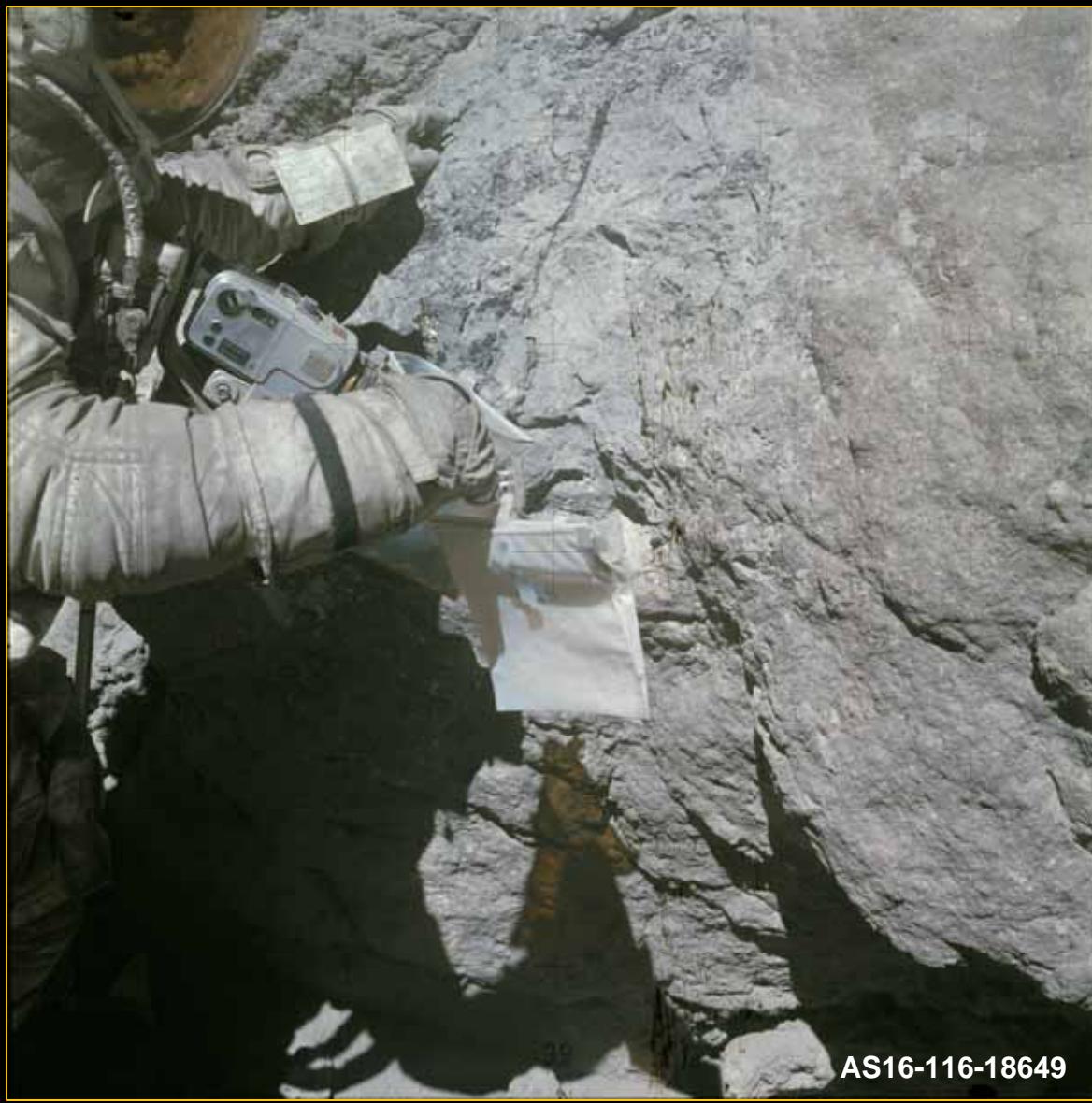
Documented Sample Bags

- Numbered bags with closures to document & separate samples
- Two basic types of bags were used:
 - cup-shaped bags
 - flat, rectangular bags (shown here)



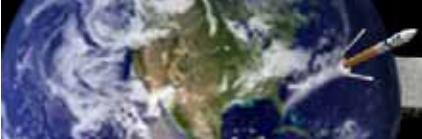
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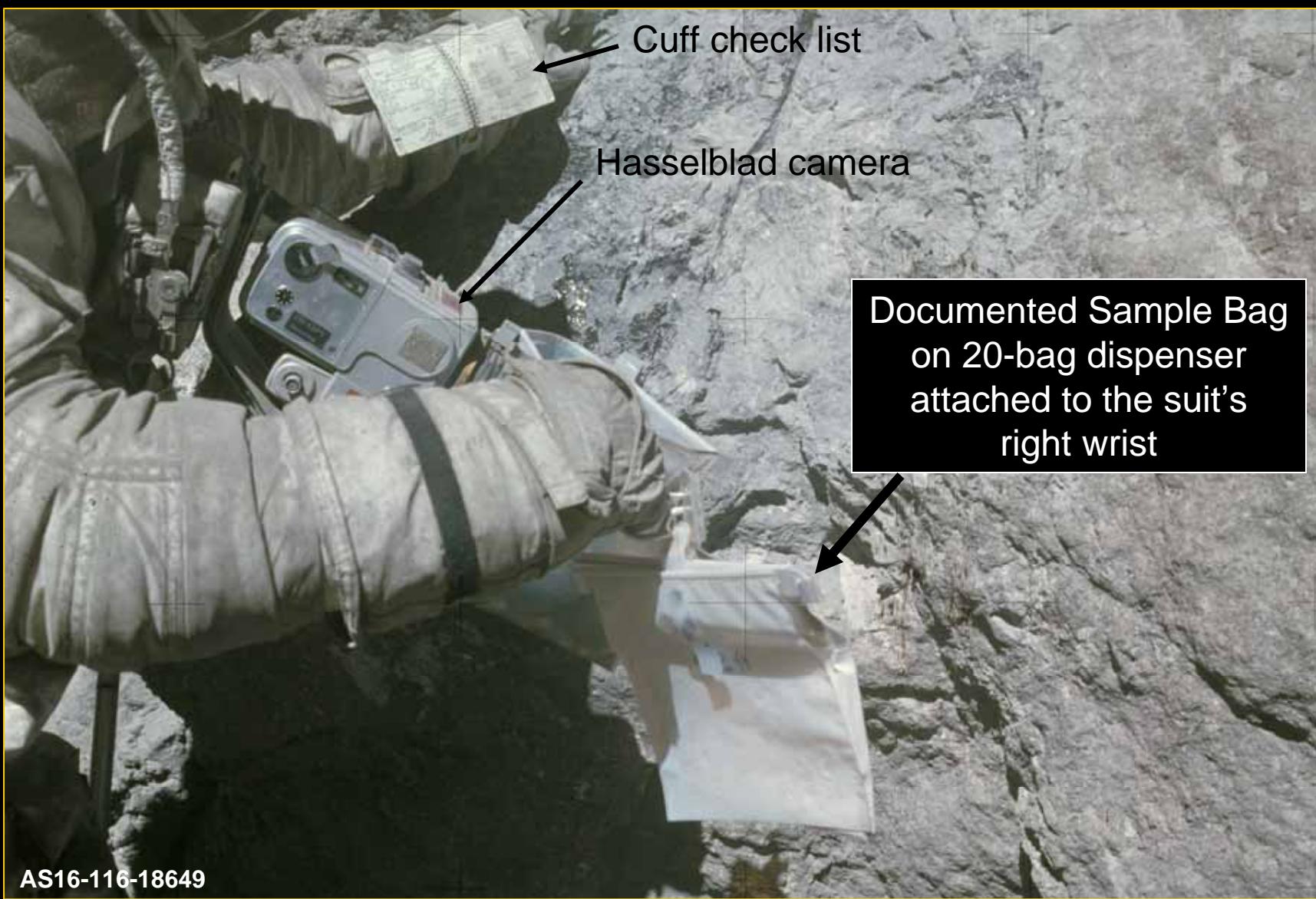
Flat, Rectangular Documented Sample Bags

- Apollo 12 & 14
 - 170 g, 15-bag dispenser
 - 15 x 15 cm bag
 - 23 cm length dispenser
 - 6 cm diameter dispenser
- Apollo 15, 16, & 17
 - 441 g, 20 bag dispenser
 - 20 x 19 cm bag size (shown here)



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Sample Collection Bags & Extra Sample Collection Bags

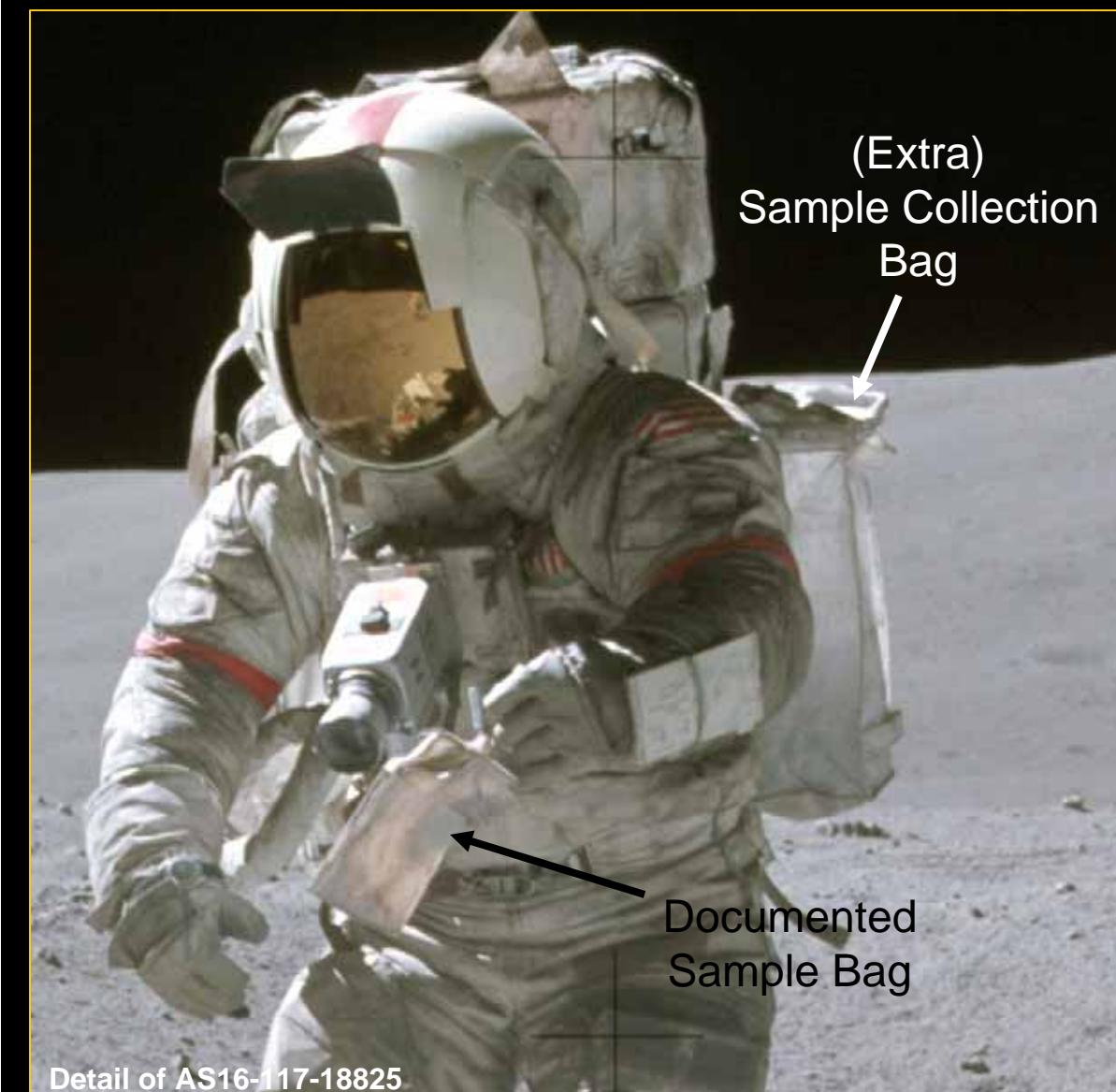


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Sample Collection Bag (SCB)

- The SCB provided storage for documented sample bags, drive tube core samples, and loose samples
- Small samples were deposited through a diagonal slit in the lid; the lid was opened for larger specimens and drive tubes
- Used on the Apollo 15, 16, & 17 missions



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Sample Collection Bag

Diagonal slit in lid for
storing small samples



Lid was opened to
deposit large
specimens & drive tubes

Detail of AS17-145-22157



AS16-107-17473

Extra Sample Collection Bag (ESCB)

- ESCBs were also carried on the LRV and deployed around a sampling site as needed
- Both SCBs and ESCBs provided storage for documented sample bags, but the SCBs also had (a) interior pockets for holding drive tubes and (b) exterior pockets for the Special Environmental Sample Container and drive tube cap dispenser

Sample Collection Bags

- The SCBs were sized to fit into the Apollo Lunar Sample Return Containers (ALSRCs); two SCBs fit into each rock box
- Remaining SCBs/ESCBs were stored in the cabin with crew



AS16-107-17473



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Special Environmental Sample Container



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Special Environmental Sample Container

- Designed with its own knife-edge seal to protect sample from spacecraft cabin gas and the terrestrial atmosphere
 - 360 g
 - 21 cm height
 - 6.1 cm outer diameter
 - 360 cm³ capacity
- The SESC was made of stainless steel, an indium alloy (10% silver) seal, and teflon seal protectors
- Used on all Apollo missions

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Close-up view of
Special Environmental
Sample Container
with lunar soil

Hasselblad camera

Cuff check list

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Apollo Lunar Sample Return Container



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S69-31080

Apollo Lunar Sample Return Container

- Machined from a single block of aluminum
- 2 mm wall thickness, reinforced with ribs
- Lined with York mesh (knitted 0.011-inch diameter aluminum wire)
- Fluorosilicone sealing-rings
- 90% indium-10% silver alloy seals
- Teflon seal protector



Apollo Lunar Sample Return Container

- Also called the ALSRC or rock box
- Nominally 6700 g, although flight masses ranged from 6400 to 7200 g (including packing mesh)
- 48 x 30 x 20 cm outer dimensions
- 16,000 cm³ capacity (with York mesh in place)
- Two rock boxes were used on each mission



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Small Tool Carrier

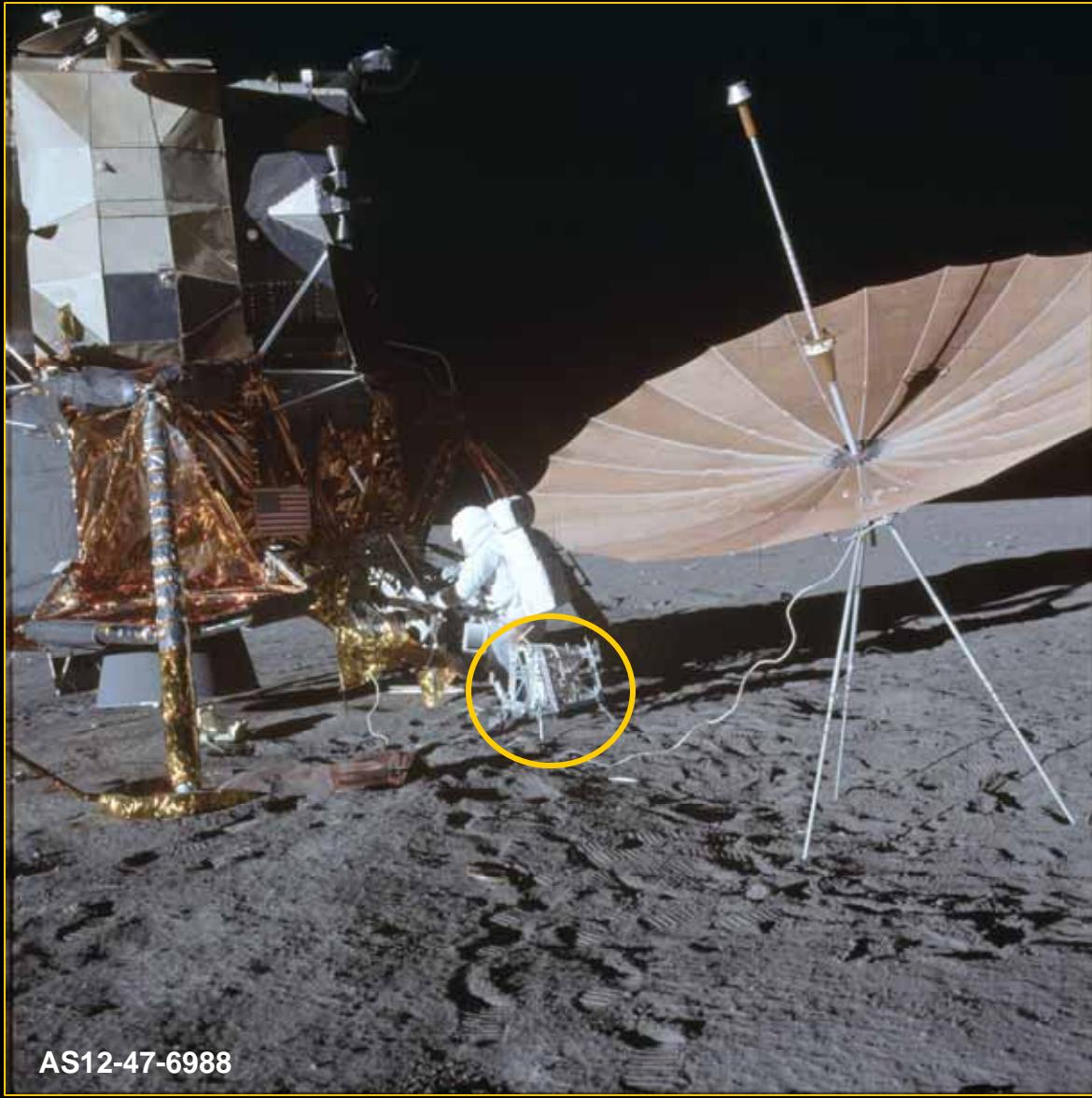


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Small Tool Carrier

- A small tool carrier was unstowed from the LEM and had legs so that it stood on the surface while crew worked on equipment or collected samples
 - 4200 g (without tools)
 - 67 cm height
 - 70 cm width at base
 - 41 cm wide tool rack
 - 47 cm height of tool rack
- The structure was made with aluminum and augmented with a cloth bag

Small Tool Carrier

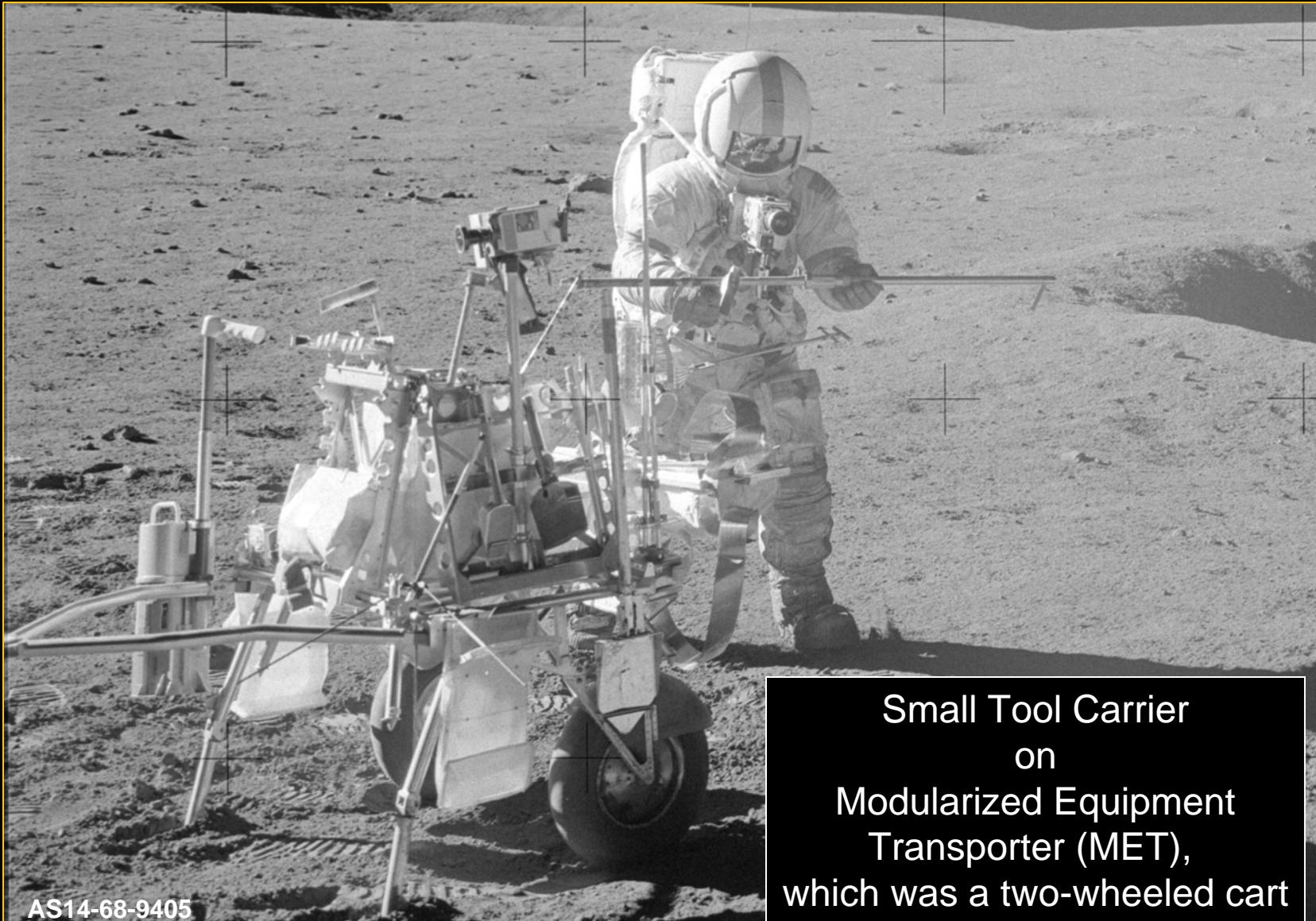
- A small tool carrier (shown here) was carried by Apollo 12 crew
- The small tool carrier was deployed on a Modular Equipment Transporter (MET) by the Apollo 14 crew

AS12-49-7320



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AS14-68-9405

Small Tool Carrier
on
Modularized Equipment
Transporter (MET),
which was a two-wheeled cart



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Large Tool Carrier



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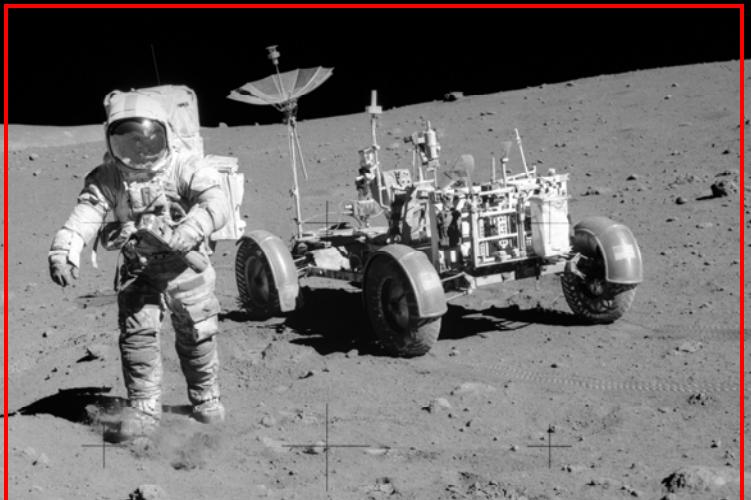


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Large Tool Carrier

- A large tool carrier was attached to the aft of the Lunar Roving Vehicle (LRV) on the Apollo 15 &16 missions
- A Sample Collection Bag (shown) and an Extra Sample Collection Bag could be hung on the tool carrier

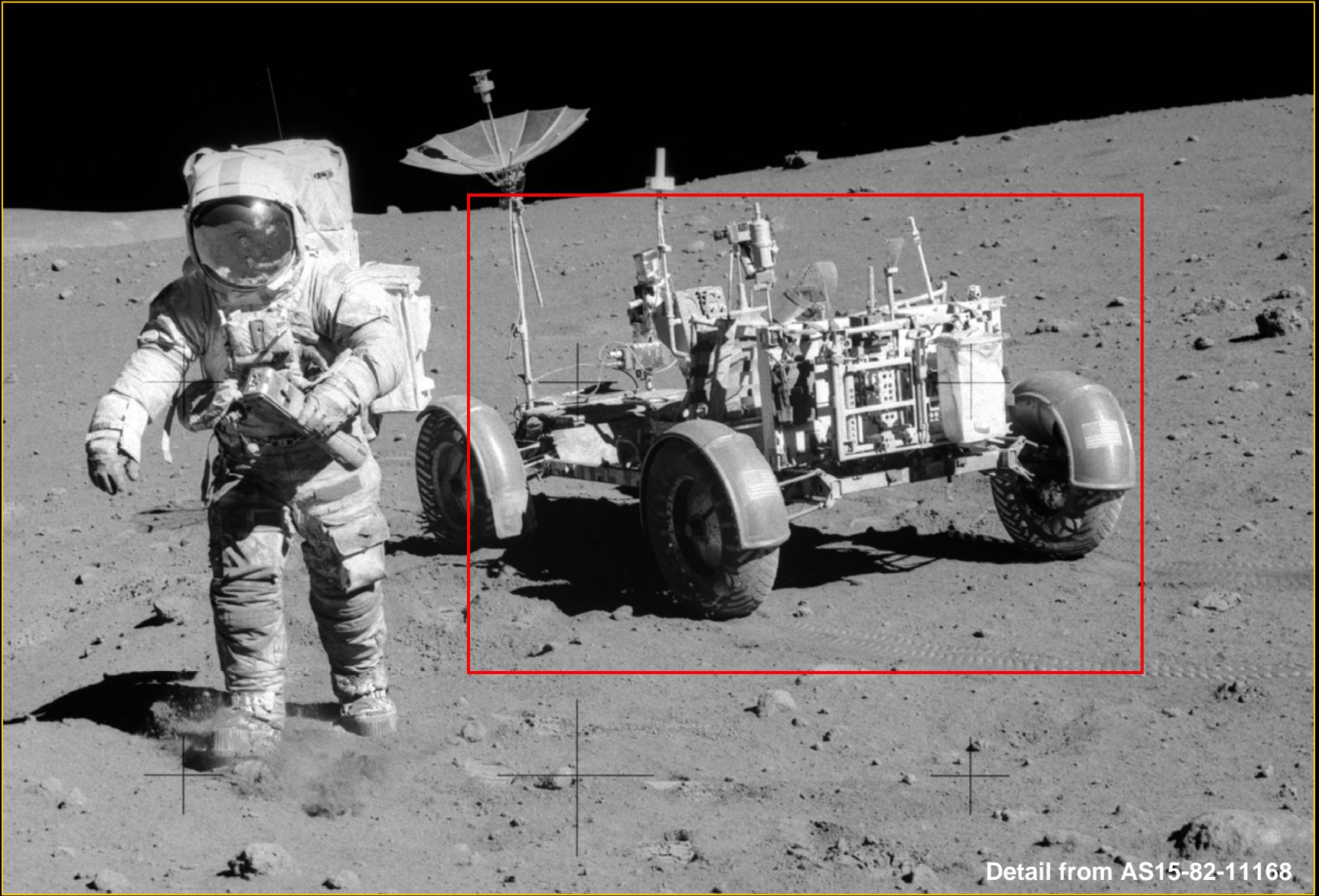


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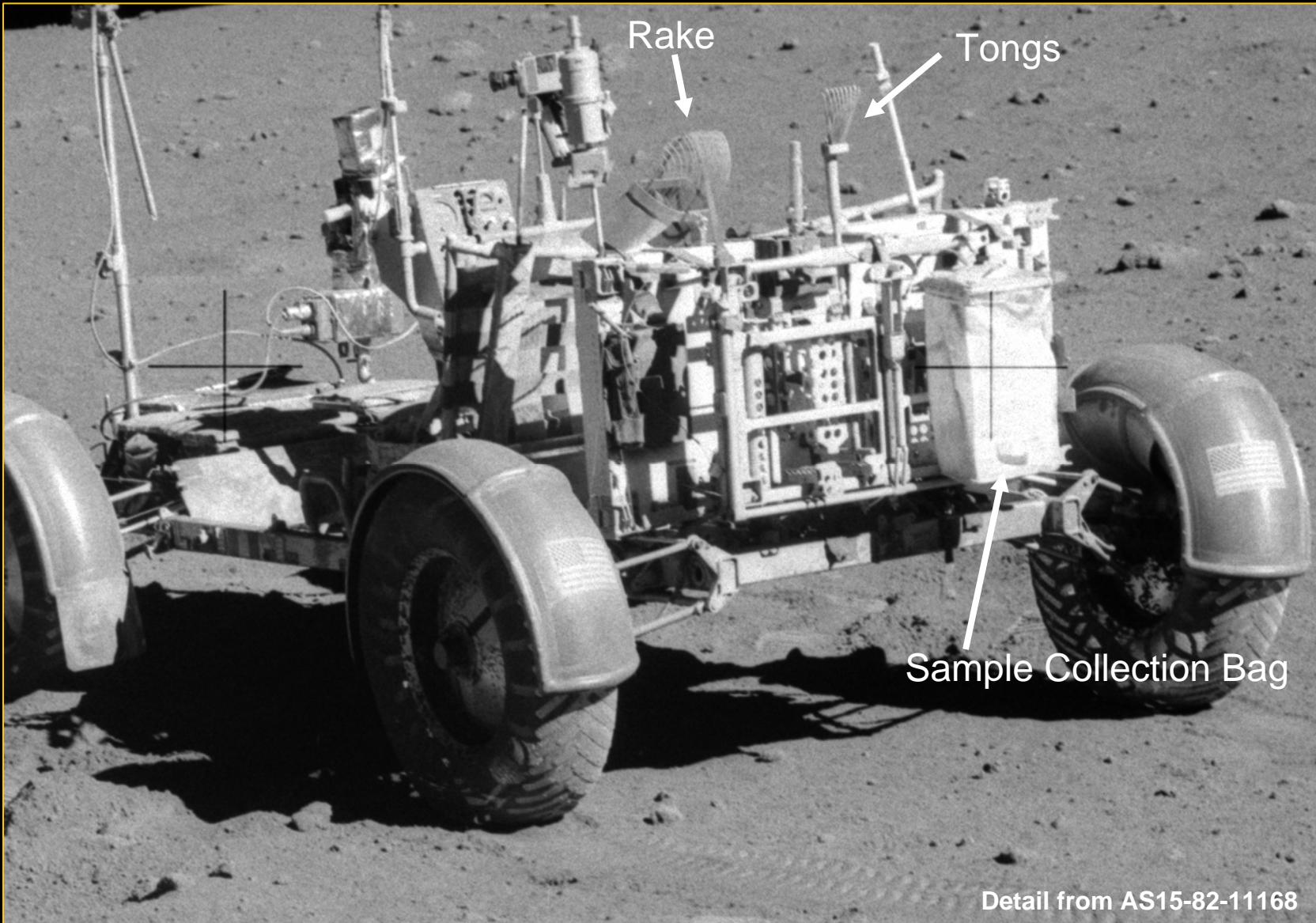
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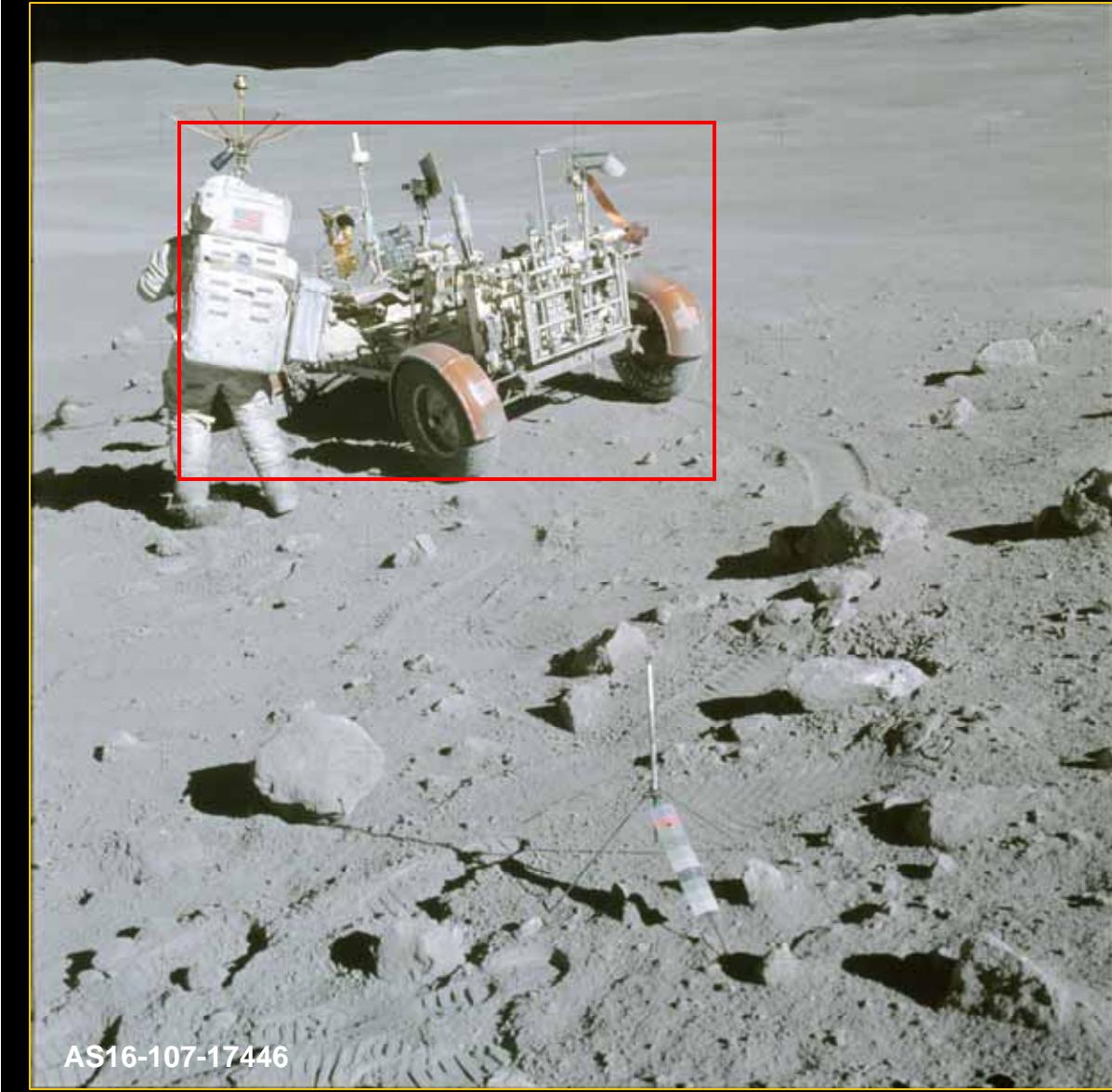




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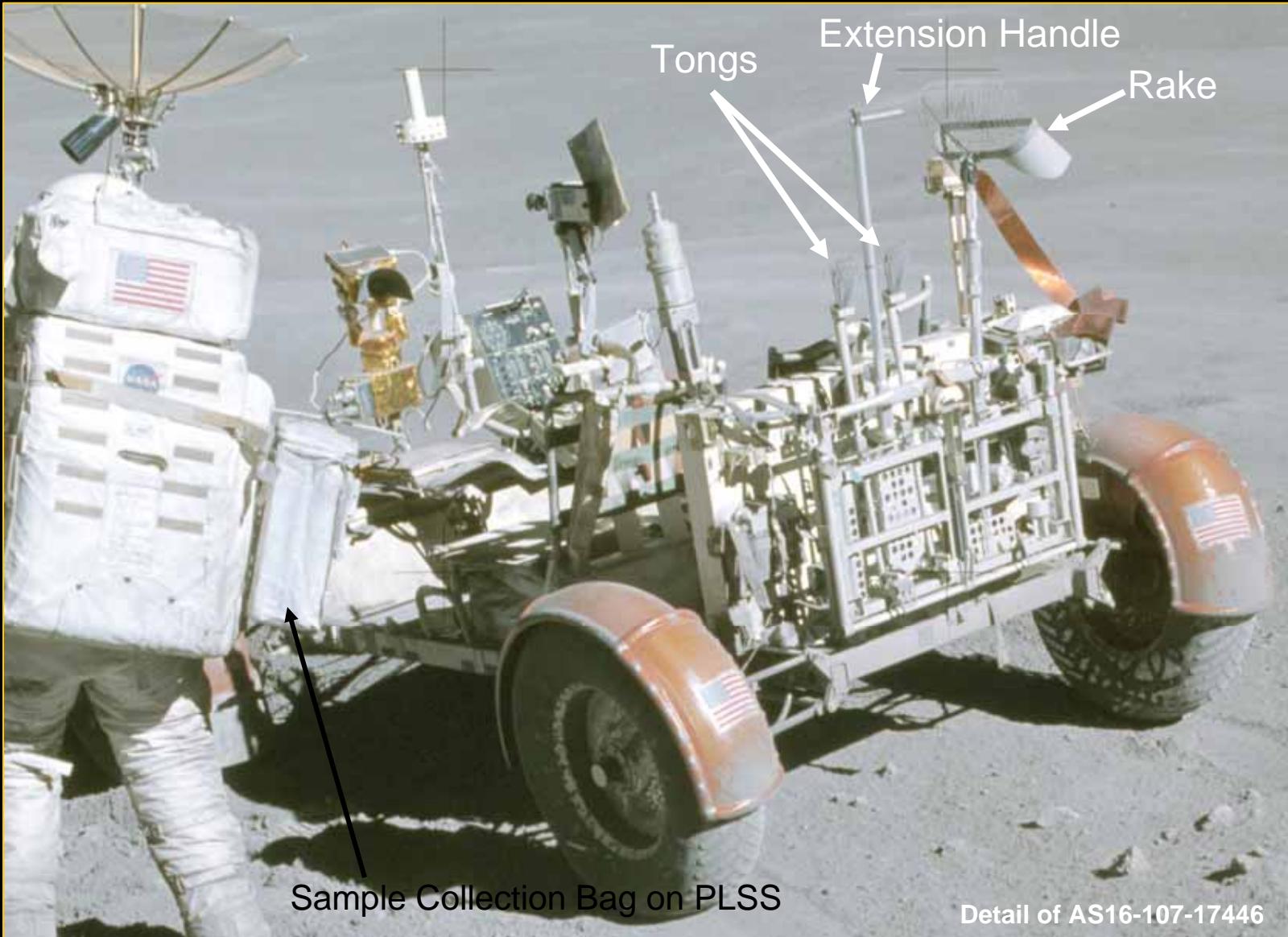
Large Tool Carrier

- The locations of tools varied between the missions and crews
- The gnomon (foreground) and a Sample Collection Bag (on crew's PLSS) have already been removed from the large tool carrier



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Large Tool Carrier

- A large tool carrier was attached to the aft of the LRV and opened outward to provide crew access to the tools which were mounted on both sides of the carrier
 - 5900 g
 - 86 cm side-to-side
 - 54 cm height
 - 16 cm thickness

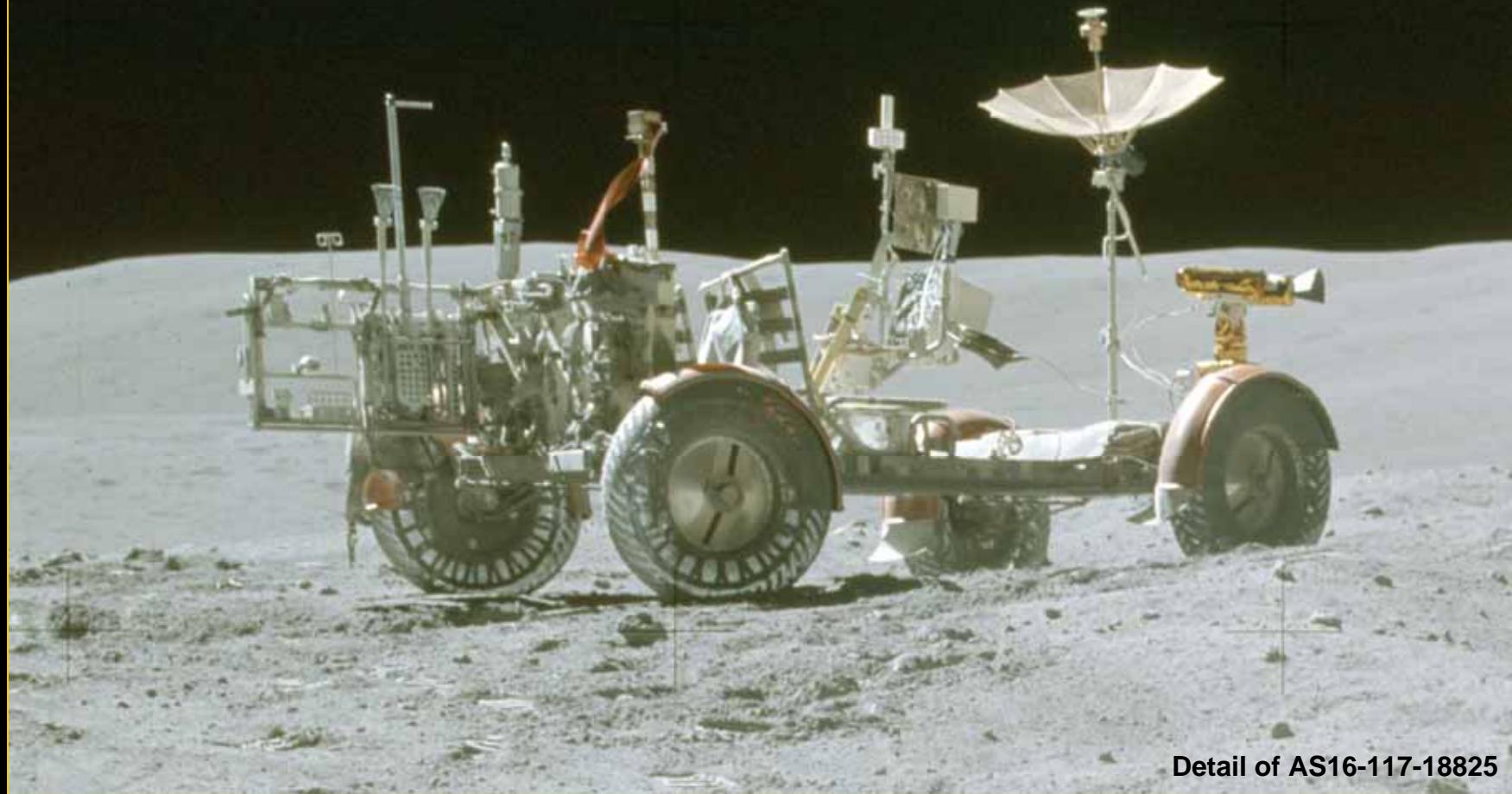
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Large Tool Carrier
opened





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Training



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Crew training with scoop, Hasselblad cameras, sample bags, and tongs, the latter of which is hanging on the simulated Portable Life Support System (PLSS; pronounced ‘pliss’)



S71-23772



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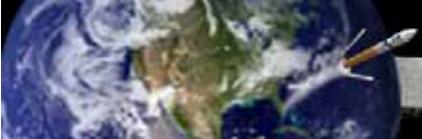
Training

- Gnomon
- Photography
- Adjustable-angle Scoop
- Documented Sample Bag
- Sample Collection Bag



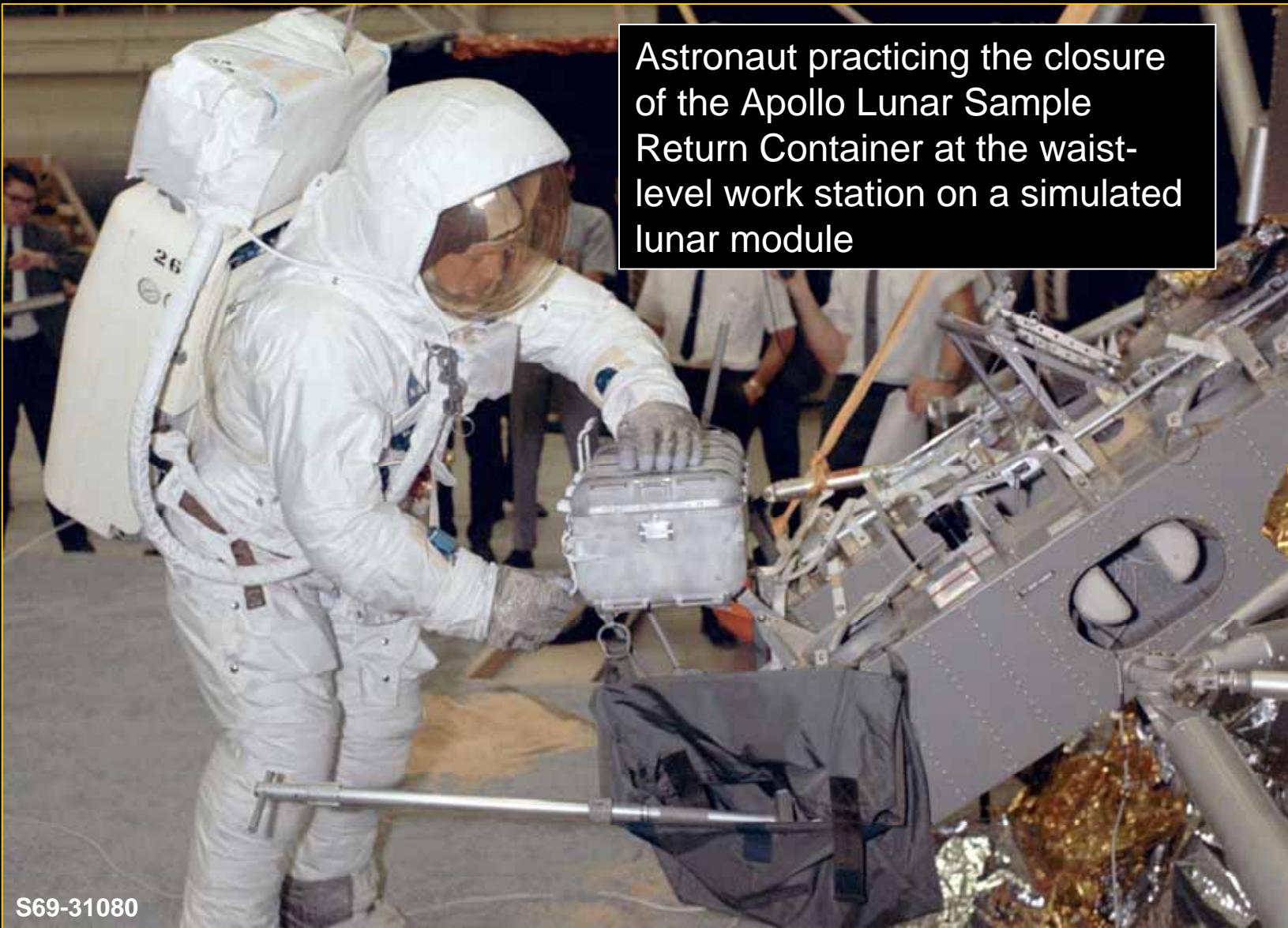
Training

- Drive tube, with extension handle, being driven with hammer
- Crew is hammering with both hands
- Sample Collection Bag is hanging on PLSS



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Additional documentation (including the references below) are available in electronic form at the LPI Lunar Science and Exploration Information Portal
<http://www.lpi.usra.edu/lunar/>

For additional details about tools, see the:

Catalog of Apollo Lunar Surface Geologic Sampling Tools and Containers
NASA-JSC-23454, 97 pages, 1989
By Judith Haley Allton

For additional details about experiments, see the:

Catalog of Apollo Experimental Operations
NASA Reference Publication 1317, 182 pages, 1994
By T. A. Sullivan



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For additional details about training, see:

The U.S. Geological Survey, Branch of Astrogeology – A Chronology of Activities
from Conception through the End of Project Apollo (1960-1973)

USGS Open-File Report 2005-1190

By Gerald G. Schaber