Curating NASA's Astromaterials Collections: Past, Present, and Future

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Apollo Sample Curator

NASA – Johnson Space Center

Moon 2020-2030 A new era of human and robotic exploration

ESTEC, 15-16 December 2015

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Presented by:
Everett Gibson - Apollo Veteran of the Lunar Receiving Laboratory, Lunar Sample Curator 1976

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Overview

There are two parts to presentation today:

- Overview of the current status of JSC Curation, focusing on the aspects that go into the long-term curation of an extant astromaterial collection (Apollo).
- Overview of the efforts that are necessary to properly plan for future sample return missions.

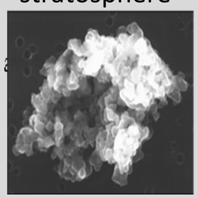
- Overall goal is to highlight the complexity that is involved in the curation of astromaterials, and to stress the need for curation to begin at the earliest stages of future sample return missions.

JSC's Astromaterials Acquisition & Curation Office

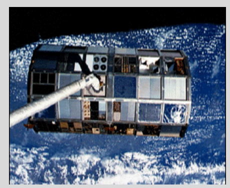
Lunar
(1969)
Apollo program lunar rocks and soils; Luna samples

Meteorite
(1977)
Antarctic Search for Meteorites (ANSMET) program

Cosmic Dust
(1981)
Cosmic dust grains from Earth's stratosphere

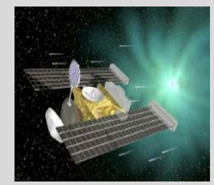


Space Hardware
(1985)
Space exposed hardware from spacecraft



Genesis
(2004)
Genesis solar wind samples at Earth-Sun L1 point

Stardust
(2006)
Cometary and interstellar samples from Comet Wild 2



Hayabusa
(2012)
Samples collected from JAXA asteroid mission to Itokawa

Our Near Future . . .

Hayabusa II
(2020)
Subset of samples collected from JAXA asteroid mission to (162173) 1999

OSIRIS-REx
(2023)
Asteroid sample return from 101955 Bennu

OSIRIS-REx
ASTEROID SAMPLE RETURN MISSION

Our More Distant Future . . .

Moon
(2020s)
Non-volatile-rich farside/polar sample return

Next New Frontiers Call

Comet
(2020s)
Surface sample return (cold curated?) from a comet

Next New Frontiers Call

Mars
(~2030s +)

Various Mars Sample Return Possibilities

Over 50 years in the planning (est. 1964)

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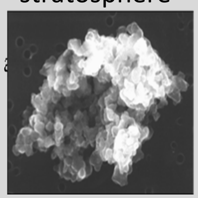

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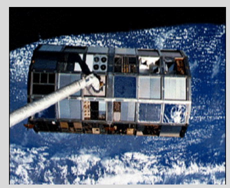

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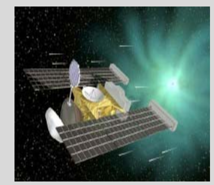

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(~2030s +)

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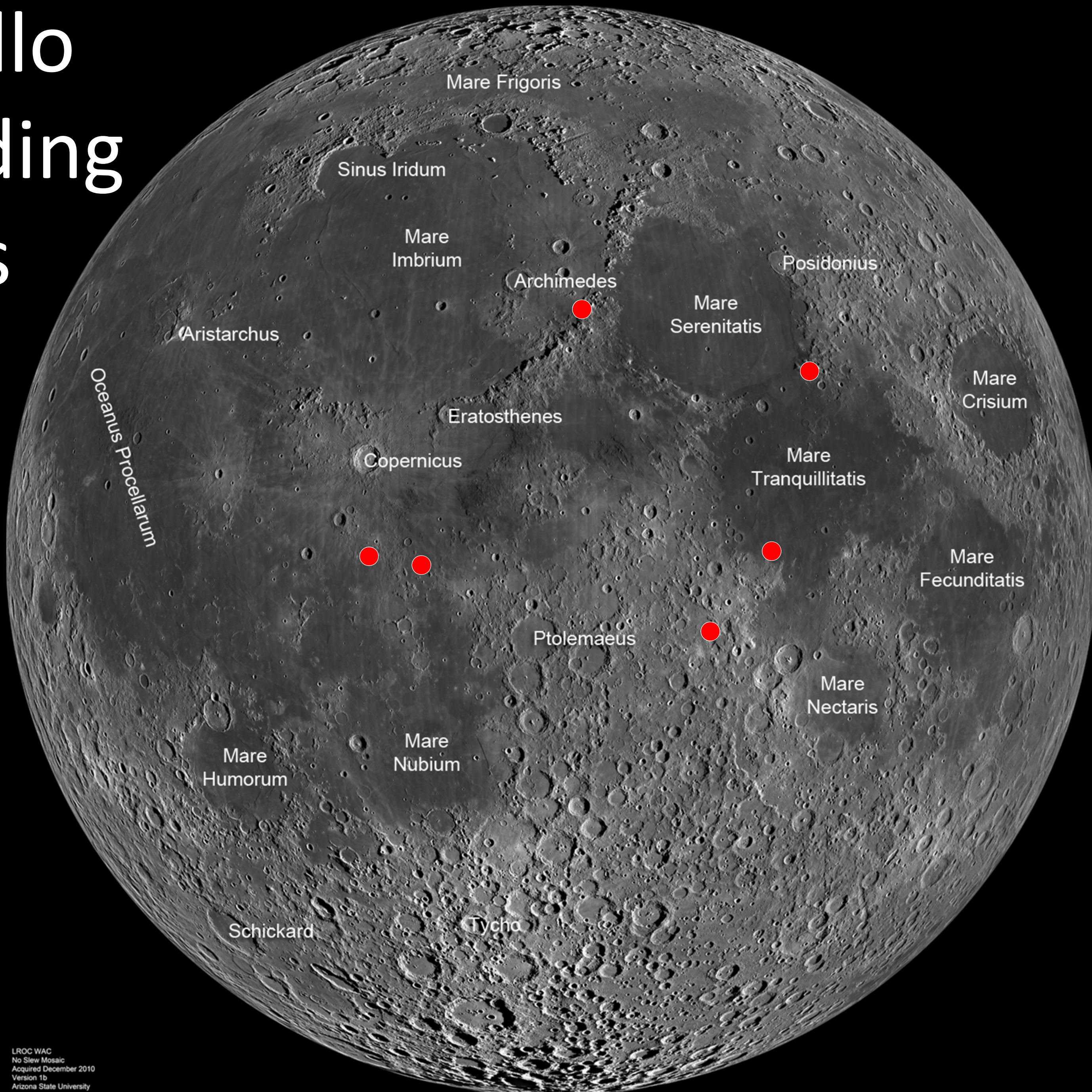
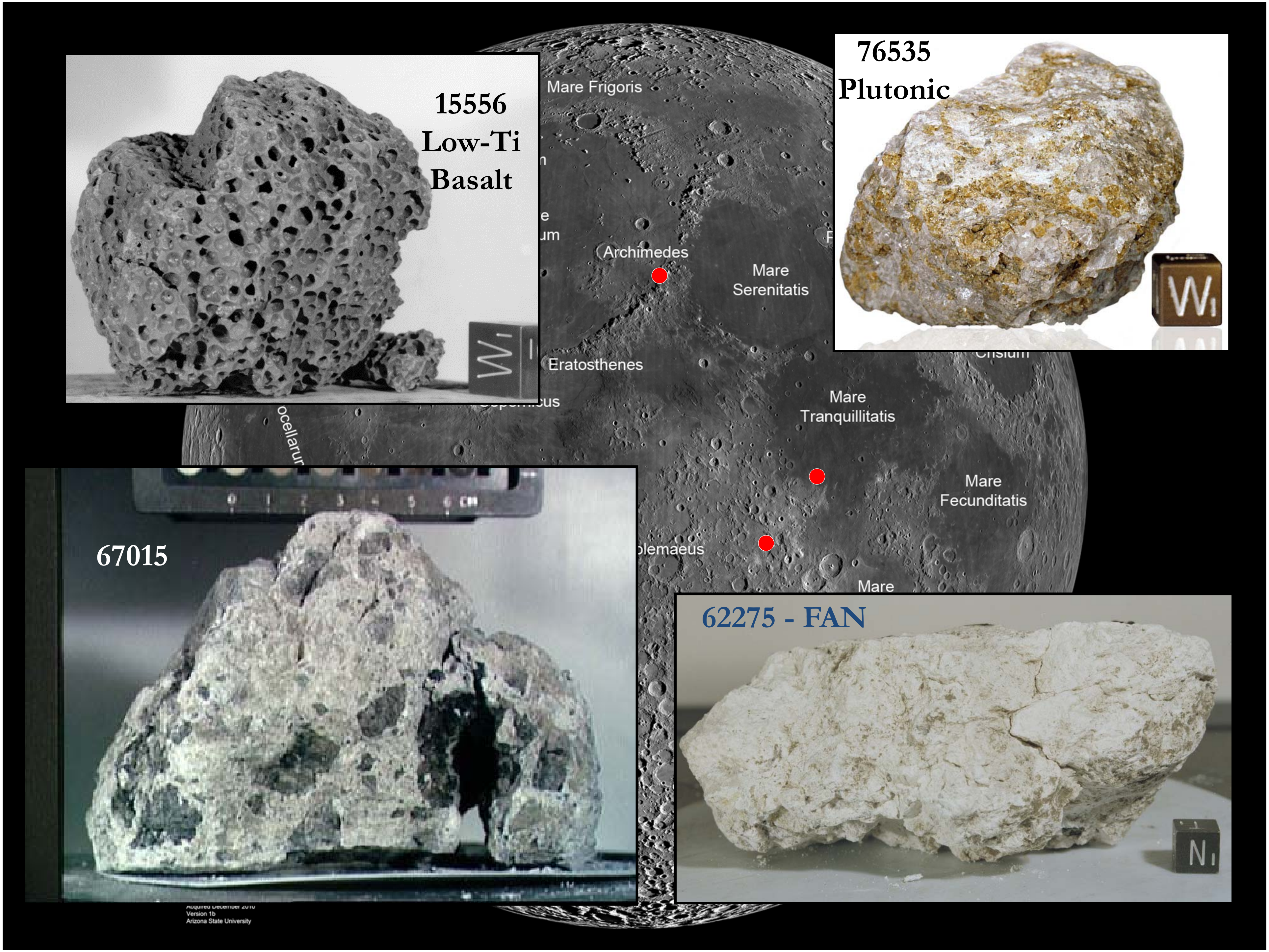
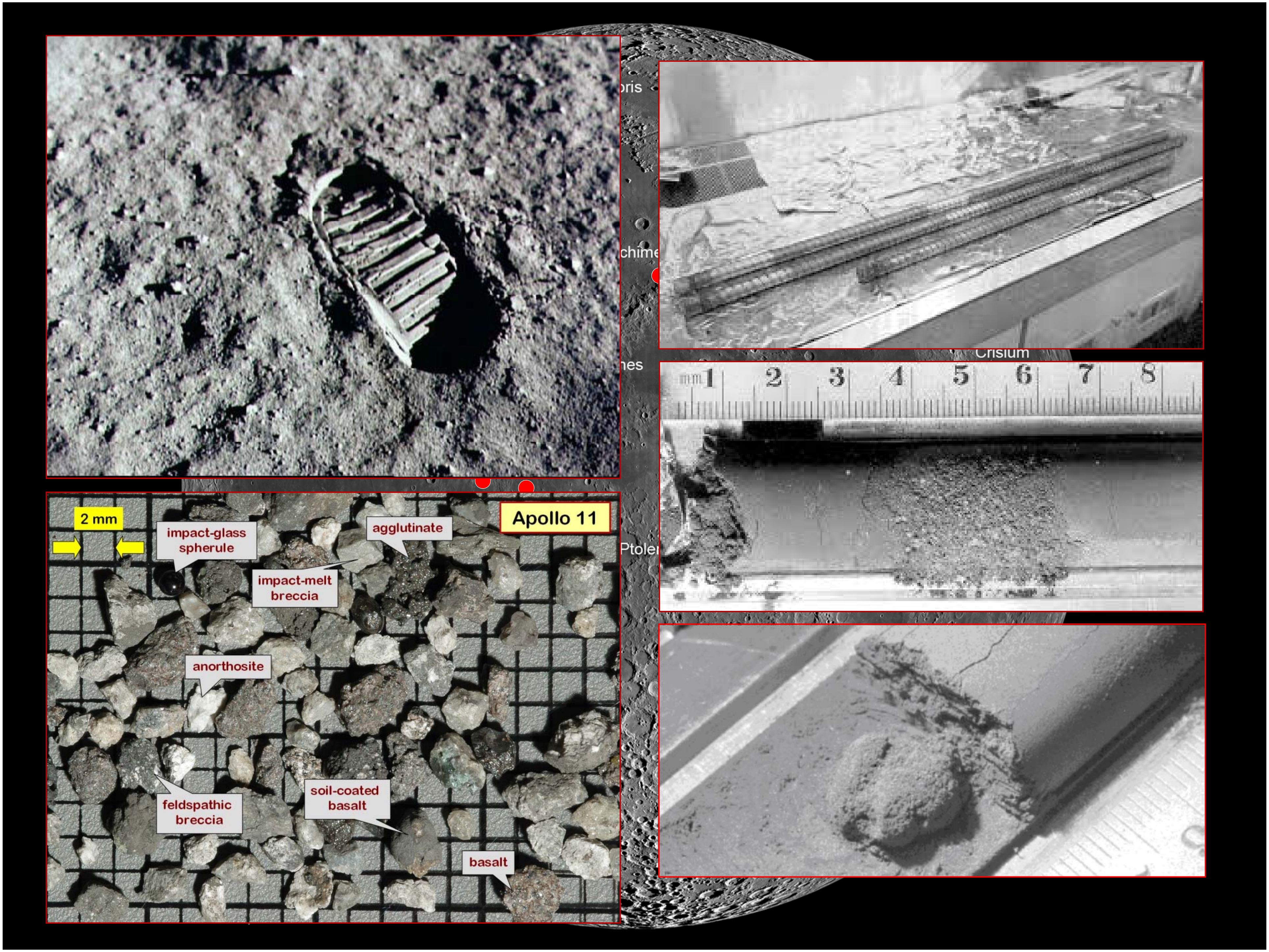
Apollo Sample Collection

- From 1969-1972, six Apollo missions collected 382 kg (2196 samples) of rock, soil, and cores from 6 geologically diverse locations on the Moon.
- Only sample suite collected by astronauts, and the only sample suite collected with detailed geologic context.
  - These two aspects of the Apollo collection greatly increased their lasting scientific impact.

Apollo Landing Sites




15556
Low-Ti
Basalt
76535
Plutonic
67015
62275 - FAN
Mare Frigoris
Archimedes
Mare
Serenitatis
Eratosthenes
Mare
Tranquillitatis
Mare
Fecunditatis
Mare
Version 1b
Arizona State University



Crisium
mm 1 2 3 4 5 6 7 8
2 mm
impact-glass spherule
agglutinate
Apollo 11
impact-melt breccia
anorthosite
feldspathic breccia
soil-coated basalt
basalt

Lunar Receiving Lab (LRL)

- As early as 1964, the need for a dedicated facility to house the Apollo samples was recognized (finished in 1967).

Designed as a Quarantine Facility

Efforts to work under vacuum

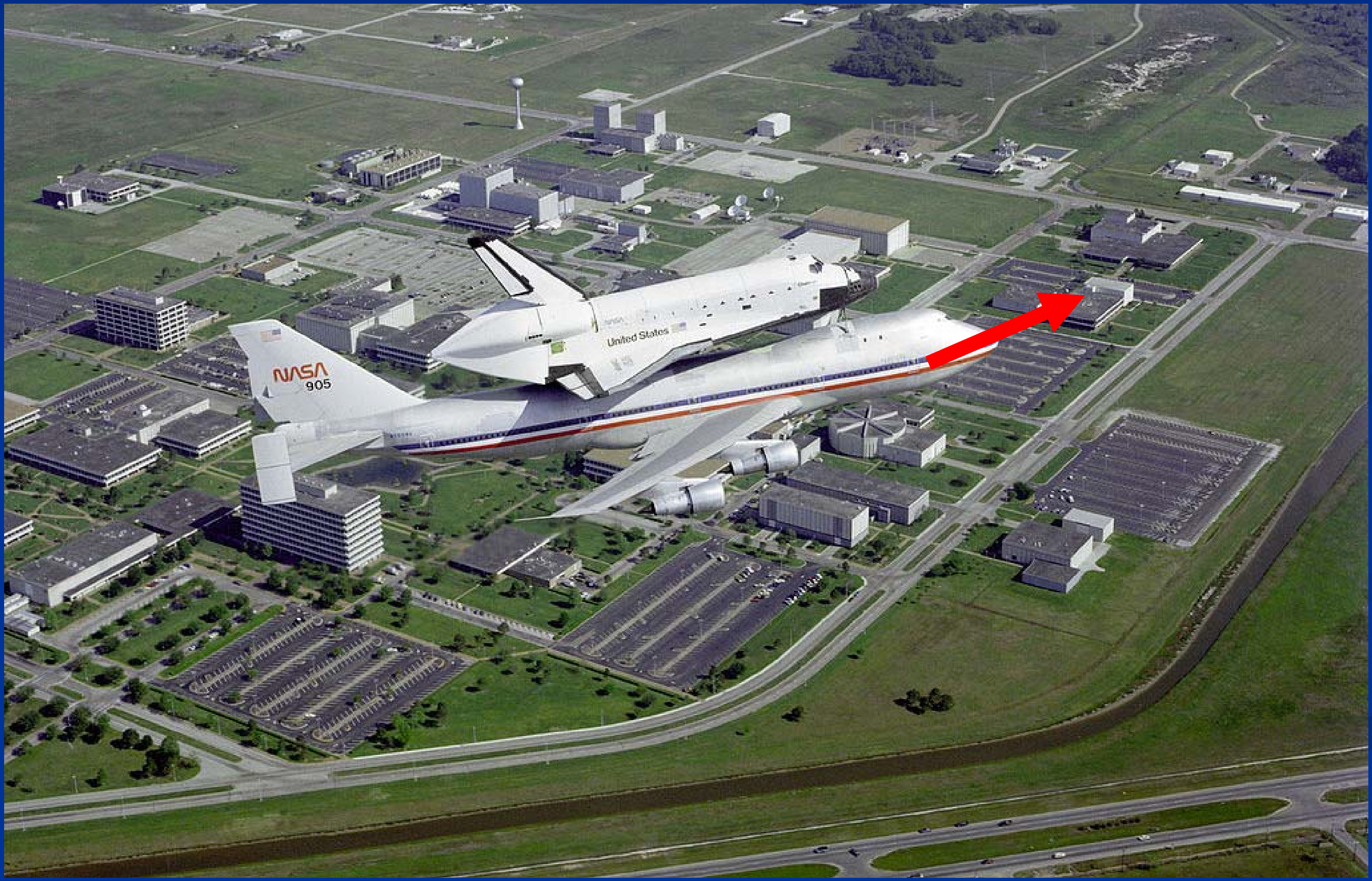

LUNAR RECEIVING LABORATORY
LRL
ROCK 15623
© 1965 1972 UNITED FEATURE SYNDICATE, INC
NASA
MANNED SPACECRAFT CENTER

Lunar Receiving Lab (LRL)

- Samples were initially described, classified, and cataloged (PET), and disseminated for additional study.

Building 31N

- As the sample return missions started to pile up, we quickly outgrew the LRL; a new facility was built in 1979.



Specifically designed to house the Apollo samples…

JSC's Building 31 with Curatorial Facility

Curatorial Facility:

Lunar Samples
Meteorite Samples
Interplanetary Dust Particles
Stardust Samples
Genesis Samples
Hayabusa Asteroid Samples
Space Exposed Materials

Research Laboratories

Study of Astromaterials
State-of-the-art Instrumentation

Apollo Labs

The door to the Pristine Vault is a bank-style door with two combination locks. It remains closed except when samples are being transferred.

This view of the Pristine Sample Vault shows about one-third of the cabinets housed there.

	Max	Meas.
Ar	<20 ppm	4.20 ppm
O_2	<10 ppm	0.14 ppm
CO	<10 ppm	0.96 ppm
CO_2	<10 ppm	0.00 ppm
H_2	<10 ppm	0.24 ppm
H_2O	<10 ppm	0.01 ppm
THC	<1 ppm	0.01 ppm
THC = total hydrocarbons		

- Pristine lunar samples are stored in a suite of ISO class 5 clean rooms.
- The samples are stored in a high security vault with numerous security counter-measures in place.
- Pristine lunar samples are stored and processed in stainless steel (316L) cabinets under continuous N_2 purge.
  - Ultrapure dry N_2 is used.
- During storage or processing, limited materials allowed within the cabinets; each mission has a dedicated cabinet.
  - Stainless Steel (304L), Aluminium, Teflon
- A separate suite of ISO class 6 vault and labs are used to store and process the returned Apollo samples.
  - Keeps returned samples from contaminating the pristine samples.

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Curation Infrastructure

- Numerous infrastructure systems must be maintained:
  - Hepafiltrated HVAC air for the labs
  - Liquid/gaseous N_2 system
  - Ultrapure water system (for cleaning)
- Significant database capabilities are needed to track the samples:
  - Currently over 100,000 Apollo subsamples, including ~10,000 with PIs.
  - There are >10^5 images that need to be archived and cross-referenced.
  - Countless sample handling/history analog records that need archiving
- We are co-located with the JSC astromaterials research group, giving us access to advanced instrumentation
  - SEM, EPMA, SIMS, TEM, TIMS, ICPMS, FIB, FTIR, XRD, Micro-CT, micro-Raman
  - Used in both sample characterization and contamination knowledge/control

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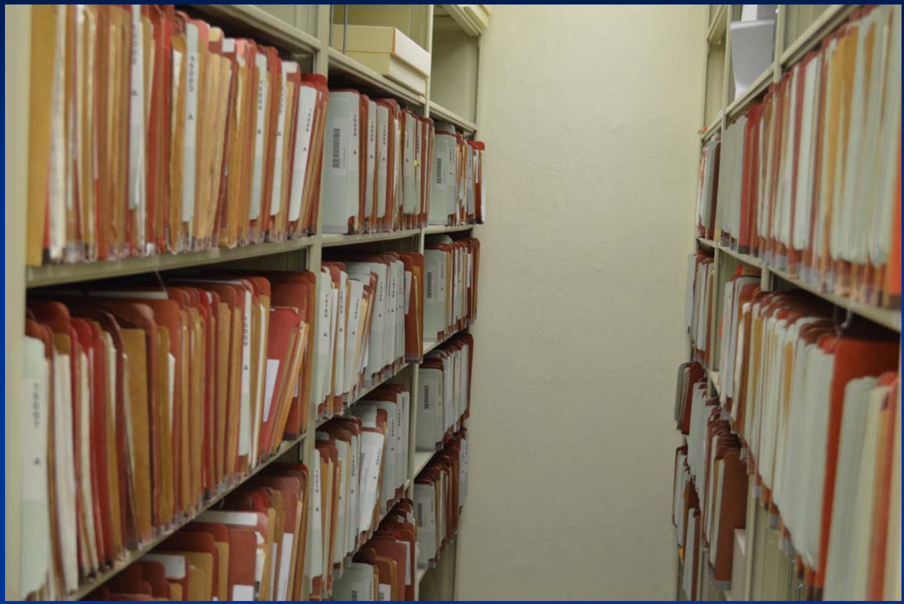

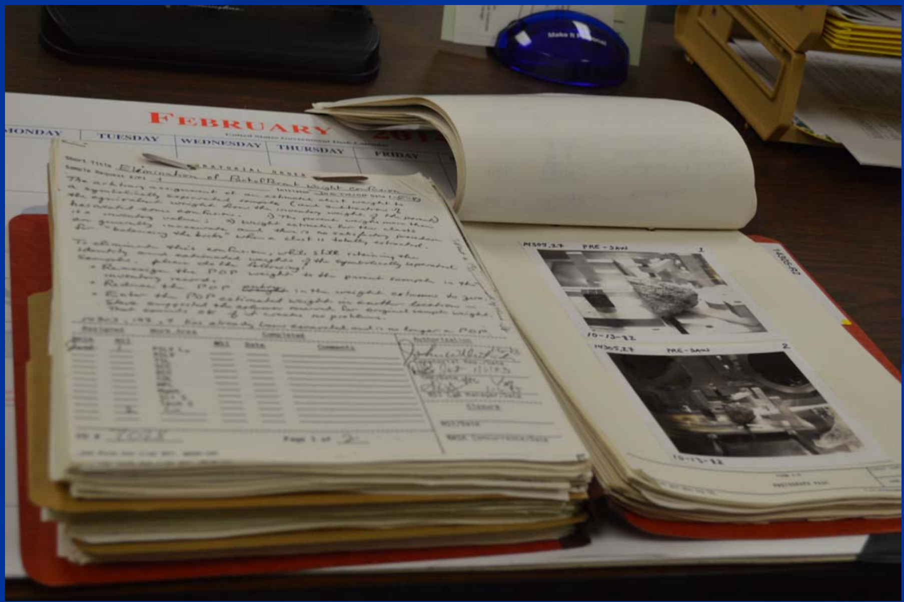

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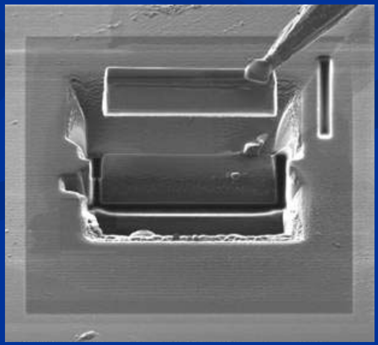
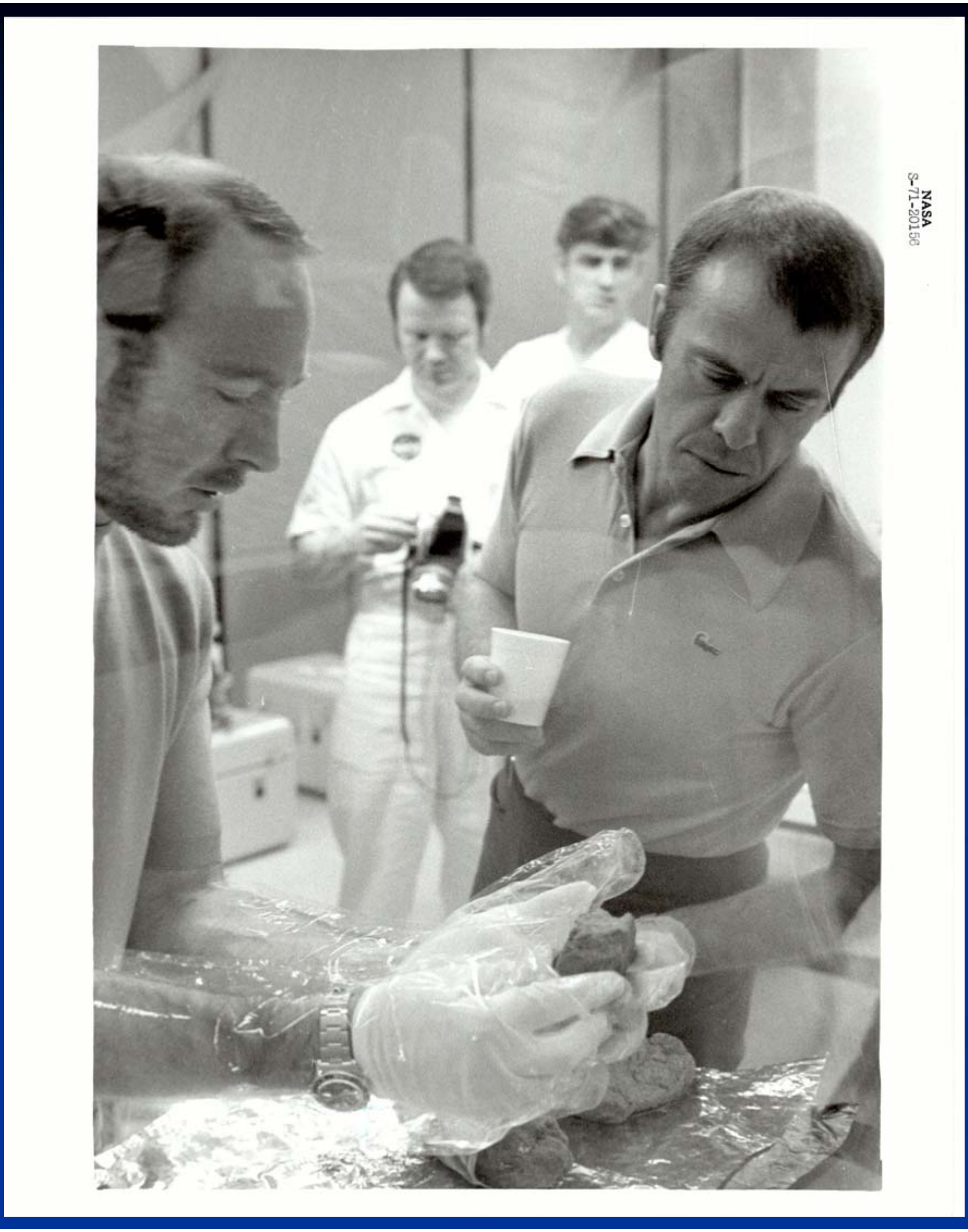


Curation of Future Sample Missions

- The curation of samples should not begin when they arrive at JSC (though this is important).
- The curation of samples should not begin when they arrive on Earth (though this is important).
- The curation of samples should not begin while you are building the spacecraft (though this is important).
- The curation of samples should begin with the initial planning and design of the mission, and be carried through every aspect of the mission.
  - This is the only way to ensure that you maximize the science return of your samples, particularly if something unexpected happens



Apollo 14 Crew surprised us with rocks in a bag.

Samples 14301-14321 from traverse to Cone Crater

Sample Bag Opened in Crew Quarters!!!

Note:
Coffee Cup!
Samples are now Compromised!

Debriefing Apollo 14 Crew & Rocks

Apollo 14 Mission Science Advisor – Lunar Receiving Laboratory 1971

Genesis

- NASA mission to collect solar wind from the Earth-Sun L1 for 28 months.
- Had an "off nominal" landing into the UTTR site in Utah.
- Despite this less than ideal turn of events, the mission has achieved all of its major scientific objectives
  - The thickness of the arrays that sampled different solar wind regimes was varied.
  - Careful preparation and training in anticipation of a worst case scenario (1000s of pre-cleaned bags, tags, etc.) allowed for rapid documentation and accountability.
  - On site clean room to begin immediate cleaning and recovery efforts.

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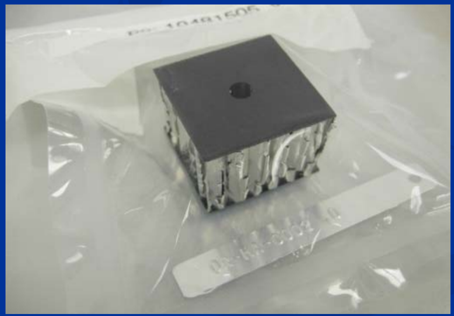
Portable Cleanroom at UTTR

GENESIS & STARDUST ISO Class 6

OSIRIS REx

- Materials Coupons – Examples of materials used in the spacecraft that are possible sources of contamination.
  - Several hundred materials in total.
  - Some analyzed now, most archived for posterity in a dedicated cabinet in an ISO 6 cleanroom.
- Witness Plates – High purity materials continuously exposed during spacecraft ATLO
  - Ultrapure Al-foil and Si-wafers are exposed during spacecraft assembly.
  - They are analyzed by SEM each month (while others are archived) for near real-time feedback on the contamination environment that the spacecraft is exposed to.

OSIRIS-REx coupon storage cabinet at JSC



Solar array panel assembly + Honeycomb composite

Perfluorinated polyether Braycote 601

OSIRIS REx

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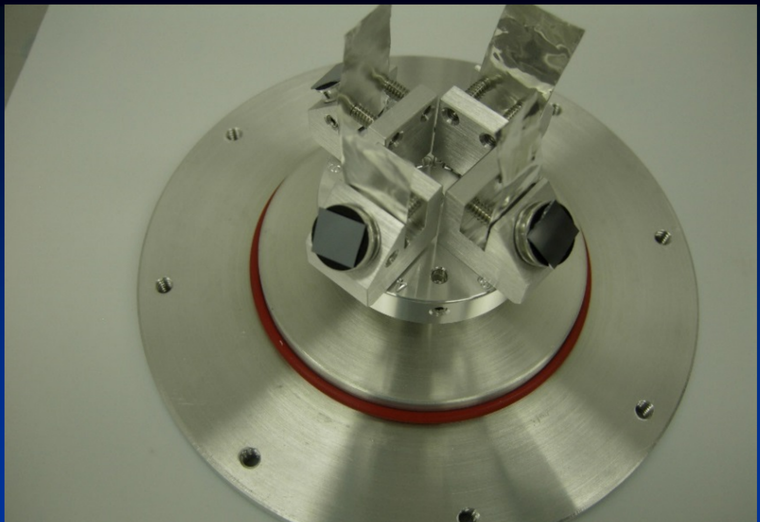


CK #2 in JSC cleanroom

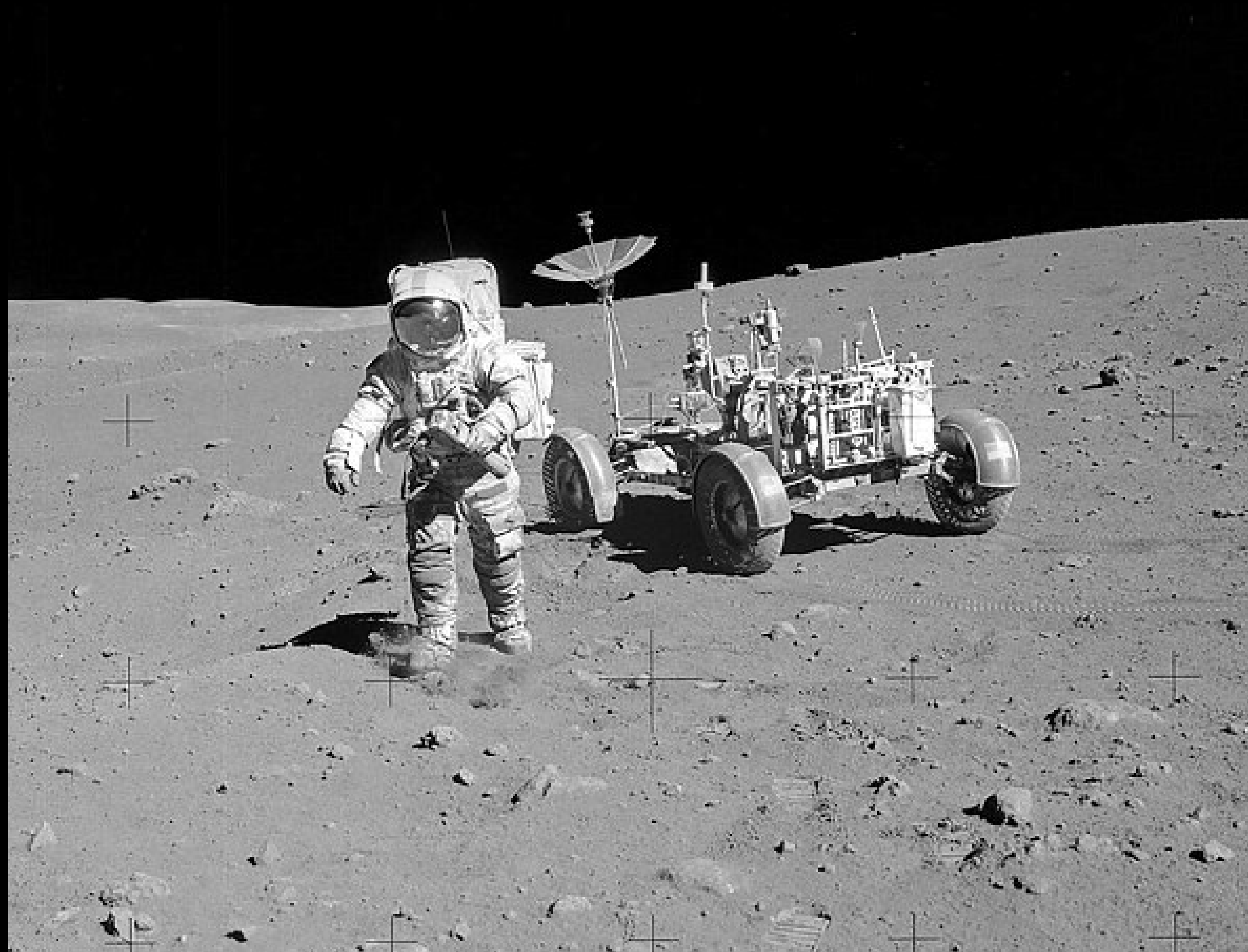
OR-CKP-02-1-Si and -01-1-Si (science team)

OR-CKP-01-2-Si, -3-Si, and -4-Si (archived)

Summary

- The Curation of Astromaterials Collections involves security, clean sample handling, infrastructure, and data handling concerns.
  - The samples will only be as clean as your dirtiest day (you can't uncontaminated a sample), so constant vigilance is necessary.
- The curation of future samples should begin with the initial planning and design of a mission, and be carried through every aspect of the mission.
  - Without this, the samples may be hopelessly contaminated before you have even brought them to your lab.

Future Return to the Moon



Curation and Contamination Prevention Involved at all Stages

Future Studies of the Moon, Planets and Comets

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Future Sampling of the Heavens

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