

LEAG Update



Dr. Samuel Lawrence
For the Lunar Exploration Analysis Group

Planetary Science Advisory Council Meeting
March 2020

~50 YEARS SINCE THE LAST AMERICAN FOOTPRINTS



ALT 0011527
Apollo 50: Go for the Moon

LEAG Activities

- 2018 Findings Posted on LEAG Website
 - <https://www.lpi.usra.edu/leag/meetings/2018-findings-annual-meeting.pdf>
- Survive the Night LEAG/SSERVI meeting report posted on LEAG website
 - <https://www.lpi.usra.edu/leag/reports/Lunar-Night-Workshop-Report-071619-update.pdf>
- Lunar ISRU 2019
 - July 15-19, USRA HQ, Columbia, MD
 - 200+Attendees
 - Meeting report:
<https://www.hou.usra.edu/meetings/lunarisru2019/workshop-report.pdf>
- Science from the Moon - Astro2020 White Papers hosted on LEAG website
- Planetary Decadal Response
 - https://www.lpi.usra.edu/leag/LEAG_CAPS_20190910.pdf
- New! Joint CAPTEM/LEAG Special Action Team on aspects of Artemis sampling and curation
 - J. Gross, Chair
- New Views of the Moon 2 chapters being reviewed!
- LEAG2020: September 15-17, Gilruth Center, Houston, TX - USA



THANK YOU PSD

- *Thank you* PSD for helping with issues relating to lunar sample studies as they pertain to EW and SSW!

The background of the top half of the image is a blue gradient with white streaks. On the left is a large, detailed image of the moon. On the right is a dark silhouette of a woman in a dress holding a bow. The text 'LEAG' is written in large, bold, white capital letters.

LEAG

Annual Meeting of the Lunar
Exploration Analysis Group

October 28–30, 2019
Washington D.C.

- 2019 LEAG at Washington Hilton, Washington, D. C.
- Day 1: Preparing for the Next Planetary Decadal Survey - in-depth breakout groups
- Day 2+3: Planning for future Human Lunar Exploration (Project Artemis, 2024 and beyond)
- Keynote Address by NASA Deputy Administrator Morhard, excellent participation from HEOMD, SMD, STMD
- Findings are up at LEAG website:
https://www.lpi.usra.edu/leag/meetings/2019_Findings_Final.pdf



LARRY TAYLOR AND B. RAY HAWKE AWARDS



Dr. Samuel Lawrence, LEAG Chair, Morgan Shusterman, Arizona State University (Taylor Award), Ryan Galinkin, University of Central Florida (Taylor Award), Stu Webb, University of Notre Dame (Taylor Award), Ariel Deutsch, Brown University (Taylor Award), Claire Thomas, Colorado School of Mines (Taylor Award), Deanna Phillips, University of Alabama, Huntsville (Hawke Award), Daoru Han, Missouri University Science and Technology (Hawke award)

2019 LEAG Meeting Findings Summary

2024 is providing much-needed urgency and focusing of resources!

Finding 1. NASA should seek to maximize the lunar sample mass to be returned by Artemis 3, to bring the current requirement of 26 kg more in line with the recommendations from the 2010 CAPTEM-LEAG “[Review of Sample Acquisition and Curation During Lunar Surface Activities](#)” analysis document (which recommended a minimum of 250 kg). If the architecture does not allow for this magnitude of returned sample mass, a greater emphasis must be placed on defining what investigations the returned samples will be prioritized for, and on providing astronauts the tools and training needed for smart sample selection to enable these investigations. Furthermore, automatic sample returns should be developed as a capability for the LDEP program.

2019 LEAG Meeting Findings Summary

Finding 2. A permanent American presence on the lunar surface has immense societal, scientific, commercial, and exploration value in its own right. LEAG strongly supports Phase 2 of the Artemis program, specifically the sustainable surface presence and permanent surface infrastructure, and encourages NASA to maintain the urgency of Phase 1 in developing a permanent lunar surface presence that will achieve the goals of the Lunar Exploration Roadmap (<https://www.lpi.usra.edu/leag/roadmap/>) in terms of science, sustainability, and feed-forward to Mars and other destinations.

2019 LEAG Meeting Findings Summary

Finding 3. A set of realistic goals and objectives is needed for a resource prospecting campaign and ISRU demonstration. NASA should work with the community to develop such goals and objectives. Recognizing the importance of ISRU to a sustainable program of space exploration, the LEAG community is eager to provide its assistance.

2019 LEAG Meeting Findings Summary

Finding 4. LEAG urges NASA to ensure that the potential to achieve high-priority planetary science and exploration objectives is fully realized by leveraging all lunar mission opportunities as part of a well-defined, coherent strategic vision. For example, as currently formulated, the CubeSat payloads for Artemis 2 are provider-funded and advance no strategic objectives; the lack of NASA-funded, lunar-focused payloads on Artemis 2 is a missed opportunity to enhance the advance knowledge of the south polar region prior to human landing.

2019 LEAG Meeting Findings Summary

Finding 5. LEAG strongly supports the CLPS program and, as it matures, task orders that require capabilities such as mobility and sample return. In many cases, rovers substantially expand the scope of science investigations possible, and many high-priority lunar science objectives are best addressed by sample return. Note also, that as part of a broad lunar science strategy, such capabilities could help alleviate the sample return mass limitations identified in Finding 1, as well as dramatically broaden geographic opportunities for sample return beyond the limited locations of human missions.

2019 LEAG Meeting Findings Summary

LEAG strongly reiterates the importance of using the decadal survey process to identify science priorities that should be addressed within the New Frontiers program.

Finding 6. LEAG recommends that more flexibility in implementation of the science goals of SPA-SR be permitted for New Frontiers 5. Allowing proposals for missions that address the science goals of SPA-SR using different approaches and different targets would take advantage of both recent advances in science and creative implementation solutions that may emerge from the planetary science community.

2019 LEAG Meeting Findings Summary

Finding 7. The representatives of the commercial teams and the senior NASA leadership stand in sharp contrast to the more diverse lunar science community (which itself continues to strive to achieve full equality). LEAG encourages our leadership and our partners to take concrete steps in hiring and promotion to harness all of the nation's talent to achieve great goals.

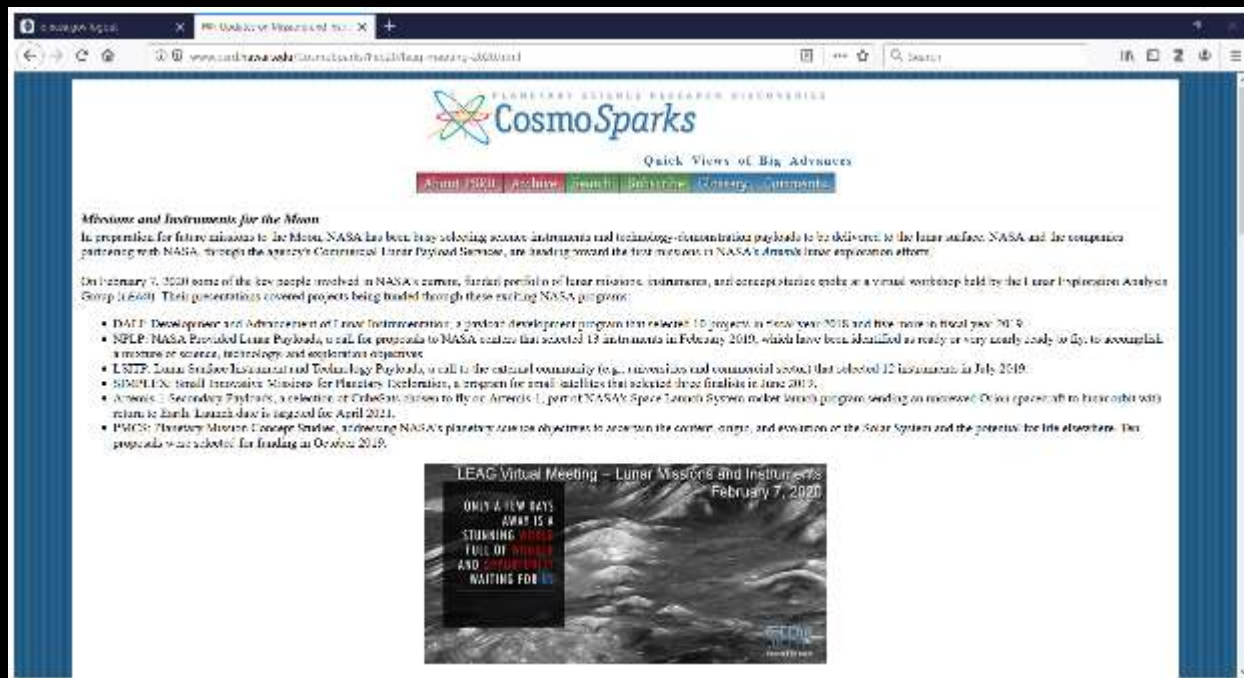
2019 LEAG Meeting Findings Summary

The National Space Council has requested that NASA develop a plan for sustainable lunar surface exploration and development, as well as feed-forward applicability to other destinations

Finding 8. The LEAG community has significant and unique domain expertise in establishing goals and objectives for sustainable lunar exploration that feed-forward to exploration of other destinations (including small bodies and Mars), and can make considerable contributions to the plan requested by the National Space Council if given the opportunity. LEAG therefore requests the opportunity to provide input into the plan, and also stands ready to contribute to other strategic plans that NASA may require in the future.

LEAG Virtual Meeting 7 February 2020

- LEAG conducted the first LEAG Virtual Meeting on 7 February - a SSERVI “Workshop without walls”
- Thank you SSERV!
- All instruments and mission concepts funded by SMD/DAAX or SMD/PSD given an opportunity to present
- Wildly enthusiastic response from the community - expect more of these!



PLANETARY MISSION CONCEPT STUDIES

- Lunar Geophysical Network (C. Neal, PI) – understand early/initial terrestrial planet evolution through defining the global interior structure and composition of the Moon.
- In Situ Chronology for the Next Decade (B. Cohen, PI) - a medium- or flag-ship-class mission for in-situ Solar System chronology
- Intrepid (Mark Robinson, PI): Intrepid will investigate over 100 major (and hundreds of minor) scientific sites over a ~1800 km traverse during four Earth years.

ANGSA Update

Specially Curated Lunar Samples

➤ Unopened Vacuum Sealed Apollo Samples

- 9 “special samples” were collected in containers that had indium knife edge seals to maintain a lunar like vacuum, and 3 remain sealed: SESC 15014 (333 g), CSVC 69001 (558 g), and CSVC 73001 (809 g).

➤ Unopened Unsealed Samples

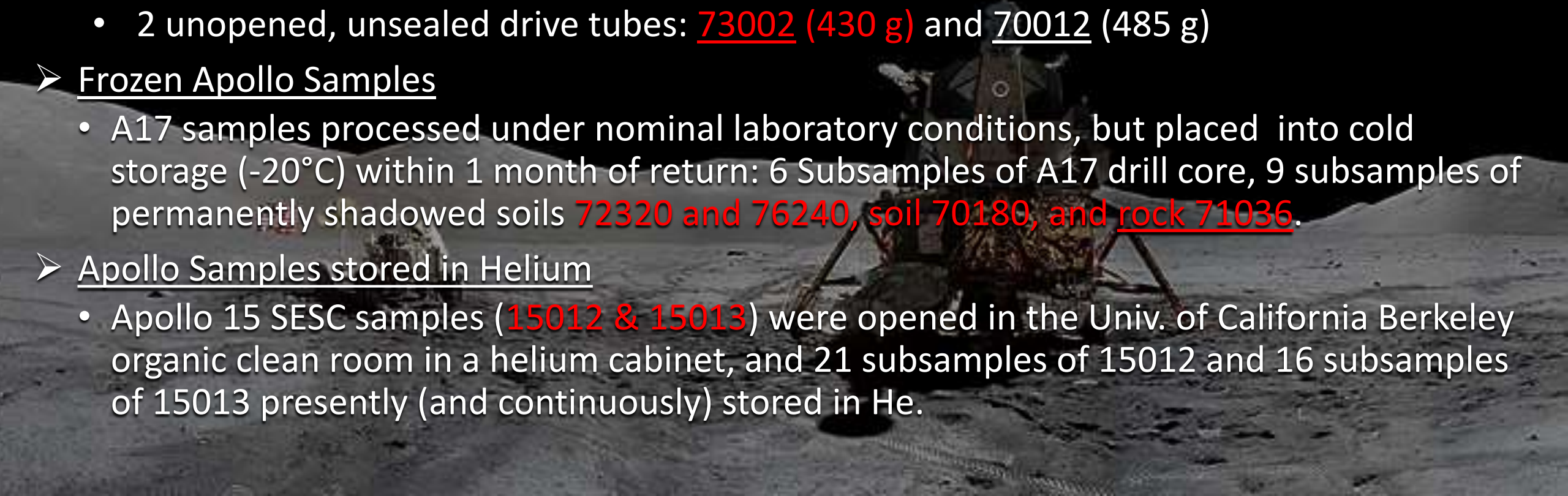
- 2 unopened, unsealed drive tubes: 73002 (430 g) and 70012 (485 g)

➤ Frozen Apollo Samples

- A17 samples processed under nominal laboratory conditions, but placed into cold storage (-20°C) within 1 month of return: 6 Subsamples of A17 drill core, 9 subsamples of permanently shadowed soils 72320 and 76240, soil 70180, and rock 71036.

➤ Apollo Samples stored in Helium

- Apollo 15 SESC samples (15012 & 15013) were opened in the Univ. of California Berkeley organic clean room in a helium cabinet, and 21 subsamples of 15012 and 16 subsamples of 15013 presently (and continuously) stored in He.



ANGSA Update

Overarching Principles for ANGSA

- Run initiative as a sample return mission that enables the **ARTEMIS PROJECT**. Therefore, the initiative has a Rules of the Road Document.
- Outstanding science.
- Nine teams consisting of over 50 scientists and engineers (US and international members)
- Integrates science with exploration.
- Links the first generation of lunar scientists and explorers with future generations.
- Hands-on training of future generations in lunar sample Preliminary Examination.
- Samples science accomplished in a consortium framework.
- Integrates sample measurements, orbital and surface observations, experiments, and modeling.
- Involves the world's best planetary sample analysis labs.
- Labs are designing measurements that are relevant to proposed science.

ANGSA Update

Examples of Science and Engineering Goals

Investigations of the volatile reservoirs and volatile cycles on the Moon:

- What are the concentrations, distributions and behaviors of volatiles in the lunar regolith?
- What are the roles of volatiles in lunar processes?
- Are volatiles from the lunar interior released from fault systems?
- How do lunar volatile reservoirs interact?
- What is the indigenous noble gas content of the Moon?
- What is the solar wind composition as recorded by the Moon?
- What are the characteristics and origin of organic species in the lunar regolith?

Determine the stratigraphy and chronology of lunar landslide deposits to refine our understanding of lunar surface processes:

- What are important variables (e.g., temperature, volatiles) and their role in lunar landslide events?
- What are the triggers and chronology (e.g., impact events, activity along lunar scarps) for lunar landslide events?
- What are the dynamics of a lunar landslide deposit?
- What exotic South Massif components are represented in the regolith?

Integrated and overarching evaluation of the collection and preservation of volatile-rich samples for future exploration:

- How well did CSVC preserve sample pristinity?
- What improvements can be made to (a) better preserve samples and (b) for easier use on the surface of the Moon?

ANGSA Update

PROCESSING OF UPPER DRIVE TUBE CORE 73002

November 2019-February 2020

- Core imaged with X-ray CT.
- Core extruded in dry nitrogen core processing glove box.
- Core derind and the first dissection pass complete.
- Lithic fragments sieved from first pass and documented through X-ray CT.
- Samples selected and allocated for volatile organics and D/H.
- Over 14 ANGSA science team members involved in PE.

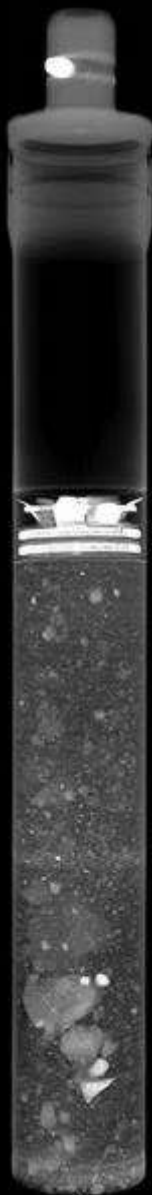


ANGSA update

X-Ray Computed Tomography

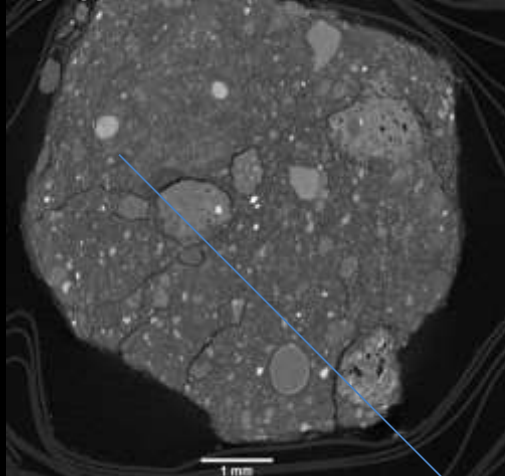


X-ray 1974

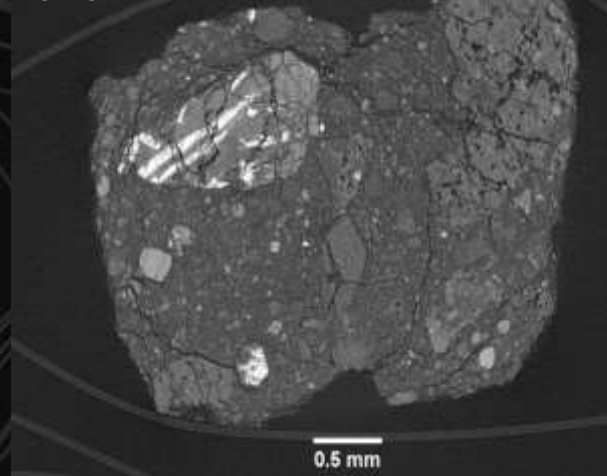


CT scan 2019

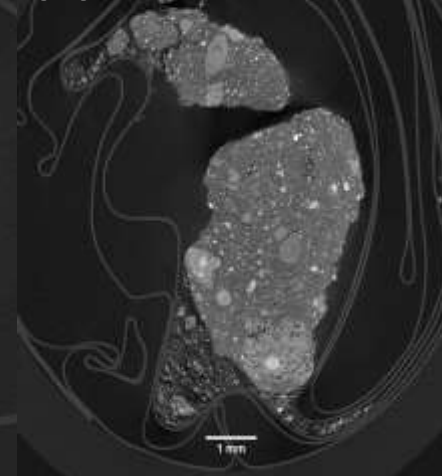
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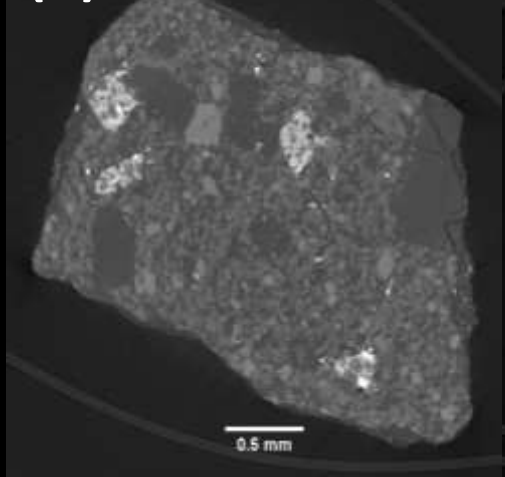
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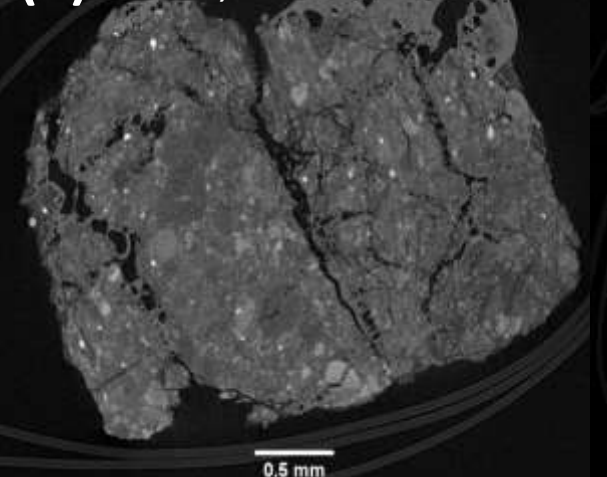
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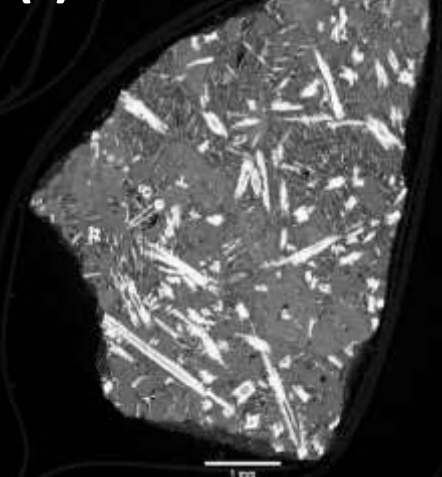
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(e) 73002,19D



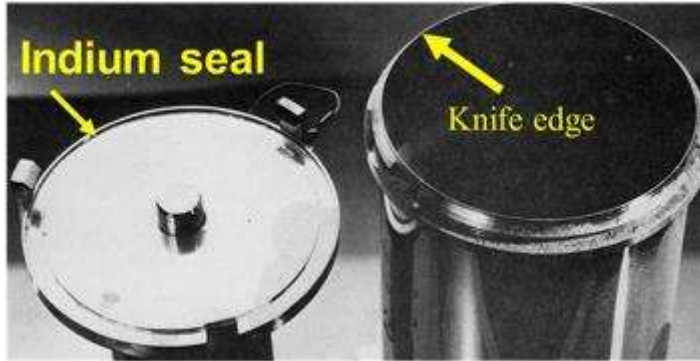
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ANGSA Update

February 2020 - June 2020

- Cold curation facility up and running.
- Tool design for CSVC gas extraction manifold is complete.
- ESA is in the process of designing CSVC piercing tool.
- At LPSC 2020 14 abstracts were submitted for oral and poster sessions.
- ANGSA Team meeting at LPSC.
- Dissection of pass 2 and 3 will start in March 2020 and completed in June 2020.
- Core samples will be distributed to team during pass 2. Cold curated samples will also be released over that period of time.
- Processing (gas extraction, CT imaging, dissection) of lower drive tube core (73001) in CSVC will start November 2020.




A TOPIC OF SIGNIFICANT CONCERN

The LEAG executive committee is surprised to see that a Category 1 Discovery lunar mission would be prioritized lower than other missions on the basis of other NASA investments in areas of lunar exploration and investigation - investments that have not demonstrated they can return science results on a level expected of a Discovery mission. *Will this line of thought be applied to the upcoming New Frontiers call and future Discovery competitions?*

- From the 2020 Discovery Selection Statement:
 - “...NASA is already making significant investments in lunar exploration and investigation, making NanoSWARM a lower priority than the selected investigations for the programmatic reason of maintaining scientific balance.”
- In multiple venues, prospective lunar-focused Discovery teams were explicitly encouraged to submit to Discovery for “Discovery-Level” science despite the existence of the LDEP program.

- **In the most absolutely resolute and uncertain of terms, LEAG strongly asserts the need for continued inclusion of Lunar Geophysical Network and SPA Basin Chronology Sample Return in the NF5 opportunity**
- LDEP activities (CLPS, VIPER, etc), as currently formulated, are **NOT** meant to replace lunar missions to conduct Discovery and NF class science. If future lunar missions will not be selected in PSD programs because of planned activities elsewhere in the Agency, then PSD, LDEP, and HEO need to engage in Decadal-level planning and strategy (including mobility, night operations, and sample return).



ONLY A FEW DAYS
AWAY IS A
STUNNING **WORLD**
FULL OF **WONDER**
AND **OPPORTUNITY**
WAITING FOR **US**
