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Topic: ExMAG response to the DRAFT ROSES22 Apollo Next Generation Sample Analysis (ANGSA-2) solicitation

Barbara A. Cohen[1], ExMAG Chair
NASA Goddard Space Flight Center, Greenbelt MD 20771 (Barbara.A.Cohen@nasa.gov)

Jessica J. Barnes, ExMAG Lunar Subcommittee Chair
Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ 85721 (jjbarnes@arizona.edu)

This response was reviewed by all current members of Lunar Sample Subcommittee and the Extraterrestrial Materials Analysis Group (ExMAG).

Background
The aim of the Apollo Next Generation Sample Analysis (ANGSA) Program is to maximize the science derived from samples returned by the Apollo Program in preparation for future lunar missions anticipated in the 2020s and beyond. To achieve this, NASA solicited proposals for the 1st ANGSA program in 2018 with proposals selected in 2019. The 1st ANGSA program (hereafter ANGSA-1) focused on the analysis of special lunar samples (unopened, vacuum sealed, frozen, and He purged). The 2nd ANGSA call is anticipated in 2022 and is expected to focus on small, high-value samples that are nearing their pristinity limit. The purpose of this white paper is to provide findings and recommendations for NASA to consider as they draft the ANGSA 2022 solicitation and plan for the execution of the 2nd ANGSA program (hereafter ANGSA-2).

Analysis
The ANGSA-2 draft call solicits comments on the proposed sample availability for ANGSA-2, including requests for potential additional samples, which we comment on in this response. However, we also feel it is important to provide NASA with additional feedback on other aspects of the program and draft call to improve the ANGSA-2 program. The ANGSA-1 program scientific progress, implementation efforts, and lessons learned documents have been presented to CAPTEM/ExMAG on numerous occasions, including at public meetings since 2019. For this white paper analysis, ExMAG drew on these presentations as well as the ANGSA lessons learned report that was prepared by the ANGSA-1 science team (https://www.lpi.usra.edu/ANGSA/news/ANGSA-Lessons-Learned-Final-September_1_2021.pdf), the experiences of current ANGSA-funded researchers, and feedback from the ExMAG committee and the Lunar Sample Subcommittee of ExMAG. Though several members of ExMAG and their subcommittees are participants in ANGSA-1, the opinions in this white paper should not be construed as exclusively theirs.

As learned through the ANGSA-1 experience, the ANGSA program is a unique opportunity to conduct next-generation sample studies using new analytical techniques not available during the Apollo program, to coordinate a range of analytical activates on a single sample/suite of samples, and to showcase the power of these analyses in the lead up to crewed lunar exploration in the

coming years. ANGSA-1 also proved that this program is a fantastic opportunity to foster collaborations between diverse groups of researchers from Apollo-era scientists to early career researchers. It is our hope that these strengths are also brought forward to ANGSA-2.

Given the nature of ANGSA is to maximize the science from Apollo samples in preparation for Artemis, we think it important that the ANGSA-2 call will allow for the proposal of new methods/instruments that could maximize the science return from upcoming Artemis missions, especially for small sample volumes.

1. Sample availability. The ANGSA-2 draft solicitation is focused on the analysis of samples that are in high demand yet have low mass and/or are nearing their pristinity limit. The ANGSA-2 program could allow allocation of up to 50% of the remaining pristine mass of the samples listed. The samples currently available as part of the call include:

- Apollo 15 KREEP basalts (15382 and 15386) and Apollo 14 KREEP Basalts (14073, 14074, 14077, 14078, 14079)
- Mg-Suite/Plutonic Samples Apollo 17 (76535, 72415, 72416, 72417, 72418, 72255) and Apollo 16 (67667)
- Granitic Breccia Apollo 12 (12013)
- Apollo 14 High-Al Basalts (14053 and 14072)
- Granulites Apollo 17 (72559 and 79215) and Apollo 15 (15418)

As NASA is investing in both robotic and crewed exploration of the Moon in this decade it is our finding that the call should be expanded to include samples that would provide the most relevant analogs to lithologies to-be-encountered during upcoming missions and/or those that would provide analog consortia-style preliminary examination and analysis experiences while providing pathways for scientific discovery.

Recommendation. The Apollo 14 samples listed as KREEP basalts are in fact KREEP-rich impact rocks (see Potts et al., 2018 and references therein). The language of the solicitation should be changed to reflect that they are "KREEP-rich rocks," so that proposers who are not as familiar with the literature are aware of this. The Proposer Information Packet (PIP) should also detail this. While they are not KREEP basalts *sensu stricto,* they are important rocks with which to unravel the significance and influence of KREEP on the Moon, and therefore we recommend they be made available for study through ANGSA-2.

Recommendation. In light of the investments made as part of the PRISM program, we recommend that the ANGSA-2 sample suite be expanded to include Apollo samples relevant to PRISM study sites. For example, PRISM-2 will investigate the origin of the felsic Gruithuisen Domes with Lunar-VISE. We recommend expanding the ANGSA-2 sample suite to include granitic/felsic clasts from 14303, 14321, 15405 (*c.f.,* Simon et al., 2020 GCA) in addition to 12013 and 72255, which have been reported to contain granite clasts (Meyer, Lunar Sample Compendium) and are listed as available for ANGSA-2.

Recommendation. NASA's Artemis III mission will investigate the geology of the lunar south polar region, including returning many different kinds of samples. Regolith and impact-melt breccias will surely be ubiquitous among the Apollo III returned samples. Breccias afford a unique opportunity for consortia studies of the type fostered by ANGSA. We recommend the addition of complex regolith and/or impact melt breccias to the ANGSA-2 sample list, as analogous materials to those returned by Artemis III. As showcased by ANGSA-1, the application of next-generation sample analysis techniques to pick apart samples (*e.g.*, with modern X-ray computed tomography, XCT) not only allows for hypothesis testing but also discovery-based science. We recommend that the same philosophy is carried through to ANGSA-2. We recommend that large sample masses still be considered for studies of breccias (*i.e.*, up to 50% of the mass of the breccia). We recommend selection of breccias that are potential analogs for the South Pole Aitken (SPA) basin and for which some knowledge is already known. For example, potential analogs might include Apollo 16 regolith and impact melt breccias, Apollo 12 and Apollo 14 impact melt breccias. Samples already scanned by XCT as part of the Astromaterials 3D initiative could be considered for inclusion in ANGSA-2 (*e.g.*, 14316,0).

Recommendation. If NASA decides not to increase the overall number of samples available for consideration in ANGSA-2 as suggested above, then we recommend NASA allow PRISM/Artemis relevant samples instead of granulites. This recommendation is made based on the rather limited interest/relevance of lunar granulites compared to the other samples listed and the benefit of ANGSA-style studies of PRISM/Artemis-relevant samples.

2. Teaming structure. While the ANGSA-1 consortium science team has been and continues to be a resounding success, the expectations for how selected teams would work together was unclear during the proposal stage. Though the draft call for ANGSA-2 specifies that proposals should represent independent consortia efforts, and that selected teams will not be expected to form one larger team, there are still some outstanding uncertainties to the intended approach. For example, the call describes a "kickoff meeting," the purpose of which is unclear, if teams are operating independently. The call does not clearly describe expectations for working groups or other coordinated efforts amongst the teams nor how such efforts would be managed. The ANGSA-2 call does not clearly describe how clear boundaries will be set to protect the scientific integrity and plans of individual teams when selected teams' measurements or sample plans overlap, or how a clear path to resolution would be established.

Recommendation. For ANGSA-2, the solicitation should clearly state what the expectations are for coordinating the efforts of selected teams. For teams working separately on similar samples or scientific goals, the solicitation should describe how teams' efforts will be managed and conflicts resolved.

Recommendation. NASA should draft a Rules of the Road (RoR) or similar document to have in place at the kickoff of the ANGSA-2 program. This draft RoR could then be modified by the ANGSA-2 teams within a reasonable timeframe of the start of the program (within two to three months of funding starting). This would help to alleviate tensions between teams that have similar

goals, lay out effective communication pathways, and clearly describe the ANGSA-2 management structure.

Recommendation. The ANGSA-2 call should specifically require PIs to address communication within their own teams as part of the proposal. Proposers should identify who will manage communication and how it will be maintained (examples include email, listservs, website, slack). In addition, NASA should provide guidelines on how communication will be handled between NASA Curation and multiple teams. NASA should provide adequate support for managing the ANGSA-2 initiative including resources for virtual meetings, email listservs, data sharing platforms (*i.e.*, ANGSA-1 used an LPI-hosted website and Box) and other means to enable inclusive participation.

3. Budgeting. The ANGSA-2 draft call describes several facilities as "available" at JSC, including thin sectioning, X-ray computed tomography, and optical photography. However, the draft does not make clear whether including use of these facilities will incur a charge to the proposal, how much funding proposers should include, or how much time should be budgeted for these services. The draft call does not explicitly state how much work effort will be expected of teams or team leads to attend other in-person meetings (besides the kickoff meeting) such as yearly ANGSA-2 team meetings. The draft call does not mention whether working groups will be expected to form among teams, and if so, the level of effort and travel required to support such efforts.

Recommendation. The ANGSA-2 call should make clear how much time / usage each team can request of the JSC facilities and whether / how much should be budgeted for this purpose. NASA should also make clear how access to JSC facilities would be granted (*i.e.*, do proposers need a letter of support or a JSC collaborator on their proposal) and how selected teams would be prioritized / scheduled time.

Recommendation: The ANGSA-2 solicitation should make clear how much effort and travel will be expected or required of each team to coordinate work among teams.

4. Data Management Plan. The draft call states that Data Management Plans (DMPs) are mandatory for this program element. However, as previously highlighted to NASA in ExMAG's response to the SPD-41 initiative, Data Ecosystem review, and in other venues, there is not a NASA-approved data repository available for all types of petrologic and geochemical data on Astromaterials. There is currently no long-term, NASA-funded, data repository to archive the broad diversity of data types generated by the sample analysis community of researchers (*e.g.,* text, tables, two- and three-dimensional images, spectra, data cubes, etc.). Currently, most sample analysis data are contained in supplemental material reposited with journal publications, in formats of the authors' choosing, which may not conform with the FAIR (Findable, Accessible, Interoperable, and Reusable) principles. Many SMD-funded analytical instruments produce data in proprietary formats that are not compliant with FAIR Guiding Principles.

Recommendation. The ANGSA-2 call should clearly name the NASA-approved repositories that are available for the data expected to be generated by the ANGSA-2 consortia. There should be a predefined archive that can handle large data volumes (e.g., XCT datasets).

Recommendation. ANGSA-2 DMPs should require information not only on expected data types and their volumes but the metadata and data collection, and processing methodologies required for archiving.

Recommendation. NASA should provide training for ANGSA-2 investigators on how to archive their data to meet FAIR principles and use NASA compliant data repositories.

References

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