

COORDINATED ANALYSIS 101: A JOINT TRAINING SESSION SPONSORED BY LPI AND ARES/JSC.

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Introduction: The Lunar and Planetary Institute (LPI) and the Astromaterials Research and Exploration Science (ARES) Division, part of the Exploration Integration and Science Directorate at NASA Johnson Space Center (JSC), co-sponsored a training session in November 2016 for four early-career scientists in the techniques of coordinated analysis.

Coordinated analysis refers to the approach of systematically performing high-resolution and –precision analytical studies on astromaterials, particularly the very small particles typical of recent and near-future sample return missions such as Stardust, Hayabusa, Hayabusa2, and OSIRIS-REx. A series of successive analytical steps is chosen to be performed *on the same particle*, as opposed to separate subsections of a sample, in such a way that the initial steps do not compromise the results from later steps in the sequence. The data from the entire series can then be integrated for these individual specimens, revealing important insights obtainable no other way. ARES/JSC scientists have played a leading role in the development and application of this approach for many years. Because the coming years will bring new sample collections from these and other planned NASA and international exploration missions, it is timely to begin disseminating specialized techniques for the study of small and precious astromaterial samples.

As part of the Cooperative Agreement between NASA and the LPI, this training workshop was intended as the first in a series of similar training exercises that the two organizations will jointly sponsor in the coming years. These workshops will span the range of analytical capabilities and sample types available at ARES/JSC in the Astromaterials Research and Astromaterials Acquisition and Curation Offices. Here we summarize the activities and participants in this initial training.

Participants: During late summer and early fall 2016, LPI stood up an online survey of the sample science community soliciting views on what sorts of sample-handling and –analysis training are needed by the sample-science community. We then decided to hold the inaugural workshop in November with emphasis on small-particle handling and coordinated analysis. We received ~30 applications and selected four early-career scientists as participants. The laboratories used in ARES coordinated analytical studies cannot accommodate more than that number at once,



Figure 1. Astromaterials Research Office Manager David Draper receives rare undivided attention while delivering introductory remarks to workshop participants at ARES/JSC. L-R: Keiko Nakamura-Messenger, Christine Jilly-Rehak, Nicole Lunning, Allan Treiman, Lindsay Keller, Kim Fendrich, Scott Messenger, Caroline Crow, David Draper.

as a practical matter, and the goal was to provide as much hands-on experience as possible. Training was conducted by ARES scientists Drs. Lindsay Keller, Keiko Nakamura-Messenger, and Scott Messenger, with support from staff scientists and technologists Mr. Zia Rahman and Ms. Nancy Todd; and Drs. Eve Berger, Roy Christoffersen, and Kent Ross. The selected trainees were Dr. Carolyn Crow, Lawrence Livermore National Lab; Dr. Christine Jilly-Rehak, University of California, Berkeley; Dr. Nicole Lunning, Smithsonian Institution; and Kim Fendrich, American Museum of Natural History (Figure 1). Travel costs for these scientists were covered by the LPI.

Activities: The training workshop was held over two days with the first day at ARES/JSC for hands-on laboratory training, and the second at LPI for classroom presentations on writing successful proposals to the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) for allocation of samples for study; a guided walkthrough of ARES Acquisition and Curation Office online sample databases; and a tour of the Lunar and Planetary Institute.

Laboratory training. Participants were trained in the use of a newly-installed computer-controlled micromanipulation system for the handling of particles as small as 10 μm (Figure 2). This system will greatly enhance the efficiency of sample handling and enable new and challenging studies to be undertaken. Trainees also worked in the Cosmic Dust and Meteorite Processing laboratories, as well as on scanning and trans-



Figure 2. Dr. Scott Messenger (with beard) describes the use of newly-installed automated micro-manipulator to Caroline Crow (L) and Kim Fendrich (R).

ence that exploit the unique combination of sample access and analytical capability at JSC. We solicit input from the community on areas of sample-based research that might most benefit from workshops of this kind. To that end, the LPI will be soliciting community input through future online surveys to garner such information. We also encourage the community to contact the authors directly at any time to volunteer views on these efforts.

mission electron microscopes. These analytical instruments are core components of any coordinated analysis approach. Trainees were also briefed on what types of steps could be taken in addition to using those instruments, such as high-resolution mapping and analysis of organics, using dual-laser time-of-flight mass spectrometry, or of geochemically diagnostic isotopic ratios using NanoSIMS.

Classroom presentations. The second day of the workshop, held at the LPI, included a highly interactive tutorial session by Dr. Allan Treiman on writing effective and successful proposals for sample allocation to CAPTEM. Ms. Nancy Todd of the ARES Astromaterials Acquisition and Curation Office (Jacobs/JETS) presented a thorough briefing on the recently retooled and updated online portals for obtaining basic information on available samples from the various astromaterial collections housed in ARES. These databases remain accessible from the Curation websites at <https://curator.jsc.nasa.gov/>.

Outcomes and lessons learned: Our four trainees provided very useful feedback on the training experience. They reported both strongly positive views of the training received and very constructive information on where our future training sessions can do better. Positives were centered around the quality of the technical information imparted, whereas constructive negatives were focused on the need for more hands-on training time and thus greater opportunity for trainees to incorporate their experience into their own research programs. We are very grateful to our participants for their candid and thorough assessments.

Future training workshops: LPI and ARES/JSC intend to hold additional training workshops of this sort that focus on this and other aspects of sample sci-