Astromaterials Research and Exploration Overview

Steven A. Hawley, *Johnson Space Center*

With the return of the first lunar samples, the Astromaterials Research and Exploration Science (ARES) Directorate assumed curatorial responsibility for all NASA-held extraterrestrial materials. Originated during the Apollo Program (1960s), this capability at Johnson Space Center (JSC) involved scientists who were responsible for the science planning and training of astronauts for lunar surface activities. Today, ARES conducts research in basic and applied space and planetary science, and its scientific staff represents a broad diversity of expertise in the physical sciences (physics, chemistry, geology, astronomy) as well as mathematics and engineering.

The curation function consists not only of the long-term care of samples, it also includes the development of new curatorial techniques and associated laboratories, support to sample return mission planning, and basic research that allows ARES scientists to provide a service to those members of the external research community who rely on access to the samples. The Lunar Sample Facility and other curation cleanrooms, laboratories, and associated instrumentation are unique NASA resources. Along with approximately 382 kg of lunar rocks and soil returned to Earth during the Apollo Program, the astromaterials collection now includes cosmic dust, particles of solar wind, comet material, space-exposed hardware, and meteorites, some of which were confirmed to have originated on the Moon and on Mars. The curation efforts are greatly enhanced by a strong group of planetary scientists who conduct peer-reviewed astromaterials research. ARES scientists conduct peer-reviewed research in planetary science and participate as Principle or Co-Investigators in many of NASA's robotic planetary missions.

ARES is organized into three offices: Astromaterials Research (KR), Astromaterials Acquisition and Curation (KT), and Human Exploration Science (KX). Each office has multiple research goals and functions. KR staff conducts basic research in astromaterials and astrobiology and shares the results through publications, conference presentations, and education and outreach activities. KT staff manages curation of the current astromaterials collections, plans for future collections, and conducts basic

research. KX staff conducts research in Earth and image sciences, the space debris environment, and mitigations for improving the tolerance of human and robotic spacecraft to the threat of space debris, supports shuttle and International Space Station (ISS) missions, and supports the planning for future human missions to the Moon and, eventually, to Mars.

Recently, ARES achieved several noteworthy milestones. For the first time since Apollo 17, extraterrestrial samples were returned to NASA from two different robotic missions. In 2004, Genesis returned samples of solar wind, even though the spacecraft crashed upon return. ARES personnel and expertise were critical to the task of recovering the science represented in the sample collectors. In 2006, Stardust returned from a mission to Comet Wild-2 with a collection of cometary particles as well as interstellar dust. During this period, ARES acquired two new state-of-the-art instruments – a NanoSIMS and a new transmission electron microscope – that provide a unique ability to perform precision, high-resolution analyses of astromaterials. ARES regularly participates in expeditions to the Antarctic to search for meteorites, and the last two

years of finds added extensively to the collection. Of major significance, the new additions include meteorites of both lunar and martian origin. ARES scientists participate in the ongoing robotic exploration of Mars including the Mars Exploration Rover missions, the Mars Reconnaissance Orbiter mission, and several other missions in the planning stages. In 2006, NASA marked the 10th anniversary of the announcement of potential indicators of primitive life found in ALH84001 by a team of ARES scientists. Although the issue remains unresolved and controversial, that research essentially originated the field of Astrobiology. New research provides more evidence suggesting the possible existence of past biology on Mars. This continues to be an active and exciting area of research. ARES scientists also have unique expertise in "ground truth" relevant to the kind of rocks expected to be studied on Mars, making ARES a distinctive contributor to instrument development and calibration.

ARES is recognized as a world leader in orbital debris research, including debris environment modeling and monitoring, debris shielding design, and policy development to control and mitigate the orbital debris population. ARES aggressively pursued refinements in the knowledge of the debris environment and hazards it represents to spacecraft. ARES researchers led the impact testing on the foam on orbiter thermal protection surfaces that resulted in the conclusive demonstration of what caused the *Columbia* accident in 2003. Additionally, the ARES Image Science and Analysis Group (ISAG) was recognized as "world class" as a result of its contribution to the *Columbia* accident investigation. The ISAG continues to provide real-time analysis of debris shedding and any associated potential damage during space shuttle missions. ARES Earth scientists manage the database of astronaut photography that is predominantly from shuttle and ISS missions but includes the results of 40 years of human spaceflight. In 2006, ARES received the 200,000th image downloaded from ISS crews. The Crew Earth Observations Web site (http://eol.jsc.nasa.gov/Education/ESS/crew.htm) continues to attract between 10 and 20 million hits per month. ARES scientists are also active in the planning of future human exploration of the Moon and Mars through the study of analog activities in collaboration with Engineering and Flight Operations disciplines at JSC.

In addition to its ongoing commitment to research, ARES serves as host to numerous students and visiting scientists as part of the services provided to the research community, as well as conducts a robust education and outreach program. ARES scientists are recognized, both nationally and internationally, by virtue of their success in publishing in peer-reviewed journals and winning competitive research proposals. ARES scientists have won every major award presented by the Meteoritical Society, including the Leonard Medal – the most prestigious award in planetary science and cosmochemistry – and the Nier Prize for outstanding research by a young scientist. ARES established numerous partnerships with other NASA centers, universities, and national laboratories. ARES scientists serve as society officers, journal editors, and members of advisory panels and review committees.