Astromaterials Research and Exploration Science Overview

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The Astromaterials Research and Exploration Science (ARES) Directorate performs a unique role within NASA by leading the Orbital Debris Program and providing curatorial responsibility for all NASA-held extraterrestrial samples. ARES scientists and engineers also conduct research in basic and applied space and planetary science as well as provide support to the human and robotic space flight programs with expertise in science planning and operations, analysis of micrometeoroid/orbital debris (MMOD) risks to spacecraft, image analysis, and Earth observations. The ARES scientific staff – representing a broad diversity of expertise in physical sciences (physics, chemistry, geology, astronomy), mathematics, and engineering – is organized into three offices: Astromaterials Research, Astromaterials Acquisition and Curation, and Human Exploration Science.

Scientists within the Astromaterials Acquisition and Curation Office preserve, protect, document, and distribute samples of current astromaterials collections. This Johnson Space Center capability originated during the Apollo Program with scientists who were responsible for the science planning and training of astronauts for lunar surface activities. Since the return of the first lunar samples, ARES has been assigned curatorial responsibility for all NASA-held extraterrestrial materials (Apollo lunar samples, Antarctic meteorites – some of which originated on the moon and Mars – cosmic dust, solar wind samples, comet and interstellar dust particles, and space-exposed hardware). The responsibilities of curation encompass not only the long-term care of the samples, but also the support and planning for future sample collection missions as well as research and technology to enable new sample types. Research into the samples allows ARES scientists to provide a basic characterization of each sample and a fundamental understanding of the entire collection – all of which is shared with the external research community that relies on access to the samples. The Lunar Sample Facility and other curation cleanrooms, the data center, laboratories, and associated instrumentation are unique NASA resources.

Curation efforts are greatly enhanced by a group of planetary scientists that conducts peer-reviewed astromaterials research. Astromaterials Research scientists conduct peer-reviewed research in planetary science (e.g., cosmochemistry, origins of solar systems, planetary geology and geophysics) and participate as principal investigators or co-investigators in many of NASA's robotic planetary missions. Since the last report, ARES has achieved several noteworthy milestones. The discovery of a new mineral and the recognition from the International Mineralogical Society with naming privilege for Brownleeite prove the value of the extremely high-resolution instrumentation for precision analysis that was acquired and described in the previous Biennial Report. ARES scientists continue to identify grains of interstellar origin in cosmic dust and now also in Stardust samples. The landing and our real-time support to the Mars Phoenix mission was a logical extension of our other Mars mission support and data analysis, including the Mars exploration rovers Spirit and Opportunity. ARES scientists have unique expertise in "ground truth" relevant to the kind of rocks expected to be studied on Mars, making ARES a unique contributor to instrument development and calibration for the Mars Exploration Program. The Lunar and Planetary Institute (Houston) and ARES harnessed a long and successful history of collaborative research and exploration activities, beginning with the Apollo Program, to be selected as an integral part of the NASA Lunar Science Institute (managed by the NASA Ames Research Center). During this period, ARES scientists continued to modernize our analytical capability and acquired two new state-of-the-art instruments – a focused ion beam and an inductively coupled plasma mass spectrometer.

ARES is a world leader in orbital debris research, including modeling and monitoring the debris environment, designing debris shielding, and developing policy to control and mitigate the orbital debris population. We have aggressively pursued refinements in the knowledge of the debris environment and hazards that it represents to spacecraft. One of many recent activities included ARES researchers participating in the automated transfer vehicle (ATV)-1 Jules Verne re-entry observing campaign in collaboration with the European Space Agency by providing a low-light "intensified" video system to analyze fragmentation of the ATV breaking up as it enters the Earth's atmosphere and then using that information to verify computer models and enhance safety assessments of re-entries of spacecraft. The ARES Image Science and

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Analysis Group has also been recognized as a world-class group as a result of the high quality of its near-real-time analysis of ascent and on-orbit inspection imagery to identify debris shedding, anomalies, and associated potential damage during space shuttle missions. ARES Earth scientists manage and continuously update the database of astronaut photography that is predominantly from shuttle and International Space Station missions, but includes the results of 40 years of human space flight. One of these photos, Atafu Atoll [ISS018-E-18129, acquired on January 6, 2009], was selected as third place in the Earth Observatory 10th Anniversary Favorite Image contest. The Crew Earth Observations Website (http://eol.jsc.nasa.gov/Education/ESS/crew.htm) continues to receive between 10 and 20 million hits per month. ARES scientists are influencing decisions in the development of the next generation of spacecraft and missions through laboratory tests on the optical qualities of materials for windows, MMOD shielding technology, and analog activities to assess surface science operations.

ARES hosts numerous students and visiting scientists as part of the services provided to the research community and conducts a robust education and outreach program. ARES scientists are recognized nationally and internationally by virtue of their success in publishing in peer-reviewed journals and winning competitive research proposals. Our scientists have won every major award presented by the Meteoritical Society, including the Leonard Medal, the most prestigious award in planetary science and cosmochemistry, the Barringer Medal, recognizing outstanding work in the field of impact cratering, and the Nier Prize, for outstanding research by a young scientist. Not only has ARES established numerous partnerships with other NASA centers, universities, and national laboratories, but our scientists also serve as society officers, journal editors, and members of advisory panels and review committees.

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