programed to scribe only one line down the exact center of the channel. The final scribe line consisted of 100 passes with a Z advance of 5 µm per pass and with the laser power set at 0.5 watts. As mentioned above, the final cutting plan was practiced in two end-to-end trials using nonflight, triangular-shaped silicon wafers similar in size and orientation to the actual DOS 60000 target sample. The actual scribing of the triangular-shaped wafers required scribing two lines and cleaving (*i.e.* scribe-cleave, then scribe-cleave) to obtain the piece requested for allocation.

Early in December 2012, after many months of experiments and practicing and perfecting the techniques and procedures, the team successfully subdivided the Genesis DoS 60000 target sample, one of the most scientifically important samples from the Genesis mission (figure 2). On December 17, 2012, the allocated piece of concentrator target sample was delivered to the requesting principal investigator.

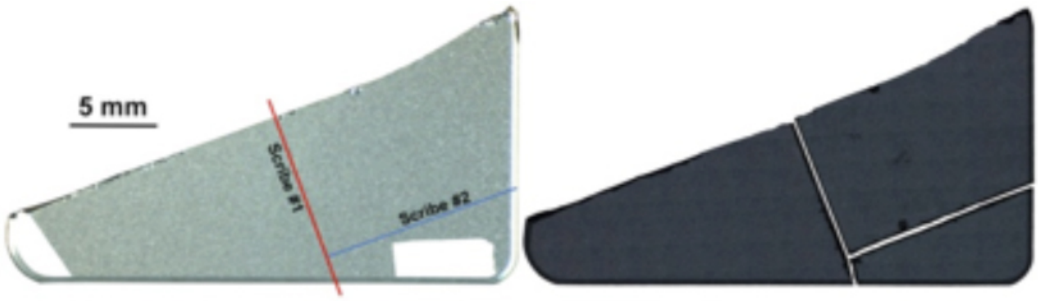

Figure 2.– Left – Image of the back side of the DoS 60000 wafer with the location of the two proposed scribing lines projected onto the surface. Right – The actual flight specimen following successful processing by the JSC Genesis Tiger Team.

The cutting plan developed for the subdivision of this sample will be used as the model for subdividing future requested Genesis flight wafers (appropriately modified for different wafer types).

The Apollo Lunar Sample Image Collection: Digital Archiving and Online Access

Nancy S. Todd, Gary E. Lofgren, William L. Stefanov, Patricia A. Garcia (U.S. Geological Survey)

The primary goal of the Apollo Program was to land human beings on the Moon and bring them safely back to Earth. This goal was achieved during six missions – Apollo 11, 12, 14, 15, 16, and 17 – that took place between 1969 and 1972. Among the many noteworthy engineering and scientific accomplishments of these missions, perhaps the most important in terms of scientific impact was the return of 382 kg (842 lb) of lunar rocks, core samples, pebbles, sand, and dust from the lunar surface to Earth. Returned samples were curated at JSC (then known as the Manned Spacecraft Center) and,

as part of the original processing, high-quality photographs were taken of each sample (figure 1). The top, bottom, and sides of each rock sample were photographed, along with 16 stereo image pairs taken at 45-degree intervals. Photographs were also taken whenever a sample was subdivided and when thin sections were made. This collection of lunar sample images consists of roughly 36,000 photographs; all six Apollo missions are represented.

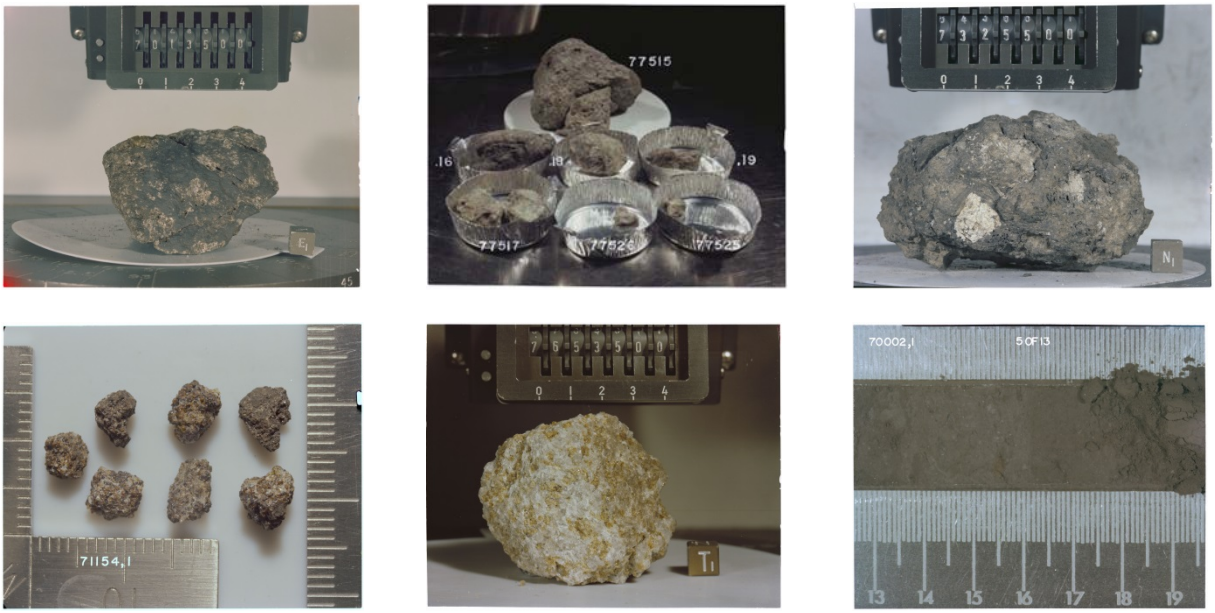

Figure 1.– Representative images of lunar samples from the JSC archive. Clockwise from top left: Ilmenite Basalt 70135, orthophoto; Rake Sample 77515, processing group photo; Impact Melt Breccia 73255, orthophoto; Core 70002, processing photo; Troctolite 76535, orthophoto; 4–10 mm Fines 71154, processing photo.

Project Objective

Throughout much of its history, the lunar sample image data set has been available only to researchers – and the public – in hardcopy at JSC or, more recently, as relatively low-resolution scanned images in Joint Photographic Experts Group (JPEG) format. Grant funding to the ARES Directorate's Astromaterials Acquisition and Curation Office at JSC was received through the NASA Lunar Advanced Science and Exploration Research (LASER) Program in 2008 to support digital scanning of the original film negatives to preserve the information contained within the aging (and degrading) film media and to develop an online database of the imagery to increase public access to the data. In many cases, these images are the only remaining record of what the samples looked like prior to subdivision, and they contain valuable information about the samples' original geologic characteristics – thus, preservation of this information in high-quality, digital form is imperative.

Creation of Digital Master Images from Original Photo Negatives

Each lunar sample image has been rescanned at 2040 pixels per inch (PPI), or 80 pixels/mm, to allow a spatial resolution of 12.5 microns and 16-bit color depth to capture the full dynamic range of the original film. Scanned images were reviewed for quality and saved in a lossless Tagged Image File Format (TIFF) format as the primary archive product. From the TIFF files, JPEG format versions of various sizes have been generated for browsing, print, and Web use.

The bulk of the work scanning the photo negatives to create the digital master images was done between 2008 and 2011; more than 27,000 photos were scanned in this period. In 2012 and 2013, another 7,000 photos were completed. The remaining photos are expected to be complete by the end of fiscal year 2013. All photo scanning work was performed by the JSC Photo Operations Multimedia Services Group.

Online Access to Lunar Sample Data

The Lunar Sample Catalog & Photo Database (http://curator.jsc.nasa.gov/lunar/samplecatalog/) was first published on the JSC ARES Astromaterials Curation Web site in November 2010, and it has been extensively reworked over the past few years to improve and extend its functionality. A completely updated interface, which incorporates additional search options, expanded references, and user-requested enhancements, was launched in the spring of 2012 and announced during the 43rd Lunar and Planetary Science Conference. The searchable database interface provides the ability to search for lunar sample information using a variety of criteria: sample generic number, mission, collection station or landmark, rock classification, and public displays that include the sample. Query results (figure 2) include sample details, photographs, listings of all reference catalogs that include the sample, and, where available, links to the petrographic and geochemical data for the sample in the Lunar Sample Compendium. Users may also search for sample images using photo numbers, type of photo, and related sample information. Image query results can be displayed in tabular or gallery format and can be downloaded as print-quality high-resolution JPEG files.

Digital Archiving of the Lunar Sample Images

As the online database is being developed, the lunar sample image collection is being archived within the NASA Planetary Data System (PDS; http://pds.nasa.gov/). The PDS archives and distributes scientific data from NASA planetary missions, astronomical observations, and laboratory measurements. The PDS also periodically conducts restoration work related to past NASA missions to migrate data from outdated media or mission-specific formats to current archive media and formats. The Apollo 17 lunar sample archive structure was developed in 2012 and 2013 by both JSC ARES and NASA PDS personnel, and the final version was released by PDS in March 2013. The archives for Apollo 11 and 12 are in the final development stages and will be released over the remainder of 2013.

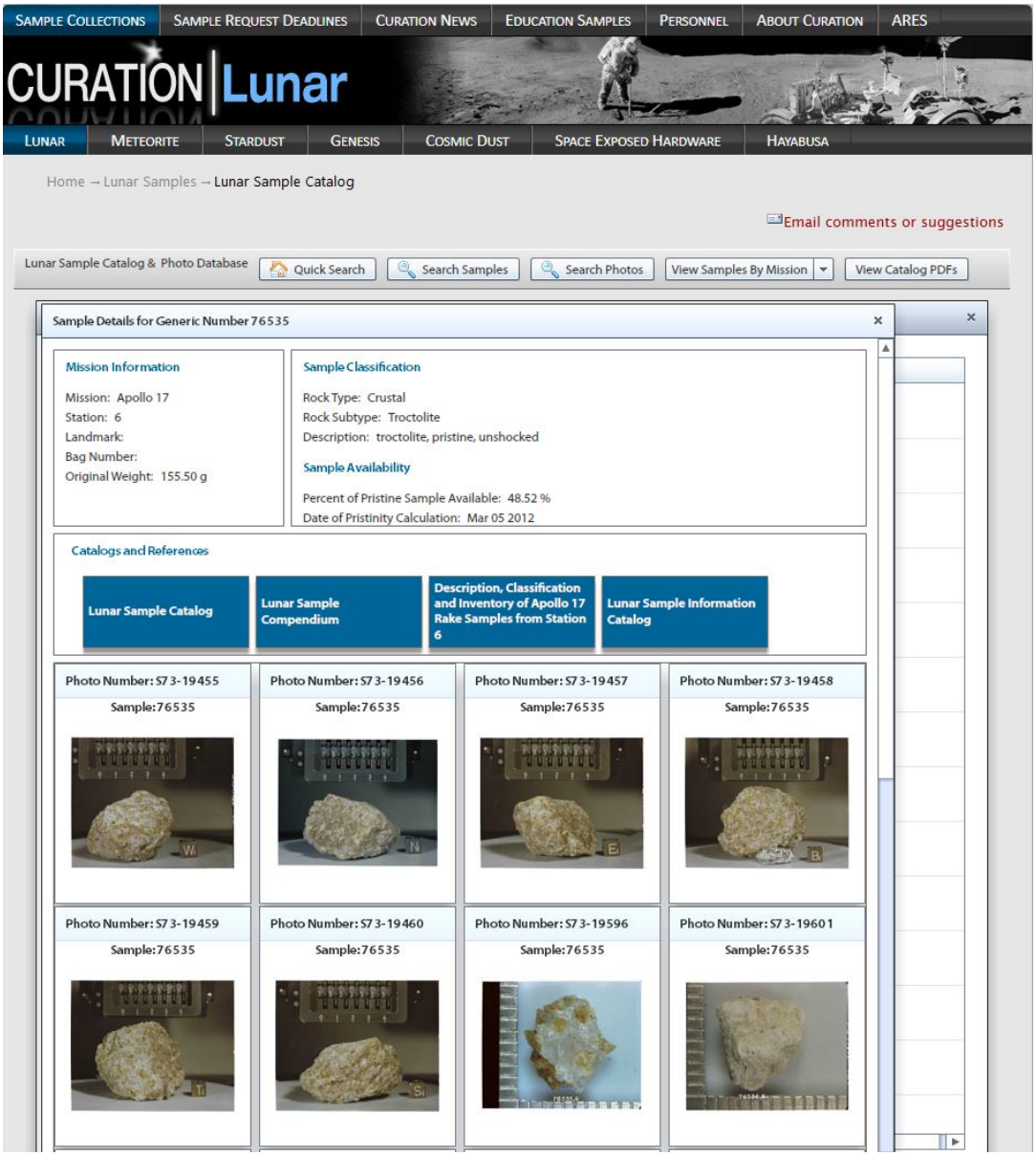

Figure 2.– Screen capture of the Lunar Sample Catalog & Photo Database interface.

For the Apollo mission archives, each sample image (a full-resolution TIFF) has a corresponding data product label. The data product label contains extensive metadata to allow ingestion into databases; query searches by sample number, mission, rock type, and descriptive mineralogical and petrographic term; and cross-mission searches by lunar landmark or collection station. Scan parameters for each image are also included in the metadata. Ancillary information provided with each mission archive includes a mission summary, references relevant to the photographs themselves (*e.g.*, film types and photographic technique), and lunar sample catalogs that correspond to the sample images.

Each archive is organized according to the geologic classification and subclassification of the samples as well as by photo type (figure 3). An Extras subdirectory contains JPEG images generated from each primary TIFF file, and a Document subdirectory contains the sample catalogs and other reference material.

Figure 3.– Partial file directory for the Apollo 17 archive available from the NASA PDS (http://pdsimage.wr.usgs.gov/Missions/Apollo/Rock_Sample_Images/).

Future Plans

Film-negative scanning is expected to be complete by the end of fiscal year 2013. The remaining photos will be available in the online JSC Lunar Sample Catalog & Photo Database by spring 2014. The archives of the lunar rock sample images associated with the Apollo 14, 15, and 16 flights will be generated and delivered to the NASA PDS during the same period. Together, these efforts will preserve the unique photographic record of the original rock samples returned from the Moon and provide greater access to the images, increasing scientific use and public awareness of the Apollo missions' legacy.