RECOVERY OF ALSEP RAW INSTRUMENT DATA AND METADATA. S. Nagihara[1], Y. Nakamura[2], W. S. Kiefer[3], M. A. Hager[3], D. R. Williams[4], P. T. Taylor[4], L. Lewis[5], H. K. Hills[6], and G. K. Schmidt[7], [1]Department of Geosciences, Texas Tech University, Lubbock, TX 79409 (seiichi.nagihara@ttu.edu), [2]Institute for Geophysics, University of Texas at Austin, Austin, TX 78758, [3]Lunar and Planetary Institute, Houston, TX 77058, [4]Goddard Space Flight Center, Greenbelt, MD 20711, [5]Retired, San Gabriel, CA 91775, [6]ADNET Systems, NSSDC, Greenbelt, MD 20711, [7]Solar Systems Exploration Research Virtual Institute, Ames Research Center, Moffett Field, CA 94035.

Introduction: The Apollo astronauts deployed scientific instruments (seismometers, magnetometers, mass spectrometers, heat flow probes, etc.) at each of their lunar landing sites. The ones deployed at Sites 12, 14, 15, 16, and 17 were collectively called Apollo Lunar Surface Experiments Packages (ALSEPs). Powered by radioisotope thermoelectric generators, the ALSEP instruments continuously operated from the time of deployment (1969 – 1972) to September 1977, when NASA terminated the observation program.

Four decades later, the ALSEP program remains the most expansive set of surface science experiments ever conducted on an extra-terrestrial body. Data from the individual experiments continue to be re-examined as new analytical techniques are developed [e.g., 1], and the data are reinterpreted as more recent lunar orbital missions yield new insight [e.g., 2].

Despite the attention it received in these four decades, the ALSEP data collection at the National Space Science Data Center (NSSDC) is far from complete. A recent inventory check has revealed that roughly half of the ALSEP data are missing from NSSDC's database [3]. The paucity of the data collection at NSSDC resulted because, when the ALSEP program ended in 1977, the principal investigators (PIs) of the individual experiments were allowed to submit only the portion of the data they had analyzed. In addition, NASA ended the PI contracts for many of the experiments by 1975 (Fig. 1). As a result, the data from the final 2 to 3 years for some experiments were not processed or archived. NASA did not require the PIs to submit the raw instrument data partly because Johnson Space Center (JSC) in Houston, TX had been generating archival data tapes for all the ALSEP stations. However, these tapes were never delivered to NSSDC for archival purposes. In the following decades, the people who had direct knowledge of these tapes left NASA (some are now deceased), and documents recording the whereabouts of these tapes were lost.

Metadata (format information, data reduction procedures, instrument calibration data, instrument operation logs, etc.) are also lacking for many of the ALSEP experiments. Contemporary researchers are unable to fully re-examine the data from some of the ALSEP experiments, because either the data themselves are missing, or they have no way of reprocessing the raw data.

Here we report on our recent progress in (1) extracting raw instrument data from 450 ALSEP data archival tapes we recently found and (2) digitally cataloguing ALSEP metadata.

History of ALSEP Archival Data Tape Production: ALSEP data transmitted from the Moon were received by the downlink stations of the Manned Space Flight Network and recorded on 14-track, analog open-reel tapes ('range tapes'). JSC collected the range tapes, extracted data for the individual experiments, recorded on digital open-reel tapes, and sent them off to the PIs. In the early years of the ALSEP operation, JSC kept the range tapes for archiving [4]. In April 1973, JSC started production of 7-track digital data tapes specifically for archival purpose ('ARCSAV tapes'). One ARCSAV tape contained 24-hour, time-edited, raw recordings from all the instruments located in one of the 5 landing sites [5]. The ARCSAV tape production at JSC continued till February 1976 (Fig. 1). In our estimate, JSC produced a total of ~5000 ARCSAV tapes in this period. Afterwards, the University of Texas at Galveston took over production of digital archival tapes similar to ARCSAV tapes ('work tapes').

Nearly forty years later, only the data from the work tapes generated by the University of Texas from March 1976 to September 1977 have been preserved. These data are now available through NSSDC. In other words, NSSDC currently has a full set of raw instrument data for only the last 19-month period of the ALSEP experiments.

With regard to the archival range tapes and ARCSAV tapes, many of NASA's official records that actually tracked whereabouts of these tapes have been lost over the decades. The archival range tapes from 1969 to 1973 have not been seen by contemporary researchers. The range tapes generated after April 1973 were recycled at Goddard Space Flight Center.

The ARCSAV tapes were sent to the Washington National Records Center (WNRC) in Suitland, Maryland [5]. However, more than a half of these tapes (~2700) were 'withdrawn' in 1980 for unknown reasons. It is also unknown where these tapes were sent

afterwards. For ~2000 other ARCSAV tapes, we cannot even confirm that they were actually sent to WNRC. So far, we have been able to find 450 ARCSAV tapes at WNRC, less than 10% of what was produced at JSC in 1973 through 1976.

Recovery of Raw Instrument Data from ARCSAV Tapes: The 450 ARCSAV tapes we found at WNRC include data from the 5 ALSEP stations transmitted in April through June 1975. We are currently recalling these tapes and extracting binary files from them. The documentation on the ARCSAV tape data packaging format has been preserved [5], and we are able to recover raw data for the individual instruments. These raw data will be made available via the Planetary Data Systems in 2015 in formats more user-friendly to contemporary researchers.

Recovery and Cataloging of ALSEP Metadata: Thousands of science and engineering reports/memos on the ALSEP instruments were generated at JSC in the period leading up to the launches and during the operation on the Moon. At the conclusion of the Apollo program, a large number of these documents were moved to the Lunar and Planetary Institute (LPI) in Houston, TX and the National Archives of Fort Worth, TX. None of these documents had been systematically catalogued previously.

The ALSEP document collection at LPI includes those related to the design, deployment, and operation of the ALSEP experiments. We have been scanning them into PDF files. The files are then processed with optical character recognition software. Cataloging information is added to each file. The files have been posted to a special section of LPI's Lunar Science and Exploration web portal (www.lpi.usra.edu/lunar/ALSEP) since October 2013.

The website has the capability for users to search the documents using user-defined keywords. As of December 2013, 427 documents totaling ~24,600 pages have been digitally archived. These documents include *Systems Handbooks* and *Flight System Familiarization Manuals* for several of the ALSEP arrays. They also include *ALSEP Data Processing Procedures*, *ALSEP Archive Tape Description Document* [5], and daily and weekly reports from the Early Apollo Scientific Experiments Package (EASEP) deployment in 1969 to the termination of the ALSEP program in 1977.

In order to systematically catalogue the metadata from these documents, we convened a meeting with some of the former ALSEP experiments participants at LPI in April 2013 and received their input.

The ALSEP documents kept at the National Archives in Fort Worth are voluminous, and they have been previously sorted into ~20 groups, but they have never been individually catalogued. One of the most notable of these groups is the Acceptance Data Package (ADP) reports. They give detailed description of the hardware system architecture, sensor calibration, and data processing workflow for the individual flight models for each component of the ALSEP experiments. We estimate that the ADP reports alone have more than 100,000 pages. These reports were submitted to JSC by Bendix Corporation and subcontractors who actually built the flight hardware. They do not include data from the Moon. We are currently extracting metadata from them.

We are also conducting reviews of the documents left behind by the deceased experiment PIs. Some of these PIs left their work as special collections at the libraries of their home institutions. So far, we have examined such document collections at the Columbia University and the University of Maryland in looking for metadata for the Heat Flow and the Lunar Surface Gravimeter experiments, respectively.

The documents recovered from the National Archives and the PI institutions will be added to the collection at LPI's web portal on ALSEP.

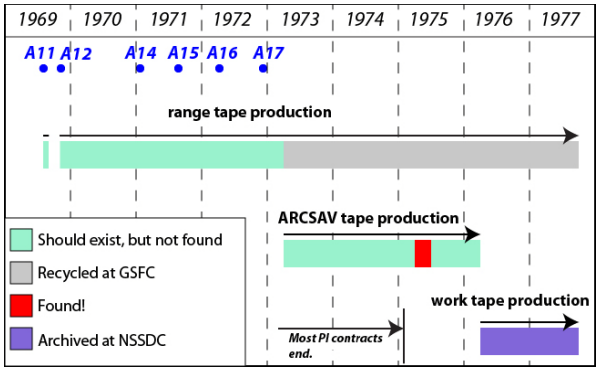

Figure 1: Timeline of the raw data archival tape production for the life of the ALSEP experiments.

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