

SEARCH AND RECOVERY EFFORTS FOR THE ALSEP DATA TAPES. S. Nagihara¹, Y. Nakamura², L. R. Lewis³, D. R. Williams⁴, P. T. Taylor⁴, E. J. Grayzeck⁴, P. Chi⁵, and G. K. Schmidt⁶, ¹Department of Geosciences, Texas Tech University, Lubbock, TX 79409 (seiichi.nagihara@ttu.edu), ²Institute for Geophysics, University of Texas at Austin, Austin, TX 78758, ³Retired, San Gabriel, CA 91775, ⁴Goddard Space Flight Center, Greenbelt, MD 20711, ⁵IGPP, University of California at Los Angeles, CA 90095, ⁶NASA Lunar Science Institute, Ames Research Center, Moffett Field, CA 94035.

Introduction: On NASA's first human lunar landing on Apollo 11 in July 1969, the astronauts deployed a set of scientific instruments called Early Apollo Science Experiments Package (EASEP). It was powered by a solar panel and operated for ~20 earth-days and transmitted data to the Earth. This paved a way for deployment of more expansive instrument packages, powered by radioisotope thermoelectric generators, on Apollo 12, 14, 15, 16, and 17 in November 1969 through December 1972. They were called Apollo Lunar Surface Experiments Packages (ALSEPs). Each ALSEP consisted of a variety of instruments such as seismometers, magnetometers, solar wind spectrometers, heat flow probes, etc. The majority of these instruments kept functioning long after their one-year design lifetime requirement, and they transmitted data to the Earth until September 1977, when the program ended [1].

During the active period of the ALSEPs, NASA contracted a principal investigator (PI) responsible for processing data from each of the experiments. For example, there were one PI for the passive seismic experiment, another PI for the heat flow probes, and so on. As new data came from the Moon, each PI received batches of open-reel magnetic tapes containing raw instrument data. Then, the PIs converted the raw data into scientifically meaningful numbers and made analysis of them. At the conclusion of their investigations, many (but not all) of the PIs delivered their processed data in various forms to the National Space Science Data Center (NSSDC) of the Goddard Space Flight Center (GSFC) [1].

Over the three decades that followed, users of the NSSDC-archived data have learned that many of the ALSEP instrument data are not complete. For example, in case of the heat flow experiments, the raw data contained lunar surface and subsurface temperatures measured every 7.25 minutes from 1971 to 1977, while the data delivered to NSSDC show temperatures with ~60-minute intervals from 1971 to 1974 [2]. A recently conducted inventory check at NSSDC estimates that nearly a half of the data recorded by the ALSEP instruments are missing [3]. The only way to restore the full record is to reprocess all the raw ALSEP instrument data. Unfortunately, large portions of the raw data have gone missing since the late 1970s, because, when the ALSEP program ended, it was up to the indi-

vidual PIs to either dispose of or preserve their raw data tapes.

The present work is a progress report on the authors' recent effort for restoring the entire raw ALSEP data that were received from the Moon.

The History of the Original ALSEP Data Tapes: While the ALSEPs were operational in the 1970s, data from the Moon were digitally transmitted in pulse-coded modulation, received real-time by the ground stations distributed worldwide (Manned Space Flight Network), and recorded on 14-track, analog, open-reel magnetic tapes ('range tapes'). These tapes were sent to the Johnson Space Center (JSC) for further processing. There, data from the range tapes were reformatted and recorded on 7-track digital magnetic tapes ('ARCSAV tapes'). The ARCSAV tapes were also called "24-hour time-edited tapes", because each tape contained 1 earth-day of data from all the ALSEP instruments of one landing site [4]. The JSC personnel also generated instrument-by-instrument digital data tapes and shipped them to the PIs ('PI tapes').

The data processing workflow at JSC, starting from the range tapes and the ARCSAV tapes to the PI tapes, remained in place till February 1976, when the University of Texas (UT) took over the work [1]. The UT personnel maintained a similar workflow, except that the ARCSAV tapes were replaced by 9-track digital tapes, which were called 'work tapes'.

These four kinds of tapes, the range tapes, the ARCSAV tapes, the work tapes, and the PI tapes constituted the original ALSEP data tapes in a sense that they contained raw instruments data from the Moon in one form or another. Currently, digital copies of only the work tapes have been preserved at NSSDC. In other words, raw data from November 1969 to February 1976 are missing, and those from March 1976 to September 1977 are preserved (Fig. 1).

Reports from the Apollo era [1,4] show that the range tapes were sent from JSC to GSFC and that only those from November 1969 to February 1973 were intended for permanent archive. The rest of the range tapes were recycled at GSFC. The same records show that the ARCSAV tapes generated from April 1973 to February 1976 were intended for permanent archive and sent to the Washington National Records Center (WNRC). However, when our investigation began in

2009, no contemporary researcher had been able to verify existence of any of these archived tapes.

Search and Recovery of the ARCSAV Tapes: Magnetic tapes deteriorate over time. People who have good memories about the ALSEP data tapes have become scarce in recent years. If the raw data tapes still exist, we must find them sooner than later. Given the urgency of the problem, the NASA Lunar Science Institute founded the ALSEP Data Recovery Focus Group in 2010, of which we are members. We have so far interviewed ~20 people who were directly or indirectly involved in handling of ALSEP data in the 1970s. We also examined thousands of pages of Apollo era documents at the Records Offices of JSC, GSFC and the Ames Research Center, the Lunar and Planetary Institute library in Houston, the JSC History Collection at University of Houston-Clear Lake, Lamont-Doherty Earth Observatory in Palisades, NY, and the National Archives Southwest Regional Center in Fort Worth, TX.

Our investigation so far has focused on finding the ARCSAV tapes, because they are the digital master tapes which contain data from all the ALSEP instruments. Five ARCSAV tapes were generated daily for the 5 Apollo landing sites from April 1973 to February 1976 (Fig. 1). We estimate roughly 5000 ARCSAV tapes were generated in that period. Only one report published in 1975 briefly describes the fate of these tapes, "ALSEP 24-hour, time-edited save tapes ... are generated at JSC and subsequently archived at the National Records Center, Suitland, Maryland" [4]. The National Records Center in Suitland has been renamed since to become WNRC.

Any material archived at WNRC may be pulled by only the federal agency that sent it there. The agency must refer to the 'accession number' of the material. Without this number, the WNRC personnel cannot locate the material of interest in their storage facilities. The aforementioned report does not list such numbers for the ARCSAV tapes.

In collaboration with the JSC Records Office, we have so far recovered documents describing 3 incidents of WNRC accessions in which a total of ~3270 'ALSEP TIME EDITED TAPES', generated in the period of April 1973 through June 1975, were sent there from JSC in 1975 and 1976 (Fig. 1). However, the same documents showed that more than 4/5 of these tapes had been 'withdrawn' in 1980. No information was given on where the withdrawn tapes went.

After finding these accession records, S. Nagihara, in coordination with the JSC Records Office, arranged a visit to WNRC and visually confirmed that the ~450 of the aforementioned tapes were still kept there (Fig. 2) and that they matched the description of the

ARCSAV tapes given in the reports from the Apollo era [1,4].

Currently we are in the process of pulling these tapes from WNRC with help from the Records Offices of JSC and the NASA Headquarters. The first batch of tapes, about 70 of them, recently arrived at NSSDC, and efforts are underway to extract binary files from them, and to convert them into usable formats.

Conclusions: We have so far confirmed existence of ~450 ARCSAV tapes, generated from April 1975 through June 1975, still kept at WNRC. They account for only ~1/10 of the ARCSAV tapes generated during the Apollo era. There may be more tapes archived at WNRC, but we have not found accession records for them. We have also learned that ~2800 ARCSAV tapes were once sent to WNRC and were later 'withdrawn' in 1980. We do not know where they went. Finally, some records show that a large number of analog magnetic tapes were recycled at GSFC in the 1980s, which included ALSEP range tapes. However, no document we have seen so far says that ARCSAV (digital) tapes were recycled in the same period. Our investigation continues.

References: [1] Bates J. R. et al. (1979) ALSEP Termination Report *NASA Ref. Pub. 1036*. [2] Nagihara S. et al. (2010) *LPS XLI*, Abstract #1353. [3] Lewis L. R. et al. (2010) *Lunar Sci. Forum* poster #105. [4] Lockheed Electric Co. (1975) ALSEP Archive Tape Description Document, *JSC-09652*.

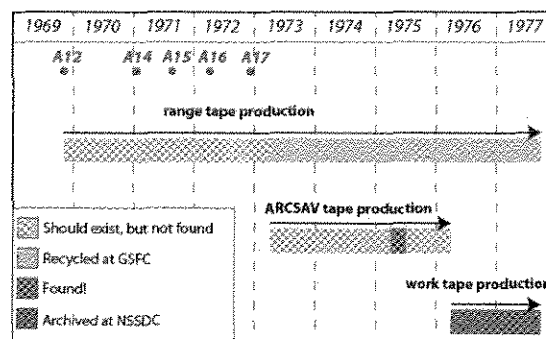


Fig. 1 ALSEP data tapes production history and their recovery status. The timings of the Apollo landings are also shown.

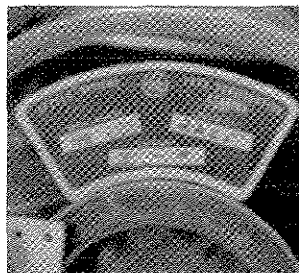


Fig. 2 A photo of one of the ARCSAV tapes found at WNRC.