RESTORATION OF 1975 APOLLO 15 HEAT FLOW EXPERIMENT THERMOCOUPLE DATA FROM THE ORIGINAL ALSEP ARCHIVAL TAPES. S. Nagihara[1], Y. Nakamura[2], P. T. Taylor[3] and D. R. Williams[3], [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]Goddard Space Flight Center, Greenbelt, MD 20711.

Introduction: Two heat flow probes were deployed at the Apollo 15 site as part of the Apollo Lunar Surface Experiments Package (ALSEP). They operated from July 1971 to January 1977 (Fig. 1). At the conclusion of this experiment, only data obtained through December 1974 were fully reduced and delivered to the National Space Science Data Center (NSSDC) by the principal investigator of the heat flow experiment (HFE), Marcus Langseth [1]. It appears that Langseth never examined the HFE data obtained after December 1974. He died in 1997 and no post-1974 HFE data have been found at the Lamont-Doherty Earth Observatory (LDEO), where he was based. Current researchers have strong interests in re-examining the HFE data for the full duration of the experiments [2-4]. The present authors are attempting to restore and fully process the HFE data for the period of April through June 1975 from the original ALSEP data archival tapes generated at the Johnson Space Center (JSC).

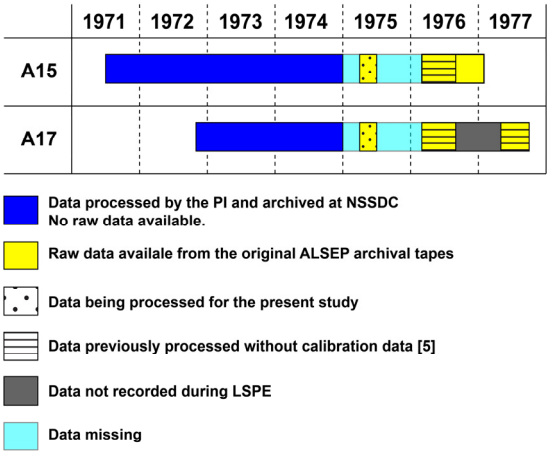

Figure 1. Archival status of the Apollo 15 and 17 HFE data [5].

Archival Data Tapes: The ALSEP archival data tapes generated at JSC were called ARCSAV tapes. They were 7-track, digital open-reel magnetic tapes. Each ARCSAV tape recorded 24 hours of data from all the instruments from one ALSEP station. From April 1973 to February 1976, five ARCSAV tapes were generated everyday at JSC. In the decades after the Apollo program, most of these tapes were lost, and so far only 440 tapes from April through June 1975 have been recovered at the Washington National Records Center [6].

The condition of the magnetic tapes varies, but the vast majority of them yielded very low rates of parity error (<< 0.01%) in our first attempt to read them. The document describing the organization of the binary file recorded on these tapes has been preserved [7], and it allows current researchers to extract raw reading from the individual ALSEP instruments. However, the metadata necessary in processing the raw data are lacking for some of the instruments. In the case of the HFE data, the final report of the experiment [8] describes the data reduction scheme only in general terms without calibration data. The present authors have re-assembled the metadata and calibration data for the Apollo 15 HFE by piecing together bits of information scattered in various memos and reports left behind by Langseth and the engineers who were involved in designing and fabricating the heat flow probes [5].

Thermocouple Data Restoration: Each of the heat flow probes deployed at the Apollo 15 site utilized 2 types of temperature sensors. Platinum resistance temperature detectors (RTD) were used for deeper subsurface measurements, and thermocouples were used for surface and shallow subsurface measurements (Fig. 2). Here we report on the thermocouple data.

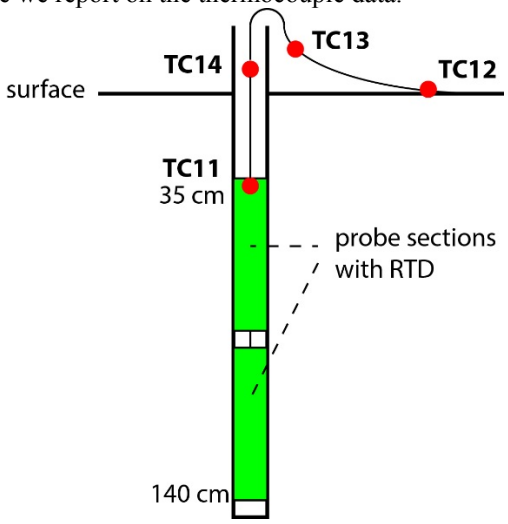

Figure 2. A schematic drawing of the thermocouple positions (red dots) of the Apollo 15 heat flow probe #1, after [8,9].

Using the metadata and calibration data recently recovered [5], we reconstructed Langseth's data reduction scheme. Because Langseth archived only his processed

HFE data and not the raw data, it is impossible to validate the reconstructed scheme by reproducing his results. Here, we compare the 1975 data processed for the present study with Langseth's results from the final months of 1974.

Figure 3 shows fully processed thermocouple data from Probe #1 of the Apollo 15 site for roughly one lunar day in mid-May to mid-June of 1975. The gaps resulted from the data reduction program stopping when it ran into a bad segment of the 24-hour binary file extracted from each ARCSAV tape. Currently efforts are underway to improve the program so that it would skip bad segiments and contine processing data in order to shorten the gaps. Figure 4 shows the data from the last full lunar day of 1974, processed and submitted to NSSDC by Langseth [1].

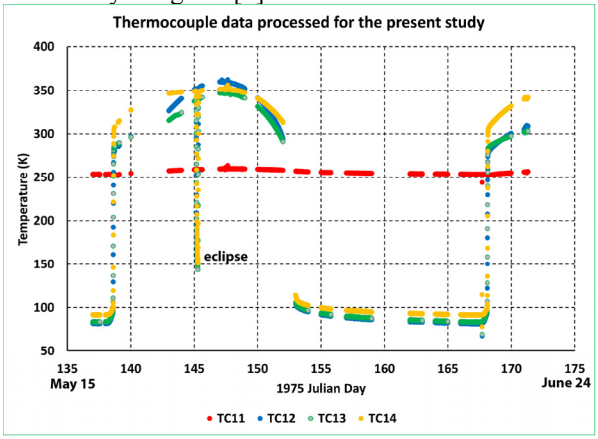

Figure 3. A portion of the 1975 HFE thermocouple data newly processed for the present study. Red, blue, green, and yellow dots correspond to the temperatures of TC11, TC12, TC13, and TC14, respectively. Refer to Fig. 2 for the locations of the thermocouples.

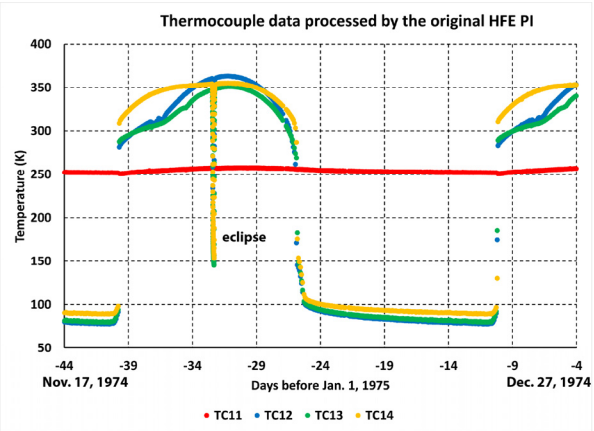

Figure 4. A portion of the 1974 HFE thermocouple data processed and submitted to NSSDC by the original HFE investigator. The color coding is the same as in Fig. 3.

Discussion and Conclusions: Overall, the two graphs in Figs. 3 and 4 have very similar appearances for each of the 4 thermocouples. TC11 was located at 35-cm depth (Fig. 2) and showed the least amount of diurnal temperature fluctuation. Comparison of the two sets shows that TC11 temperatures of May-June 1975 are almost 2 K greater for the corresponding times of the lunation cycle. Currently we are in a processing of determining whether the temperature difference is real, or if it was caused by discrepancy in the processing scheme and other metadata utilized by us and the original investigator. It should be noted that the lunation-averaged temperature of TC11, like those of all the subsurface sensors of the Apollo 15 HFE, showed gradual increase from July 1971 to December 1974 [8]. Diurnal average temperature of TC11 increased by ~2K in the same period, which probably resulted from long-term changes in the lunar surface thermal environment [3,4]. In addition, there is seasonal fluction. Temperature of the shallow subsurface of the Apollo 15 site should have been warmer in May-June of 1975 than in December 1974. However, it is not certain whether or not these two factors alone can explain the ~2K difference between the two processed data sets.

References: [1] Langseth M. G., et al. (2014) Apollo 15 heat flow thermal conductivity RDR subsampled, v1.0, Planetary Data System. [2] Wieczorek M. A. and Huang S. (2006) *LPSC XXXVII*, abstract #1682. [3] Saito et al. (2006) *Bull. Japanese Soc. Planet. Sc.,16*, 158-164. [4] A. J. Dombard (2010) *Ground-based Geophysics on the Moon*, 3015. [5] Nagihara S. et al. (2015) *LPSC XXXXVI* abstract #1243. [6] Nagihara S. et al. (2011) *LPSC XXXXII*, abstract #1103. [7] Lockheed Electric Co. (1975) ALSEP Archive Tape Description Document, *JSC-09652*. [8] Langseth M. G. (1977) Lunar Heat-Flow Experiment, Lamont-Doherty Geol. Obs. p. 289. [9] Mission Evaluation Team (1971) Apollo 15 Mission Rep. p. 286.

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