THE APOLLO 17 LUNAR NEUTRON PROBE EXPERIMENT, Dorothy S. Woolum, D. S. Burnett, C. A. Bauman, California Institute of Technology, Pasadena, California 91109.

The Lunar Neutron Probe Experiment (LNPE), one of the surface experiments flown on Apollo 17, was designed to measure the rates of low energy neutron capture as a function of depth in the lunar regolith. A variety of studies on the lunar samples, particularly those involving isotopic variations in Gd and Sm (1), have documented the long term exposure of lunar materials to neutrons and have shown how such data can be used to calculate regolith accumulation and mixing rates and ages for stratigraphic layers in lunar core samples. Comparison of a neutron capture product and a spallation product in lunar rocks can also be used to infer average irradiation depths which are required to obtain accurate exposure ages. In addition, the Apollo 15 orbital gamma ray experiment (2) has detected gamma rays from neutron capture on elements such as Fe and Ti, from which the relative chemical abundances of these elements could be inferred. In all these cases, the strength of the conclusions has been necessarily limited by the lack of experimental values for the relevant rates of neutron capture. The neutron probe experiment was proposed to obtain these data.

The LNPE made use of two particle track detection systems. A cellulose triacetate plastic detector was used in conjunction with ^{10}B targets to record the alpha particles emitted with the neutron capture on ^{10}B. For the second system mica detectors were used to detect the fission fragments from neutron-induced fission in ^{235}U targets.

The neutron probe has the form of a rod which yields an essentially continuous record of the neutron capture rate from the lunar surface down to a depth of 2 meters. The probe is activated and deactivated by a rotational motion which brings the target and detector systems in and out of alignment. An on-off mechanism was necessary to prevent accumulation of background events produced in flight by neutrons from the ALSEP power generator (RTG) and from cosmic ray neutrons produced in the spacecraft. Point sources of ^{238}U were included at 3 positions along the probe to provide fiducial marks to verify that the probe was properly activated. In addition, 18 mil cadmium absorbers were included in the center and bottom of the probe in order to obtain information about the neutron energy spectrum. The cadmium strongly absorbs those neutrons which are below .35 eV. Consequently, only the fraction of the capture rate which occurs above this energy will be measured. Further spectral information will be available from analyses of ^{80}Kr and ^{82}Kr produced by bromine neutron capture in KBr contained in evacuated capsules which were inserted at the top, middle and bottom of the probe. The bromine neutron capture occurs at energies significantly higher than for ^{235}U and ^{10}B. Krypton analyses will be performed by Marti and Osborne and will appear separately.

The surface deployment of the LNPE was nominal. The 2 meter probe, which is in two sections, was activated and emplaced in the deep drill core

stem hole during EVA 1. It was retrieved and deactivated at the end of EVA 3, accruing 49 hours of exposure. From all present information it appears that this site was 40-45 meters from the RTG. We expect that corrections due to the RTG, which is a strong source of neutrons, should be small.

The LNPE has been returned to us and has been disassembled. The targets and detectors were all in excellent condition. Temperature indicators showed that the probe never reached temperatures exceeding 60°C. The posssibility of reaching high temperatures was a serious concern because thermal annealing of the particle tracks in the plastic can occur.

To date we have examined only the mica detectors. A full analysis of all the available data will require additional time, but some tentative conclusions based on preliminary data are possible. Although our calibration data have not been completely processed, the track densities are in the expected range. It appears that the neutron capture rates are within a factor of two of those estimated from the theoretical calculations of Lingenfelter et al. (3).

Independent of the absolute magnitudes, it is possible to compare the relative track densities with the shape of the theoretical neutron flux depth profile as shown in figure 1. The experimental data are shown as points in the figure. The error bars are one standard deviation based only on counting statistics. The solid curve is the theoretical profile which has been normalized to the measured track density at 145 g/cm^2. No adjustment of the depth scale of the curve has been made. The profile assumes a uniform chemical composition corresponding to sample 10084. Depths in grams per square centimeter were calculated from the measured densities of the samples in the Apollo 17 deep drill core sections (4). The deep core material will provide a check on possible chemical variations with depth which will have to be considered in comparing the experimental and theoretical profiles. In addition, relative efficiencies for individual target-detector positions will have to be included in figure 1 and these could alter the experimental depth profile slightly.

Nevertheless, taking figure 1 at face value, we conclude that the trend of the data points is in very good agreement with the theoretical profile, except that the drop-off at greater depths appears slightly steeper than predicted. A steeper drop-off would tend to decrease the area under the curve which is of particular interest for mixing depth calculations. However, the change is probably insufficient to account for the differences between the regolith depths calculated from Gd isotopic variations assuming a uniformly mixed regolith and those inferred from photogeology.

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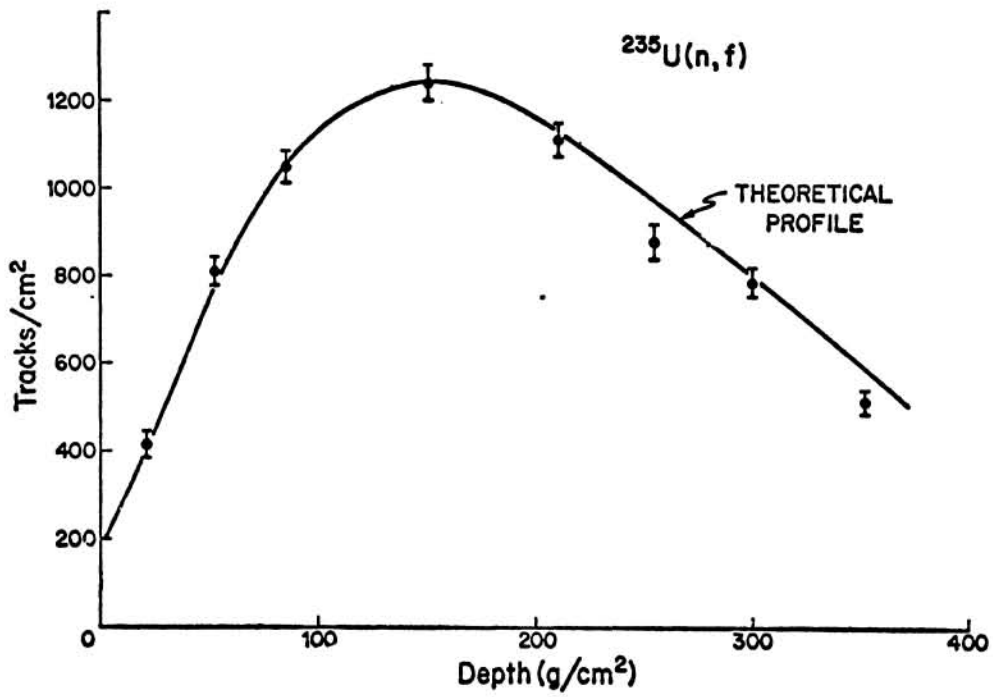

FIGURE 1. Comparison of the fission track data from the mica detectors with the shape of the theoretical profile which has been normalized to the data at 145 g/cm^2.