RECENT DEPOSITION AND MIXING HISTORY OF THE APOLLO 17 DRILL CORE 70009-70001. K. Nishiizumi[1], K. C. Welten[1], and M. W. Caffee[2], [1]Space Sciences Laboratory, University of California, Berkeley, CA 94720-7450, USA (kuni@berkeley.edu), [2]Department of Physics and Astronomy, Purdue University, West Lafayette, IN 47907-2036, USA (mcaffee@purdue.edu).

Introduction: Our knowledge of the formation and evolution of the lunar regolith comes from many sources, but the Apollo cores are the single most important source of information [e.g., 1, 2]. Long-lived cosmogenic radionuclides, such as ^{53}Mn, ^{10}Be, and ^{26}Al provide detail depositional and mixing events on the Moon in the last ~10 Myr. These data have been used to constrain models of regolith gardening (reworking) [e.g., 3] and to improve our understanding of the history of individual cores [e.g., 4, 5].

To study surface regolith activity we measured cosmogenic ^{10}Be ($t_{1/2}$ = 1.36 Myr) and ^{26}Al (0.705 Myr) from the Apollo 17 deep drill core 70009-70001. We compare our results to profiles from the Apollo 15 deep drill core and consider processes of regolith reworking. The measurements of ^{36}Cl ($t_{1/2}$ = 0.301 Myr) and ^{41}Ca (0.104 Myr) from the core are in progress.

Core Descriptions: The Apollo 17 deep drill core was taken at the ALSEP site, approximately one crater diameter east of the 400 m-diameter Camelot Crater [6]. The recovered core is the deepest (292 cm - 541 g/cm^2) among the three Apollo drill cores. The stratigraphy of the core is characterized by measurements of FeO and the surface maturity index I_s/FeO [7], the percentage of agglutinates [8], nuclear track densities [9], and modal petrologic data [10]. These studies determined that the core is not homogeneous along its length so the core has been subdivided into 5 [10] or 8 units [7, 8]. All agree that (1) the surface layer (0 ~ 20 cm) has a high agglutinate abundance and also has a high level of irradiation, (2) underlying this surface layer is a coarse-grained layer (24 ~ 60 cm) that is immature and has extremely low levels of irradiation and was likely deposited as a single ejecta blanket approximately 100 Myr ago, and (3) the deeper part (below 60 cm) consists of high variable maturity material that has a high level of irradiation [7-9].

The ^{22}Na ($t_{1/2}$ = 2.6 yr) profile in the top portion of the core indicates no significant alteration or disturbance during its collection and subsequent handling [11, 12]. Long-lived radionuclides indicate a complex depositional history. Fruchter *et al.* [12] proposed, on the basis of ^{26}Al and ^{53}Mn measurements, that an impact excavated 50 - 60 cm of material at the core site no longer than 0.5 Myr ago. The crater subsequently refilled with about 25 cm with near-surface material. The neutron fluence profile, measured by Sm and Gd isotopic shifts, also shows a demarcation between low and high irradiation regimes corresponding to depths between 52 and 64 cm [13].

Sample Descriptions and Methods: To further investigate the depositional and mixing history of the Apollo 17 drill core, we selected 23 samples from the surface to bottom (292 cm) of the core. The sample depth selection was based on two criteria: (1) more samples were taken near the surface (0 ~ 16 cm) of the core to resolve shallow gardening processes and recent deposition, and (2) at least one sample was taken from each proposed unit [7, 8, 10] to identify depositional relationships or mixing between these units.

After weighing, each sample (~60 mg) was dissolved with an HF/HNO_3 mixture along with Be and Cl carriers. Aliquots of the solution were used for chemical analysis by ICP-OES measurements. Aluminum and Mn carriers were added, followed by chemical separation and purification for accelerator mass spectrometry (AMS) measurements. Concentrations of ^{10}Be and ^{26}Al in each sample were measured by AMS at Purdue University [14].

Results and Discussion: The ^{10}Be and ^{26}Al depth profiles of the Apollo 17 drill core are shown in Figures 1 and 2 along with previous ^{26}Al measurements [11, 12]. As a reference, the ^{10}Be [15, 16] and ^{26}Al [11, 17, 18] depth profiles of the undisturbed Apollo 15 drill core are shown in figures as well. We use g/cm^2 as unit of depth based on the density of core [19].

The ^{10}Be depth profile from Apollo 17 drill core shows a perfectly straight attenuation line with a half-attenuation length ($d_{1/2}$) of 112 g/cm^2 between 150 and 540 g/cm^2 (Fig. 1). The profile is parallel to that of Apollo 15 drill core but is shifted 60 g/cm^2 (32 cm) toward the surface. The ^{10}Be profile indicates that at least below 150 g/cm^2, the core is completely recovered and undisturbed in the last few Myr. The previously reported ^{26}Al concentrations at deeper portion had large uncertainties due to the difficulty of nondestructive low-level counting [12]. In this work we obtained a straight attenuation line with $d_{1/2}$ = 116 g/cm^2 between 150 and 540 g/cm^2 (Fig. 2). The Apollo 17 ^{26}Al core profile is also parallel to that of Apollo 15 drill core and it also shifted 60 g/cm^2 toward surface. Although ^{53}Mn measurements for both Apollo 15 and 17 drill cores show larger uncertainties, the Apollo 17 profile is roughly 80 g/cm^2 shifted toward surface (Fig. 3). The consistent shift in the depth profiles of all three nuclides from Apollo 17 indicate that the original surface of the core must have been 32 cm higher than present surface. Removal of this surface material was most likely caused by a small cratering event and occurred much less than one half-life of ^{26}Al ago. Calcium 41 and ^{36}Cl measurements in progress may provide a tighter constraint on this event.

The ^{26}Al and ^{53}Mn concentrations in the surficial materials (0 ~ 40 g/cm^2) of the Apollo 17 core are substantially higher than can be accounted for by steady state production from both galactic and solar cosmic rays. This interval corresponds to the top unit which contains a high agglutinate concentration. The average of these nuclide concentrations, ~110 dpm ^{26}Al/kg and ~450 dpm ^{53}Mn/kg Fe, corresponds to production at depths of 0 to ~2.5 g/cm^2. As suggested by Fruchter *et al.* [12], the upper 20~22 cm of the core consists of material exposure in near-surface (0~1.5 cm) regions before emplacement in the core.

Another conspicuous feature in both the ^{26}Al and ^{53}Mn profiles are dips in concentration between ~40 and ~120 g/cm^2. The source of this feature is unexplained.

The measurement of radionuclides with shorter half-lives, in particular ^{41}Ca, may better constrain the timing of the excavation and subsequent refilling events.

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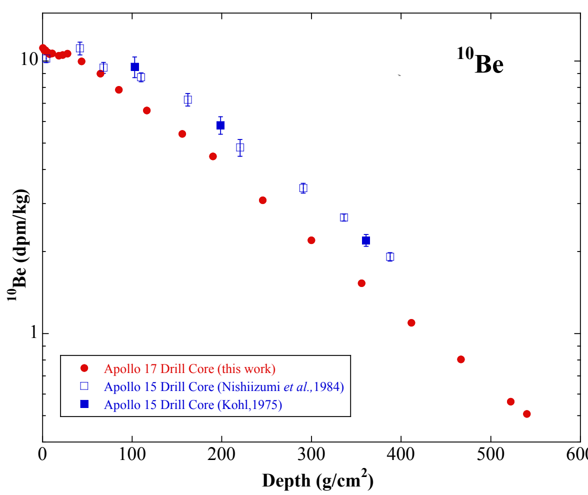

Figure 1. Depth profile of ^{10}Be in Apollo 15 and 17 (this work) drill cores.

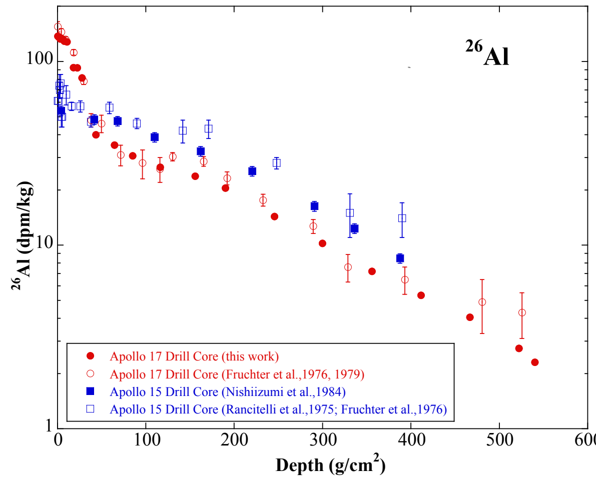

Figure 2. Depth profile of ^{26}Al in Apollo 15 and 17 [this work, 11, 12] drill cores.

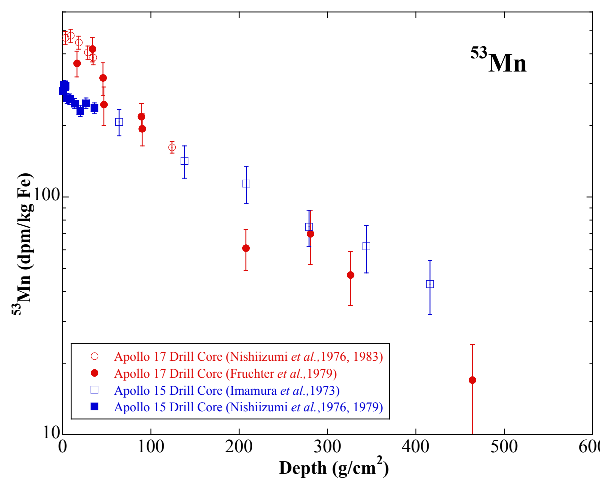

Figure 3. Depth profile of ^{53}Mn in Apollo 15 and 17 drill cores.

References:

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