THE APOLLO 16 DEEP DRILL CORE

Henry O. A. Meyer, and Robert H. McCallister, Dept. of Geosciences, Purdue University, West Lafayette, Ind. 47907.

In attempting to relate mineralogical and petrological studies of <1mm fines in the Apollo 16 core to other physical and chemical measurements it became obvious that a complete synthesis of all studies made on samples from the core was necessary and timely. Accordingly, we have attempted to compile in a single review all the past and current investigations on material from the Apollo 16 drill core. As the various data from diverse studies were examined, and the location of the samples in the drill-string noted it became apparent that in certain instances duplication of effort on the same samples had occurred, whereas in other instances critical supporting data for a particular sample were absent.

A major problem in relating samples to their true position in terms of depth below the lunar surface is the absence(or loss) of material in the 40cm length of the 60005 drill section. There is also some difference in total core length between that of the X-radiographic units and the stratigraphic units of Duke and Nagle (1). These authors have revised and updated the core catalog (2) and it is probably preferable if all workers quote sample depths in terms of the maximum depth scale of Duke and Nagle(2). This uncertainty in the true depth for samples in the core section 60004 and below is a major problem for those interested in the depth profiles for the products of solar wind, solar flares, and galactic cosmic rays (3,4,5).

On the basis of X-radiography and direct observation of core structures Duke and Nagle (1,2) recognize 46 stratigraphic units in the Apollo 16 deep drill core. However, in gross terms they suggest only three major horizons are present with the lowest of these occurring below about 190 cm depth, at the boundary between units 12 and 13, and the upper stratigraphic discontinuity being at the base of the 60006 drill section. The discontinuity at 190 cm depth has also been recognized in studies of modal petrology (6), track density (7), and noble gases (8,9); but has not been clearly defined on the basis of possible differences in bulk chemistry, and mineral and clast chemistry (10,11,12,13). It has been suggested this lower stratum is very old regolith material and contains a large component of what Heymann et al. (14) refer to as Group II soils as well as some component resembling that noted by the same authors in the unique surface sample 61220 (15).

No other discontinuity is as well defined by such diverse studies although Vaniman et al. (6) believe on the basis of modal petrology that a division in the core occurs at approximately...
6 cm depth from the surface. Interestingly, it has been suggested that this portion of the core, possibly to 10 cm depth, represents infilling of a shallow crater (16).

In comparison to the macrostratigraphy discussed above much smaller units, some on the scale of a few mms, have been observed by some investigators (7,17,18). The recognition of these units is in part due to the unique method of core impregnation and subsequent thin-section preparation devised by Nagle and Duke (19). These sections have been extremely valuable in retaining core structures and enabling detailed modal analysis (6,20) and track density studies (7,17,18) to be made. At the present time, probably the study of Blandford et al. (7) is the most detailed on track stratigraphy. Unfortunately, there is some disagreement between investigators of track data as to whether one can recognize "micro" layers, <1mm in width, within the core.

Recent studies (21,22) of the ferromagnetic resonance in the drill cores has opened a new technique for regolith study. At the present time both studies have been done on the same samples from core section 60003. It is somewhat reassuring to note both investigations produced similar conclusions, especially that the lower part of this core section contains coarser grained Fe metal. The results of FMR studies on the Apollo 16 core samples depend upon the Fe contents of the agglutinates and it would be interesting to compare the FMR results with modal analyses and agglutinate studies of comparable samples.

Various isotopic studies have concentrated on providing data on rates of deposition and related processes (3,4,5,8,9, 16,23,24,25). On the basis of Mn, Na and Al isotope studies Fruchter et al. (25) suggest the top 10 cm of the core may have been deposited between 0.5 and 1.4 m.y. ago. Most workers agree that the regolith process at the site has been accretion and Russ (3) has estimated from Gd and Sm data a possible rate of about 70 gm/cm² for a period in the region of 100 m.y.

The following are some of the points that have resulted from investigations of the core with specific relevance to the formation of the regolith:

1) Accretion of material has been the major regolith process at the Apollo 16 core site with deposition occurring on the order of 10⁸ years.
2) There is at least one well defined ancient lunar surface at about 190 cm depth. Below this surface the soils are old, poorly sorted and have abundant lithic clasts.
3) Soils above 190 cm depth are generally finer grained and better sorted, up to about 55 cm depth at which level there is a change to an apparently rapidly deposited layer.
4) Track density data indicate stratigraphy in the core, with some investigators noting microstrata <1 mm in width.
5) Almost all samples examined show evidence of mixing either on mm or micron scale.
6) It is distinctly possible that most of the material in the core is locally derived of Highlands origin with a very tiny component of mare-type material.
7) It is most probable that the regolith is sufficiently heterogenous that both vertical and lateral correlation of horizons, other than in unique cases, is impossible.

A singular character of all core studies is that apart from the samples examined during the early allocation most recent studies have been such that different investigations have used samples from different levels of the core. This alone makes cross-reference and comparison difficult, and it is to be hoped a suite of samples will be made available for comparative studies by a group of interested investigators.

References