# COSMOGENIC AND PRIMORDIAL RADIONUCLIDE MEASUREMENTS IN APOLLO 12 LUNAR SAMPLES BY NONDESTRUCTIVE ANALYSIS[a]

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Apollo 12 lunar samples have been analyzed for their cosmogenic and primordial radionuclide contents by nondestructive gamma-ray spectrometry. The radionuclides measured include $^{22}Na$, $^{26}Al$, $^{40}K$, $^{46}Sc$, $^{54}Mn$, $^{56}Co$, $^{60}Co$, $^{232}Th$, and $^{238}U$, while upper limits were obtained for $^{7}Be$, $^{44}Ti$, $^{48}V$, $^{51}Cr$, and $^{57}Co$. Radionuclide measurements were made on lunar rock specimens 12002,93 through 97, 12005,0, 12016,0, 12031,2, 12034,9, 12051,1, 12051,3, 12053,38, 12053,41 through 44, 12062,0, 12063,0, and 12065,0; on lunar soil samples 12033,19 and 12070,3; and on lunar core tube samples 12025,4 through 14.

Aluminum-26 and sodium-22 measured in slices from vertical sections of lunar rocks 12002 and 12053 showed concentration gradients between the top and bottom surfaces of as much as three- and twofold, respectively. The major reduction in concentration of these radionuclides occurs in the first centimeter from the top surface.

Beta-gamma-gamma coincidence counting measurements on whole lunar rocks have established $^{26}Al$ concentrations in their top 0.5 mm of thickness and show concentrations similar to those in the first centimeter of the rock. This relatively low surface concentration may reflect the erosion rate of the lunar rocks. Aluminum-26:sodium-22 ratios ranging from about 1.0 to 2.7 have been

(a) This paper is based on work supported by the National Aeronautics and Space Administration - Manned Spacecraft Center, Houston, Texas, under Contract NAS 9-7881.



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observed in the Apollo 12 lunar samples compared with values of about 2.0 for Apollo 11 samples. This wide range in ratios cannot be accounted for by size differences of the rock samples or their degree of burial in the lunar soil and is apparently due to variations in their chemical composition. The $^{56}Co$ content of the Apollo 12 lunar fines was substantially higher than was observed in the Apollo 11 samples and reflects the combined contribution from the April 12, 1969, and November 10, 1969, flares. The radioisotope ratios continue to indicate a rather constant solar and galactic cosmic-ray flux over the past million years. Depth gradients of cosmogenic radionuclides in lunar core sample 12025, together with radionuclide concentrations in materials returned from Surveyor III, are helping to construct the average solar cosmic-ray intensity and energy spectrum in the recent past and over the past million years.

The Apollo 12 samples showed a much wider range in primordial radionuclide concentration than the Apollo 11 samples and also a wider range in the thorium to uranium ratios. The primordial radionuclide content of Apollo 12 soil was significantly higher than the crystalline rocks, in marked contrast to the Apollo 11 fines and rock which contained comparable amounts of thorium, uranium, and potassium. If lunar rock of the composition sampled at the Apollo 12 site is the source of the adjacent soil, the primordial radionuclide composition of the soil could be satisfied with about a 20% mixture of a feldspathic differentiate, such as 12013 and the other crystalline rocks.



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