COMPARATIVE RADIONUCLIDE CONCENTRATIONS AND AGES OF APOLLO 11 AND APOLLO 12 SAMPLES FROM NONDESTRUCTIVE GAMMA-RAY SPECTROMETRY*

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ABSTRACT

Two gamma-ray spectrometers with low backgrounds were used to determine radioactivity of a suite of lunar samples from the Apollo 11 and Apollo 12 missions. A spectrometer installed at the Lunar Receiving Laboratory permitted rapid analysis of samples during the quarantine period, so that radionuclides of short half-life could be determined. Studies at later times were carried out on a spectrometer of similar sensitivity at Oak Ridge National Laboratory. Data acquisition and analysis methods were the same as those previously described for studies of Apollo 11 samples.

Concentrations were determined for the primordial radioelements K, Th, and U, and for eight radionuclides produced through bombardment by galactic cosmic-ray and solar-flare protons. Detection limits were set for other nuclides in some cases. Rapid access to Apollo 12 samples permitted the determination of 16-day ^{48}V in six samples and 5.7-day ^{52}Mn in two samples. These concentrations are correlated with solar-flare activity and with chemical composition.

The concentrations of K, Th, and U for 11 crystalline rocks examined from the Apollo 12 mission are relatively constant at about 500, 1.0, and 0.24 ppm, respectively. These Apollo 12 rocks do not show the large variations noted for the crystalline rocks of Apollo 11 but are similar to the low-potassium rocks of Apollo 11. The fines and breccia together are relatively uniform in composition, but because of their much higher concentrations of radioactive elements, they could not have been formed directly from the crystalline rocks examined. These studies also show that the ratio K/U exhibits little variation over a range of about 40 in K or U concentration. Now that more extensive data are available, it appears that the K/U ratios fall into characteristic groups.

The high concentrations of K, Th, and U in rock 12013 which we reported during the preliminary examination have been confirmed

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*Work carried out under Union Carbide's contract with the U.S. Atomic Energy Commission through interagency agreements with the National Aeronautics and Space Administration.

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by further studies. Rock 12013 not only has the highest concentrations of these radioactive elements, but the ratio Th/U is anomalously low, namely, 3.3 compared with the usual value of about 3.9 for most lunar material.

Rock 12034 was dug from a trench and concentrations of cosmogenic radionuclides show evidence of attenuation of the bombarding particle flux.

The high concentration gradients of radionuclides produced by solar-flare protons were used to identify the tops of several rocks. This information allowed us to deduce the selenographic orientation of these rocks.

The variation with depth for the concentrations of radionuclides produced by cosmic-ray and solar-flare proton bombardment was studied in two rocks. The results are in qualitative agreement with theoretical calculations.

Concentrations of primordial radioelements and of ^{22}Na and ^{26}Al were combined with rare gas data from other workers to obtain gas retention ages and cosmic-ray exposure ages.