COSMIC RAY PRODUCED Mn AND Be RADIONUCLIDES IN THE LUNAR REGOLITH;

R. C. Finkel, University of Bern, Physikalisches Institut, Bern, Switzerland; M. Imamura, Dept. of Chemistry, Faculty of Sci., Univ. of Tokyo, Tokyo, Japan; M. Honda, K. Nishiizumi, Inst. for Solid State Physics, Univ. of Tokyo, Tokyo 106, Japan; C. P. Kohl, S. M. Kocimski, and J. R. Arnold, Univ. of Calif., San Diego, La Jolla, Calif. 92037.

Once the depth profiles for the various effects produced by high energy particle bombardment of the undisturbed lunar surface are measured and understood, they can be used as probes for the rates of surface processes, in particular of the mixing of the lunar regolith. The long-lived radionuclides are especially useful because of their well-established timescales.

Mn^{53} ($t_{1/2} = 3.7 \times 10^6$ years) is the most important of these. It is measured using a sensitive neutron activation technique (1) which allows us to obtain activities using fairly small samples. The fact that it is produced mainly from Fe eliminates complicating effects due to variations in the chemical composition of different samples. Measurements have been made on a series of samples taken from the ends of sections of the Apollo 16 drill stem. These measurements agree very well with our earlier data for the Apollo 15 long core (2) and like our Apollo 15 measurements are in good agreement with the theoretical activity profile calculated using the model of Reedy and Arnold (3). Thus it appears that the lunar regolith at the sites of both the Apollo 15 and 16 long cores has been undisturbed on a meter scale for the past five million years. According to a Monte Carlo model of mixing by meteoritic impact, being developed by one of us (J.R.A.), mixing of the lunar surface in times comparable to the Mn^{53} half-life (using present-day bombardment fluxes) has usually been confined to a depth of the order of centimeters. The Mn^{53} data are consistent with expectations on this model and also with evidence from other properties, such as Gd isotope anomalies. One section (60005) of the Apollo 16 drill stem was not completely full when returned from the moon. It was not known if material had been lost from this section or if the drill stem had not been completely filled and some of the material had slid up creating a gap. The Mn^{53} activities we measured give a better fit with the previous profile if $\sim$180 g of material is assumed to have been lost from section 60005.

Mn^{53} was also measured in soil sample 63321, a "permanently shadowed" soil. The high activity of Mn^{53} indicates that it was not shielded from cosmic-ray bombardment to an appreciable extent.

Various cosmogenic radionuclides were measured in Apollo 17 trench soils 78481 (0-1 cm depth) and 78421 (10-25 cm depth). Included were Fe^{55}, Al^{26}, Na^{22} and Be^{7}. These nuclides have high activities in the surface sample reflecting the intense solar flare of August 4, 1972 and decrease to the expected values for GCR bombardment in the deep sample.

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The ratio of the production rates of the radioactive Be isotopes (Be^{10}, 1.5×10^6 years; Be^7, 53 days) is of interest for lunar studies and also for broader reasons. For example, it enters into the question of the mean lifetime of "galactic" cosmic rays. Because the production rates depend similarly on the energy of the bombarding particle, and because the GCR flux appears to have been constant, the observed activity ratio should be close to the production rate ratio. The direct measurements of the French group (4) suggest a ratio close to 0.08. Radiochemical measurements (5) have given a much higher value. Correction for the new Be^{10} half-life (6) reduces the radiochemical ratio to about 0.15. Our measurements of the ratio in an Apollo 17 trench soil 78421 (10-25 cm depth), and also in the chondrite Canon City, give values close to 0.14. It appears that either the radiochemical measurements are more accurate, or the assumptions are violated. Dependence on the nature of the bombarding particle (proton or neutron) may be important.

REFERENCES

(1) Imamura, M., Finkel, R. C., and Wahlen, M., Depth Profile of ^{53}Mn in the Lunar Surface, Earth Planetary Sci. Letters 20, 107 (1973).

(2) Finkel, R. C., Wahlen, M., Arnold, J. R., Kohl, C. P., and Imamura, M., (Abstract), The Gradient of Cosmogenic Radionuclides to a Depth of 400 g/cm^2 in the Moon, Lunar Sci. Conf. IV, (J. W. Chamberlain and C. Watkins, editors), 242 (1973).

(3) Reedy, R. C. and Arnold, J. R., Interaction of Solar and Galactic Cosmic Ray Particles with the Moon, J. Geophys. Res. 77, No. 4, 537 (1972).

(4) Yiou, F., Siede, R., and Bernas, R., J. Geophys. Res. 74, 2447 (1969).

(5) Amin, B. S., Biswas, S., Lal, D., and Somayajulu, B. L. K., Radiochemical Measurements of ^{10}Be and ^{7}Be Formation Cross-Sections in Oxygen by 135 and 550 MeV Protons, Nuclear Physics, A195, 311 (1972).

(6) Yiou, F., and Raisbeck, G. M., Phys. Rev. Letters 29, 372 (1972).