MEASUREMENTS OF ^{26}Al IN APOLLO 15 DRILL CORE USING ACCELERATOR MASS SPECTROMETRY.

K. Nishiizumi, J. R. Arnold, Dept. of Chemistry, B-017, Univ. of Calif., San Diego, La Jolla, CA 92093; J. Klein, and R. Middleton, Dept. of Physics, Univ. of Pennsylvania, Philadelphia, PA 19104.

We have measured cosmic ray produced ^{26}Al ($t_{1/2}$ = 7.2x10^{5} y) in the Apollo 15 long core for study of the galactic cosmic ray (GCR) production profiles using accelerator mass spectrometry. ^{26}Al in the core was previously measured by the Battelle group [1], but some of the data include higher statistical errors (up to ∿25%) because of lower activity levels of deep core samples. As a part of a program to complete measurements of several cosmic ray produced nuclides in the long core, we have re-measured ^{26}Al.

Al was chemically separated from the soil sample. Even though highly sensitive accelerator mass spectrometry requires only a small sample size for ^{26}Al measurements, we used relatively large sample sizes (50-350 mg) to permit also measurement of ^{36}Cl and ^{10}Be in the same samples [2]. The ^{26}Al measurements were performed on the University of Pennsylvania FN tandem Van de Graaff accelerator. The 7+ charge state was selected at the 7.5 MV terminal of the tandem. We have measured ^{26}Al/^{27}Al ratios of 4x10^{-12}-2x10^{-11} (∿3-20x10^{-4} dpm ^{26}Al). In these measurements we have reached a background level $\lesssim$7x10^{-16} ^{26}Al/^{27}Al. Fig. 1 shows ^{26}Al activity in the Apollo 15 long core along with previous measurements of ^{26}Al by decay counting in the same core [1,3,4]. The experimental error of accelerator mass spectrometry is 4-7%; however, the chemical analysis is still in a preliminary stage so that the final values may be changed by ∿10%. In Fig. 1, a solid line shows the Reedy-Arnold calculated depth profile [5] normalized to our preliminary experimental values. The absolute calculated values are about 20% higher than this line. However, the shape of the profile is in good agreement with the Reedy-Arnold profile except for the deepest sample (15001,361). Our preliminary chemical analysis indicates that 15001,361 has a distinct chemical composition from the other samples. The average Al content in the core is 6.3%. On the other hand, 15001,361 contains 4.9% of Al, and also lower Ca, K and higher Fe than the other samples. If we normalize the ^{26}Al in 15001,361 to the average chemical composition and assume 21.9% Si, using the elemental production ratio calculated by Reedy-Arnold [5], the ^{26}Al content will be increased by 11% and fit nicely on the model curve.

The absolute ^{26}Al activity observed in this experiment is about 25% lower systematically than that measured by Rancitelli et al [1] by non-destructive γ-γ coincidence counting. The ^{26}Al content of one surface sample, 15006,267, is in good agreement with Fruchter et al [4] within error. Kohl [3] measured ^{26}Al in four samples by β-γ coincidence after radiochemical separation. Even though her results have a large error, the values are in fairly good agreement with this experiment. The discrepancy between nondestructive and destructive methods is not yet understood.

For comparison with ^{26}Al, the ^{53}Mn ($t_{1/2}$ = 3.7x10^{6} y) depth profile is shown in Fig. 2. Twenty-three ^{53}Mn data (below 20 g/cm^{2}) are selected from four core samples [6-9]. Using units of dpm ^{53}Mn/kg Fe, the ^{53}Mn activity can be directly compared to other samples of different chemical composition, because Fe is the only significant target element from the production of ^{53}Mn in lunar samples.

High energy GCR, 1 GeV or higher, produce secondary particles with various energies by nuclear interaction in the moon. The production rates of cosmogenic nuclides change with depth due to the changing flux of secondary particles.

Below 50 g/cm^2, the production rate decreases approximately exponentially with increasing depth. Both ^{26}Al and ^{53}Mn are low energy products, which are produced by similar nuclear reactions such as ^{27}Al(n,2n), ^{28}Si(n,p2n), (n,3n) .... and ^{54}Fe(n,pn), (n,2n), ^{56}Fe(n,3np) .... From this experiment the half-attenuation length ($d_{1/2}$) for ^{26}Al production can be calculated to be 122 g/cm^2 (150-400 g/cm^2 region) or 133 g/cm^2 (100-400 g/cm^2 region) after normalizing the data to average chemical composition. On the other hand, Imamaura et al reported that the half-attenuation length ($d_{1/2}$) for ^{53}Mn of Apollo 15 drill core was 162 g/cm^2 [6]. However, if we combine all available ^{53}Mn data, $d_{1/2}$ is calculated to be 123 g/cm^2 (150-400 g/cm^2 region) or 134 g/cm^2 (100-400) and is in excellent agreement with ^{26}Al.

Because of the small sample size now required for measurements of ^{26}Al and other long-lived radionuclides, it is now possible to resolve experimentally the production rates in important target elements, using mineral fractions of distinct composition.

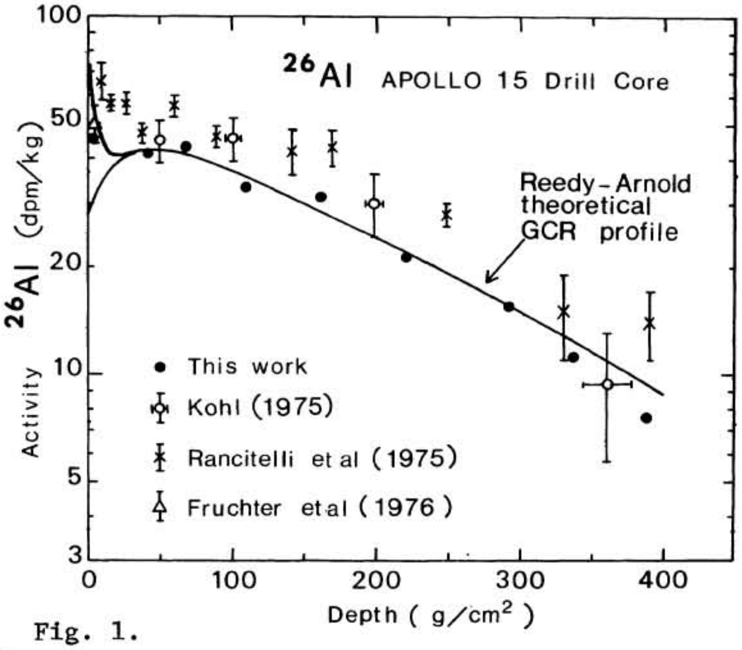

Fig. 1.

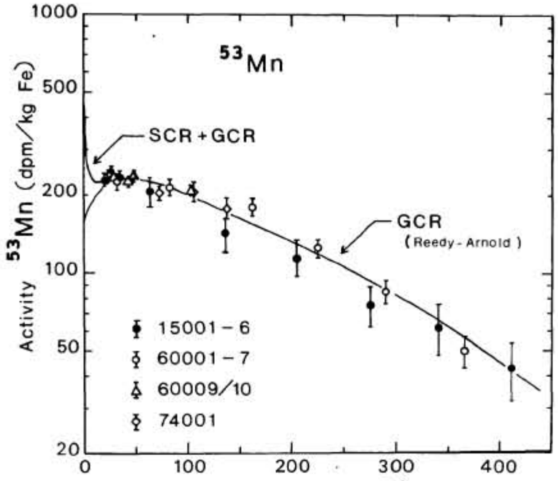

Fig. 2.

References

[1] Rancitelli L. R., et al (1975) Proc. Lunar Sci. Conf. 6th, 1891-1899.
[2] Nishiizumi K., et al (1983) Lunar Planet. Sci. XIV (this volume).
[3] Kohl C. P. (1975) Ph.D. Thesis, UCSD.
[4] Fruchter J. S., et al (1976) Proc. Lunar Sci. Conf. 7th, 27-39.
[5] Reedy, R. C. and Arnold J. R. (1972) J. Geophys. Res. 77, 537-555.
[6] Imamura M., et al (1973) Earth Planet. Sci. Lett. 20, 107-112.
[7] Imamura M., et al (1974) Proc. 5th Lunar Conf., 2093-2103.
[8] Nishiizumi K., et al (1979) Earth Planet. Sci. Lett. 44, 409-419.
[9] Murrell M. T., et al (1979) Lunar Planet. Sci. X, 881-883.