FINAL RESULTS OF COSMOGENIC NUCLIDES IN LUNAR ROCK 64455 ; K. Nishiizumi, Space Sciences Laboratory, University of California, Berkeley, CA 94720, C. P. Kohl, J. R. Arnold, Department of Chemistry, University of California, San Diego, La Jolla, CA 92037, R. C. Finkel, M. W. Caffee, CAMS, Lawrence Livermore National Lab., Livermore, CA 94551, J. Masarik, R. C. Reedy, NIS-2, Los Alamos National Lab., Los Alamos, NM 87545

Nineteen samples were ground from the glass-coated lunar rock 64455,82 with an average depth resolution of 50 µm. We report here the final detailed depth profiles of cosmogenic nuclides ^{10}Be ($t_{1/2}$=1.5 My), ^{26}Al (0.71 My), and ^{36}Cl (0.30 My) using AMS (accelerator mass spectrometry). Results show clear evidence of SCR (solar cosmic ray) effects for both ^{26}Al and ^{36}Cl. The flat ^{10}Be depth profile and its activity level are consistent with a 2 My exposure history for the rock. These highest SCR profiles, after exposure age correction, indicate that rock 64455 had a very low erosion rate and is a nearly ideal sample for the investigation of SCR history.

Concentrations of cosmic-ray-produced nuclides in lunar surface rocks provide important information on past solar activity. The most detailed study to date has been done on the highland breccia 68815, which experienced a relatively high erosion rate [1]. We extended our studies of detailed depth profiles to the Apollo 16 impact melt breccia 64455, which was collected from the northeast slope of Stone Mountain. 64455 is a small object, 5.6x4.0x2.5 cm, which is coated with a very thick (more than 2 mm) smooth glass layer. The surface that was exposed on the moon contains a high density of pits formed by micrometeorites and exhibits high solar flare track densities [2, 3]. The bottom surface is covered by a smooth glassy layer without any evidence of micrometeorite damage. A slice of sample 64455,82 (10x19x24 mm) was mounted on an X-Y-Z stage and was ground using a dental drill with measurements at each point of a 1 mm x 1 mm grid in the same manner as in previous work on 68815 [1]. Partial results measured on samples from the bottom of the rock were reported at LPSC25 [4]. In this work, we report data, including previously reported results, on 19 samples from a profile through the rock. Be, Al, and Cl were chemically separated from each sample. ^{10}Be, ^{26}Al, and ^{36}Cl were measured by AMS at LLNL [5]. The concentrations of major target elements were determined by atomic absorption spectrometry. ^{10}Be, ^{26}Al, and ^{36}Cl depth profiles in 64455,82 are shown in Figs. 1-3. The depths of our samples were measured parallel to the top surface of the rock and the deepest samples are equivalent to depths of 6 - 7 g/cm^2 (2 -2.5 cm) on the moon. The density of the glass, calculated from the grinding dimensions and the weight removed, is 2.74 g/cm^3. The ^{81}Kr exposure age is 2.01 My and the rock is associated with the South Ray cratering event (K. Marti, pers. comm.). The distribution of microcraters and the ^{10}Be activity are consistent with exposure of 64455 to cosmic rays for only 2 My.

The flat and nearly undetectable SCR contribution to the ^{10}Be profile is in good agreement with observations for 68815 [6]. Nearly all of the ^{10}Be is produced by GCR (galactic cosmic rays), even at the topmost surface. The very low amount of SCR produced ^{10}Be constrains the spectral shape, in rigidity, of the solar protons to low R_0. ^{26}Al and ^{36}Cl profiles, on the other hand, show clear SCR effects. SCR production rates are defined by SCR rigidity (R_0), flux (J), erosion rate, and sample geometry. The absence of impact pits and our earlier data [4] indicate that the rock has not tumbled within the last 2 My. Still, previous work indicates that there is not a unique solution of R_0 and J that fits the SCR-produced ^{26}Al and ^{53}Mn profiles as long as the erosion rate is unconstrained [7]. Fortunately the erosion rate of 64455 is very well characterized. The rock is completely covered by ~2 mm of smooth, glassy material. During grinding we observed that, although the top surface of the rock was damaged by micrometeorite impacts, there were visible, though small, areas that seemed not to be eroded at all. These uneroded areas on the upper surface appeared identical to the entire uneroded bottom surface.

Second, except for a very few points, there were no individual craters deeper than 1 mm. Finally, the cross-section photographs show that the thickness of the glassy layer at the top surface was equal to that of the bottom layer within 1 mm. Most likely the top glassy layer was less than 0.5 mm thinner than that on the bottom. These observations imply that the erosion rate of 64455 was much less than 0.5 mm/My. The figures illustrate Reedy-Arnold SCR (+GCR) theoretical profiles with 0 and 1 mm/My erosion rates and 2.0 My exposure age [8]. The ^{10}Be profile shows only 0 mm/My erosion rate. The ^{26}Al profile is in good agreement with R_0 = 75 MV and J(>10 MeV) = 100 p/s·cm^2 4π. The ^{36}Cl profile is reasonably well fit with the same SCR parameters. In this work, we have used a new experimentally determined excitation function for Ca(p,x)^{36}Cl [9]. Theoretical calculations of SCR produced ^{36}Cl are now in much better agreement with the measured profiles than in previous work [10]. These calculations will be further improved with measurement of the K(p,x)^{36}Cl excitation function. Small discontinuity of ^{10}Be and ^{36}Cl profiles at 5.3 g/cm^2 is due to the chemical composition change between basaltic interior and glassy surface. Our determination of R_0 is in good agreement with the R_0 obtained by ^{10}Be and noble gas studies in 68815 [6, 11].

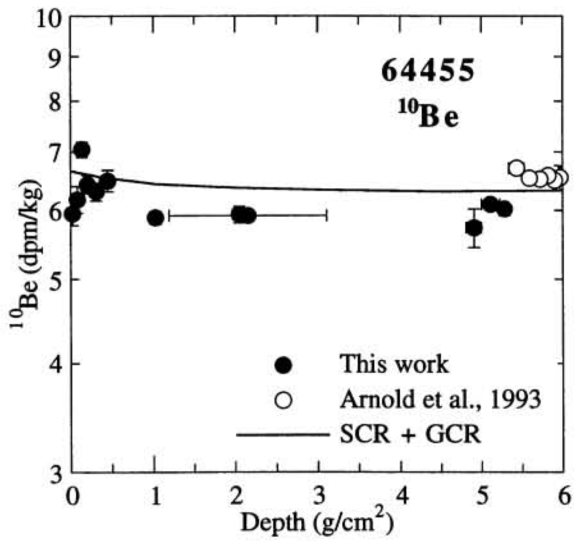

Fig. 1

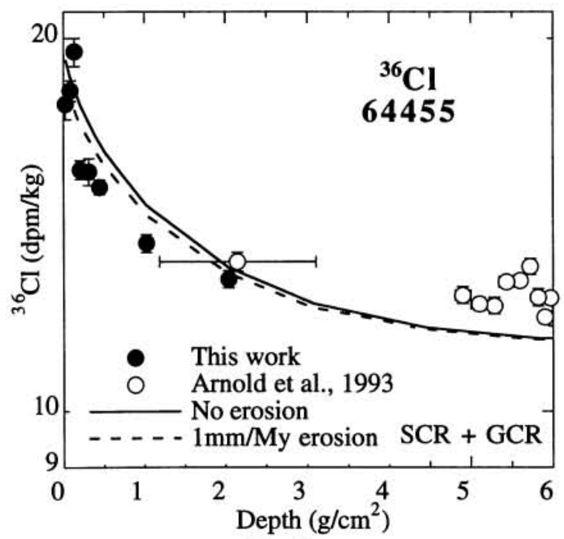

Fig. 3

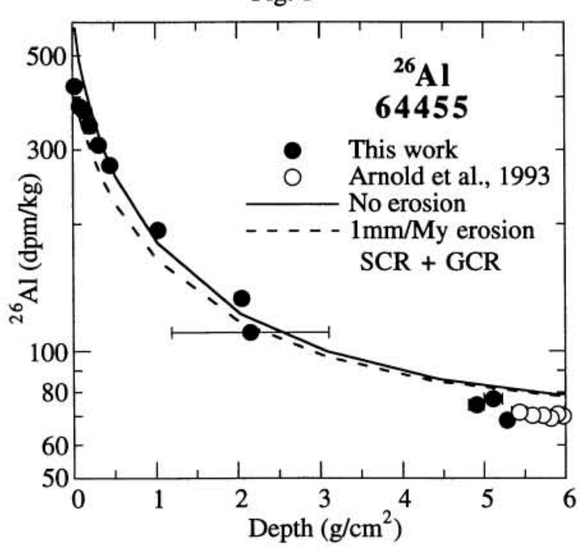

Fig 2

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