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The comparison of ^{26}Al($t_{1/2}$ = 7.05x10^5 years) and ^{53}Mn(3.7x10^6 years) depth profiles in the surfaces of three lunar rocks (12002[1], 14321[2], and 68815[3]) with the theoretical SCR(solar cosmic rays) production profiles[4] indicates that the flux of solar protons over the past five to ten million years was similar to that during the past million years and that the average SCR spectrum and flux were characterized by a rigidity R_o = 100 MV and a flux J = 70 protons/cm^2 sec (E > 10 MeV, 4π). These calculations assume 0.5 - 2.2 mm/My erosion rates for the three rocks[3,5]. In this present work, we measured ^{10}Be (1.6x10^6 years) in rock 68815 to understand the SCR production of this nuclide and to verify the SCR parameters.

Fourteen samples were separated from aliquant samples that we had used previously for ^{26}Al and ^{53}Mn measurements[3]. The samples measured were from three different zenith angles (A-45^o, B-37^o, and C-12^o) and four different depths (0 - 4 mm). The ^{10}Be measurements were carried out at the University of Tokyo tandem Van de Graaff accelerator[6]. The ^{10}Be concentrations in samples from face C are shown in the figure. The ^{10}Be results were adjusted to saturation using the ^{81}Kr-Kr exposure age (2.04 ± 0.09 My)[7]. The ^{10}Be profiles for face A and B are essentially the same as for face C, within error. The figure also shows data for two deeper samples. The ^{10}Be profiles are extremely flat for all three phases and show a very slight increase with increasing depth. This shape is in contrast to the ^{26}Al and ^{53}Mn profiles, which show sharp increases in activity toward the surface due to SCR production of these nuclides[1,2,3].

It is necessary to subtract the GCR (galactic cosmic rays) produced ^{10}Be from the observed ^{10}Be to see the SCR component. The expected GCR production profile was calculated based on the Reedy-Arnold model[4] and is shown in the figure. The original model[4] and new cross sections[8] were used for both GCR and SCR calculations. The Reedy-Arnold GCR profile fits the 68815 data very well. However, there is no sign of SCR produced ^{10}Be in this rock. The Reedy-Arnold SCR model predicts an SCR production of about 2 dpm ^{10}Be/kg in the surface layer using a flux with R_o = 100 MV and J(>10 MeV) = 70 p/cm^2 s, the values we had obtained from ^{26}Al and ^{53}Mn. There are several possible explanations for the discrepancy between the model and the data: (1) The ^{10}Be proton induced cross sections are too high, especially at the low energies that dominate the SCR flux. There are no cross section measurements below 135 MeV for protons on oxygen, which is the main target element for the production ^{10}Be in our sample. Low energy cross sections for ^{10}Be production from oxygen and other elements should be measured by AMS (accelerator mass spectrometry). (2) The average SCR flux and mean rigidity over the last two million years differed from the above values. In particular, the R_o was lower than 100 MV. The Reedy-Arnold model shows that the ^{10}Be production rates are very sensitive to changes in R_o. Although the production rates of ^{26}Al and ^{53}Mn are less sensitive at near surface depths to changes in R_o, a higher SCR flux and larger erosion rates would be required to fit those profiles if we use a lower R_o. It is known that R_o = 100MV and J = 70 p/cm^2 s are not unique parameters to fit the ^{26}Al and ^{53}Mn profiles in lunar surface rocks[5]. However, lowering the R_o conflicts with the argument by Bhandari et al.[9] who proposed a higher R_o than 100 MV. Reedy [10], using ^{81}Kr data of Yaniv et al.[11], also found a somewhat higher R_o for the period 3x10^5 years, but this is not necessarily a contradiction. (3) The calculated GCR production rates are too high near the surface due to the difficulty of estimating the Reedy-Arnold fluxes. This requires that the GCR production profile decrease about 20% from 1 g/cm^2 to the surface to obtain 2 dpm ^{10}Be/kg SCR production in this region. There is no theoretical and experimental support for such an abrupt change.

Previous ^{10}Be measurements in 12002, 14310, and 14321 using decay counting techniques[1,2] are in good agreement with the ^{10}Be activity found in 68815 by AMS measurements and show no increase at the surface. Since substantially all the ^{10}Be was produced by GCR, we can conclude that no significant changes in the GCR flux were observed during the last few million years.

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