^{26}Al MEASUREMENTS IN INDIVIDUAL LUNAR GRAINS. J. Klein, R. Middleton, Physics Dept., University of Pennsylvania, Philadelphia, Pa 19104; G. M. Raisbeck, F. Yiou and Y. Langevin, Laboratoire René Bernas, 91406 Orsay, France.

INTRODUCTION. ^{26}Al concentrations in lunar samples have been used extensively to obtain information on regolith mixing, the constancy of cosmic ray intensity, and erosion rates. Up to now such measurements were carried out by γ-ray counting techniques requiring $\gtrsim$ 1 g samples [1]. Langevin, Nishiizumi and Arnold [2] have discussed how measurements of long-lived cosmogenic nuclides in individual lunar grains can impose severe constraints on models of regolith mixing. Using a very sensitive activation technique, ^{53}Mn (half-life 3.7 m.y) has been measured in "rocklets" as small as 8 mg in weight [3]. Variations by up to a factor of 7 were observed in core 60010, which severely constrained the depositional history at that site [2]. With a half-life of 0.72 m.y., ^{26}Al has the potential for probing the history of the core sites on a shorter time scale.

ACCELERATOR MASS SPECTROMETRY MEASUREMENTS. We have recently developed an accelerator mass spectrometry technique that improves the sensitivity of ^{26}Al detection by at least 4 orders of magnitude. It is thus now possible to measure ^{26}Al in individual grains less than 1 mg in weight. In order to demonstrate the possibilities of this new technique, we have measured ^{26}Al activities in 4 individual lunar grains less than 1 mm in size. These grains were separated from the "skim" sample 69920, and thus lied at a depth of less than 1 g/cm^2. The grains were first dissolved in HF, and the Al content measured by atomic absorption spectrometry. After addition of 1 mg of Al carrier, Al was chemically extracted and transformed into Al_2O_3. Measurements of the concentration of ^{26}Al were performed with the Tandem accelerator at the U. of Pennsylvania, using a mass spectrometry procedure similar to that outlined in [4].

The results are summarized in Table 1. Uncertainties have been calculated from the number of events counted, together with an instrumental uncertainty (~ 10%). The latter, which does not depend on the sample mass, was estimated from the standard deviation of a series of measurements on a ^{26}Al enriched standard. We should emphasize that as this experiment was essentially intended as a "survey" experiment, we made no attempt to maximize the number of events detected, using less than 20 % of the available Al_2O_3. It is thus clear that our technique has the potential for measurement at similar precisions of still smaller samples, probably as little as 25 μg, which corresponds to a grain

TABLE I

	weight (μg)	^{27}Al (wgt %)	^{26}Al (events)	^{26}Al/^{27}Al (x 10^{-12})	^{26}Al (x 10^9at/g)	normalized ^{26}Al activity (dpm/kg)
1	221	17.4	193	1.36 ± 0.16	142 ± 12 %	196
2	422	14.4	237	2.37 ± 0.28	133 ± 12 %	184
3	256	17.5	64	0.75 ± 0.12	68 ± 16 %	94
4	287	17.4	214	1.31 ± 0.16	107 ± 12 %	147
blank			0	< 0.01		

size of 250 μm. Contrary to the present lower limit of 8 mg rocklets for ^{53}Mn measurements, such grains are abundant in all soil samples.

In order to compare our results with those obtained on bulk soils or model computations, it is convenient to normalize for the abundances of the major parent nuclei, ^{27}Al and ^{28}Si. If the Apollo 15 composition is taken as a standard, as in [2], the normalization factor for 69920 which is an aluminum rich soil is ~ 0.75. Once this factor is taken into account, the average over this very limited statistical sample of near surface grains (~ 155 dpm) is similar to the mean value (~ 145 dpm) measured by the Battelle group [1,5,6] in the top g/cm^2 of 7 lunar cores. Similarly, Monte-Carlo mixing models yield an expected mean value of 150 dpm [2] in the 0 - 1 g/cm^2 region (with a total SCR flux J = 70 protons/cm^2.s, and a rigidity R_o = 100 MV).

VARIATIONS BETWEEN INDIVIDUAL GRAINS AND THE HISTORY OF THE SITE. We observed variations in ^{26}Al activity by a factor of two between individual grains (see Table I). The activity can be separated into two contributions: that acquired before the grain was emplaced at its present location ("preirradiation") and that acquired in-situ. The latter is of course identical for all grains at the same depth. Thus, variations between the activities of neighbouring grains essentially stem from their different preirradiation history. When the observed variations are large, the preirradiation contribution should dominate, which indicates that emplacement of the grains occurred less than a half-life ago (0.72 m.y.). Indeed, Monte-Carlo simulations of core deposition histories [2] yield in 35 % of the cases a local deposition rate exceeding 2 g in the last m.y. (either from deposition of an ejecta blanket or, more likely, from the rapid fill-up of a small crater by ballistic downward "creep" of individual grains [7]. The in-situ contribution to the activity represents a minimum value for all individual grains (corresponding to no preirradiation). It typically lies between 30 and 60 dpm at a depth of 1 g/cm^2 for disturbed sites. For a given scenario, the distribution of activities at each depth can also be predicted, and could be compared with experimental measures on a statistically significant number of grains. It should however be noted that the grains measured in this work and even more so the 10 mg rocklets in which ^{53}Mn has been measured are larger than the mean grain size ($\lesssim$ 100 μm), and do not necessarily represent an unbiased sampling of individual grains in the soil.

CONCLUSION. ^{26}Al activities measured in individual lunar core grains can provide constraints on the in-situ contribution to the activity, and thus the recent history of the core. Measurements of ^{26}Al and ^{53}Mn activities in the same grains should enable one to discriminate between the possible scenarios leading to depth profiles similar to that observed in each core. In addition to opening up these new possibilities, the much smaller quantity of lunar material required with the accelerator mass spectrometry technique should greatly facilitate more systematic measurements of ^{26}Al profiles in cores and rocks, with improved depth resolution.

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