^{22}Na-^{26}Al CHRONOLOGY OF LUNAR SURFACE PROCESSES, Y.Yokoyama, J-L.Reyss and F.Guichard, Centre des Faibles Radioactivités, CNRS-CEA, 91190-Gif-sur-Yvette, France.

The method is based on the fact that ^{22}Na and ^{26}Al were produced on lunar surface through similar reactions, but with different half-lives: the activity of ^{22}Na ($T_{\frac{1}{2}} = 2.6$ y) in a sample can be saturated in several years, whereas the saturation takes about 2 to 3 million years for ^{26}Al ($T_{\frac{1}{2}} = 7.16 \times 10^6$ y).

Up to the present, more than 300 determinations of the pair ^{22}Na-^{26}Al have been made in many laboratories on the samples returned from Apollo 11 to 17 missions. The $^{26}Al/^{22}Na$ ratios of about 30 samples were unusually low, and attributed to the under-saturation of ^{26}Al activity, but with a certain reserve because very unusual chemical compositions could also explain the unusual $^{26}Al/^{22}Na$ ratios.

In the present work, by using the method proposed in a previous paper (1), all data available up to the present were normalized for their chemical compositions, and compared with the general distribution pattern of the pair ^{22}Na-^{26}Al, in order to see if the samples are saturated in ^{26}Al activity or not.

For Apollo 16 rocks, the results are summarized in Table 1.

Table 1. Classification of Apollo 16 rocks by their saturation (or no) in ^{26}Al activity.

Station	No. of samples				
	Total	Saturated	Unsaturated	No decidable	
LM,10	6	4 (0135,0255, 0275,0335)	1 (0315)	1 (0115)	
1	7	4 (1155,1156, 1175,1295)	1 (1195)	2 (1016,1135)	Plum Crater
2	5	1 (2235)	3 (2236,2237, 2275)	1 (2295)	Buster Crater
4,5,6	9	7 (4476,5035, 5056,5075, 5095,6035, 6075)	0	2 (5055,6095)	
8,9	7	4 (8415,8416, 9935,9955)	1 (8115)	2 (8815,8035)	South Ray Crater
11,13	15	4 (7055,7435, 7475,7955)	7 (7095,7115, 7915,7935, 7936,7937, 7975)	4 (3335,3355, 7035,7455)	North Ray Crater

The first digit (6) of the LRL number is omitted for brevity.

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A striking feature seen in Table 1 is that there are more unsaturated samples than saturated ones among the samples taken on the rim of North Ray Crater (at station 11) and also on the rim of Buster Crater (at station 2), whereas saturated samples dominate at the other stations.

North Ray Crater is a large young crater (900 to 950 m across) which was, for the first time in lunar exploration, investigated along its rim, and several samples were taken from large boulders for the age determination. The formation of North Ray Crater was dated to be 35 to 50 m.y. by rare gas and track studies (2,3). Four chips were sampled within a freshly broken spall zone surrounding a percussion cone. The depth of the spall zone (i.e., the thickness of the material removed) is approximately 2 to 3 cm (4). Since the penetration depth of solar cosmic rays (S.C.R.) is about 2 to 3 cm, just the material containing the S.C.R. products should be removed by this impact. Indeed, the three of them, 67935,67936, and 67937 were reported as unsaturated in ^{26}Al (5,6). It was confirmed by the present work. The other chip taken from the same zone (67955) was saturated. Another chip, 67915, was taken from the area about 2 m away from the spall zone,but of the same boulder (South Boulder). It was unsaturated in ^{26}Al. These facts suggest a rather complex history of this boulder. Two chips taken from a white breccia show that one is saturated (67475) and the other is probably not (67455). Among 6 small breccias studied, three (67095,67115, 67975) was unsaturated. The fact that about half of samples are unsaturated in ^{26}Al activity suggests that either this region was recently bombarded with an intense flux of relatively small (and probably secondary) projectils, or these unsaturated fragments are the same origin.

Buster Crater (90 m in diameter) is a fresh and probably primary crater (4). Six rock samples which can be associated with the Buster ejecta blanket with high confidence were collected at its rim. Five of them were measured and three was unsaturated in ^{26}Al. The dating by rare gas- and track- methods are not yet reported for these samples (a soil sample taken on the rim, 62241 shows an exposure age of 56 m.y.(3).The short exposure age (about one million years) deduced by the ^{22}Na-^{26}Al data may be the age of a post-cratering recycle event rather than the age of Buster Crater itself, because a rock sample, 62235 rested completely saturated in ^{26}Al on the rim, that is unprobable if the crater formation is so recent.

Among the Apollo 15 samples studied, the exposure history of anorthosite, 15415 seems interesting. The ^{26}Al activity of 116 $\pm$ 9 dpm/kg and $^{26}Al/^{22}Na$ ratio of 3.2 $\pm$ 0.5 (7) are apparently in the range of saturation. After the normalization for the chemical composition, the ^{26}Al activity of 68 $\pm$ 6 dpm/kg and the ^{26}Al/^{22}Na ratio of 1.8 $\pm$ 0.3 were obtained. The sample 15415 was taken from the Top of a poorly indurated breccia, 15435. From its postion, the sample 15415 should be well irradiated for S.C.R. The expected saturation ^{26}Al activity of the sample having 4 to 5 cm thickness is about 110 dpm/kg. Since the rare gas exposure age of this sample is 100 m.y. (8), the sample should be saturated for galactic cosmic rays(G.C.R.), which is estimated to be 55 dpm/kg. About a quater of the saturation for S.C.R. gives an exposure age of 0.4 $\pm$ 0.4 m.y. for S.C.R. The breccia, 15431 from which 15415 was picked up is also unsaturated and shows the same age. Keith et al.(7) suggested that the unsaturation of the very friable breccia 15431 is due to a rapid erosion. It is therefore possible that the anorthosite 15415 was incorporated in the breccia and"weathered out"very recently to the actual"come and sample me" situation on top of sample 431-435. It was very fortunate for the astronauts and the lunar sample investigators. A frible green clod, 15426 taken at the same station 7 as that of 15415 is also unsaturated, indicating also rapid erosion.

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