SOLAR COSMIC RAY PRODUCED NEON AND ARGON ISOTOPES AND PARTICLE TRACKS IN APOLLO 16 SOILS AND ROCKS AND THEIR SOLAR FLARE EXPOSURE AGES. M.N. Rao, T.R. Venkatesan, J.N. Goswami and C.M. Nautiyal, Physical Research Laboratory, Ahmedabad - 380009, India.

Last year, we have demonstrated in case of Apollo 14 and Luna 24 soils that the neon isotopic compositions obtained in step-wise heating analysis of selectively etched feldspar size separates could be quantitatively decomposed into trapped, galactic and solar cosmic ray (GCR and SCR) produced components using detailed analytical procedures developed in our laboratory (Bhai et al., 1978). At present, we extend these studies to three other soil samples 69921, 69941 and 61221 from Apollo 16 mission. Further we describe a new technique for delineating the SCR produced Ne and Ar components in lunar rocks, using an anorthositic rock 61016. As a result, these studies provide for the first time, quantitative procedures for deducing the solar flare exposure ages of these soils and rocks on lunar surface.

The soil sample 69921 (skim soil) is sieved into several size fractions and the resulting material was subjected to magnetic and density separations to obtain pure feldspars. These feldspar size separates were selectively etched to remove the surficial solar wind (Bhai et al., 1978) and then they were subjected to step-wise heating mass spectrometric investigations. In case of rock 61016, three samples were obtained representing shielding depths between about 100 microns to 2 mm (R-1 sample) 2 to 5 mm (R-2 sample) and at about 2.2 cm (R-3 sample) with reference to the exposed (zero depth) surface.

One of the aims of this work is to provide a method for calculating the SCR exposure ages for lunar rocks based on neon and argon isotope systematics. Using well documented rocks first we determine the Ne-21 and Ar-38 excesses in the surface samples where both SCR and GCR contribute to the production of these isotopic excesses (at depths around 0.5 g/cm^2 with reference to the top exposed surface of the rock, as revealed by particle track studies). The GCR produced Ne-21 and Ar-38 concentrations, measured in the deep interior samples in the same rock (with proper depth corrections for GCR) are then subtracted from the sum of SCR and GCR contents determined in the above surface sample . From the residual Ne-21 and Ar-38 excesses, the solar flare exposure ages are calculated using proper production rates.

In case of 61016, the Ar-38 excess due to GCR production in the R-3 sample (about 7 g/cm^2) is determined and the GCR exposure age of this rock is estimated to be (4.6 $\pm$ 0.6) m.y. (using composition and depth corrected Ar-38 production rate of 0.77 x 10^{-8}cc STP/g m.y.) Reedy (person.comm.) and Hohenberg et al. (1978). The GCR exposure age given by Stettler et al. (1973) for this rock is $<$7 m.y. and they attribute this high age

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due to the difficulty in resolving the small amount of GCR produced Ar-38 from the enormous amount of Ar-38 from Cl-37 (n, γ) reaction due to reactor thermal neutron irradiation of this rock. It is possible that in our case also small contribution of Ar-38 from Cl-37 (n, γ) reaction due to natural thermal neutron irradiation during the subsurface residence of this rock in lunar regolith may be present but the anomalous Ar-38 cannot be accounted by this process.

The solar flare exposure age of 61016 is deduced by comparing the trapped and cosmogenic gas contents in 61016 - R1 sample with those of R-3 sample, after applying depth-dependant production corrections. The resulting Ar-38 excess in R-1 is attributed to SCR-production. Using an Ar-38 SCR-production rate at 0.5 g/cm^2, the solar flare exposure **age** of 61016 is calculated to be (2.3 $\pm$ 0.4) m.y. which could be considered to be in rough agreement with the solar flare track exposure age of 1.5 m.y. (Bhandari et al., 1976).

In case of Ne data for 61016, the procedures employed for resolving the multicomponent noble gas mixtures are similar to those of Ar, discussed above. The GCR produced Ne-21 in case of 61016 - R3 sample is 0.342 x 10^{-8}cc STP/g and this yields a GCR age of (3.4 $\pm$ 0.8) m.y. using Ne-21 production rate given by Reedy's systematics (person. comm.) and Hohenberg et al.(1978) at 7 g/cm^2. Similarly the Ne-21 based SCR exposure age for 61016 rock is found to be (1.3 $\pm$ 0.6) m.y.

Skim soil 69921 collected at station 9 represents the top 5 mm of lunar regolith. The Ne isotopic compositions, determined for etched feldspar size-separates are decomposed into trapped, GCR and SCR components using the procedures described by Bhai et al. (1978). For this soil, based on Ne-21, the SCR exposure age is calculated to be about 120 m.y. and the GCR exposure age is found to be about 300 m.y.

REFERENCES: (1) Bhai N.B. et al.(1978), Proc. Lunar and Planet. Sci. Conf. 9th (in press). (2) Hohenberg C . et al. (1978), Proc. Lunar and Planet. Sci. Conf. 9th (in press). (3) Stettler A. et al.(1973), Proc. Lunar Sci. Conf. 4th p.1865-1888. (4) Bhandari N. et al.(1976), Proc. Lunar Sci. Conf. 7th p. 513-523.

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Table 1 : Particle track data for Apollo 16 soil samples

Sample No.	Grain-size (microns)	N_H/N	ρ_q (x $10^6 cm^{-2}$)	ρ_{min}
69921	40-90	0.83	100	12
	90-200	0.8	100	24
	200-750	0.9	100	16
69941	Bulk	0.77	75	2
61221	Bulk	0.12	6	1.4

Table 2 : Elemental and isotopic composition of neon and argon in Apollo 16 soils and rocks.

Sample	Temp.	Neon 20/22	Neon 21/22	Argon 40/36	Argon 38/36	10^{-8} cc STP/gm 22	10^{-8} cc STP/gm 36
69921,9	500°c	11.196	0.087	0.90	0.216	88.58	81.99
fines	1000°c	9.192	0.135	4.68	0.253	153.49	430.99
(>200 micron)	1600°c	3.787	0.562	9.75	0.349	6.35	145.85
	Total	9.768	0.129	5.33	0.270	248.42	658.83
61016-R1	500°c	11.618	0.039	6.47	0.188	17.87	3.86
(rock)	1600°c	11.460	0.139	5.22	0.199	2.58	69.26
	Total	11.598	0.052	5.29	0.198	20.45	73.12
61016-R3 (rock)	1600°c	3.413	0.647	526.19	0.847	0.54	0.52