RELATIVE ABUNDANCES OF SUB-IRON TO IRON NUCLEI IN LOW ENERGY (50-250 MeV/N) COSMIC RAYS AS OBSERVED IN THE SKYLAB EXPERIMENT

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ABSTRACT

A Lexan polycarbonate detector exposed on the exterior of Skylab-3 for 73 days during a solar quiet period was used to study the relative abundances of calcium to nickel ions in low energy cosmic rays of 50-250 MeV/N. The method of charge identification is based on the measurement of conelength (L) and residual range (R) of these particles in various Lexan sheets. Since more than one cone (sometimes as many as five) is observed and is measured, the charge accuracy becomes precise and accurate. The ratio of (calcium to manganese) to (iron and cobalt) obtained at three energy intervals of 50-80, 80-150, 150-250 and 50-250 MeV/N are 7.6 ± 3.8, 2.7 ± 0.8, 1.4 ± 0.6 and 3.3 ± 0.7 respectively. These data thus indicate a large increase of this ratio with decreasing energy. The origin of this strong energy dependence is not understood at present.

<u>1. Introduction</u>. The origin and propagation of low energy (<200 MeV/N) cosmic ray nuclei in source regions, interstellar space and interplanetary space could be inferred from a study of the composition and energy spectra of calcium to nickel nuclei of the same energy. For this purpose, it is assumed that iron is the most abundant element in this group in the source region. It is further assumed that most of the other elements (calcium to manganese) result from the spallation of iron nuclei in the interstellar medium. The balloon studies relate to particles of energy above 200 MeV/N. The intensity of calcium to iron ions in the vicinity of the earth are quite low, so that fairly large detector areas with long exposure times outside the earth's atmosphere are necessary to study the nuclei in the cosmic radiation. In the present work, we report the results of fluences and relative abundances of calcium to nickel ions in the energy range 50-250 MeV/N. The detector used is a plastic Lexan polycarbonate detector of collecting power $1.1 \times 10^9 \mathrm{cm}^2$sec exposed for 73 days during a solar quiet time, from 22nd Nov. 1973 1800 UT to 2nd Feb. 1974 1800 UT.

No prominent solar activity was recorded during this period. Thus low energy galactic cosmic ray nuclei could be easily observed at the Skylab orbit. The method and accuracy of charge identification used, the estimation of energy, fluences and relative abundances were described earlier (Biswas and Durgaprasad 1980). A discussion of the results will be made in the third section. Earlier results of the work were reported before (Biswas et al.,1975, Durgaprasad et al.,1979 and Ramadurai et al.,1984).

2. Experimental Procedure. A stack of 32 sheets of Lexan polycarbonate sheets, each of dimensions 20 x 8.8 x 0.025 cm, covered with aluminium foil of various thicknesses ranging from 27 mg cm^{-2} to 108 mg cm^{-2} was used to record nuclei from calcium to iron. Actual dimensions of sheets used in this analysis, is one-fourth sheet, each of dimensions 10 x4.4 x 0.025 cm. The top ten and bottom ten sheets of 32 plates were scanned for double cones and followed further till they were either brought to rest or left the stack. An area of about 25.0 cm^2 was scanned in each of the top ten sheets. The trajectories of the tracks were followed through the stack, until the end of their ranges. Tracks due to heavy nuclei entering through the top surface and stopping in the first ten sheets were used for analysis of particles of energy around 60 MeV/N, while those stopping in the bottom ten sheets were used for analysis of particles around 150 MeV/N. The measurement and analysis of track parameters were done according to standard procedures (see for details Biswas and Durgaprasad, 1980).

The charge calibration of nuclei was done as follows: For each nucleus, track conelength (L) vs residual range(R) plots were made. In such a plot, well defined groups of tracks occurring for tracks of $R < 100\mu$ were assigned to oxygen. The highest range points were ascribed to iron nuclei. Calcium to iron nuclei in passing through the stack give rise to various cones before coming to rest. Charge assignment for each cone has been made to the nearest charge $\Delta Z = 0.1$. A nucleus may produce more than one cone. In such a case, the most probable value is estimated to the nearest value of 0.1 charge accuracy ($\Delta Z/\sqrt{n}$ where n is the number of cones).

Charge values have been assigned to all the cones and later to the incident nuclei. From the residual range and charge value, the energies have been assigned using the range-energy relationship of Henke and Benton (1967).

3. Results and Discussion. In Table 1, we show the fluences of particles of charges ranging from 20 to 27 for energy intervals of 50-80, 80-150, 150-250 and 50-250 MeV/N.

Table 1 - Relative Abundances(R, A) of Ca-Co Nuclei in Skylab Experiment

Z \ E	50-80 MeV/N		80-150 MeV/N		150-250 MeV/N		50-250 MeV/N	
	N	R.A.	N	R.A.	N	R.A.	N	R.A.
20	6	1.52	3	0.37	2	0.81	11	0.67
21	1	0.25	3	0.39	0	0.00	4	0.26
22	7	1.76	8	0.97	0	0.00	15	0.91
23	5	1.27	3	0.36	1	0.33	9	0.54
24	9	2.30	7	0.77	0	0.00	16	0.90
20-24	28	7.11	24	2.86	3	1.15	55	3.29
25	2	0.48	3	0.34	1	0.21	6	0.33
20-25	30	7.59	27	3.20	4	1.35	61	3.61
26	4	1.00	10	1.00	5	1.00	19	1.00
27	0	0.00	2	0.19	0	0.00	2	0.10
26-27	4	1.00	12	1.19	5	1.00	21	1.10
25-27	6	1.48	15	1.53	6	1.21	27	1.43
Ratio								
$\frac{20-24}{25-27}$	4.8 ± 2.2		1.9 ± 0.6		1.0 ± 0.7		2.30 ± 0.5	
$\frac{20-25}{26-27}$	7.6 ± 3.8		2.7 ± 0.8		1.4 ± 0.6		3.3 ± 0.7	

The relative abundances of the particles of charges of Z = 20-24 and Z = 20-25 as well as of Z = 25-27 are shown in this table. It can be seen from this table that nuclei of even charge Z = 20, 22, 24 are as abundant, if not more than, as iron nuclei in the low energy 50-80 MeV/N range. Their abundances decrease with increasing energy. The ratios of Z = 20-25/26-27 in the energy intervals of 50-80, 80-150, 150-250 and 50-250 MeV/N are 7.6 ± 3.8, 2.7 ± 0.8, 1.4 ± 0.6 and 3.3 ± 0.7.

In Fig. 1, we plot the ratio Ca-Mn/Fe obtained in balloon and other experiments. This ratio also shows a decreasing trend towards increasing energy. This is interpreted as that the matter traversed by the Fe group nuclei is much larger, may be as nearly as five times (Ramadurai, et al.,1984) than the ones by the high energy particles.

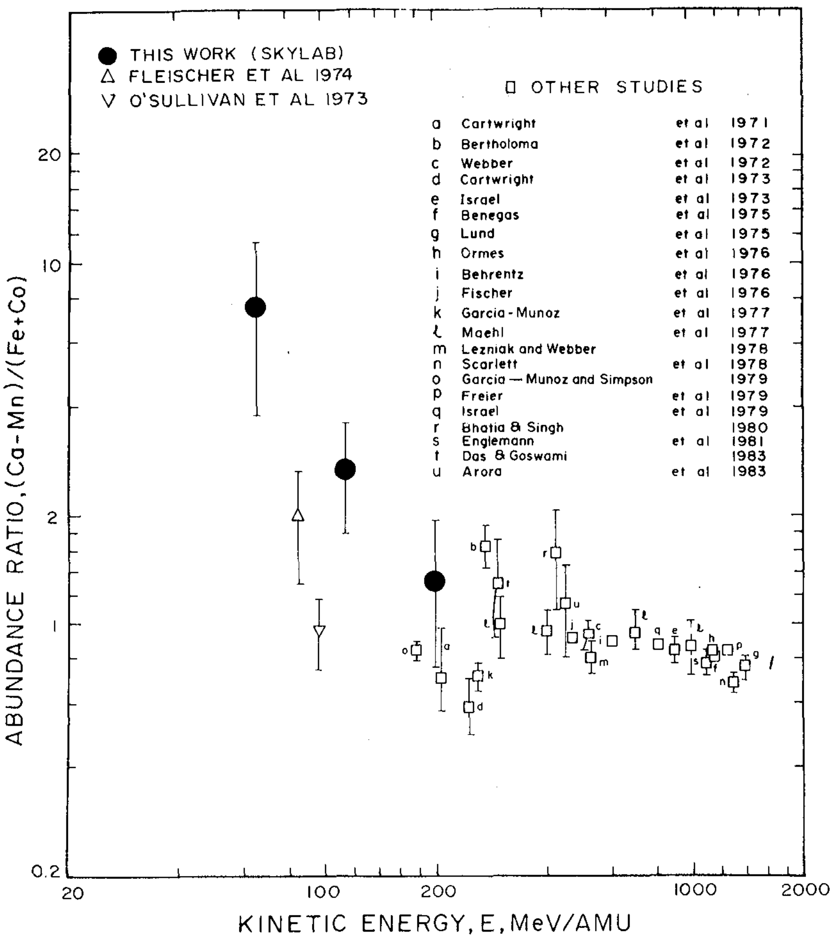

Fig. 1 Ratio of abundances of (Ca-Mn) to (Fe+Co) group as a function of energy.

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