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SATELLITE MEASUREMENTS OF THE CHEMICAL ABUNDANCES FROM Li THROUGH Ni IN GALACTIC COSMIC RAYS

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The experiment S67 on board of the ESRO TD1 satellite, designed for identification of relativistic nuclei in galactic cosmic rays, operated for 3 periods of time ranging from March 1972 until April 1974. Preliminary results were already reported by Julliot et al. (1973). In this paper improved results from a more extensive set of data are presented. The chemical abundances from Li to Ni are given which tend to confirm similar results obtained from balloon borne experiments. The ratios Be+B+N/C+O, C/O and Fe/O in different energy ranges are also presented.

1. Introduction. Improved results on the chemical composition of galactic cosmic rays were recently reported (Webber, 1972 and Juliusson, 1974). However satellite data are still scarce in the GeV region especially for elements Si to Ni. Since our last paper about our experiment aboard TD1, we have processed additional data and made a more sophisticated treatment of these data. This permits us to give with better accuracy the abundances of nuclei from Li to Ni at energies higher than 0.4 GeV/n.

2. Data analysis. A detailed description of the telescope has been made already by Julliot et al. (1973). Charge identification of individual nuclei is achieved by measurement of the energy loss in two semi-conductor detectors (SC) and of the Cerenkov light emitted in the sapphire window of a photomultiplier. The telescope is surrounded by an anticoincidence guard counter. The geometrical factor is 1.6 cm^2 ster.

A first selection criterion was applied to the raw data based on the consistency of the responses given by the solid state detectors.

. For elements Li to Si, only events registered at geomagnetic cut-off greater than 2.5 GV were considered. The Cerenkov response is then practically energy independent, ensuring an accurate charge resolution.

. For elements Si to Ni, no selection based on the geomagnetic cut-off was applied in order to improve the statistics. But in this case the charge resolution is poorer. Corrections for nuclear interactions in the telescope material (4 g/cm^2 sapphire and 2 g/cm^2 Al and Si) were applied. Since the anticoincidence detector, designed to eliminate nuclear interactions can also be triggered by δ rays, an additional correction was applied to take into account this effect which is charge and energy dependent. This was made possible by comparison of the rate of the events flagged by the anticoincidence and the estimated rate of nuclear interaction in the instrument.

The Cerenkov C and average SC $J = \frac{J_1 + J_2}{2}$ responses for each selected event are plotted on a bidimensional diagram. The diagram of low Z events with rigidity R>2.5 GV is shown on fig. 1. The distribution of response of each type of detector and the corresponding standard deviation σ are plotted on the same figure.

No further analysis is required for those elements since the charge resolution is quite good varying from 0.15 charge unit for Carbon to 0.25 charge unit for silicon. This is no more the case for elements 14 < Z < 28 as shown on fig. 2. In order to know which zone of the diagram should be ascribed to each species, a Monte Carlo method was applied.

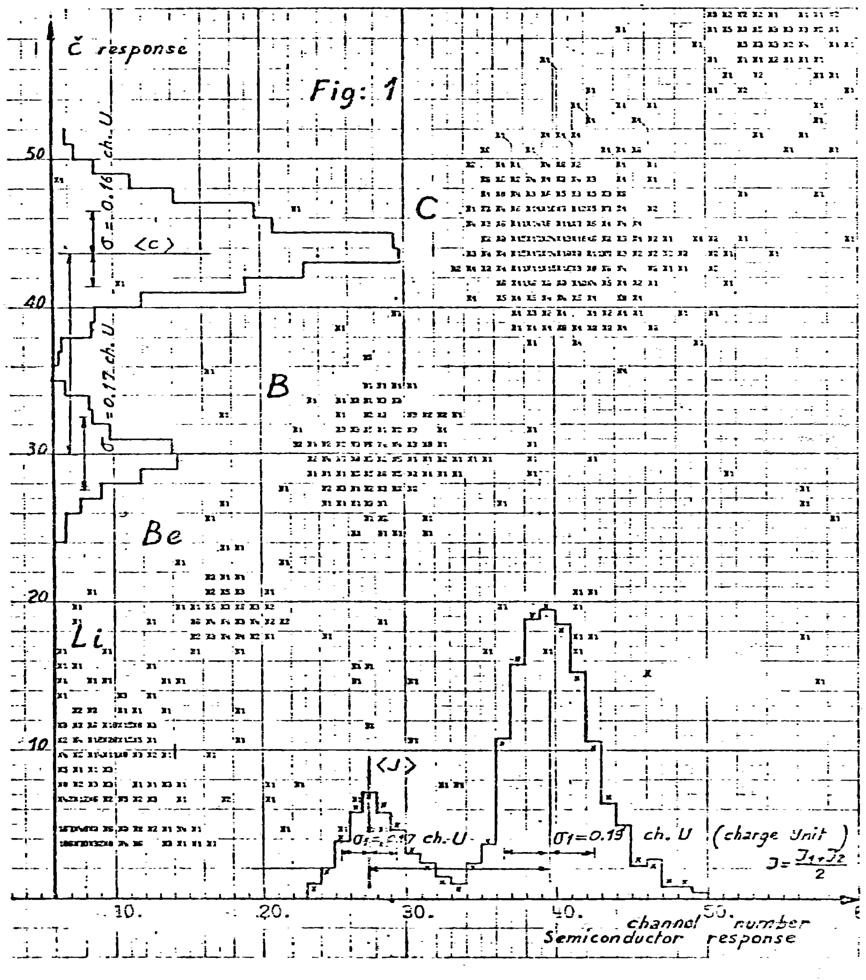

Fig. 1. Bidimensional representation of the responses of the Cerenkov and semiconductor detector from Li through Carbon.

As an example the area which is expected to enclose 90% of the events is shown for Ca. The overlap between two neighbouring elements was thus estimated and corrected for. Events expected are simulated taking into account the rigidity spectrum sampled along the orbits and the charge resolution of each detector determined at high energy for the most abundant elements.

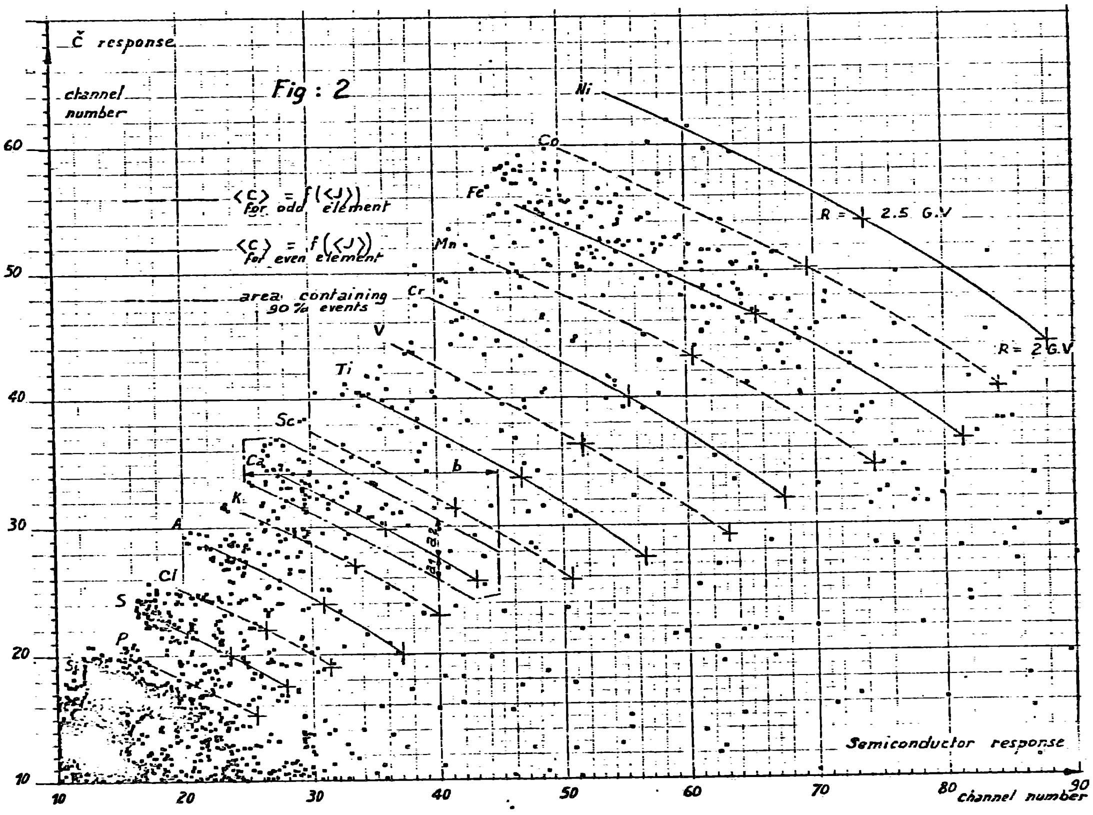

Fig. 2. Cerenkov-semiconductor matrix from Silicon through Nickel. The lines correspond to the mean Cerenkov < C > and semiconductor < J > signals for each element.
a1 and a2 are equal respectively to 1.6 and 2.5 σc, σc is the standard deviation of the Cerenkov detector response < C >.
b variation of mean S. C. response < J > from R $\geq$ 10 GV down to R = 2 GV with minor corrections taking into account standard deviation $\sigma_{S.C.}$

3. Results. Our abundance values are presented in Table I. As mentioned in the preceding section the range of energies sampled for these measurements is not exactly the same for charges $\leq$ 14 and charge > 14 : 70% of the events are in the range 0.8 to 6 GeV/n for Z $\leqslant$ 14 and in the range 0. 4 to 5 GeV/n for Z>14 .

	Raw data	Corr. data	Relative abundance				Raw data	Corr. data	Relative abundance		
			This exp.	Juliusson 1974	Webber 1972				This exp.	Juliusson 1974	Webber 1972
Li	452	520	222±18	217±13	151± 7	S	270	366	39±3.7	32.6±1.5	34 ±3
Be	242	284	100±10	107± 4	89± 5	Cl	64	56	5.5±1.7	6.2±1	4.9±1.2
B	737	866	307±21	312± 4	302± 9	A	140	199	20±2.4	16.6±1	12 ±2
C	2589	3029	1075±43	1099± 7	1121±20	K	65	71	7±1.8	9.4±1	12.5±2
N	629	739	262±16	298± 3	266± 9	Ca	203	297	29.5± 3	27.2±1.2	26 ±2.5
O	2407	2816	1000	1000	1000	Sc	46	50	5±2.2	6.2±1	3.6±1.1
F	25	29	10± 3	19.2±1.5	8± 2	Ti	130	203	20.7±2.1	17.6±1	14.5±2
Ne	414	492	174± 9	159±2.5	176± 7	V	47	63	6.3±2.4	7.4±1	4.8±1.2
Na	27	33	11±4	32.6±1.5	26± 3	Cr	97	164	16.2± 2	15 ±1.2	9.8±1.8
Mg	518	626	222±10	207± 3	205± 7	Fe	917	1298	129±10	129 ±3	108 ±5
Al	61	74	26± 5	37.8±1.5	24± 3	Ni	34	49	5±1.6	7.2±0.5	4.4±1.1
Si	402	493	175± 9	174± 3	135± 6						

Table I

All abundances values were normalised to the Oxygen abundance value found in the range of energy considered. The values obtained are compared in Table I with recent balloon results with refined corrections for atmospheric interactions (Meyer et al., 1975).

We took advantage of the rigidity cut-off variation along the orbit to study the energy dependence of some important abundance ratios.

The values obtained for the ratios Be+B+N/C+O and C/O in three rigidity cut-off intervals are presented in table II. For each rigidity interval, the most probable value of the energy sampled is given.

Cut-off Interval GV	2.5 - 4	4 - 8	> 8
Most probable energy GeV/n	1.2	2.1	6.
Be+B+N/ C+O	0.336 ± 0.04	0.337 ±0.04	0.279 ± 0.04
C/O	1.066 ± 0.07	1.035 ± 0.08	1.073 ± 0.08

Table II

The Fe/O ratio obtained in three rigidity intervals is presented in Table III.

Cut-off interval GV	0 - 2.5	2.5 - 6	> 6
Most probable energy GeV/n	0.7	1.5	4.7
Fe/O	0.116 ± 0.007	0.123 ± 0.007	0.148 ± 0.017

Table III

Due to the small range of energy sampled, the variations observed are marginal. They are significant only for the ratios Be+B+N/C+O and Fe/O and the values obtained are in good agreement with the results of Juliusson (1974).

4. Discussion. The relative abundances from this experiment are in good overall agreement with previous balloon results as seen in Table I.

The abundances of Li Be B agree well with those obtained by Juliusson (1974) but are definitely higher than those obtained by Webber (1972) taking into account the refined atmospheric corrections mentioned above. The escape length would be accordingly increased.

The relatively low chlorine abundance : Cl/Fe = 0.042 ± 0.015 is confirmed. It supports the decay of Cl^{36} (Cassé, Goret and Reignier, 1975) which implies a lower limit of $\sim 10^6$ years to the age of cosmic rays.

The low Ni abundance Ni/Fe = 0.04 ± 0.015 is consistent with the delay time between synthesis and acceleration of iron peak elements of at least a few weeks (Soutoul, Cassé and Juliusson, 1975).

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References

W.R. Webber, S.V. Damle and J. Kish, Astro. and Space Sc. 15 (1972) p. 245.

E. Juliusson, Ap. J. 191 (1974) p. 331.

C. Julliot et al., 13th Int. Conf. on Cosmic Rays, Denver, 1973, OG 5-484

M. Cassé, P. Goret and S. Regnier, 1975, this conference OG 9.3-5

A. Soutoul, M. Cassé and E. Juliusson, 1975, this conference, OG 9.1-10

J.P. Meyer, M. Cassé and N. Westergaard, 1975, to be published.