ISOTOPES OF COSMIC RAY ELEMENTS FROM NEON TO NICKEL

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Introduction. We are reporting here on the results obtained from a balloon exposure of a cosmic ray detector flown in 1977. This detector, described elsewhere, Gilman and Waddington (1975), Young (1979), measures elemental charge from scintillation and Cherenkov signals and mass from Cherenkov and total energy determined from a measure of residual range in nuclear emulsion. The charge resolution obtained ranged from 0.19 to 0.21 charge units between neon and nickel. This resolution was sufficient tc ensure that all but a few percent of the nuclei were correctly identified, even for those elements of low abundance that have neighbors with high abundances, such as Cl or Al. The mass resolution obtained for those nuclei that stopped in the emulsions ranged from 0.40 to 0.70 amu for A between 20 and 60 amu. This was not adequate to uniquely resolve neighboring mass peaks in many cases, but was adequate to draw a number of conclusions regarding many of the more abundant elements.

Neon to Aluminum. Our results on these elements will be published shortly (Freier *et al.*, 1980) and we only summarize them here. Both Ne and Mg show evidence for neutron enrichment relative to the solar system abundances. Neon relative isotopic abundances calculated at the "source" are ^{20}Ne: ^{21}Ne: ^{22}Ne = 69.0±8.9: 10.3±2.7: 20.7±3.4 compared with solar (Ne-A) values of 88.9: 0.3: 10.8. Similarly for magnesium at the source, we calculate for ^{24}Mg: ^{25}Mg: ^{26}Mg = 65±5.6: 17.5±3.6: 17.5±2.9, compared with solar values of 78.7: 10.1: 11.2. Na and Al, on the other hand, are both in good agreement with all the source abundances being ^{23}Na and ^{27}Al. The significance of the neutron enrichments, particularly if confirmed for Mg, has still to be clarified, although it may well be a consequence of a particular form of explosive Ne burning, requiring an enhanced metallicity in the source.

Silicon to Potassium. In view of the above results, it is of obvious interest to examine the next range of elements for similar effects. In particular, Si, S and Ar should have appreciable abundances and hence a good fraction of those observed should be of primary origin. We find, however, that Si and S are consistent with solar abundances, while Ar has no significant source abundances, as shown in the Table. The odd-charged elements, P, Cl and K have

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essentially no primary component and the isotopic distribution observed is quite consistent with that expected from propagation. No appreciable abundance of the clock isotope ^{35}Cl is observed, consistent with the observed absence of the longer lived ^{26}Al.

Calcium to Nickel. Iron and nickel are almost all primary in origin as is ^{40}Ca, but the heavier Ca isotopes are almost all secondary as are all the other elements in this charge range. The results for Ca are given in the Table and show an indication of an excess of ^{44}Ca at the source, which, if verified, would be another indication of high metallicity in the source. Iron is an important and difficult element that merits a full discussion. Mewaldt et al. (1980) have placed an upper limit on the abundance of ^{58}Fe of $\leq$ 6%, consistent with either a high or low metallicity. Our own results, based on an analysis of the shape of the iron peak and a comparison with the shapes of other strong mass peaks, such as that at Si, lead us to conclude the abundance of ^{58}Fe is $\leq$ 9%. Finally, Ni shows an interesting 1 to 1 ratio for ^{58}Ni to ^{60}Ni, unlike the 2.5:1 ratio in solar system material. This implies an intermediate metallicity, inconsistent with either the high or low values suggested above; see Mewaldt et al. (1980). It also suggests that ^{57}Ni may not be produced as abundantly as expected, casting doubt on the significance of a very low abundance of Co in the cosmic rays.

Table. Percentage source and solar system abundances (SS)

	Source	SS		Source	SS
^{28}Si	86±7	92.2	^{40}Ca	72±14	97
^{29}Si	14±4	4.7	^{44}Ca	23±7	2.07
^{30}Si	0±3	3.1	^{46}Ca	5±3	.003
Si/Fe	1.26	1.20	Ca/Fe	.079	.087
^{32}S	88±19	95.0	^{54}Fe	0±3	5.8
^{33}S	2.5±2	0.8	^{55}Fe	0±5	0
^{34}S	7±3	4.2	^{56}Fe	72±9	91.7
^{36}S	2.3±2.3	.01	^{57}Fe	$\leq$19±6	2.2
S/Fe	0.168	0.169	^{58}Fe	$\leq$ 9±4	0.3
^{36}Ar	100±20	84.2	$^{56,57}Ni$	3.4±3	0
Ar/Fe	.016	.048	$^{58,59}Ni$	48±15	67.9
			$^{60,61}Ni$	45±15	27.39
			$^{62,63}Ni$	3±3	3.66
			Ni/Fe	.057	.058

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