THE CASE OF 20 AND 50 PROTONS

Ca, with 20 protons, has 5 isotopes, which is not too unusual for this region of the periodic table. The difference in mass number between its heaviest and lightest isotope is 8 mass numbers, which is quite outstanding, since this difference does not exceed 4 for elements in this neighborhood.

Sn, Z = 50, has, without exception, the greatest number of isotopes of any element, namely 10. Its heaviest and lightest nuclei differ by 12 neutrons. Such a spread of isotopes is encountered in only one other case, namely at Xe, where it may be attributed to the stability of Xe^{136} with 82 neutrons.

Incidentally, the next largest difference, 10, in mass number between heaviest and lightest isotope of an element, is encountered once only, in samarium, and may be attributed to the unusual stability of Sm^{144} with 82 neutrons.

THE CASE OF 82 PROTONS AND 126 NEUTRONS

Lead, Z = 82, is the end of all radioactive chains. It has only 4 stable isotopes, of which the heaviest one, Pb^{208}, has 126 neutrons.

Evidence for the stability of 82 protons and 126 neutrons can be obtained from the energies of radioactive decay. If, for constant value of the charge of the resultant nucleus the energies of α decay are plotted against the neutron number of the resultant nucleus, a sharp dip in energy is encountered when N drops below 126, indicating a larger binding energy for the 126th neutron. From these considerations, Elsasser[1] estimates the discontinuity in neutron binding energy at 126 neutrons to be 2.2 Mev or larger, the discontinuity in proton binding energy at Z = 82 to be 1.6 Mev. These relations have been studied in detail by A. Berthelot.[3]

ABSOLUTE ABUNDANCE

Absolute abundances are notoriously uncertain. The best estimates are probably contained in the book by Goldschmidt,[4] Figure 1, page 117, or Figure 2, page 118. For the light elements, the abundances vary erratically; for heavy elements, from about Se on, they remain roughly constant. In the region of heavy elements, the following abundance peaks are apparent—at Zr (50 neutrons), at Sn (50 protons); at Ba (82 neutrons), at W and at lead (82 protons or 126 neutrons). In Goldschmidt's plot of abundance against neutron number, page 127, the Zr and Ba peaks are seen to be at neutron number 50 and 82 and become much more pronounced and narrow, whereas the peak at Sn, Z = 50, as well as the peak at W, become much broader than in the plot against Z.

Most trustworthy among absolute abundances is probably the relative abundance of the rare earths, since these are not likely to have been appreciably fractionated in the earth's crust. The case of 82 neutrons falls just on the edge of this region. According to Goldschmidt's data on the abundance of rare earths in eruptive rocks (which are probably more reliable chemical analyses than the abundance in meteorites), the abundances of rare earths heavier than samarium are reasonably constant, except that the elements with even Z are about 5.7 times as abundant as those with odd Z. Of the lighter rare earths, however, praseodymium, (N = 82), is about 8 times, and lanthanum (N = 82), about 27 times as abundant as the average of the odd rare earth with greater Z. Nd, with a 26% isotopic composition of isotopes with N = 82, is about 5 times as abundant; cerium, with 90% composition of isotopes with N = 82 is about 12 times as abundant as the average of the heavier even rare earths. In the composition of meteors the differences are not quite as striking, but still very pronounced.