Long-Lived Radio Cobalt Isotopes

We have already reported[1] confirmation of a long-lived radio-cobalt produced by irradiating cobalt with neutrons. This effect was first observed by Sampson, Ridenour and Bleakney,[2] who gave the half-life as over a year. Recently Risser[3] has quoted the figure as 2.0 ± 0.5 years, after observing the decay for six weeks.

We have been following chemically separated radio-cobalt samples, obtained from neutron and from deuteron bombardment of C.P. cobalt oxide, for about a year and find the decay curves not to be simple exponentials. For the first 100 days the rate of decay does indeed suggest a 2-year period, but for the remaining interval the half-life is much longer, appearing to be about 10 years or more. When this is well established, subtraction will show the initial decay to be due to a much weaker activity of the order of several months half-life. A somewhat older deuteron-activated sample of cobalt oxide, but without chemical analysis, bears out these observations, as may be seen in Fig. 1.

Absorption curves in Al and in Pb of the 10-year cobalt (chemically separated from a Co+D bombardment) are shown in Fig. 2. No appreciable difference is found in such curves taken a year apart, indicating that the shorter period is in fact very weak. The gamma-ray is reduced to half-value by 12 grams per cm^2 Pb, indicating an energy of about 1.3 Mev. The range of the electrons is not well defined and may indicate two electron groups with ranges of 0.03 to 0.06 and perhaps 0.3 gram per cm^2 Al, respectively. These absorption measurements are in substantial agreement with those of Risser.[3]

It is not yet certain that the shorter-lived and low intensity radio-cobalt is actually formed from cobalt; slight traces of iron or nickel in the cobalt oxide could yield radio-cobalt with a period of this magnitude, as we have shown

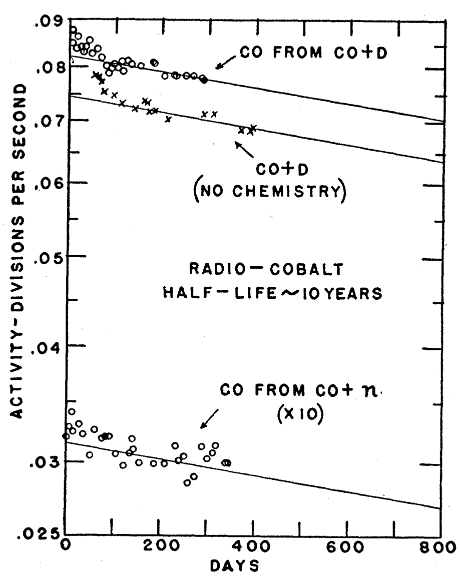

FIG. 1. Activity of cobalt.

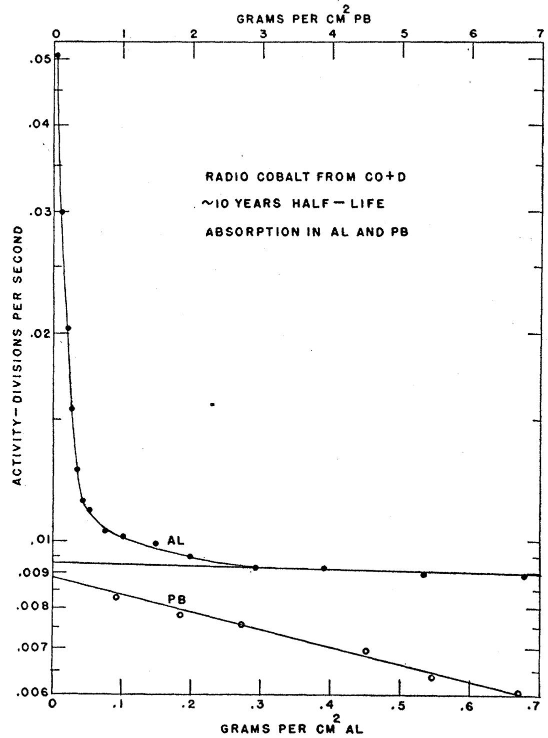

FIG. 2. Absorption in lead and aluminum of radiation from cobalt.

from bombardments of iron with deuterons[1] and of nickel with neutrons and deuterons.[4]

Perrier, Santangelo and Segrè[5] have reported radio-cobalts of half-lives about 1 month and about 215 days obtained from copper filings from the deflector plate of the Berkeley cyclotron, the decay having been followed for about a year. Since cobalt should not be formed from copper by deuterons, they suggest that stray neutrons on copper have produced Co^{60} and Co^{62} by the (n, α) reaction. However, they were unable to confirm this, after irradiating copper for several weeks with the neutrons from 500 mC of Rn+Be. We have looked for such an activity by examining borings taken from beneath the surface of the copper utility target holder of the cyclotron after it had received the neutrons from at least 1000 microampere hours of 4 to 6 Mev deuterons on Be, and must also report negative results. We would like to suggest that iron sputters onto the deflecting plate from the iron lid and base plate of the cyclotron vacuum tank (marks of this are always evident) and hence that Perrier *et al.* are really observing the two cobalt periods that are known[1] to be produced from the deuteron bombardment of iron. In fact, their curve is identical with ours (for Co from Fe+D) for about a year; beyond that, our half-life has lengthened somewhat and there is no assurance that it will not continue to increase even more, with consequent lengthening of the period of the shorter lived component.

The bombardment of iron for 1 hour with 100 microamperes of 3.2 Mev protons yields a long-lived activity (as well as the 18-hour Co^{55}) and a slow decay is also found after activating manganese for 1 hour with 0.1 microampere of alpha-particles at 16 Mev. The present apparent half-lives of these samples are about 180 days and 80 days, respectively. But since these activities, as well as those of the above-mentioned radio-cobalts from the activated nickel[4] and iron, apparently have not yet settled down to a single rate of decay, it seems premature to attempt to analyze them into component periods which might be identified with each other or to speculate on their isotopic origin.

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April 29, 1938.

[1] Livingood, Seaborg and Fairbrother, Phys. Rev. **52**, 135 (1937).
[2] Sampson, Ridenour and Bleakney, Phys. Rev. **50**, 382 (1936).
[3] Risser, Phys. Rev. **52**, 768 (1937).
[4] Livingood and Seaborg, Phys. Rev. **53**, 765 (1938).
[5] Perrier, Santangelo and Segrè, Phys. Rev. **53**, 104 (1938).

Erratum: Ferromagnetic Anisotropy of Nickel-Iron Crystals at Various Temperatures

I wish to take this opportunity to point out and correct a mistake in the discussion of "Results" in my paper in the *Physical Review*.[1]

The fourth sentence in this section of the paper which now reads "The most unexpected result is that the direction for easiest magnetization changes not from <111> to <100> as iron increases beyond a critical amount, but from <111> to <110>," should read "The most unexpected result is that the direction for most difficult magnetization changes not from <100> to <111> as iron increases beyond a critical amount, but from <100> to <110.>"

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[1] Phys. Rev. **50**, 1178–1181 (1936).

On the Penetrating Component of the Cosmic Radiation

In a previous work[1] we have pointed out, that at a great depth (about 800 meters water equivalent) the ionizing part of the cosmic radiation consisted only of shower particles produced by a nonionizing radiation. We emphasized also our view, that these penetrating nonionizing rays are neutrinos, created somewhere in the atmosphere or in the earth, in multiple shower processes (as described by Heisenberg[2]). In a recent article V. C. Wilson[3] comes in consequence of his measurements to the same conclusion, but he even believes that at great depth successively two kinds of radiation are perceivable "heavy electrons" and "neutrinos." In Fig. 1 we can see the intensity variation of cosmic-ray showers from 4000 m above sea level down to 1000 m water equivalent depth. The points represent experimental data of different authors.[1,3,4] We may notice bends on the curve 2: at about 10–20 m and a second somewhere near 250 m water equivalent, but the place of the second bend cannot be located with great accuracy. The first bend may perhaps signify that from this depth onward the majority of the observed showers are produced by heavy electrons and from 250 m on by neutrinos. This interpretation is also in best agreement with the results arrived at by V. C. Wilson.

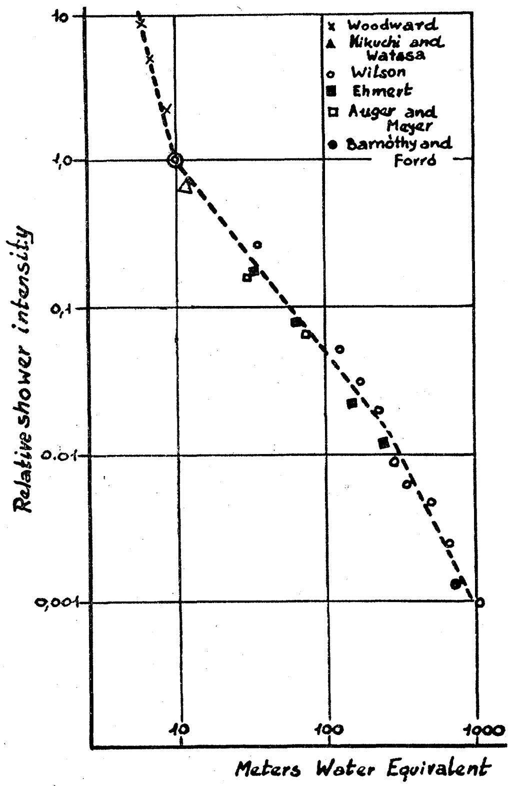

FIG. 1. Relative intensity of shower *versus* depth from the top of the atmosphere plotted on a logarithmic scale. All intensities, observed by different authors, were put equal to 1 at sea level.

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[1] J. Barnóthy and M. Forró, Zeits. f. Physik **104**, 744 (1937).
[2] W. Heisenberg, Zeits. f. Physik **101**, 533 (1936).
[3] V. C. Wilson, Phys. Rev. **53**, 337 (1938).
[4] R. H. Woodward, Phys. Rev. **49**, 711 (1936); S. Kikuchi and J. Watasa, Proc. Phys. Math. Soc. Japan **18**, 210 (1936); P. Auger and G. Meyer, Comptes rendus **204**, 572 (1937); A. Ehmert, Zeits. f. Physik **106**, 751 (1937).