off. An increase of dose to 600 μg daily brought about further suppression. Noteworthy is the rapidity and uniformity with which the uptakes went back to their original levels or higher when iodide was discontinued. Figure 1 is representative of the results obtained in the other children except that the degree of suppression achieved was in direct correlation with the dose of iodide and size of the child. This relation is shown graphically in Fig. 2, where the I^{131} uptake after the second week of iodide administration is represented on the ordinate. Each dot represents the response of one child. It is evident that the maximum suppression is achieved with a dose of iodide of from 1500 to 2000 $\mu g/m^2$ per day. On this dose the minimum uptake of about 5 percent was reached in 2 to 4 weeks, at which point the neck and thigh radioactivity counts were approximately the same and the neck-to-thigh ratio was 1. Even after these higher doses, as soon as the iodide was stopped, the uptakes rebounded to near pretreatment levels. Increasing the dose to over 2000 $\mu g/m^2$ per day did not increase either the rate or the degree of suppression.

When a single dose of 1500 $\mu g/m^2$ was given an hour before the tracer dose, the uptakes 24 hours later fell to about 50 percent of their control values. The dose of iodide used in these investigations did not cause any toxic effects.

The following correlation of ideas emerged from the data obtained in this study. First, it became apparent that the response with respect to suppression of uptake of radioactive iodine is related to the magnitude of the dose of stable iodide. In turn, this dose was related to the size of the individual regardless of age. For this reason, we employed the surface area of the body as an index of the thyroid mass. Perhaps in the normal population correlation with age might be possible, but in the group investigated age loses its significance since mentally defective children are usually physically retarded. It was found that the minimal effective dose of iodide required to suppress completely the uptake of radioactive iodine by the normal human thyroid was 1500 to 2000 $\mu g/m^2$ per day. Thus for the adult, the minimal effective daily dose of iodide becomes 3 to 4 mg and for children 1 to 2 mg. Suppression of uptake begins almost immediately after the oral administration of these larger doses and by 24 hours, a 50-percent reduction is achieved. Subsequently, there is a gradual decrease in uptake to a minimal value of 5 percent in 4 to 6 weeks.

There was no relation in most of the individuals between the degree of suppression and the radioactive iodine uptake before treatment.

A surprising finding was the rebound of uptake within a week after iodide administration was stopped. In some instances, these uptakes were even higher in subsequent weeks, and there is a suggestion that after very small doses of iodide (100 μg), the uptakes reached were higher than obtained before administration of iodide. This indicates the necessity for continued daily administration of iodide in adequate (1500 to 2000 $\mu g/m^2$) doses for the protection of individuals exposed to possible contamination with I^{131}.

Toxic effects of iodide from doses of this order of magnitude given over relatively short periods of time are extremely unlikely. We know from clinical experience (*3*) that toxic effects of iodide are not observed with doses of 100 mg of iodide per day given to children over a course of years. Iodide goiter has been observed (*4*) to occur only following daily doses of several hundred milligrams of iodide administered for years, a fact which indicates that it is desirable to have a ceiling on the doses used for prophylactic purposes (*5*).

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5. This study was sponsored by the U.S. Public Health Service, Division of Radiological Health, Research Branch. We are indebted to Dr. John B. Stanbury for his generous help and wise counsel. Completion of the studies would have been impossible without the assistance of Miss Katherine Davey and the full cooperation of the staff of the Wrentham State Hospital of which Karel de Haas is the clinical medical director.

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Two Meteorites of Unusually Short Cosmic-Ray Exposure Age

Abstract. The chondrites Cold Bokkeveld and Farmington seem to have reached the earth less than 200,000 years after they left their parent body. Either these meteorites came from the moon, or, more probably, the collision life times of interplanetary objects are occasionally much shorter than has been assumed heretofore.

Eberhardt (*1*), Stauffer (*2*), and Zähringer (*3, 4*) have recently measured the noble-gas content of over 50 stony meteorites. A plot of the Ne^{21} produced by cosmic rays in these meteorites, corrected for any primordial Ne^{21} present, is shown in Fig. 1. If differences in shielding, which are not likely to exceed 30 percent, are neglected, the Ne^{21} content should be proportional to the period of time during which the meteorite was freely exposed to cosmic rays—that is, to the "cosmic-ray exposure age" of the meteorite. The production rate of Ne^{21} in chondrites has been variously estimated as 2.5, 4, and 5×10^{-9} cm^3 (STP)/g per million years (*1, 2, 5*). Taking the latter value, we can convert the Ne^{21} contents shown in Fig. 1 to the exposure ages indicated on the abscissa. These values are probably accurate to within a factor of two.

Two meteorites, Cold Bokkeveld and Farmington, have much lower Ne^{21} contents than any of the others. This may well indicate an exceptionally short exposure age, but since both meteorites are rather dark in color, an alternate explanation would be that they lost gas because of solar heating at perihelion (*6*). To decide between these alternatives, I measured the Al^{26} content of two samples of these meteorites, weighing 44 and 84.5 grams, respectively (*7*), by γ-γ coincidence spectrometry, using instruments and nondestructive techniques described previously (*8*).

If the true exposure age of these meteorites were long compared with the half-life of Al^{26} (740,000 years), then their Al^{26} content should approach the saturation value, N_∞, of about 54 disintegrations per minute per kilogram, which is typical of chondrites (*9*). (In the case of Cold Bokkeveld, only about 39 dpm/kg would be expected, owing to its lower Si and Al content.) For shorter exposure ages, on the other hand, a value lying somewhere on the growth curve in Fig. 2 would be expected, possibly as low as 15 to 20 percent of N_∞, if the short age indicated by the Ne^{21} content is correct.

The Al^{26} content of both the Cold Bokkeveld and Farmington chondrites is indeed very low (0.6 ± 3.0 and 3.6 ± 2.5 dpm/kg, respectively). Their Al^{26} content thus contrasts strikingly with the high and nearly constant Al^{26} content (about 54 dpm/kg) of the 20-odd chondrites measured so far (*9*). This does indeed suggest an age as short as 1 to 2×10^5 years (Fig. 2). The possibility cannot be ruled out entirely that the low Al^{26} content is due to shielding. But if the low Al^{26} content is due to shielding, the meteorites' masses before they entered the atmosphere would have had to be at least 5 tons, which is considerably more than the masses actually recovered (about 4 kg and 85 kg, respectively). Such a large loss in mass during passage through the atmosphere is contrary to all previous experience. Moreover, meteoroids of this size would produce far more spectacular fall phenomena than those actually observed.

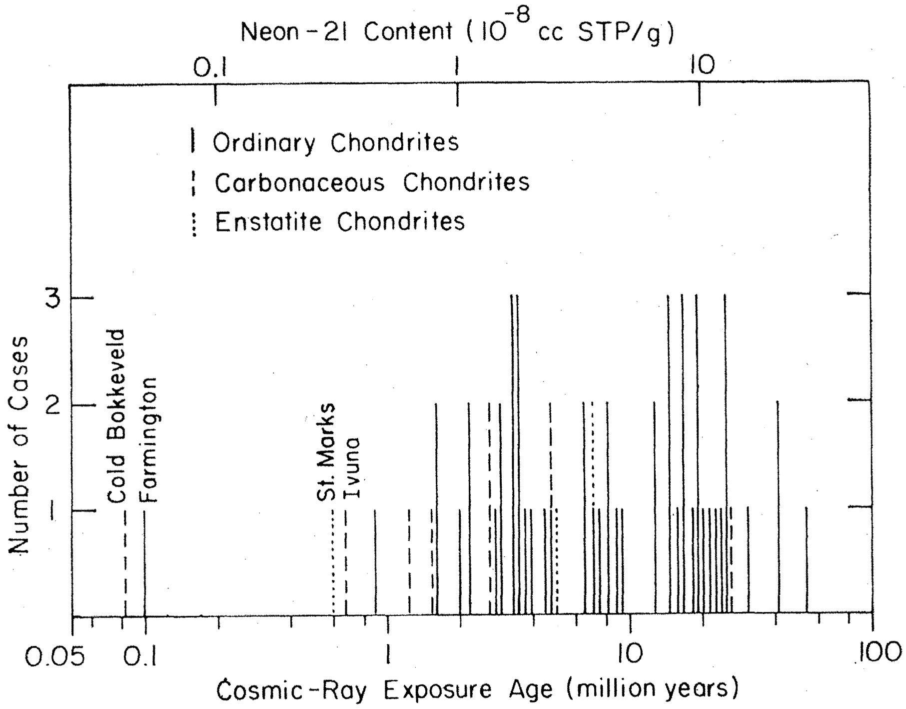

Fig. 1. Neon-21 content and cosmic-ray exposure ages of chondrites (after *1–3*). The ages were calculated for an assumed Ne^{21} production rate of 5×10^{-9} cm^3 (STP)/g per million years, neglecting differences in shielding and chemical composition. Note short ages of Cold Bokkeveld and Farmington.

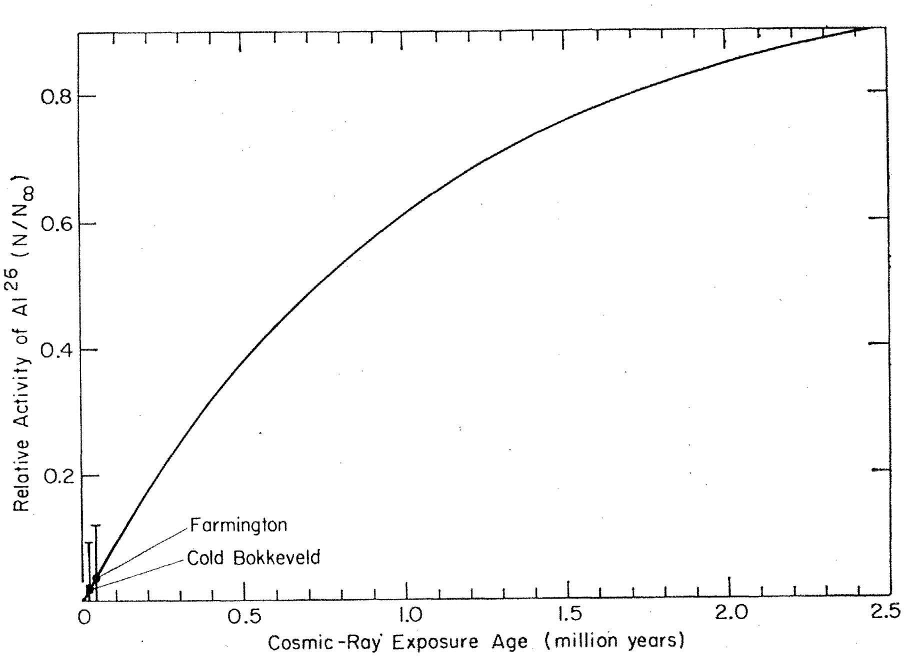

Fig. 2. Aluminum-26 content as a function of exposure age. Low activity level in Cold Bokkeveld and Farmington again implies a very short exposure age.

As a check, the Al^{26} content of the Murray carbonaceous chondrite was determined on a 43-g sample (*10*). By correcting the observed positron activity for a small amount of residual Na^{22}, I found that the Al^{26} activity in this chondrite was 41 ± 4 dpm/kg, which agrees well with the value of 39 dpm/kg predicted from its chemical composition.

Thus it appears that both meteorites arrived on the earth less than 200,000 years after they left their parent body. This transit time is remarkably short, at least when viewed against previous estimates. As pointed out by Öpik (*11*) and reemphasized by Urey (*12*), the collision lifetimes for objects coming from the asteroidal belt should be of the order of 10^8 to 10^9 years, whereas objects in earth-like orbits (as might be expected for objects coming from the moon) should have lifetimes of the order of 10^6 to 10^7 years. Urey (*12*) has proposed on these grounds that the iron meteorites (with exposure ages of 10^8 to 10^9 years) come from the asteroidal belt, whereas the chondrites (with exposure ages near 2×10^7 years) come from the moon. I have never been enthusiastic about this suggestion, but now that two chondrites with exposure ages 1/100 as long as 2×10^7 years have turned up, the problem has become 100 times more vexing. Carbonaceous chondrites are rare, and since they tend to have shorter exposure ages than ordinary chondrites (Fig. 1), a lunar origin is not at all implausible. Farmington, on the other hand, is a chondrite like any other, though it has shorter K-Ar and U-He ages (0.83 and 0.71×10^9 years) (*4*) and shows stronger evidence of shock than most ordinary chondrites. If Farmington comes from the moon, then they all do. While one cannot rule out this possibility altogether, it is not in particularly good accord with the evidence.

1) The Pribram chondrite, the only one for which a well-determined orbit is available, has an aphelion of 4.1 astronomical units (*13*). The most straightforward interpretation is that it came from the asteroidal belt rather than from the moon.

2) An analysis of the apparent radi-

ants of 116 stony meteorites (*14*) and the diurnal variation in the frequency of fall show that these meteorites approached the earth with an average geocentric velocity of 8 km/sec. Such a high velocity is much more consistent with an asteroidal than with a lunar origin.

3) If the chondrites and achondrites, comprising together some 90 percent of all known falls, were ejected from the moon by the impact of other meteorites coming from the asteroidal belt, then the efficiency of ejection of lunar matter and its capture by the earth must be great enough to cause lunar meteorites to predominate over asteroidal meteorites. Let A represent the flux of "lunar" stony meteorites at the earth and B the flux of "asteroidal" (iron and stony-iron) meteorites at the earth or moon. From the observed frequencies of fall,

$$A/B \approx 10.$$

Let C represent the ratio of capture cross sections of the earth and moon. If a factor of 3 is allowed for the larger gravitational field of the earth,

$$C = 3(6372/1738)^2 = 40.$$

Let D represent the ratio of mass of ejecta ($v \geqq 2.3$ km/sec) to mass of projectile. From Bjork's analysis of the Arizona Meteor Crater (*15*), this ratio appears to be

$$\backsim 1 \times 10^6 \text{ tons}/7.1 \times 10^4 \text{ tons} \approx 14$$

for a projectile velocity as high as 30 km/sec. Let E represent the capture probability of lunar ejecta by the earth. Obviously,

$$A/B = DE/C$$

and

$$E = AC/BD = 30$$

While this figure is rather approximate, owing to the uncertainty in D, it is quite unreasonable that the collection efficiency of lunar ejecta by the earth should be *greater than unity*. Although this difficulty can be circumvented by assuming that lunar meteorites are ejected by comet impacts (*16*). I consider it more likely that the meteorites come from the asteroidal belt. But this leaves the question unanswered why the Cold Bokkeveld, Farmington, and even some iron meteorites (for example, Braunau, exposure age 8×10^6 years) (*17*) got to the earth in so short a time. Perhaps these meteorites are the forerunners of the debris from a very large collision about 200,000 years ago. Perhaps they are freaks in the sense that they happened to be thrown into very unusual orbits of short collision lifetime. But the prevalence of short ages among the chondrites raises the possibility that the collision lifetimes of interplanetary objects are generally shorter than has heretofore been estimated. However, a puzzle remains: if neither the tektites (*18*) nor the stony meteorites came from the moon, what objects then do come from the moon? (*19*). Perhaps the next Ranger shot will provide some clues (*20*).

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20. My work was supported in part by the U.S. Atomic Energy Commission. I am indebted to Leonard Levin for doing most of the counting.

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Fission Product Radioactivity in the North Polar Stratosphere

Abstract. Balloon-borne gamma-ray detection equipment flown from Thule, Greenland, during April 1962, indicated that there was considerable radioactivity above 70,000 feet. Gamma-ray spectra obtained indicated the source of much of the activity to be the Soviet nuclear tests in late 1961.

Five balloon flights were made at Thule Air Force Base, Greenland (lat. 77°N, long. 69°W), between 8 and 14 April 1962, for the purpose of locating and measuring fission-product radioactivity in the upper atmosphere (*1*). The balloons were manufactured by the Darex Corporation (*2*). Aluminum foil attached to the balloon train provided a radar reflector, and the altitude was determined by radar tracking. The entire system operated satisfactorily in four flights to altitudes in excess of 80,000 ft. In the fifth case (flight No. 4) tracking difficulties precluded obtaining useful data above 50,000 ft. Each balloon carried γ-ray detection circuitry, transmitter, and battery supply, the total payload weighing less than 8 lb. The detector consisted of a cylindrical CsI(Tl) crystal, 1¼ inches in diameter by 1¾ inches long, enclosed in scintillating plastic, forming a phoswich for the detection of γ-rays and the rejection of events due to the passage of charged particles through the system. By this means it was possible to reject charged particles of energy greater than 0.25 Mev. Events due to the interaction of γ-rays in the CsI crystal were transmitted by a standard U.S. Weather Bureau radiosonde transmitter operating on 1680 Mcy/sec, the carrier of which was turned off for a time interval proportional to the pulse height in CsI. The signal was received by a Signal Corps GMD-1A receiver-tracking antenna system, and the time-modulated signal was then converted back into pulse-amplitude form. Pulse-height data were collected in a multichannel analyzer and on magnetic tape. The latter mode of data collection possesses considerable advantage in that it is possible to examine the spectrum pertaining between two altitude limits by playing the appropriate portion of the tape into a multichannel analyzer. The tape recording speed is constant. Hence the time elapsed from balloon launch provides a measure of altitude. The gross counting rate was recorded on a strip chart, and the total count was tallied on a scaler.

The vertical distribution of γ-radiation in the atmosphere was essentially the same for all flights, but differed in the magnitude of counting rate observed. The counting rate in the energy region of 0.25 to 4.0 Mev, as a function of altitude, obtained on flight No. 2 (9 April 1962) is shown in Fig. 1. The change in count rate with altitude for γ-radiation due to natural sources over the same energy range was determined with a similar device in flights at Fort Churchill, Canada, in late 1961. Corrections were made for fission activity which appeared as discrete layers of radioactivity on the Fort Churchill flights. The same intensity distribution from