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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19. This paradox was first brought to my attention by Prof. H. E. Suess.
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

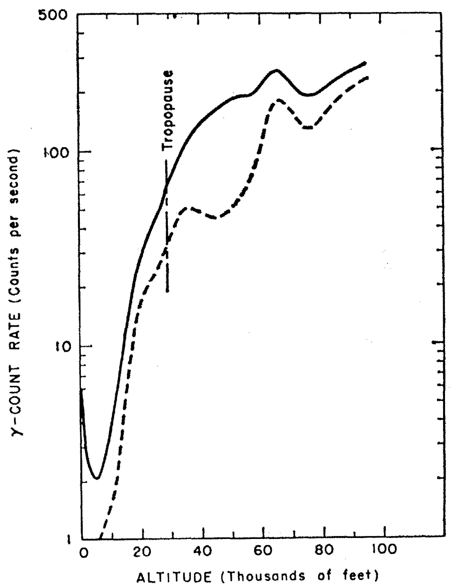

Fig. 1. Gamma-ray count rate as a function of altitude. Solid line, gross count rate; dashed line, net count rate, cosmic ray component removed.

natural sources has been assumed to occur at Thule, and has been subtracted, yielding the net γ count rate curve also indicated in Fig. 1.

Three peaks in the net γ distribution are apparent; one slightly above the tropopause (tropopause height, 29,200 ft on this date), a second located in the vicinity of 65,000 ft, and a third rise in count rate above 80,000 ft. This particular flight terminated with balloon burst at 97,000 ft. Similar distribution patterns were observed on the other three flights to altitudes above 80,000 ft, with the highest counting rate occurring at the highest altitude attained. In

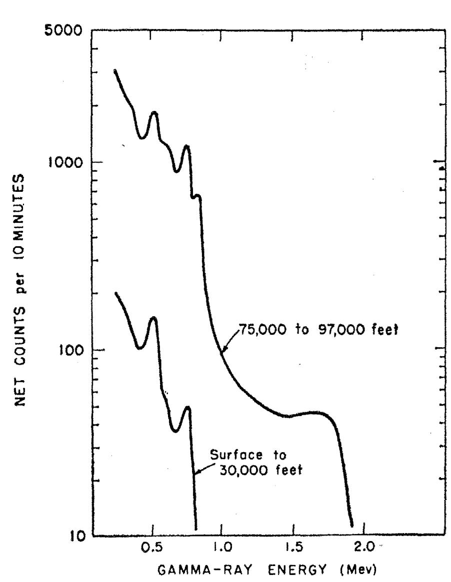

Fig. 2. Net γ-ray spectra observed *in situ.*

three flights a sharp transitory rise in count rate was observed between 1500 and 2000 ft, at which height a strong temperature inversion was noted in the radiosonde flights. Because of the decreasing density of the atmosphere with altitude, the net count rate data per se may be misleading, as the mean free path, and hence the effective physical volume from which γ-radiation is being detected, varies inversely as the air density. Suffice it to say at this time that fission product radioactivity was present at the time of these flights at altitudes up to 100,000 ft.

Gamma spectra accumulated directly on a multichannel analyzer as well as from magnetic tape support the contention that the net γ count rate arises from fission product radioactivity. Figure 2 shows net γ spectra observed between the surface and 30,000 ft, and 75,000 to 97,000 ft during flight No. 2. The photon spectrum due to cosmic ray interactions in the atmosphere has been removed by assuming that the spectral shape of this component as seen by the phoswich is a continuum and may be represented by a simple mathematical function. The magnitude of this component in a specific case was determined in the region 2.0 to 4.0 Mev, and its spectral contribution then subtracted from the spectrum in the region 0.25 to 2.0 Mev. Both spectra shown in Fig. 2 indicate γ-ray lines at 0.5 and 0.75 Mev. The former is attributable to positron annihilation and Ru^{106}, with a lesser contribution from Ru^{103} and possibly naturally occurring Be^{7}. The line at 0.75 Mev is presumably due to Zr^{95}–Nb^{95}. The spectrum observed above 75,000 ft is more complex, with indications of a line near 0.6 Mev, one at 0.85 Mev, and a low intensity line in the region of 1.6 to 1.7 Mev. The presence of Zr^{95}–Nb^{95} in relative abundance signifies a fairly recent origin, and it was presumably produced in the Soviet tests conducted during the autumn of 1961. The line at 0.85 Mev is attributed to Mn^{54} on the basis of energy and of a half-life sufficiently long to survive until April 1962; in similar fashion the lines at 0.6 and 1.6 to 1.7 Mev are attributed to Sb^{124} (*3*).

These investigations have shown the presence of readily detectable quantities of fission radioactivity in the atmosphere up to 100,000 ft over northern Greenland in early April 1962. The bulk of this activity was contained well within the stratosphere and may reflect the initial injection of debris to high altitude in the two largest shots of the series. Furthermore, it was observed that the remnants of the circumpolar vortex, a band of strong winds from the west at high altitudes in the arctic winter, were still present at the time that these measurements were made (*4*). The presence of a portion of the debris from the Soviet 1961 series at high altitude (> 80,000 ft) within the polar stratosphere as late as April 1962 may explain, in part at least, the fact that observed fallout levels at temperate latitudes have been somewhat lower than anticipated thus far this year.

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References and Notes

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29 August 1962

Chloroplasts and Mitochondria in Living Plant Cells: Cinephotomicrographic Studies

Abstract. Chloroplasts *in situ* are surrounded by jackets of a material which does not contain chlorophyll. The chlorophyll-bearing inner structure lacks motion while the jackets constantly change shape. Long protuberances may extend from the jackets into the cytoplasm and may segment into particles that cannot be distinguished from mitochondria. Segmentation and other dynamic characteristics of living plant cells have been recorded on cine film.

We have photographed (*1*) a structural feature of higher plant chloroplasts which may be a factor in understanding the metabolism of chloroplasts. In the living condition, as viewed by phase contrast microscopy, chloroplasts are surrounded by jackets of material not containing chlorophyll. The chlorophyll-bearing inner structure appears to lack motion, whereas the jackets constantly change their shapes. Frequently, long