to be the chief factor influencing the strontium-isotopic composition of the noncarbonate fraction of deep-sea sediments.

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References and Notes

1. T. J. Chow and C. C. Patterson, *Geochim. Cosmochim. Acta* **26**, 263 (1962).
2. P. M. Hurley, B. C. Heezen, W. H. Pinson, H. W. Fairbairn, *ibid.* **27**, 393 (1963).
3. P. E. Biscaye, *Bull. Geol. Soc. Amer.* **76**, 803 (1965); thesis, Yale Univ., 1964.
4. W. Compston and R. T. Pidgeon, *J. Geophys. Res.* **67**, 3493 (1962); C. E. Hedge and F. G. Walthall, *Science* **140**, 1212 (1963); G. Faure, P. M. Hurley, J. L. Powell, *Geochim. Cosmochim. Acta* **29**, 209 (1965); V. R. Murthy, *Trans. Amer. Geophys. Union* **45**, 113 (1964).
5. M. L. Jackson, *Soil Chemical Analysis—Advanced Course* (Author, Univ. of Wisconsin, Madison, 1965), pp. 33, 34.
6. K. K. Turekian, *Geochim. Cosmochim. Acta* **28**, 1479 (1964).
7. Eimer and Amend, $SrCO_3$, lot No. 492327.
8. G. Faure and P. M. Hurley, *J. Petrol.* **4**, 31 (1963); P. W. Gast, G. R. Tilton, C. E. Hedge, *Science* **145**, 1181 (1964).
9. S. R. Hart and G. R. Tilton, *Trans. Amer. Geophys. Union* **45**, 114 (1964).
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Optical Environment in Gemini Space Flights

In the debriefings of all astronauts of the Gemini and Mercury space flights there has been a continual insistence by the astronauts that "stars cannot be seen in the daytime," the only qualification of this statement being that planets and the moon or perhaps the brightest stars (for example, Sirius) could be seen.

If surface brightness of the daytime sky at orbital altitude precluded observation of stars, a real scientific dilemma would have to be faced. In this note we propose to (i) outline the scientific problem that would be presented if stars of second magnitude could not be seen in the daytime sky; (ii) consider the possible sources of background illumination which might account for the "nonobservation" of daytime stars by the astronauts; and (iii) present evidence from the on-board tape recorder used in Gemini V during the performance of the S-1 experiment which indicates that, if proper precautions are taken, first- and second-magnitude stars can be seen in the daytime sky.

The problem of observing stars against a background illumination was investigated theoretically and experimentally by Tousey (*1*). Figure 1, derived from Tousey's results, shows surface brightness of the sky as a function of the magnitude of stars that may be observed against this background. In the visible region of the spectrum, first-magnitude stars can be distinguished when background illumination is approximately 10^{-8} of the sun's surface brightness. If we suppose that astronauts are unable to see first-magnitude stars in the daytime, it must be assumed that the reason is a background illumination of the order of 10^{-8} ssb. (Hereafter, ssb will be used as a measure of the surface brightness in terms of the average sun's surface brightness.) For comparison we quote a few values in Table 1.

The conclusion then is that the required surface brightness of the background to limit observations to first-magnitude stars is a brightness of about 2×10^5 greater than the sea level nighttime sky (without a moon) and about 100 times dimmer than the daytime zenith sky at sea level.

We have divided the possible sources of illumination into three classes: (i) true illumination of the distant sky; (ii) a cloud around the spacecraft (spacecraft corona); and (iii) illumination on the spacecraft window.

True illumination of the distant sky could come either from scattering by air and dust above the spacecraft or from day airglow. Pressure at the spacecraft altitude is not greater than 10^{-9} of pressure at sea level so the expected scattered light should be about 10^{-15} ssb. This is 10^7 times too dim to account for the required 10^{-8} ssb (see entries B and C in Table 1).

About one-half of the nighttime sky brightness is produced by airglow. If we call this brightness 10^{-13} ssb, to enhance it to the required level would mean that the daytime airglow would have to be more than 10^5 times brighter than the nighttime airglow. In addition, this airglow would have to arise at altitudes in excess of 150 km. [Most of the nighttime airglow is in the layer centered at 90 km and is viewed in profile from above by the astronauts (*2*) at night.] The bright airglow postulated here would have to come from higher altitudes where the most pronounced airglow emission is the 6300 line of atomic oxygen. Barbier (*3*) has found evidence that the 6300-Å OI emission does indeed increase toward the sun (that is, as the elongation angle is decreased the airglow brightens). However, the absolute value of the 6300-Å brightness at 15° elongation is about 700 rayleighs. This corresponds to a continuum brightness of about 1 rayleigh per angstrom or about 10^{-13} ssb. If the background brightness is due to the 6300-Å line of OI, it would have to be enhanced by a factor of 10^5 from its value at 15° elongation angle as observed at night. It seems therefore that the required brightness of 10^{-8} ssb to just allow the observations of first-magnitude stars in the day-

Table 1. Surface brightness at 5400 Å.

Entry	Object	Surface brightness (ssb)
A	Full moon	2×10^{-6}
B	Daytime zenith sky at sea level (−3 magnitude stars visible)	6×10^{-7}
C	Background against which first-magnitude stars may just be seen	10^{-8}
D	Zenith sky (night) with full moon (5.0 magnitude stars visible)	2×10^{-12}
E	Average nighttime sky away from Milky Way	4×10^{-14}

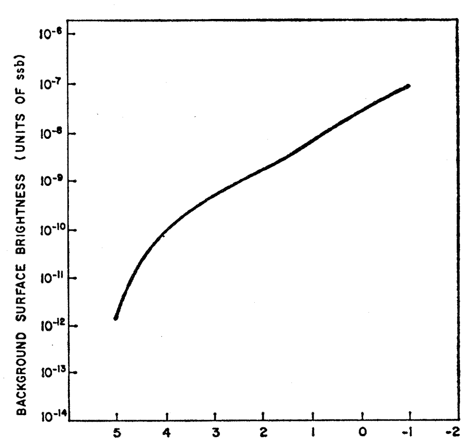

Fig. 1. The limiting magnitude of visible stars which may be seen in the presence of background illumination as a function of the brightness of the background.

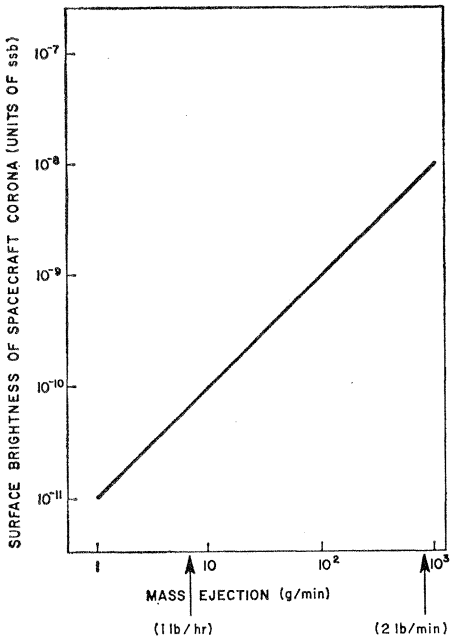

Fig. 2. Calculated surface brightness of spacecraft corona as a function of the mass ejection rate of particulate matter.

time is 10^7 times brighter than the rayleigh scattering above the spacecraft and at least 10^5 times brighter than the daytime airglow.

It is known that particles are in orbit with the spacecraft. They are observed by the astronauts at sunrise and sunset and were originally called "space fireflies." These particles arise as garbage from the spacecraft from fuel-cell purging, urine dumping, and so forth. We wish to consider the quantity of material required to produce a brightness of 10^{-8} ssb.

We have calculated the mass of material around the spacecraft to produce various values of surface brightness when the material is illuminated by sunlight. For particles with a radius of a cm, surface brightness due to isotropic scattering is given by B, $B_{\odot}$ is the sun's surface brightness, and $\Omega_{\odot}$ is the sun's solid angle. The number of particles per square centimeter above the viewing point is S.

$$B/B_{\odot} \equiv \tfrac{1}{4}\Omega_{\odot} S a^2 \qquad (1)$$

If q is the mass/area of scattering particles in a column, then:

$$q \equiv 3 \times 10^5 (B/B_{\odot}) a \qquad (2)$$

The total mass of particles required to produce a surface brightness of 10^{-8} ssb is therefore 0.3 g of 1-micron particles, if we assume a spacecraft surface area of 10^6 cm^2. Correspondingly, higher values of the mass are required if particle sizes are larger. The treatment above does not apply to particles smaller than about 1 micron because smaller particles would cause rayleigh scattering of the light and therefore be much less effective in producing an illuminated cloud. (The rayleigh scattering goes as a^6.) The cloud around the spacecraft is assumed to be ejected at a velocity determined by the equation: $P = \tfrac{1}{2} \rho v^2$, where P is the cabin pressure of $\tfrac{1}{2} \times 10^6$ dynes/cm^2 and ρ is assumed to be unity. This velocity is about 10 m/sec. Once in the "air stream," the particles are accelerated by molecular impacts. The acceleration produced is inversely proportional to the particle radius and is 1000 cm/sec^2 for a 1-micron particle in the medium of density 10^{-12} g/cm^3. A 1-micron particle therefore stays in the vicinity of the spacecraft for about 1 second and a 100-micron particle for 100 seconds. Because residence time is proportional to radius of the particle, and because scattered brightness per gram is inversely proportional to the radius, we can see that a constant rate of mass ejection by the spacecraft will lead to a fixed value of surface brightness independent of the sizes of particles ejected, provided the particles have a radius larger than about 1 micron. Figure 2 shows the expected average surface brightness as a function of the rate of mass ejection for the spacecraft. The effect of particle size will be to produce short decay times of the cloud if the particles are small, but the average surface brightness is determined only by the average rate of mass ejection. The mass ejected ultimately ends up in the wake of the satellite and should be observable as a kind of contrail.

These calculations show the necessity of limiting the mass ejection by the satellite if a clean optical environment in daytime is required. Our surface brightness of 10^{-8} ssb will be produced by about 2 lb/min of garbage dumped. To keep the brightness at as low a value as would be required to see fourth-magnitude stars would involve mass ejection 100 times smaller or about 1 lb/hr or less. Discharge rates of 1 lb/hr are typical of the Gemini space flights.

Finally, we consider the effect of scattered light in the window for observations taken from inside the spacecraft. It is very difficult, if not impossible, during most of the day to keep both sunlight and earthlight off the viewing window while observing the sky. Total illumination by the earth is approximately equal to that from the sun. Only when the terminator is below the spacecraft can viewing directions be found where the window is not illuminated by sun or earth. For a window which scatters only 1 percent of the light incident on it, a surface brightness about 10^{-7} ssb would be produced by the full earthlight or sunlight. It is therefore evident that during most of the day the scattered light from the window will preclude seeing stars. The window must frequently be as bright as one-tenth the brightness of the daytime sky at sea level.

At certain times of the day the spacecraft can be oriented so that one window is not illuminated either by earthlight or sunlight (that is, just before twilight or just after sunrise). Then brightness must be determined by the spacecraft corona previously discussed. We present the following data to show that the spacecraft corona is at least as dim as 5×10^{-9} ssb which allows the visibility of first- to second-magnitude stars.

In the performance of the zodiacal light experiment on Gemini V, the command pilot (Cooper) acquired and identified the stars in the Southern Cross at 3½ minutes before spacecraft sunset. The acquisition of these stars was required for guiding the spacecraft for subsequent zodiacal light exposures. At the time of acquisition and recognition of the Cross, the sun was streaming in the other window of the spacecraft and Pilot Conrad shielded this light with a book so it did not distract Cooper. At 2½ minutes before sunset, Cooper remarked, "All these particles going out," and Conrad replied, "Of course they will disappear as soon as the sun is off." We believe that the observation of the particles comes when the scattered window-light is reduced to a low enough value to see the "spacecraft corona." It should be pointed out that the observation of the Southern Cross stars occurred with a solar elevation of about 14° and the particle cloud at about 10° solar elevation. Our best estimates of the background surface brightness in Gemini flights are therefore: Mid-daytime, with earthlight on the window, 10^{-7} to 10^{-8} ssb; spacecraft corona, illuminated by sunlight, 10^{-9} ssb. It is also of interest to repeat that the spacecraft corona of brightness 10^{-9} ssb requires only 2 lb/hr of mass ejection and 0.1 to 10 g of particles in residence around the spacecraft.

In the previous consideration we did not discuss the problem of dark adaption. The dark-adapted eye becomes approximately 10^4 times more sensitive. Dark-adaption effects will be important in the range below about 10^{-11} to 10^{-12} ssb. If the spacecraft corona can be reduced to this order of brightness (requiring discharge rates of less than ounces per day), then considerations of dark adaption will become important.

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References and Notes

1. R. Tousey and M. J. Koomen, *J. Opt. Soc. Amer.* **43**, 177 (1953).
2. F. C. Gillett, W. F. Huch, E. P. Ney, G. Cooper, *J. Geophys. Res.* **69**, No. 13, 2827 (1964).
3. D. Barbier, *Ann. Geophys.* **15**, 179 (1959).
4. We express our appreciation for the effective performance of the S-1 experiment by astronauts C. Conrad and G. Cooper and acknowledge helpful conversations with many of the astronauts and with L. Dunkelman and R. Tousey.

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Radiocarbon Dating of Coastal Peat, Barrow, Alaska

Abstract. *A buried, frozen section of peat from sea level yielded radiocarbon dates between 700 and 2600 B.C.; it suggests burial by a transgressing sea.*

Recent studies at Barrow, Alaska, help to enlighten the late-Pleistocene and Recent history of the arctic coastal plain of Alaska (*1*). During the last 10,000 years the tundra landscape has been modified by cryopedological processes and thaw-lake migration; coastal shorelines have been altered by erosion and fluctuating sea levels. Radiocarbon dates from the Barrow spit indicate that the highest ridges formed, at sea levels slightly above the present datum, between A.D. 250 and 1100; archeological dating of the Birnirk settlement suggests occupancy during a period of a lower sea level within this interval (*2*). We now report three radiocarbon dates, from a nearby buried peat section, between 700 and 2600 B.C.; they predate formation of the northern extension of the spit (Fig. 1).

In October 1963 a severe storm, with a wave surge 3 to 4 m above normal sea level, breached the spit in three places (*3*). As a result, masses of peat were exposed at and slightly below sea level in the area indicated in Fig. 1. The existence of this massive buried peat had been known from the early days of construction at Barrow when canals were seasonally dredged through the spit for access to the lagoons (*4*). Several pits dug by us on the existing islands uncovered a continuous frozen peat section extending to a depth of 1.5 m below sea level; it contained small amounts of interbedded coarse sands in the upper section. The peat, where still buried, is perennially frozen and has high contents of salt and ice. The upper, mid, and basal 25-cm-long portions of a 1.5-m-long core yielded, by radiocarbon dating, ages of 2650 ± 160 (I-1868), 2860 ± 140 (I-1949), and 4570 ± 130 (I-1869) years, respectively. Botanical composition was of freshwater vegetation—principally mosses.

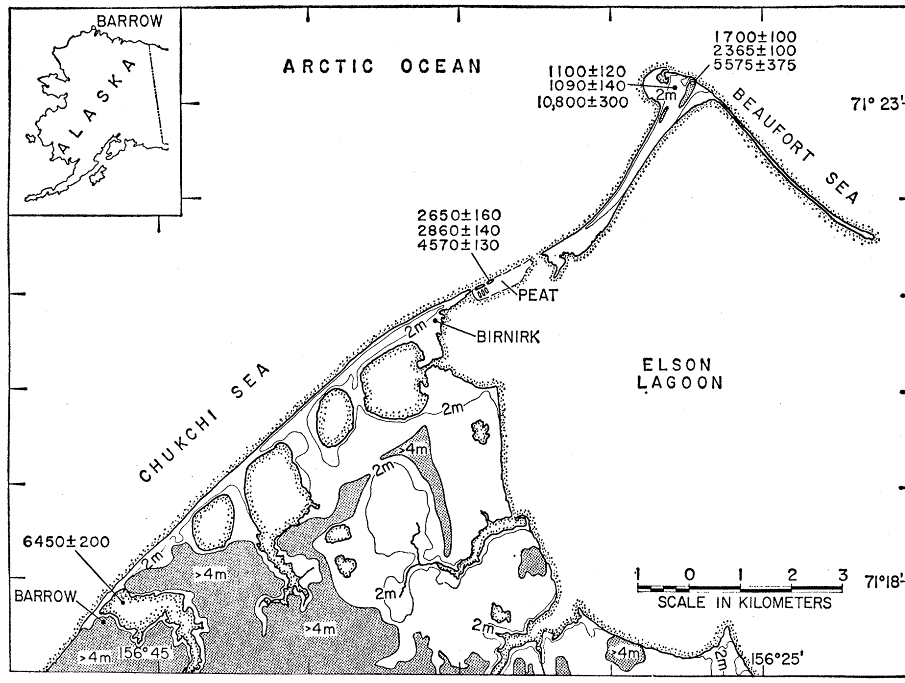

Fig. 1. The Barrow, Alaska, area, showing sources of samples from the spit, radiocarbon ages (years), and 2- and 4-m contour intervals.

The organic section developed in a shallow, predominantly freshwater lake and was encroached upon by the ocean late in its development. Drowning and subsequent burial of the peat occurred as the result of either encroachment of the ocean by inland erosion or a rising sea level. Regardless of the position of the paleo-shoreline, it is unlikely that sea level was higher than the proposed pond during the development of the peat section. This evidence does not agree with a 3-m rise in sea level, shown in Fairbridge's curve, between 2050 and 1450 B.C. (*5*). A substantially lower sea level before the initiation of peat formation is suggested by the age of a wood fragment [6450 ± 200 years (Tx220)] recovered from the base of a black clay layer (−11 m) in the Barrow village estuarine sequence (*6*).

Burial of the small-lake fill by bench gravels was followed by development of the major portion of the spit. On the basis of two series of radiocarbon ages from the spit [1100 ± 120 (I-387), 1090 ± 140 (I-388), 10,800 ± 300 (I-389); 1700 ± 100 (GX 0380), 2365 ± 100 (GX 0381), 5575 ± 375 years (GX 0230)], Hume postulated the following sequence: a rise in sea level to 1 m above that existing to form the oldest and highest ridge sometime after A.D. 265; a presumably rapid fall of 3 m, at which time the Birnirk site was occupied (A.D. 500); a rise of 3 m to form the next youngest ridge (A.D. 1000–1100); and a fall to the present sea level.

Objections can be raised to these relatively rapid rises and falls in sea level, but the present alternatives for the time and mode of formation of this compound ridged spit are only speculative or unsubstantiated. However, a sea level within several meters of that existing has persisted at Barrow since 700