late prophases of a frequency, spread, and quality not attained by the experimental technique previously described.

With the prophase-synchronization technique, we have been able to detect minute chromosome defects previously unidentified. This includes three patients with the cat-cry (5p-) syndrome and deletion of the small dark and light subbands of the distal end of the short arm of chromosome 5 (*5*), and one patient with moderate mental retardation and deletion of the minute distal light and dark subband of the short arm of chromosome 9 (Fig. 2).

In my study, it was also possible to obtain a large number of early and mid-prophases in which approximately 2000 to 3000 dark and light units were observed. At this stage of cell division, however, chromosomes remained highly extended, and their optimal spread is limited by the persistence of nuclear membrane and nucleoli. Efforts should now be placed toward the development of a suitable technique for their analysis in order to obtain a resolution comparable to that observed in the giant chromosomes *Drosophila* and thus begin to bridge the gap between genes and chromosomes in man.

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References and Notes

1. T. Ohta and M. Kimura, *Nature (London)* **233**, 118 (1971).
2. R. Rueckert and G. Mueller, *Cancer Res.* **20**, 1584 (1960).
3. J. J. Yunis and O. Sanchez, *Humangenetik* **27**, 167 (1975).
4. *Paris Conference (1971): Standardization in Human Cytogenetics* (National Foundation-March of Dimes, New York, 1972).
5. R. C. Lewandowski and J. J. Yunis, in *Chromosomes in Biology and Medicine, Volume I: New Chromosomal Syndromes*, J. J. Yunis, Ed. (Academic Press, New York, 1976).
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Stratospheric Aluminum Oxide

Abstract. *Balloons and U-2 aircraft were used to collect micrometer-sized stratospheric aerosols. It was discovered that for the past 6 years at least, aluminum oxide spheres have been the major stratospheric particulate in the size range 3 to 8 micrometers. The most probable source of the spheres is the exhaust from solid-fuel rockets.*

Although much is known about submicrometer stratospheric aerosols, very little is known about particles larger than a few micrometers. The spatial density of the larger particles is so low that most collection techniques have been incapable of adequately sampling them. Over the past 5 years we have flown very sensitive, high-volume air sampling collectors into the stratosphere to collect extraterrestrial dust. Although extraterrestrial particles were collected (*1*) the majority of the collected particles were spheres of Al_2O_3, a previously unknown stratospheric aerosol.

In 1970 and 1971 we flew two balloon-borne collections at 34 km, sampling 1.1×10^4 m^3 of ambient air (*2*). The flights were launched from Palestine, Texas, and the collections occurred over the southeastern United States. In March 1974 we began collections at 20 km, using U-2 aircraft of the National Aeronautics and Space Administration. To date, we have logged 100 hours of collection time with the U-2's, sampling 10^5 m^3 of ambient air. The U-2 collections crisscross the United States, and typical flight runs consist of consecutive exposures of ~ 4 hours each. In both the balloon and U-2 methods particles are collected by inertial deposition from a 200-m/sec airstream onto thick films of silicone oil (kinematic viscosity 5×10^5 centistokes). In the balloon collector (Vacuum Monster) air is pumped past an array of cylindrical collection surfaces. In the U-2 collector a single 18-cm^2 rectangular collection surface is rammed through the ambient air. Both collectors are clean, have negligible particle bounce-off problems, and have high impaction efficiency for particles larger than 3 μm (density = 3 g/cm^3). Two micrometers is considered the lower cutoff limit of the particle size range that can be sampled by the collector.

Collected particles (> 2 μm) were studied optically, and more than 600 particles were individually removed from the collection surfaces, washed in xylene, and analyzed in a scanning electron microscope (SEM) for morphology and elemental composition. In all collections, 90 percent of the particles < 6 μm were transparent spheres. Analysis of typical spheres both in

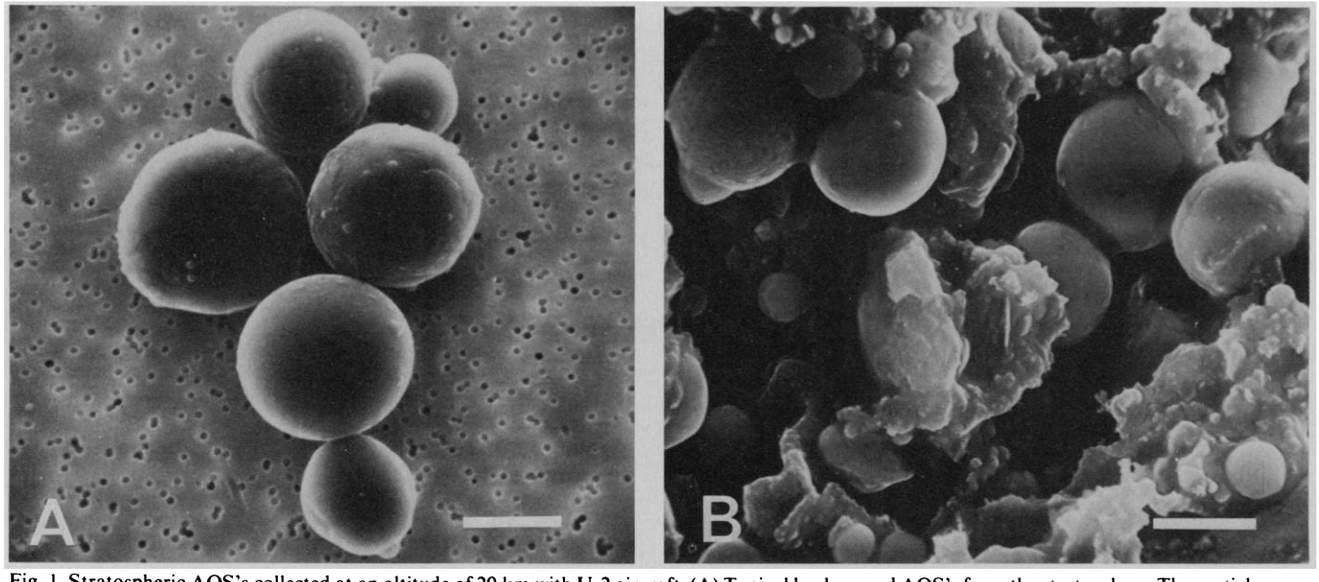

Fig. 1. Stratospheric AOS's collected at an altitude of 20 km with U-2 aircraft. (A) Typical background AOS's from the stratosphere. The particles were collected on silicone oil and were individually moved to the Nuclepore mounting medium for photography in the SEM. The small holes are part of the Nuclepore filter substrate material. (B) Aluminum oxide spheres collected from the smoke plume of a Titan III rocket. The particles were collected on cellulose filter paper, which was ashed at 450°C. The spheres are from the rocket and the other material is filter paper ash. Scale bars, 5 μm.

the SEM and in an electron microprobe demonstrated that they were Al_2O_3 (*2*). The spheres were colorless and are pure Al_2O_3, with no impurities at the 0.5 percent detection level. Typical particles are shown in Fig. 1. The aluminum oxide spheres (AOS's) did not have perfect spherical symmetry, but departures from sphericity were usually small. Highly oblate, prolate, or dumbbell shapes were not observed. Some of the AOS's had smaller spheres bonded to their surfaces. Many of the larger spheres had brain-textured surfaces suggestive of multicrystalline interiors.

The spatial density of AOS's is shown in Fig. 2. Although ~ 90 percent of the collected particles ≤ 6 μm were Al_2O_3, the size distribution was so steep that for sizes larger than 10 μm, the AOS's became a minority among collected particles. Most of the collected particles > 10 μm had elemental compositions like those of primitive meteorites (*1*), or they were opaque, irregular particles composed of Al with minor amounts of Fe, Cu, and sometimes other elements. The irregular Al particles may be contaminants, but because they were not found on control surfaces, we suspect they may be stratospheric and genetically related to the AOS's.

The pure Al_2O_3 composition of the AOS's suggests an exotic source. While it is conceivable that a few spheres could be produced by high-temperature condensation in meteor wakes, we believe the most reasonable source is solid-fuel rocket exhaust. Powdered aluminum is an additive put in solid rocket fuels to increase specific impulse. During combustion the aluminum is oxidized, and laboratory experiments (*3*) have shown that Al_2O_3 spheres are the major particulate in the exhaust. That rockets are definite contributors of Al_2O_3 to the stratosphere was proved by U-2 sampling flights through the exhaust plumes of two Titan III rockets (*4, 5*). The collections were made at 20 km and yielded large quantities of Al_2O_3 spheres virtually identical to the AOS's normally collected as background aerosol. Both the Titan III and the background Al_2O_3 spheres have identical elemental abundances and optical properties, and in the SEM many of the spheres from both sources have brain-textured surfaces or adhering surface blebs or spherules. The total mass of background AOS's appears to be compatible with the solid-fuel rocket source. Assuming that our density measurements are representative of the entire earth we estimate that the total mass of AOS's > 2 μm in the stratosphere is on the order of 10^8 g.

Our measurements indicate that for the past 6 years AOS's have been the dominant stratospheric aerosol in the size range

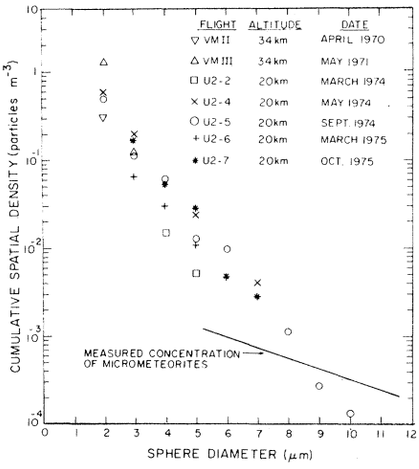

Fig. 2. Spatial density of AOS's measured at 34 km with balloons and at 20 km with NASA U-2 aircraft. The particle diameters are uncertain by ~ 1 μm because of the difficulty of optically measuring the diameters of small transparent spheres. The errors due to counting statistics are comparatively unimportant, except for the point at 10 μm, which is based on only two particles. The accuracy of the points at 2 μm is uncertain because of microscope counting difficulties and uncertainties in the collection efficiency for 2-μm particles.

3 to 8 μm. Within a factor of ~ 5, or possibly much less, the spatial density has been constant between 20 and 35 km in the atmosphere. Apparently the concentration has been maintained in quasi-equilibrium by injections of new material from solid-fuel rockets. Because of the altitudes of the collections and the low fall speeds of the particles [0.1 cm/sec for 2-μm AOS's (*6*)] there can be little doubt that the aerosol is a hemispherical if not global phenomenon. Possible climatological effects of Al_2O_3 from the solid-fuel boosters of the space shuttle have been evaluated by Hofmann *et al.* (*7*).

Our new measurements indicate that the composition of the stratospheric aerosol is strongly size-dependent. In the submicrometer region the majority of particles are the well-known sulfate aerosol (*8*). For the size range bounded by 8 μm and approximately 3 μm the majority of particles are Al_2O_3. Particles larger than 10 μm are largely extraterrestrial in origin (*1*) and are similar in composition to primitive meteorites.

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References and Notes

1. D. E. Brownlee, D. Tomandl, P. W. Hodge, *Int. Astron. Union Colloq. No. 31*, in press; D. E. Brownlee, F. Horz, D. A. Tomandl, P. W. Hodge, *Int. Astron. Union Colloq. No. 25*, in press.
2. D. E. Brownlee, P. W. Hodge, W. Bucher, *NASA Spec. Publ. SP-319* (1973), p. 291.
3. R. Sehgal, *JPL Tech. Rep. No. 32-238* (1962).
4. G. V. Ferry and H. Y. Lem, *Eos* **56**, 1123 (1974).
5. ———, in *Second International Conference on Environmental Impact of Aerospace Operations in the High Atmosphere*, A. J. Broderick, Ed. (American Meteorological Society, Boston, 1974), p. 27.
6. F. Kasten, *J. Appl. Meteorol.* **7**, 944 (1968).
7. D. J. Hofmann, D. E. Carrol, J. M. Rosen, *Geophys. Res. Lett.* **2**, 113 (1975).
8. R. D. Cadle and G. W. Grams, *Rev. Geophys. Space Res.* **13**, 475 (1975).
9. We are grateful to L. Nelson (Sci Med Inc.), H. Lem (Ames), the personnel of the National Center for Atmospheric Research balloon flight station at Palestine, Texas, and the Ames Airborne Application Research Branch under the direction of M. A. Knutson. This work was funded in part by NASA grant NGR 48-002-033.

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Prostaglandin B_1: The L-Shaped Prostaglandin

Abstract. *The crystal and molecular structure of prostaglandin B_1 (PGB_1) has been determined. The conformation is L-shaped, with the α and ω side chains roughly perpendicular to one another. This arrangement differs from the "hairpin" or approximately parallel disposition of side chains observed for other prostaglandins. The ω chain, which normally turns at the 15-hydroxyl back toward the α chain, is fully extended. The conformation is stabilized by the conjugation of the dienone chromophore. The 15-hydroxyl, which is normally directed away from the centroid of the prostaglandin in the hairpin model, is turned inward in L-shaped PGB_1. The low biological activity of PGB_1 in many systems and especially its inhibition of the metabolizing enzyme 15-hydroxyprostaglandin dehydrogenase may be attributable directly to the observed L-shape conformation.*

Studies of prostaglandin conformation by single crystal diffraction techniques (*1–5*) suggest that a conformational characteristic of the active prostaglandins is the hairpin alignment of the α (C-1 through C-7) and ω (C-13 through C-20) side chains. In addition to diffraction studies, spectral studies (*6*) of the conformations of prostaglandins in solution also suggest the importance of the hairpin model of active prostaglandins. With this in mind, the crystal structure of prostaglandin B_1 (PGB_1) (**1**), a generally less active prostaglandin and a noncompetitive inhibitor of the major metabolizing enzyme 15-hydroxyprostaglandin dehydrogenase