served unit of a chromosome (*2*) is used as a template for the first time, it is attached permanently to a structure distinct from that to which its parent chromosome was attached." If the centriole produced in preparation for the next mitosis is that structure to which attachment is made by all those "conserved units" that are being used as templates for the first time, we can understand how one set of chromatids with a similar history (that is, time of synthesis) would go to one pole and the other set (the sisters of the first group of chromatids) with a different history would go to the other pole. Presumably, the "conserved units" that had been used as templates during prior replications would be associated exclusively with the pre-existing centriole.

Another way of looking at this model is to envision, as have Lettré and Lettré (*3*), that the chromosome and centriole, with a permanent fiber connecting the two, replicate as a unit. In the light of Lark, Consigli, and Minocha's data, this would mean that the entire chromosomal complement and the centriole, with all the permanent connecting fibers, would be duplicated as a physically integrated unit. There is, however, no need to imagine that the centrioles and the connecting fibers replicate in a semi-conservative fashion similar to that of chromosomal DNA replication.

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References and Notes

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2. This conserved unit can be envisioned as that DNA-containing subunit, of a 2-unit chromosome, that had been synthesized at the immediately preceding replication period; its "complementary" subunit would have been synthesized during an earlier replication.
3. H. Lettré and R. Lettré, *Naturwissenschaften* **44**, 406 (1957); see also D. Mazia, in *The Cell*, J. Brachet and A. E. Mirsky, Eds. (Academic Press, New York, 1961), vol. 3, pp. 221–25 for detailed discussion of problems related to chromosome-to-pole connections.

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It is, of course, natural to search for a structure to which the centromeres remain attached during a succession of cell cycles. It is also natural to choose for such a structure one which has been implicated by cytological measurements.

That this may be dangerous is exemplified by the comment of Goldstein. Recently, we have found that nonrandom segregation of sister chromatids can be observed in *Vicia faba* and *Triticum boeoticum*. Our experiments only demonstrate that each set of chromatids appears to be attached to a structure with a centriole-like function. While Goldstein's hypothesis is a plausible one, I feel it would be premature to assign a primary role to the centriole merely because it can be seen.

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Properties of Lunar Surface Rocks

We shall assume that, in the absence of closer observations, O'Keefe, Lowman, and Cameron (*1*), have indeed correctly identified the Flamsteed Ring as an extrusive volcanic feature similar to terrestrial ring dikes. We shall assume further that they have derived "a reasonable value for the viscosity of the mass regarded as a single flow," of 10^{13}cgs units (poises). [It should be noted that the use of a "coefficient of thermal diffusion" (that is, thermal conductivity divided by density times heat capacity) for a nonvesicular rock ("granite") may not be appropriate for an extruded lava exposed to the hard vacuum at the lunar surface.] Clearly, however, the high value of the viscosity so derived does not allow one to conclude that the magma is highly acidic on that basis alone.

Viscosities of terrestrial lavas are dependent not only upon SiO_2 content but also upon such factors as temperature, content of volatiles such as H_2O and CO_2, degree of vesiculation and content of crystallites. Thus, the viscosity of basaltic lavas of identical SiO_2 content may range from the very high values characteristic of the low-temperature ejecta which form spatter cones, and which essentially stick to whatever they fall upon, to the low values associated with pahoehoe flows. Indeed, the range of viscosity at the high end is essentially undefined; basaltic cinder cones are often composed almost exclusively of solid ejecta, with respect to which the concept of viscosity has little meaning. All gradations may be observed, from solids to very fluid lavas, without invoking any chemical distinctions.

As another example, in the compilation of viscosities of melted rocks by Clark (*2*), values from 1.7×10^5 to 4.4×10^6 are listed for obsidians. Shaw (*3*) states that granitic melts have viscosities of 10^5 to 10^8 poises at various temperatures above the liquidus. Values as high as 10^{13} poises are found at temperatures of the order of 500°C provided that water is present. The data of Shaw (*3*) show clearly the dependence of viscosity on temperature, water content, and crystal content. The value of 10^{13} poises derived by O'Keefe and coworkers (*1*) indicates a body with viscosity similar to terrestrial glasses at a few hundred degrees centigrade. The value is removed by several orders of magnitude from terrestrial lava flows, and certainly yields no information about the composition of the body.

Any conclusion about the acidity or basicity of the putative magma which formed the Flamsteed Ring is mere speculation as long as there is no information available on the temperature of the magma, its crystallite and volatile content at the time of extrusion, and the history of changes in these parameters (especially the volatile content) as the flow spread. One should be especially cautious about extrapolation of terrestrial observations of the behavior of lava flows to considerations of their possible analogs on the lunar surface; many terrestrial magmas are thought to have abstracted volatiles from their surroundings as they neared the surface, while lunar magmas would almost certainly lose volatiles near the lunar surface.

We differ from O'Keefe *et al.* regarding their interpretation of the gamma-ray data from the Russian Luna-10 instrument package. Vinogradov and coworkers state that not more than 10 percent of the observed activity could have been due to the presence of K, U, and Th. This indicates that the *upper* limits for the concentrations of these elements are of the same order as observed in terrestrial basalts, while even material with the K, U, and Th contents of ultramafic rocks or chondrites is not excluded. The abundances in australites [K, 1.8 to 2.1 percent; Th, 9.0 to 14.5 ppm; U, 1.9 to 3.1 ppm (*4*)] are several times greater than those in basalts (typically with K$\sim$ 0.8 percent, Th 2 to 3 ppm, and U $\sim$ 0.5 ppm). Unless there are unknown errors in the Russian data and their interpretation, the lunar surface is a very unlikely source for tektites. If, as some workers believe, K was volatilized during tektite formation, then larger concentrations of this element would be required in the parent material, leading to an even more severe disagreement with the Luna-10 observations. Further experiments will no doubt shortly resolve these problems.

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Slopes on the Moon

O'Keefe, Lowman, and Cameron (*1*) argue that the slopes of the Flamsteed Ring could not be produced by mass wastage, but are the fronts of coulées or very viscous acid lava flows. Several of their points call for comment.

The slopes of the Flamsteed Ring are lower than the angle of repose of broken rock and do not have the profile of terrestrial talus slopes. Does this mean that all processes of mass wasting can be eliminated from consideration? The angle of repose is the angle at which fragmental material will stand when gravity is the only accelerating force and rolling of fragments on the surface is the principal mechanism of slope modification. But if there are any other disturbing forces, such as shaking by earthquakes, the mechanics are different and the stable slope will be gentler than the angle of repose. Seed and Goodman (*2*) have investigated the stability of slopes of dry sand subjected to horizontal accelerations. They found, for example, that for sand with an angle of repose of about 40°, a horizontal acceleration of $0.5g$ causes visible slippage and one of $0.8g$ causes failure on slopes as low as 21°. Moreover, their work provides a basis for explaining the convex bulge at the toe of many lunar slopes, one of the most striking and unexpected features of the Orbiter photographs (*1*, fig. 1). Seed and Goodman found that even a small shear strength (which can arise merely from the interlocking of grains and does not imply cohesion) has a very significant effect on the nature of sliding. First, it causes sliding to occur on a critical surface which lies some distance beneath the surface of the slope. This introduces a secondary effect of the passive resistance of the base to the sliding mass at the toe of the slope. The resultant pattern of sliding thus can be very complicated, but a typical slope (*2*, fig. 17) has a convex bulge at the toe. The effect of shear strength is an inverse function of the length of the slope and would be small for slopes of sand greater than 15 meters. On the other hand, shear strength is a direct function of particle size (*2*). The profiles of the walls of Flamsteed Ring are thus not inconsistent with their being slides of noncohesive boulder-sized fragments activated by moonquakes (*3*).

Talus slopes on Earth have a different profile because they are controlled by processes occurring at the surface, such as rain wash or rolling of frost-heaved boulders, rather than by ground accelerations from infrequent seismic events. Where slopes of similar profile are found terrestrially, they are produced by processes involving internal cohesion, such as solifluction in permafrost regions. Some cohesion of the materials on lunar slopes is probably indicated by the fine-scale patterning of the ground.

If the slopes of the Flamsteed Ring are underlain by fragmental debris, this, of course, says nothing about the origin of the Ring itself and does not preclude its being a ring of coulées. Loney (*4*) has mapped a coulée at Mono Craters, California, and found that the front of the flow as it advanced was covered by a talus slope of blocks. The interpretation of the Flamsteed Ring as the surface expression of a ring dike seems dubious, however. The comparison with the ring of volcanoes in the Valles Caldera (*1*) is misleading. At Valles the volcanoes are but one feature within a complex structure dominated topographically by the outer caldera rim and the uplifted center. There is no terrestrial example to compare with a ring of volcanoes standing isolated on a plain that is level both inside and outside the ring.

Finally, the extreme velocities calculated for a basalt flow having the depth of the Flamsteed Ring (*1*) were derived erroneously. The conditions indicate a Reynolds number of 90,000 or more, at which the laminar flow formula (*1*, eq. 1) would of course be completely inapplicable.

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Positions of Quasi-Stellar Objects with Large Red-Shifts

Strittmatter, Faulkner, and Walmsley (*1*) have presented evidence that all known quasars with red-shift $z > 1.5$ are contained within two areas, in antipodal directions occupying 6 percent of the sky. I think it appropriate to point out that the directions defined by quasars with $z > 1.5$ coincide with the direction of the Virgo cluster of galaxies ($l^{II} \approx 287°$; $b^{II} \approx +75°$) which, according to de Vaucoleurs (*2*), is the center of the supergalaxy, and with the antipodal direction ($l^{II} = 107°$; $b^{II} = -75°$). These coincidences suggest that quasars are a phenomenon related to the supergalaxy rather than to our galaxy, as suggested by Strittmatter *et al.*

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3 April 1967