of sulfuric acid. This seems to corroborate previous suggestions that the Atlantic is an ammonia source. On the other hand, samples from all other sites showed that sulfuric acid was present in substantial amounts as a characteristic aerosol.

If all the sulfate found in unpolluted tropospheric air by a number of investigators is free sulfuric acid, the resulting sink for ammonia cannot exceed 10^{-13} g cm^{-3}. Ambient ammonia concentrations, whether from Junge's data or from our data, are at least two or three orders of magnitude greater than that required to convert all sulfuric acid to ammonium sulfate. The progressive decrease of ammonium sulfate and the increase of sulfuric acid droplets over the land indicates that another sink for ammonia must exist, and that the replenishment rate of sulfuric acid must exceed the rate of the reaction between sulfuric acid and ammonia for these concentrations.

The apparent enrichment of nitrogen dioxide levels over the land and the rapid decrease to a lower level over the sea indicate that processes may occur on land which oxidize ammonia. Our data suggest that nitric oxide could be the oxidation product, and that nitrogen dioxide is a transient product of further oxidative reactions.

To summarize, we present the hypotheses that a forested tropic land mass is not a source of atmospheric ammonia or hydrogen sulfide because these are oxidized in the forest environment; that the land mass is a source of atmospheric oxides of nitrogen; that sulfuric acid aerosol is an atmospheric sink for ammonia over the Atlantic (an atmospheric ammonia source); and that oxidation is a major ammonia sink over land and sulfuric acid aerosol is not.

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Vacuum Welding of Olivine

Abtstract. *Welding of olivine was demonstrated by grinding it in a ball mill in an atmosphere of about 2 × 10^{-7} torr. Most of the sample adhered strongly to the container and grinding balls although adhesion in air is only slight. Similar adhesion should be expected on the lunar surface and may account for the roughness needed to explain the optical properties of the moon and the detail of the Luna 9 photographs.*

An experiment demonstrated the substantial self-welding to be expected when dusts (powdered solids) come in contact under conditions such that their surfaces are at least partially free from gas films (*1*). This process could be expected to occur on the lunar surface when debris from a meteorite collision returns to the surface.

A 10-g sample of coarsely ground (147 to 177 μ) olivine (*2*) was placed in a 10-cm-diameter stainless steel container with 57 18-mm irregular porcelain balls (Fig. 2*b*); the container was rotated about a nearly horizontal axis at about 95 rev/min in the manner of a ball mill. With the container at atmospheric pressure, a run of 22.5 hours produced substantial grinding of the olivine sample. There was some difficulty in removing the material from the container; it adhered weakly to the surface and to the balls; it was mostly removed from the balls by vigorous brushing with a camel-hair brush. To remove the material from the interior of the container, about 20 g of (about 20) freshly broken glass fragments were placed inside and moved over the interior by slow rotation of the tank in various directions by hand; this procedure removed most of the sample, which was sieved (Table 1).

A similar sample was then ground with the container evacuated. The vacuum equipment consisted of a 5-liter/sec sputter-ion pump sealed to the container with a copper gasket. Container, pump, and pump magnet were mounted as a unit in a cradle, with the high-voltage lead of the pump protruding through the axial bearing so that high voltage could be applied during the grinding operation (Fig. 1). The system and sample at room temperature were evacuated overnight by a mechanical pump. The ion pump was then started and the valve to the mechanical pump was closed. The container was heated to 100°C for 18 hours and a considerable amount of gas (presumably mainly water) was evolved. The temperature of the sample was then raised to 200°C for an additional 6.5 hours, with further evolution of much less gas. When the heater was removed the pressure in the system fell rapidly; after 15 hours it was well below 10^{-8} torr.

The container at room temperature was then rotated slowly, with bursts of pressure to as great as 10^{-6} torr; mean pressure was about 2×10^{-7} torr. When the system was operated at full rotation speed, the pressure rose to about 7 to 8×10^{-7} torr, with the pressure bursts rapidly diminishing. At the end of the 22.5 hours of grinding the pressure was about 2×10^{-7} torr; it then fell to 1×10^{-7} torr within 2 minutes and to 5×10^{-8} torr within 20 minutes.

The container was then opened to the atmosphere and the porcelain balls were extracted. A thick coating of olivine was bound to the balls and unattached olivine was negligible (*3*). Very vigorous brushing of the balls yielded a total of 2.04 g of sample powder, which was sieved (Table 1). Rotation within the container of a 20-g sample of about 20 glass fragments removed a negligible amount of olivine.

The container was then halved with a tubing cutter. Olivine was found uniformly attached to the surface, except for a narrow ring at the joint between end cap and wall (where a ball could not touch the surface of the container) and a ring around the pump tube, which also could not be reached by the balls because of the slight tilt of

Table 1. Free (unwelded) products from the 22.5-hour grinding of pulverized olivine in air and in partial vacuum. Each sample was initially of 10 g and between 147 and 177 μ in size.

Particles (μ)	Weight (g)	
	In air	In vacuum
> 177		0.18
177–147	0.45	.20
146–105	1.67	.67
104– 74	2.28	.47
73– 44	3.89	.25
< 44	1.31	.27

the system axis. This tilt was intentional to prevent powder from entering the pump in any quantity. When the tank was cut, about 0.35 g of olivine was dislodged from the surface near the cut.

The olivine attached to the balls and to the container walls was very firmly bonded and required hard scraping with a sharp instrument to dislodge it. Figure 2*a* shows the interior of the cut container; the pile of olivine is the 0.35 g dislodged from the surface during cutting; a reflection can be seen from the bare metal surface at the joint between wall and end cap of the right-hand section. Figure 2*b* shows the balls bearing a heavy coating of material; the three standing apart and lighter in color were not used.

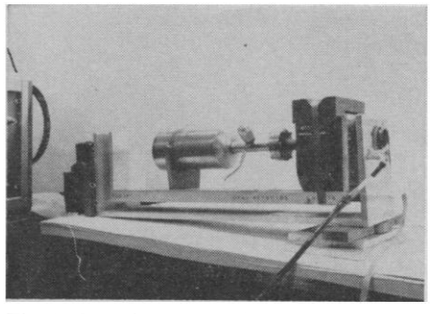

Fig. 1. Container ("ball mill") and vacuum pump.

A third sample was degassed in the manner described, but exposed to laboratory air before grinding began. The result of grinding was intermediate: adhesion was considerably greater than with the undried sample but less than with the sample ground in vacuum.

This experiment is quite qualitative, but it does demonstrate quite tenacious bonding of olivine to itself, to stainless steel, and to procelain. The vacuum conditions were good in that there were no oils, greases, or elastomers in the system, but the pressure was not very low even at the end of the grinding period. At the final pressure of 2×10^{-7} torr a gas monolayer would form on a clean surface in 10 to 100 seconds, depending on the sticking probability of the gas. Because the surfaces in question were freshly formed and the principal gas was most likely water vapor, the shorter time is the more probable. Despite this fact, enough clean or partly covered surfaces of olivine met to bond most of the material together.

A conclusion is that a solid particle returning to the lunar surface at moderate speed has a good chance to bond to the surface struck, since these surfaces should be relatively free of gas films because of the "ion cleaning" effect of the solar wind and the gas-desorption effect of the solar ultraviolet flux. The cleaning effect of ion and ultraviolet bombardment is well known (*4*).

Since the flux of returning particles would be nearly isotropic in the upward 2π solid angle, any projection of the surface would be more likely to be struck; thus, irregularity of the surface would increase. Such an irregular surface seems to resemble somewhat that required to satisfy the small-scale irregularity needed to provide the optical reflectivity observed on the lunar surface; it could also resemble the peaked surface seen in the Luna 9 photographs. Further more quantitative experiments with different materials are obviously required.

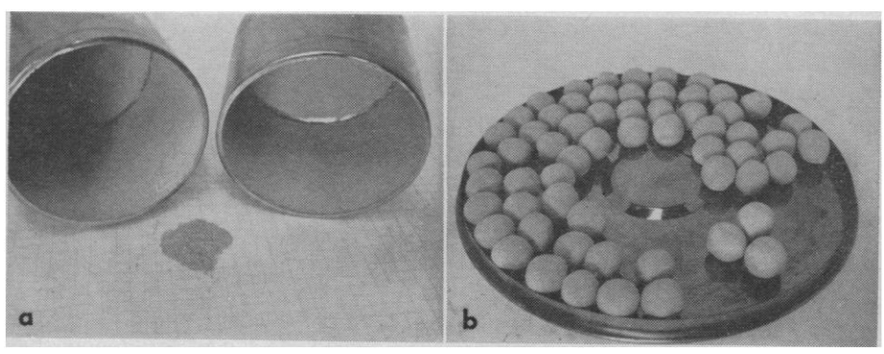

Fig. 2. After the run in partial vacuum: *a*, the cut container; *b*, the porcelain balls, with olivine adhering (the three grouped at right are unused).

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Neutral Hydrogen Survey of Andromeda Galaxy

Abstract. *A neutral hydrogen survey of the Andromeda galaxy (M31) has been conducted with the 260-foot (80 m) Ohio State University radio telescope. The neutral hydrogen is concentrated in the spiral arm regions, with but relatively small amounts near the center of the galaxy. Similar deficiencies have been found near the center of M33 and our galaxy, suggesting similar evolutionary processes in the three galaxies.*

Studies of the neutral hydrogen distribution in the Andromeda galaxy were made by van de Hulst, Raimond, and van Woerden (*1*) in 1957, and by Burke, Turner, and Tuve (*2*). Both studies were based on observations along the major axis of the galaxy and selected axes at right angles. The first complete survey of the galaxy was made by Argyle (*3*) in 1963 with a