flushed with carrier gas (nitrogen) for 30 minutes. The sample was heated to 150°C, then to 250°C, and finally to 500°C in the flash heater zone of the gas chromatograph. The temperature of the sample tubes was maintained at each temperature level while the column was temperature-programmed from 50° to 180°C at the rate of 3°C per minute. A control containing solvent-washed glass beads was substituted for the lunar sample and analyzed in a similar fashion. There was no evidence of organic compounds' being eluted from the sample. Similar results were obtained when these analyses were repeated on a 1.5-m by 0.058-cm SCOT column coated with Apiezon L and programmed to 210°C.

Aliquots from both the acid hydrolyzate and the organic solvent extracts of the sample and reagent blanks were concentrated and then subjected to the gas chromatographic procedures described above. Again, the findings were negative.

In all mass-spectrometry experiments, the spectrometer (M-S 9, Associated Electronics Industries, Manchester, England) was operated at 70 ev and at 100 or 300 μa trap current. The resolution was approximately 1:1000.

All samples, extracts, and reagent blanks were introduced via the direct insertion probe. Prior to sample introduction, the operating parameters of the instrument were optimized with perfluorotributylamine as a reference compound. After this material was pumped off, the ion source was baked at 250°C for 4 days.

A 10-mg portion of the lunar sample was loaded into a special quartz capillary tube attached to the direct-insertion probe. The probe was inserted into the mass spectrometer and spectra were recorded at various temperatures as the temperature of the ion source was increased from 50° to 250°C. The various spectra were dominated by peaks due to H_2O, N_2, O_2, and CO_2. The mass spectral patterns of the remaining peaks were indicative of very small quantities of low-molecular-weight hydrocarbons consistent with that noted as background. A repeat analysis gave similar results.

Studies of the extracts and reagent blanks by mass spectrometry did not reveal the presence of any components which could be considered to be indicative of endogenous material derived from the lunar sample.

In conclusion it is assumed that the principal components of the various spectra were contaminant gases and traces of low-molecular-weight hydrocarbons which had adsorbed onto the surface of the lunar sample during handling and exposure to the atmosphere.

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Micropaleontological Studies of Lunar Samples

Abstract. *Optical and electron microscopic studies of rock chips and dust from the bulk sample box returned by Apollo 11 and of petrographic thin sections and acid-resistant residues of lunar material have yielded no evidence of indigenous biological activity.*

Although the present lunar environment is inimical to known biological systems, more favorable conditions may have existed in the geologic past. Urey (*1*) has suggested that the moon may have become "contaminated" with terrestrial organic matter early in the evolution of the earth-moon system. If this suggestion is correct, and if life became established, evidence of fossil organisms might be detectable in lunar rocks. It is even conceivable that such organisms might have been the progenitors of an extant biota, adapted to the harsh conditions of the lunar surface; such organisms probably could not survive in the terrestrial environment and therefore would not be recognized in studies designed to detect vital processes (such as metabolism, growth, and pathogenicity). The approach and techniques successfully used in Precambrian paleobiology (*2*), and the criteria developed to establish the indigenous and biogenic nature of Precambrian microfossils, seem well suited for the detection, characterization, and interpretation of any fossil or recently dead microorganisms that might occur in lunar materials (*3*).

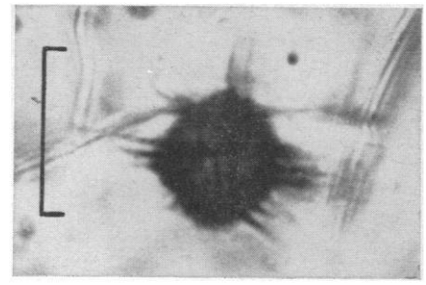

Fig. 1. Optical photomicrograph showing actinomorphic pseudofossil, apparently produced by partial devitrification of the surrounding glassy matrix, in a petrographic thin section of a microbreccia (sample 10046,56); the scale represents 10 μm.

In an effort to detect evidence of lunar organisms in the Apollo 11 samples, studies were made with a light microscope (L) at magnifications ranging from 4 to 1500, and, after the specimens had been coated with a thin gold-palladium film, with a scanning electron microscope (SEM) at magnifications ranging from 30 to 30,000. I examined samples as follows: (i) lunar dust (sample 10086,18 from the bulk sample box), divided into four size-fractions by sieving (>246 μm, 246 to 124 μm, 124 to 74 μm, and < 74 μm)—L and SEM; (ii) residue resulting from dissolution of lunar dust in hydrofluoric and hydrochloric acids—L; (iii) surfaces of rock chips from the exterior and interior of a microbreccia (sample 10002,54 from the bulk sample box), and fragments of these chips—L and SEM; (iv) petrographic thin sections of microbreccias (samples 10019,15, 10046,56, 10059,32, 10059,37, 10061, 27, 10061,28, and 10065,25)—L; (v) as a member of the Ames Lunar Sample Consortium, I studied (L) samples being investigated by Ponnamperuma *et al.* (*4*) (sample 10086, bulk A fines); (vi) as a member of the Lunar Sample Preliminary Examination Team for the Apollo 11 mission, I studied (L) rocks, chips, dust, and bioquarantine samples (including portions of both cores) (*5*).

Several thin sections (among them 10046,56, 10059,32, and 10061,27) contain elongate, spheroidal, spinose, or actinomorphic structures (Fig. 1) that superficially resemble terrestrial microfossils; many of these mineralogic

"pseudofossils" are the result of partial devitrification of glassy inclusions. During preliminary studies at the Lunar Receiving Laboratory I detected birefringent organic fibers, a few microns in diameter, in the lunar dust and bioquarantine samples; a few similar fibers were noted in samples i and ii listed above, and in the mounting medium (but *not* within mineral grains) of several petrographic thin sections. With the exception of these terrestrial contaminants, apparently derived from lens tissue or similar substances, no biogenic materials were detected in these investigations.

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