LUNAR PROTOLIFE

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Jack Green, Department of Geological Sciences
California State University, Long Beach
1250 Bellflower Blvd., Long Beach, CA 90840
jgreen3@csulb.edu
(562) 985-4198; Fax: (562) 985-8638

Factors of lunar tidal and gravity effects, terrestrial lunar analogs and present day volcanic activity on Io support the probability of past regional volcanism on the moon. Endogenic lunar transients in historic time may mark defluidization sites. Most fumarolic fluids vented into lunar shadow at 40K would freeze as ices and would be retained over geological time. Such ices would likely be admixed and covered with ejecta, both meteoritic and pyroclastic. Some ices would be mobilized and refrozen by conditions of intermittent sunlight. Fumarolic fluids (H_2O, CO_2, CO, N_2, C1, HCN, CS_2, S, CH_4, NH_3) contain the ingredients for lunar protolife; the fumarole itself would offer a wide range of eH, pH, temperature, pressure and mineralogy within a distance of meters. Many volcanic phenomena favor the genesis of lunar protolife in shadow, five of which are unique to lunar shadow environments.

Only nano quantities may be required for the evolution of protolife. Flow charging and triboelectric processes in volcanic vents can create electrical potentials, which even in minute levels can create formaldehyde (HCHO), which in shadow would not decompose. Formaldehyde can also by produced by shock phenomena attendant cavitation and bubble collapse in fumarolic systems. Cyanogen was detected in 1969 during a transient event in Aristarchus (also in ices on Callisto). Cooling of ammonium cyanogen compounds in the presence of formaldehyde can produce amino acids and proteinoid microspheres that react to electrical potentials by undergoing fission and shedding of buds. Freezing in lunar shadow also constitutes a concentration mechanism in which ammonium compounds, even in nano amounts, could yield adenine ($C_5H_3N_4NH_2$) – a component of nucleic acids. Fischer-Tropsch catalysis involving the reaction of formaldehyde on hydrothermal kaolin could produce ribose ($C_5H_{10}O_5$) where HCN concentrations are low. Ribose reacting with adenine can product adenosine ($C_{10}H_{16}N_5O_{13}P_3$) – a metabolizer. Fumarolic emanations also contain tungsten, which is a critical component of a metallo-enzyme necessary for the evolution of Archean hyperthermophiles on earth. Iron sulfide (troilite) films on rising bubbles in fumaroles would constitute a biofilm with a positive surface charge to which polar organic molecules could attach. Concentration of these organic molecules might be achieved by thermal diffusion and convective processes in the fumarolic vent.

Lower gravity and surface pressure of the moon also provide favorability factors for the evolution of lunar protolife. Under lesser lunar gravity, bubbles in fumaroles would nucleate deeper and rise more slowly providing for higher probabilities for reactivity in biofilm bubbles. Surface vacuum would lower boiling points of pre-biotic fluids (such as formic acid) extending the vapor phase of these fluids, likewise enhancing reaction probabilities.

Candidate sites for looking for protolife (possibly fossil extremophiles?) would be in shadow zones at the poles where evidence of water ice exists, beneath dark mounds at fracture intersections (as in Alphonsus) or in breached central mountains in craters with reported transients. Copernicus is an example and is interpreted as a caldera hosting a breached volcano suggestive of a directed volcanic blast (Figure 1). The possibility of protolife in lunar shadow offers incentive for our return to the moon.

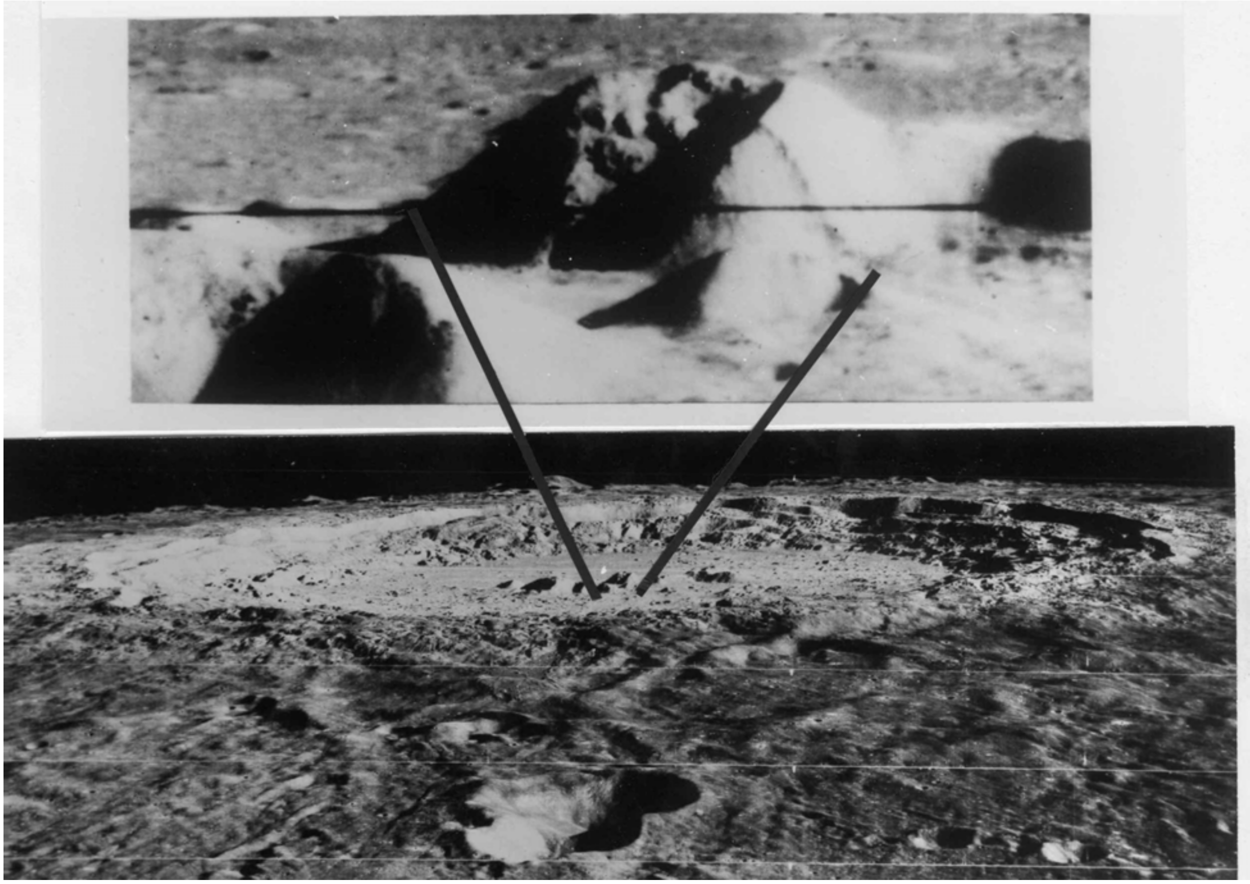

Figure 1. Orbiter 2 oblique photograph of the lunar crater Copernicus, 97 kilometers in diameter, view to north. If the breached central mountain is a volcano it may host hydrothermal alteration products and protolife. Supporting an endogenic (volcanic) origin for Copernicus are the following: (1) several reports of transient events, (2) well defined polygonality of the crater, (3) leveed sinuous flow channels suggestive of lava flow morphologies, (4) near horizontal apparent dips of crater wall units, (5) lavas of different ages on terraces, (6) multiple central mountains difficult to explain by rebound, (7) lava-like flow patterns on the crater floor, (8) conjugate craterlets on "loop" patterns on the southeast flank of Copernicus that can be explained by magmatic inflation/deflation processes in the evolution of a caldera and (9) axes of conjugate craterlets on "loops" that do not point back to the center of Copernicus but are oriented along a regional northwest tectonic lineament direction.