Title of Investigation:

Lunar Lava Tubes for Safety, Power, Endurance, and (Possibly) Ice or Hydrogen

Principal Investigator:

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Other In-house Member of Team:

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Initiation Year:

FY 2004

FY2003 Authorized Funding:

$0

FY2004 Authorized Funding:

$33,000

Actual or Expected Expenditure of FY04 Funding:

In House: $5,000; Contracts: RSI Research Systems Inc., $2,400; Dell, Inc., $5,200; and University of Maryland, $20,000

Status of Investigation at End of FY 2004:

Project has just begun and will continue in FY 2005 with funds already committed.

Expected Completion Date:

September 2006

Purpose of Investigation:

The main purpose of our study is to provide NASA with new candidate sites for a lunar base. The new sites must offer greater safety to humans and equipment. One such possibility is a lava tube. Figure 1 shows a lava tube in Hawaii that is 5 or 10 meters high. On the moon, we can see much larger tubes.

Basing sleeping quarters and most equipment inside such a tube would provide long-term protection from micrometeorites and from solar and cosmic short-wavelength radiation. Also, the inside of a tube would be nearly constant in temperature day and night, providing considerable savings in power consumption and design complexity. Rock is such a poor thermal conductor that a roof only 1 meter thick would already be thick enough to insulate from heat fluxes to and from space.

Our study will document the size, length, and orientation of suitable lava tubes and characterize the surrounding terrain for future mission planners. We also will address the power question in some detail and encourage the design of highly focused imaging instruments to test for hydrogen or water ice in the immediate vicinity of the tube's entrance.

Accomplishments to Date:

Funding for this project arrived only about one month before the end of FY 2004. In that month or so, we were able to contract for support and order some equipment, but no firm results were yet available.

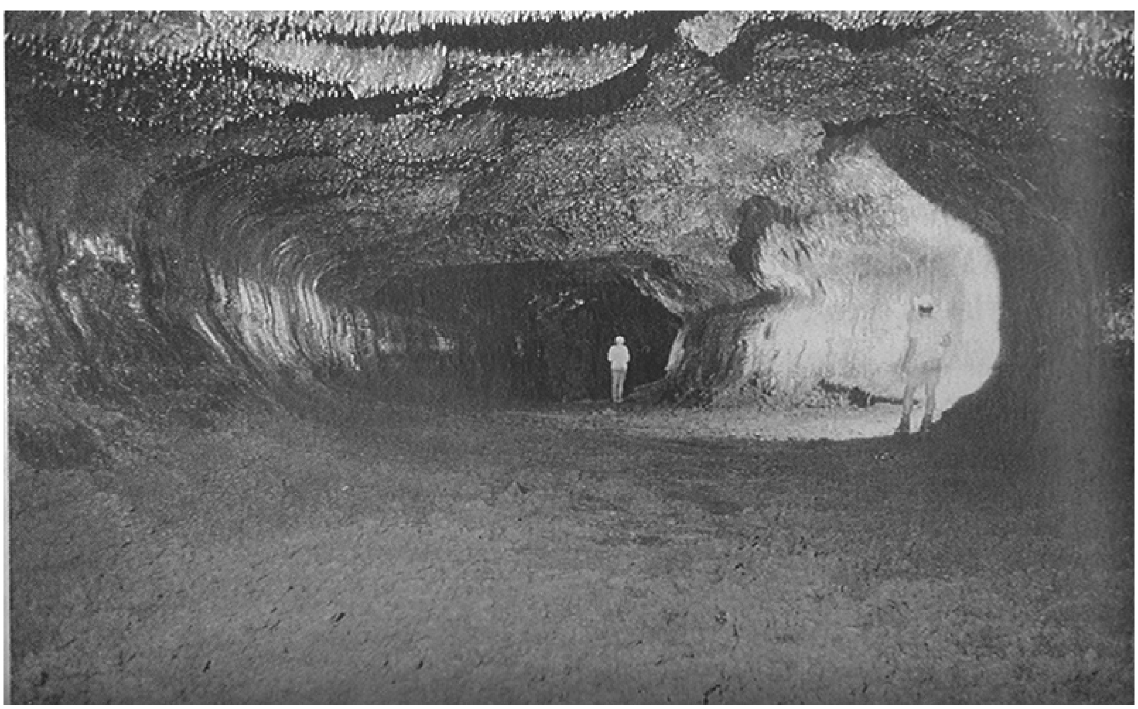
Summary:

A lunar base located inside a lava tube offers a variety of benefits. It would provide protection from radiation and meteorites, and allow designers to use lightweight, thin-walled construction techniques for the dwellings, including the use of plastic materials. Structures inside the tube would be largely immune from metal fatigue, especially at the joints, because they could endure the monthly 300-degree thermal cycling between daytime and nighttime temperatures. Finally, we expect a large reduction in the station's dependence on battery power because temperatures would remain steady.

Many lava tubes exist on the moon, especially near boundaries between the old mountainous terrain and the relatively young and flat "maria." Lava tubes are found along the moon's "sinuous rilles," which are river-like channels that flowing lava created as it melted some of the underlying rock during its passage. Here and there, the lava has left behind a frozen crust, which became the roof of a tube after the rest of the lava drained out. Figure 2 shows a meandering channel. Shadows of at least a dozen segments show that they bulge upward, as a roof would, in contrast to adjacent segments where the shadows are reversed, indicating a depressed channel.

One risk is that the best available pictures (e.g., Figure 2) have barely enough resolution to identify a lava tube and they certainly can't show whether steep slopes or boulders near the entrance would inhibit use of the tube. A future orbiting mission would have to determine the best candidate sites with photography and ground-penetrating radar to measure roof thickness and the volume of the hollow space inside. Another risk is the challenge of detecting from orbit hydrogen or water ice in small, permanently shadowed areas near and inside the mouth of the lava tube.

Figure 1. Two men standing inside a lava tube in Hawaii. With less gravity on the moon, tubes 30 meters high would be common and their measured widths exceed several hundred meters.



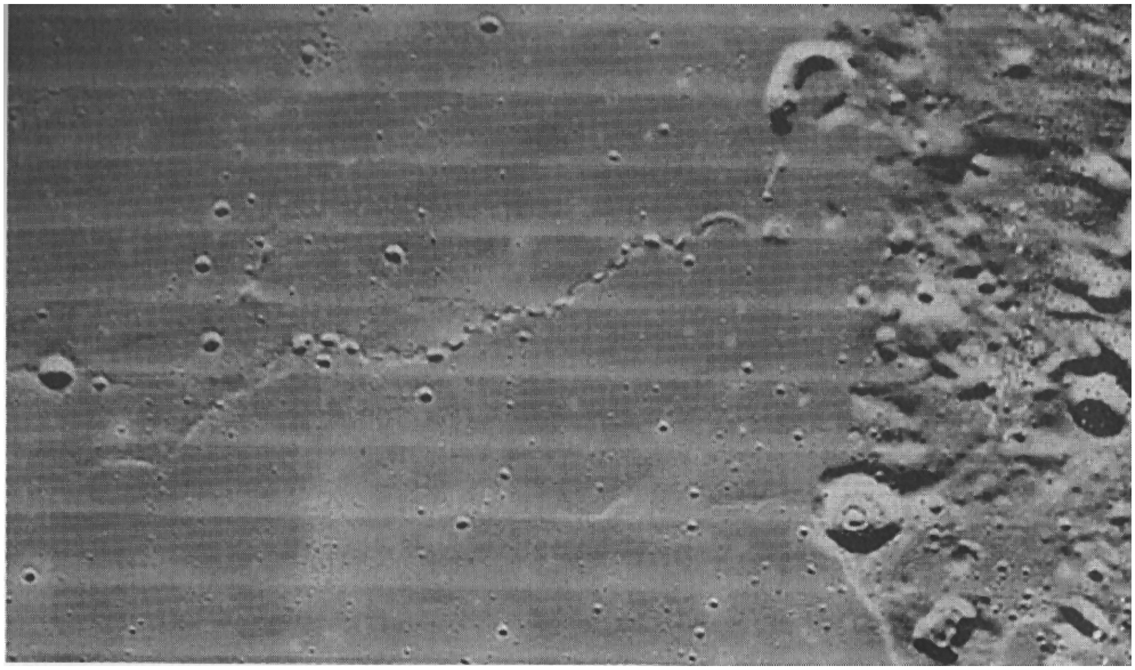


Figure 2. A very long lava channel with many roofed segments. In this case, most of the unroofing probably happened more than a billion years ago when the still-hot and flexible roof crust collapsed as lava drained out.