Brainstorming a Lavatube Skylight Explorer Probe

By Peter Kokh

Ever since Apollo 15 landed on the edge of Hadley Rille, 40 years ago this july, we have been aware that the dusty rubble pile surface is like the carapace of a tortoise—there could be a lot more underneath than meets the eye. Lunar geologists soon reached a consensus that the moon's many sinuous rilles, like Hadley, had to be collapsed lavatubes. But were there any intact lavatubes as well? Given that here and there, as in Hyginus Rille, we see a number of "interruptions" in the rille, hard to explain other than as uncollapsed sections, there has been a general expectation that the answer is yes.

Lunar rilles are quite generous in size and the scale of the lavatubes that collapsed to form them had to be generous as well. Apparently, the scale, as compared with those we are familiar with on Earth, is enormous, and must be in some inverse ratio to the gravity level: the lower the gravity, the larger in scale will be for any lavatubes. As Mars' gravity is more than twice that of the moon but less than half that of Earth, any intact lavatubes there must be of intermediate scale.

Here and there, an incidental meteorite hit on a lavatube ceiling might be enough to collapse it, forming a pit with no shoulders and with a dark center no matter what the sunlight angle. But such features would be pretty small and none showed up on orbiter photos. So we went on faith, a faith that the moon possessed substantial volumes of "lee" vacuum shielded from the cosmic elements or radiation, extreme thermal variation, and the incessant micro-meteorite rain.

Then along came Kaguya, the Japanese (JAXA) orbiter with its superior resolution Terrain Camera, and found the first such skylight collapse pit in the Marius Hills in Oceanus Procellarum on May 20, 2008. The measurements were just about right. 65 meters (214 ft) in diameter (Fig. 1).

There could be, there must be, more and the search was on.

Since then, Lunar Reconnaissance Orbiter has

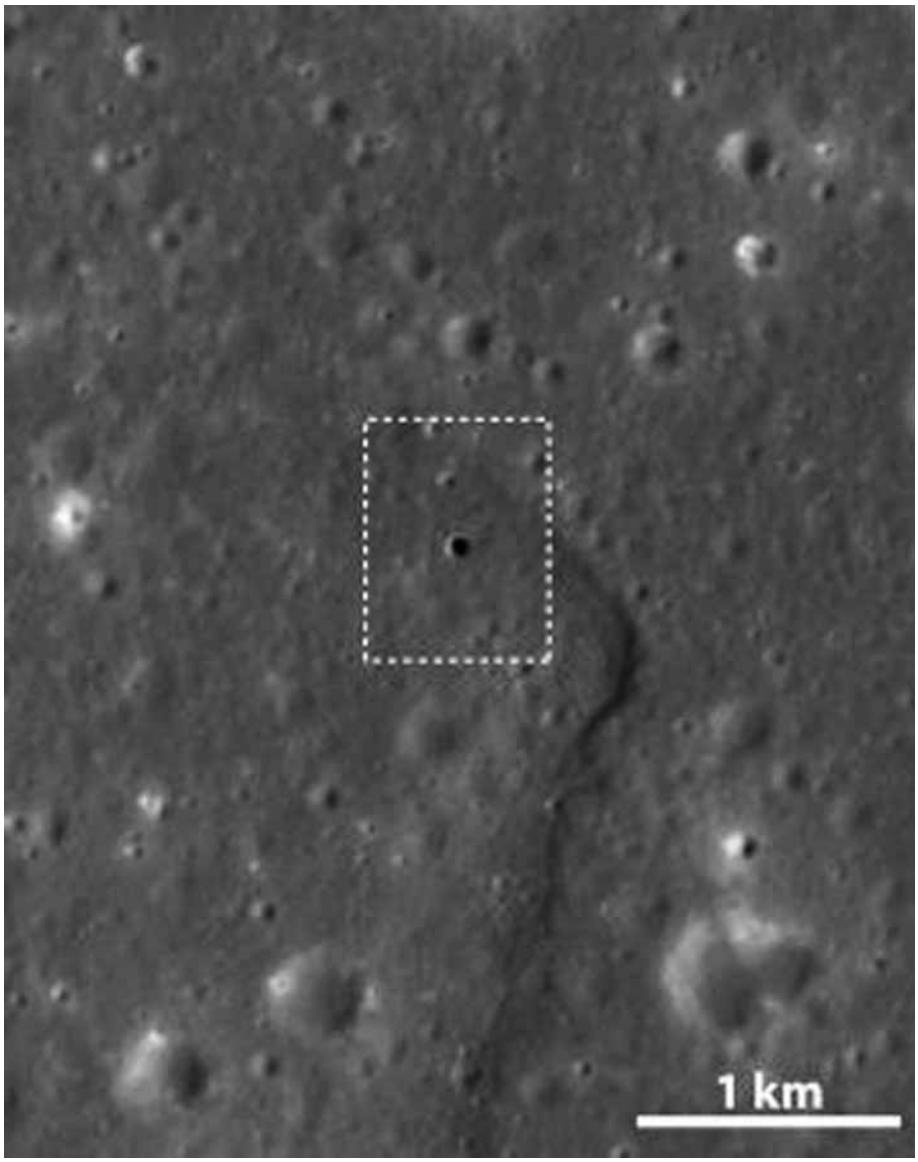

Figure 1: Kaguya Terrain Camera image of a skylight collapse pit in the Marius Hills in Oceanus Procellarum. http://www.planetary.org/image/Haruyama2009Fig1_context_med.jpg

found a few more: in Mare Tranquilitatis and even one on the farside in Mare Ingenii. Searching through the LRO data, at least ten more dark patches aroused suspicion, but await another pass at higher resolution to be sure.

Given that a good guess of how thick the ceiling of a lunar lavatube must be to avoid collapse, on the order of 40-50 meters, it is not surprising that there are not many more. But in time the count of confirmed skylights could grow to some dozens.

So now, of course, our curiosity is very high. We want to go down and take a look, map these tubes, study their interior surfaces. If ever we establish outposts on the moon, proximity to a lavatube entrance would be a major asset. As spacious as these hidden tubular voids promise to be, they would be ideal for industrial parks, warehousing, lunar agriculture and other acre-intensive uses, all pre-shielded, protected from the elements.

Figure 3: A rover anchors itself on the rim, and a 2-wheel rover lowers itself down by paying out a cable. http://www-robotics.jpl.nasa.gov/roboticImages/img811-414-browse.jpg

Lunar lavatubes that are still intact have been so for some 3.5 billion years or more. That would make them the most ideal location in all the solar system for some grand archival project to store all the records of humanity, our history, our works, our knowledge, our artifacts, plus samples of flora and fauna.

Indeed, if you are one who thinks that interstellar travel is sufficiently probable to the point that our system could have been visited some time in the past, a lunar lavatube would have presented the most secure place in the solar system to have left a calling card. Perhaps someone will make a science-fiction film along such lines.

Back to the moon. We are eager to explore one of these skylights. Just how do we do it? Not to long ago, I came across an article about a unique lunar rover concept developed at JPL: the AXEL rover (video: *http://www.youtube.com/watch?v=aPUFsKxQaOk*).

Lets take a side trip to Mars for a minute. The Mars rover Opportunity had visited a small but intriguing crater named Victoria with exposed bedrock areas. It would have been too risky to let the rover try to negotiate down the crater rim, of course, because it might not be able to climb out. To solve this problem, JPL researchers came up with the AXEL concept. A rover anchors itself on the rim, and a piggyback 2-wheel rover of very special design lowers itself down by paying out a cable from a winch on its axel. It is important that the winch be on the descending vehicle in order to keep the cable from rubbing on the rim and fraying (Fig. 3).

Back to the moon. Could not a two-part rover of similar design descend down into a skylight pit? The cable would have to be much longer, and to maintain low weight, it would have to be much thinner but equally strong. It might be 500 or so meters down to the bottom which would likely be the top of a collapse rubble pile.

On the way, instruments could scan the hole itself and map it and, once below the ceiling level, start mapping what it "saw" of the lavatube interior. But radar instruments are too heavy. What about a laser flash with camera? That might produce photos, but not the scale.

Well, I thought, this idea has possibilities. Why not run an engineering competition to design such a probe? Or at least key elements of it. Competing teams could come up with their own ideas for instrumentation. We could find some vertical drop of enough height for the various teams to test their systems. The 510 ft drop tower at NASA Glenn in

Figure 4: Vertical drop tower at NASA Glenn in Cleveland. http://microgravity.grc.nasa.gov/DIME_IMAGES/picture2005_09.jpg

Cleveland would be ideal, if they would welcome us to use it (Figure 4).

If not, there are here and there tall buildings that have no windows to break.

Would the National Park Service let us use Devils Tower?

Recently, The Moon Society, the Lunar Reclamation Society (NSS-Milwaukee, publishers of Moon Miners' Manifesto) and the National Space Society were the recipients of equal bequests over $7.000 each from an elderly couple in South Carolina who had contacted me in the Spring of 2005. They wanted the money to go to help open the space frontier. All three organizations have pledged $500 each as prize money for such an engineering competition.

Last November, I went to the University of Illinois Urbana-Champaign for SEDS Vision 2010, the annual conference for the Students for the Exploration and Development of Space and gave a Power Point Presentation on this idea. It met with considerable interest.

You can download this presentation "SkylightExplorer.ppt" from:

http://www.moonsociety.org/competitions/engineering/.

We are not ready to launch this competition. We need to develop the competition rules and design constraints, what has to be built vs. simply designed, what has to be demonstrated, where and when the demonstrations will be held, how they will be judged, who will be the judges, etc.

Currently, we (Moon Society and LRS) are looking for expertise to help us develop this competition. But we are also looking for support and co-sponsorship from other organizations, large and small. Prize money is welcome, of course, but so are prizes of memberships, subscriptions, software, tools, etc. We are open to all proposals.

What's at stake? For one, we hope to catch NASA's interest and that of potential principal investigators to the point where a real such mission to one of the lavatube pits on the moon is funded and developed. The payoff is not only knowledge and satisfaction of our insatiable curiosity, but that this competition, and then the announcement of such a mission, will arouse public curiosity anew. The moon will suddenly become much more than a dusty rubble pile. It will become a world with an extensive network of hidden valleys protected from the elements and waiting for human exploration, use, and occupation. Then maybe the Aldrinites will realize that we haven't "been there, done that" at all. Why, we've barely scratched the surface!

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Would the American Lunar Society be interested in coming aboard as a cosponsor?

Helping advertise the competition when the competition is ready to go public?
Offering a subscription to Selenology?
Donating an amateur telescope ideal for studying the Moon?

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