A Radar Flashbulb on the Moon

Probing Lunar Lavatube Caves by Radar Illumination

By Tom Billings

Lavatube caves under the lunar surface may be very useful as lunar base sites. They have left surface indicators that can be found in computerized searches of the Clementine data. A funding proposal to a private foundation for such a search is being put together by the Lunar Base Research Team (LBRT) of the Oregon L-5 Society, Portland's local chapter of the National Space Society.

Lavatube sites that are located will bear much further investigation before commitment to a lunar base there. Ground-penetrating radar images of actual voids at particular sites seem the next step, if images can be obtained cheaply. This paper describes what LBRT believes is the cheapest combination of technologies that can obtain such images of lavatube voids on the Moon.

As early as the Apollo Lunar Sounder Experiment, radar has penetrated the Moon to substantial depths. Only soundings were possible given the combination of penetrating wavelengths (1-20 meters) and the aperture of any antenna that could be carried by the Apollo Service Module. Now, operation of the Very Long Baseline Array (VLBA) by NRAO provides an aperture that, even from the Earth, could provide a resolution of 40-200 meters at the lunar surface with wavelengths of 1-5 meters. Lava-tube surface indicators have been found in Apollo photos for caves up to 1100 meters across. But where is the radar energy reflecting off the walls of these lava-tube voids to come from?

The 4th power range coefficient in the denominator of the Radar Equation makes this extremely costly if the rf source is on Earth. Likewise, transport to lunar orbit of a powerful rf source is beyond any present budgetary reality. However, if we are investigating only the immediate areas around sites found by the Clementine data search, then a very localized rf source, of appropriate power and wavelength, becomes useful. Such a localized source would give a signal/noise ratio governed by a 2nd power range coefficient in the Radar Equation. This factor, combined with the resolution of the VLBA may make a cheap mission possible.

We would propose that unconventional rf sources can be placed close to some lavatube sites located by lunar surface indicators for far less than an orbiting rf source would cost. A free falling object launched from Earth would posses much kinetic energy at the lunar surface. Converting a large portion of that kinetic energy to rf energy is possible with a two-part probe shaped like two extended concentric metal cylinders that slide past each other as the forward cylinder's end strikes the lunar surface. By allowing a strong magnetic field to brake the rearward cylinder's motion, very large electrical currents can be generated in the second cylinder. These large currents would have to be conditioned and turned into appropriate wavelength rf energy, then radiated into the local lunar surface very rapidly.

At a 2.35 km/sec. impact speed, the probe would have less than 1/1000th of a second to "flash" the lunar surface with rf energy before the transmitter and power conditioners at the back of the probe smash into the surface themselves. If it can "flash" successfully, then the rf energy can penetrate the dry lunar surface, reflecting off large discontinuities within the lunar material, including the voids of lavatube caves in the local area.

That rf signal would bounce back to Earth and be picked up by the receivers of the VLBA. Processing of the received signal should allow us to discern which local sites do in fact have lavatube caverns and characteristics such as overburden, width, depth and length. Further characteristics might be determined by more sophisticated analysis.

The mass of the probe will be determined by the energy requirements for penetration at a given wavelength and for reception at the VLBA, as well as the total efficiency of conversion from kinetic energy to rf energy. Each probe's "flash" may be able to illuminate strata for a few kilometers around the probe impact site. This may allow several voids to be confirmed, or even newly found, from one probe. The observation time for the VLBA will be short enough to not intrude much on the normal VLBA observation schedule. This should allow small enough "flashbulb" probes to be sent along with other lunar missions on a "mass-budget available" basis.

If a special lunar mission is set aside for these probes, then timing of individual impacts might be made provisional by selecting a figure-8 trajectory passing close to both Earth and Moon that would return the spacecraft "bus" to a release window once each orbit. Kicking the next small probe out at a slightly different time, with a slightly different push during that window could change the impact point on the Moon and allow a wide range of sites on the Moon to be sampled by these probe's. If there is sufficient excess capability available on a commercial comsat launch, then a small package with it's own booster might "piggyback" to GTO. From there the delta-v requirements for lunar impact are much reduced. Multiple launch opportunities might be available over some years for a continuing program of exploration with this basic flight concept.

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