AN OUTLINE OF THE JULES VERNE DISCOVERY MISSION TO EXPLORE THE LUNAR MANTLE VIA SOUTH POLE-AITKEN BASIN; Charles Meyer, SN2, NASA Johnson Space Center, Houston TX 77059

A Discovery-class mission is being designed to analyze a portion of the lunar mantle using specially instrumented rovers to explore an ultramafic 'island' of uplifted mantle within the South Pole-Aitken Basin on the backside of the Moon. The main purpose of this mission will be to check the validity of the 'magma ocean hypothesis' as the igneous process for the original chemical differentiation of the Moon. Planning for such a mission will focus our thinking about the whole Moon and lead to multiple working hypotheses for its internal differentiation.

The Clementine orbiter and Galileo flyby missions have verified the existence of a huge impact basin (South Pole-Aitken) on the lunar farside. This basin appears to be ~2500 km across, indicating a transient crater ~1000 km wide and ~500 km deep [1]. Material within this basin has a low albedo and a moderately strong absorption band at ~ 1 µm in the UV/Vis spectrum [2,3]. Cratering models [4], if they can be extended this far, would predict excavation to 120-140 km depth (see figure). Assuming that, before the SP-A impact event, the lunar crust on the backside was only about 70 km thick [5], as much as 20% of the volume excavated by this impact could be mantle material. Based on our understanding of melt rocks from the Apollo collection [6], this material would be mixed with the crustal materials in a giant melt sheet (~10^8 km^3) that would fill the low-lying regions within the resulting basin. Such a large impact would have thinned the lunar crust in this region by spreading ejecta over the rest of the Moon! Of course, the younger basins (Orientale, Imbrium, etc.) would have returned crustal materials as a thick ejecta blanket covering the surface of the South Pole-Aitken Basin. Apparently, only minor mare basalt flooding has occurred in this large basin [3].

The shock wave from the SP-A impact compressed the interior beneath the transient crater, resulting in rebound of deep material (mantle) into the basin. SP-A has no central peak, but there is vague evidence of an inner ring (~2000 km), typical of giant basins [7]. The impact melt sheet would have drained away from the higher elevations, leaving them as 'islands' with exposed mantle material from depth within the Moon. However, extensive cratering since the SP-A basin formation, has partially obliterated the original topography of this multi-ring basin.

The large interior basins, Apollo (480km), Schrödinger (320km), Plank (325km), Poincaré (325km) and others, within the South Pole-Aitken Basin provide another way to sample beneath the SP-A melt sheet. Fresh craters in the ejecta of these interior basins (e.g., Hess) should yield rock samples from beneath the SP-A melt sheet and thick regolith on top (figure). Ejecta from SP-A impact itself is less desirable - although some of it is on the frontside of the Moon near the South Pole (e.g. Schomberger). Arguments based on topography and photogeology will be supported by data from a polar-orbiting geochemical mission with a high-resolution X-ray spectrometer [8]. Combining the results of mineralogical distribution from Clementine, with data from an orbiting chemical mapping mission, we will be able to identify the most mafic region for our landing site.

The inherent complexity of the regolith at a given landing area will require mobility, because the scientific instruments must be brought into close contact with the rock samples, to select those that are mantle material from those that are melt rock or ejecta from distant basins. Planetary rovers are being developed by numerous institutions. For this mission, rovers do not need to be designed to survive a lunar night, but they will require large solar panels and a heavy-duty thermal control system. Two relatively large rovers are required to support the scientific instruments required by this mission. One rover would be dedicated to gamma-ray spectroscopy.

The measurements needed to characterize ultramafic rocks include precise chemical composition (e.g., pulsed-neutron gamma-ray and X-ray fluorescent spectroscopy), mineralogical content (Mössbauer, UV/Vis spectroscopy) and texture (close-up field lens) [9]. Since ultramafic rocks have low levels of some elemental concentrations, chemical instruments must be highly sensitive. Mg/Fe ratios are needed with precision. Recent advances in cryogenics [11] allows the use of solid-state sensors (Ge, Si(Li)) held at ~80 ^{o}K, which will allow better sensitivity in chemical measurements. Multi-spectral cameras will require high-data-rate telemetry.

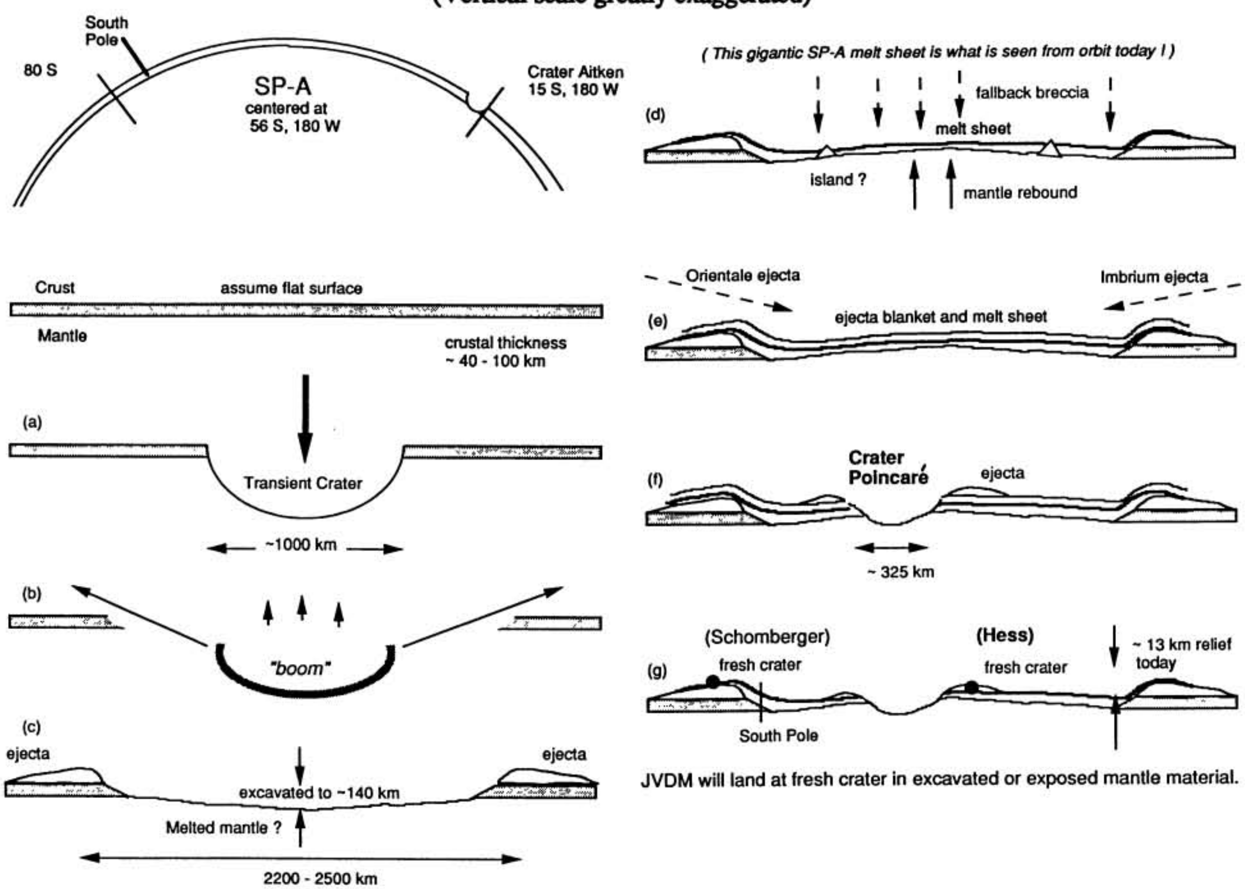
International Space Enterprises, working with Lavochkin, have reconfigured the Phobos spacecraft to work as a large lunar lander (landed weight 600 or 1500kg). If a commercial lunar mission that is planned for this vehicle is successful [10], or it is first used to land a telescope [12,13], then a dependable, low-cost means of transportation for a Discovery-class mission would be available to explore the lunar surface. However, a carefully-integrated communications system will be needed to teleoperate the rovers and relay the data from the backside of the Moon to the Earth.

"If our tale seems improbable today, it need not do so tomorrow, thanks to the resources science will make available in the future, and nobody will think of calling it fanciful".

Jules Verne, The Carathian Castle

[1] Head et al. (1993) *JGR, 98,* 17149. [2] Pieters et al. (1993) *JGR, 90,* 17127. [3] Lucey et al. (1994) *Science 266,* 1855. [4] Melosh (1989) *Impact cratering: A Geological Process. Oxford.* [5] Simonds (1975) *Proc. LPSC 6th,* 641. [6] Zuber et al., (1994) *Science 266,* 1839. [7] Spudis et al. (1994) *Science 266,* 1848. [8] Trombka et al. 1977 *in NASA SP-370,* 153. [9] Meyer et al. (1994) *Proc. International Lunar Exploration Conference. San Diego.* [10] Katragadda et al. (1994) *ibid.* [11] Tward, (1994) personal communication [12] McBrayer et al. (1993) LUTE, AIAA 93-4740. [13] Mendell (1993) An International Lunar Farside Observatory. IAF-93-Q.2.389

Cross Section of the Formation of the South Pole-to-Aitken Basin
(Vertical scale greatly exaggerated)



Note: A cross section of the SP-A basin should be drawn to scale on a curved surface, because this gigantic basin extends ~ 1/5 of the circumference of the Moon. The crater Hess on the rim of the Poincaré inner basin is tentatively chosen to sample through the ejecta blanket and melt sheet of the SP-A basin. The devil is in the details.