THE CONFLUENCE OF GANGIS AND EOS CHASMAS (5-12°S, 31-41°W): GEOLOGIC, HYDROLOGIC, AND EXOBIOLOGIC CONSIDERATIONS FOR A LANDING SITE AT THE EAST END OF VALLES MARINERIS. S. M. Clifford* and J. A. George**. *Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058, clifford@lpi.jsc.nasa.gov; Johnson Space Center, Houston, TX 77058, jeffrey.a.george@jsc.nasa.gov.

Over its 3,500 km length, Valles Marineris exhibits an enormous range of geologic and environmental diversity. At its western end, the canyon is dominated by the tectonic complex of Noctis Labyrinthus; while in the east it grades into an extensive region of chaos – where scoured channels and streamlined islands provide evidence of catastrophic floods that spilled into the northern plains [1,2]. In the central portion of the system, debris derived from the massive interior layered deposits of Candor and Ophir Chasmas spills into the central trough. In other areas, 6 km-deep exposures of Hesperian and Noachian-age canyon wall stratigraphy have collapsed in massive landslides that extend many tens of kilometers across the canyon floor. Ejecta from interior craters, aeolian sediments, and possible volcanics emanating from structurally-controlled vents along the base of the scarps, further contribute to the canyon's geologic complexity [1,2].

Following the initial rifting that gave birth to Valles Marineris, water appears to have been a principal agent in the canyon's geomorphic development – an agent whose significance is given added weight by its potential role in both sustaining and preserving evidence of past life. In this regard, the interior layered deposits of Candor, Ophir, and Hebes Chasmas, have been identified as possible lucustrine sediments that may have been laid down in long-standing ice-covered lakes [3,4]. The potential survival and growth of native organisms in such an environment, or in the aquifers whose disruption gave birth to the chaotic terrain and outflow channels to the north and east of the canyon, raises the possibility that fossil indicators of life may be present in the local sediment and rock.

Because of the enormous distances over which these diverse environments occur, identifying a single landing site that maximizes the opportunity for scientific return is not a simple task. However, given the fluvial history and narrow geometry of the canyon, the presence of a single exit at its eastern end provides an opportunity for sampling that appears unequaled elsewhere in the system.

Throughout the western two-thirds of Valles Marineris, the width of the canyon rarely exceeds 100 km. However, as it extends eastward, the canyon broadens significantly to include a region ~10^5 km^2 in size that lies at the confluence of the Aureum Chaos and Gangis and Eos Chasmas (5-12°S, 31-41°W; Figure 1). This area is the largest open expanse that occurs anywhere within the canyon system. At its most northward extent, this region is drained by a 50-75 km-wide channel, which is the sole conduit between the canyon and the northern plains. The region is characterized by large areas of chaos and extensive evidence of fluvial erosion by catastrophic floods (both within the canyon and in the downstream areas adjoining the canyon's principal drainage to the north).

Recently released MOLA topographic data indicate that much of this area lies at an absolute elevation of between -3 and -4 km (Fig 10 in [5]). Although this data indicates that the central portion of the canyon is ~1-2 km lower in elevation, there is considerable geomorphic evidence that enormous fluvial discharges occurred from the eastern end of the canyon and into the northern plains. This flow may have originated from local sources of water in the east end of the canyon, by the flooding and overflow of the central canyon, or by subsequent tectonic uplifting and subsidence that has modified the original topographic relationships within the canyon.

Whatever the cause, the geomorphic evidence for eastward flow, combined with the expanse, depth, and location of the confluence just before the canyon's sole exit to the northern plains, would have made this area an efficient trap for sediment and debris originating from interior sources lying further to the west. It also suggests that this depression may have been one of the most frequently wet regions on the planet, having necessarily been flooded to a minimum depth of several hundreds of meters over an area of as much as ~$5x10^4$ km^2 before any water discharged from the interior of the canyon could have spilled into the northern plains.

If the aquifers from which this water originated were already sustaining an active subsurface ecosystem, then it is likely that a geologic record of that life is preserved in the sediments and rocks that were deposited on the canyon floor. The repeated occurrence of such discharges, and their inevitable formation of a standing body of water at the terminus of the canyon, may have left a rich stratigraphy of biological and geochemical markers that could provide invaluable insights as to how the subsurface ecosystem evolved with time.

One of the great assets of this location is the opportunity it provides to obtain samples of the planet's oldest rocks. This potential is seen in the presence of valley networks on the plateau to the south, and in the exposure of several kilometers worth of underlying strata in the canyon walls. Samples of this material, originating from all depths within the stratigraphic column, have likely been distributed across the canyon floor by local landslides and extensive flooding, providing a wide variety of potential targets for investigation by the 2001 rover. In both Figure 1 and Table 1 we identify three specific landing sites that maximize the opportunity for: (1) obtaining dramatic descent and surface images of the canyon walls and nearby fluvial landforms; (2) acquiring samples of rocks and sediments of varying age, composition, and origin; and (3) compliance with virtually all of the engineering constraints identified for the 2001 mission.

The elevations of all three proposed sites lie near the -3 km minimum established for the 2001 Lander (although there is some ambiguity based on the spatial density of the early MOLA data and the fidelity of the color reproduction in the recently released high-resolution map of Valles Marineris (Fig. 10 in [5]). The greater air column and surface pressure associated with these low elevations will benefit the Lander mission in several ways. First, by enabling greater landing precision (≤ 20 km landing circle) through the use of aeromaneuvering. Second, by permitting improved discrimination between the surface and orbital radiation environments by MARIE. And, finally, by increasing the efficiency of CO_2 acquisition and O_2 production by MIP.

A common attribute of all three sites is their proximity to the canyon wall – which should provide both dramatic descent images and surface panoramas that are considerably different from those obtained by the Viking Landers and Pathfinder. Depending on which location is chosen, and how closely the landing circle is placed to the canyon wall, the 2-4 km scarps will subtend ~5°-22° on the local horizon. Some additional characteristics of these sites are summarized below and in Table 1:

Site A (-10.5°, 37.1°) The 20-km landing circle seen in Figure 1 lies on smooth canyon floor material that is interpreted to be fluvial deposits derived from Eos Chasma and more westerly sources within the canyon. The center of the landing circle lies approximately midway between a large massif to the north and an ~60-km-diameter cusp in the south canyon wall. The canyon truncates a number of valley networks in the Late Noachian plateau material to the south – a relationship that indicates that the underlying ~3 km stratigraphy, visible in of canyon wall, significantly pre-dates the end of heavy bombardment.

Site B (-6.5°, 37°) Lies on smooth canyon floor material that is interpreted to be a mixture of fluvial deposits originating from Gangis Chasma, local material derived from the collapse and retreat of the north canyon wall, as well as smaller contributions from Eos Chasma and Aureum Chaos. The landing circle is located ~20-km due south of a 60-km crater on the northern plateau whose SE rim has been incised and exposed by the canyon.

Site C (-4.1°, 35.2°) Lies near the point of maximum constriction in the sole channel that drains Valles Marineris to the northern plains. The landing circle again lies on smooth canyon floor material that is likely a mixture of rocks and sediment transported from both local and distant sources. The proposed landing site is located at the eastern edge of the channel. The nearby plateau exhibits considerable evidence of local subsidence and erosion by catastrophic floods, an interpretation that is also supported by the presence of several streamlined islands on the canyon floor ~20 km to the SSW. The plateau material on both sides of the channel appears to be Late Noachian or Early Hesperian in age [2].

Summary. The confluence of Aureum Chaos and Gangis and Eos Chasmas offers a unique potential for conducting geologic, hydrologic, and exobiologic investigations of the planet's past. For this reason, it is logical target, not only for the Mars Surveyor 2001 mission, but also for later, more ambitious robotic and human investigations. Its location within Valles Marineris provides direct access to a stratigraphic record whose exposure and accessibility is unequalled at any other location on the planet. Given the geometry, and hydraulic history of the canyon, eastward flowing floodwaters may have deposited sediments and debris originating from locations up to several thousand kilometers further west. This material is likely to represent a wide range of physical environments, origins, and ages, within the stratigraphic column.

Within the immediate vicinity of the confluence, lie two key relics of the planet's fluvial history -- the valley networks (on the high plateau to the south of Site A), and several vast regions of chaotic terrain that gave birth to the later outflow channels. Investigations of these features will provide important clues to understanding the distribution and cycling of water in the ancient Martian crust.

The presence of a robotic or human outpost on the floor of Valles Marineris would also be invaluable to understanding the state and distribution of subsurface water during the present epoch. Theoretical considerations suggest that the geophysical detection of groundwater, and its eventual accessibility by deep drilling, will be optimized at those sites that combine low latitude (which minimizes the thickness of frozen ground) with low elevation (which minimizes the distance to a water table in hydrostatic equilibrium) [6]. There is no better location on the planet that combines these attributes than Valles Marineris. The identification and sampling of such deep reservoirs of water is a stated goal of the Astrobiology program and a logical step in assessing the availability of *in situ* resources to support future human exploration.

A 2001 Lander mission to Valles Marineris would be an important precursor for these more ambitious future investigations -- providing the initial reconnaissance necessary to plan long distance traverses; geophysical sounding; shallow and deep drilling; and other activities related to the search for water and life, and the eventual establishment of the first human outposts on Mars.

References: [1] Lucchitta et al., Mars, University of Arizona Press, 453-492, 1992; [2] Witbeck et al., Geologic map of Valles Marineris Region, Mars, USGS Map I-2010, 1991; [3] Lucchita, B., NASA TM-85127, 233-234, 1982; [4] Nedell et al., Icarus 70, 409-441, 1987; [5] Smith et al. Science 284, 1495-1503, 1999; [6] Clifford, S.M., Lunar Planet. Sci. Conf. XXVII, 233-234, 1996.

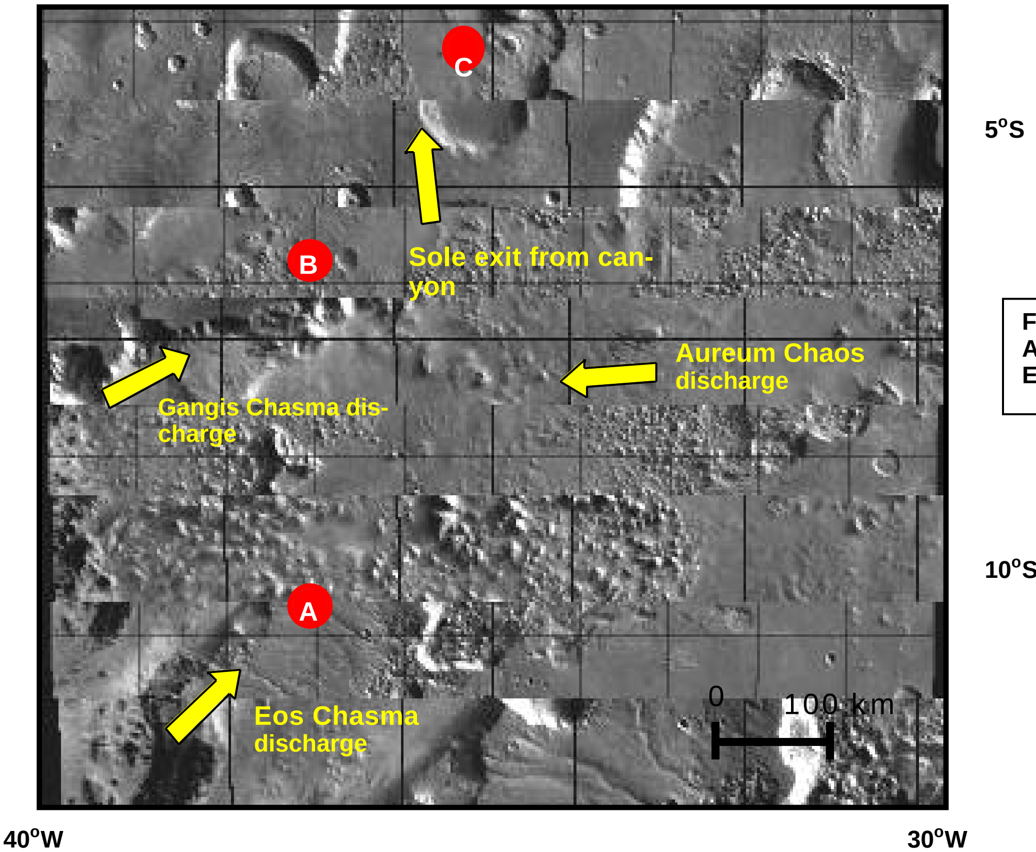

Figure 1. Confluence of Aureum Chaos and Gangis and Eos Chasmas.

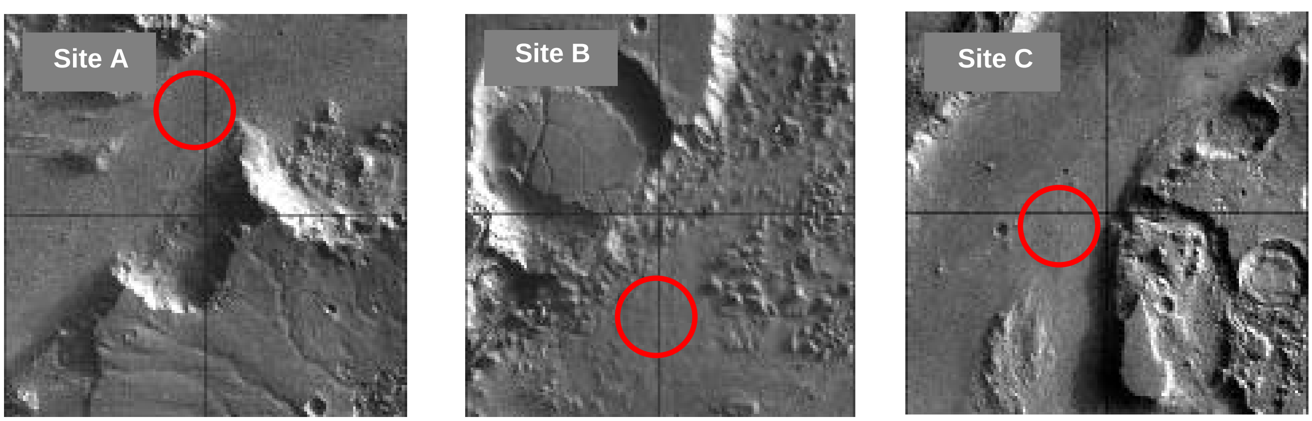

Table 1. Site Location and Compliance with Engineering Constraints.

	Center of 20-km Landing Circle	Elevation (MOLA)	Local Slope (MOLA)	Rock Abundance	Fine Comp. Inertia (cgs)	VO 100-m Coverage	Radar Reflectivity
Site A	(-10.5°, 37.1°)	-3.3 to -3.5 km	≤8°	Appear to be ~5%	≥ 8	~1/2 of landing circle	As yet unverified
Site B	(-6.5°, 37°)	~ -4.3 km	≤8°	~7%	≥ 8	Yes	As yet unverified
Site C	(-4.1°, 35.2°)	~ -3.0 km	≤8°	~12-13%	≥ 8	Yes	As yet unverified