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CHRYSE PLANITIA AS A MARS PATHFINDER LANDING SITE: THE IMPERATIVE OF BUILDING ON PREVIOUS GROUND TRUTH. L. S. Crumpler, Department of Geological Sciences, Brown University, Providence RI 02912, USA.

Introduction: Based on consideration of the geological characteristics of Chryse Planitia, the requirements for Mars Pathfinder landing sites, the nature of the mission, the scale of the observations to be made, and the need to build outward from previous experience, a new mission to Chryse Planitia offers several advantages that are difficult to ignore and offers a low-gamble/high-return mission scenario. Considering the need to ensure a successful mission, and to ensure the continued health of planetary exploration, the reasons for a new mission to Chryse Planitia are compelling.

Results of 1:500,000 Mapping: Based on recent geologic mapping [1,2], Chryse Planitia is the result of the following generalized sequence of erosional and depositional events: (1) an early impact basin [3] centered at 32.5°N, 35.5°W [4]; (2) basin resurfaced during emplacement of an unspecified material, possibly lavas; (3) geologic unit on which the Viking Lander is situated was buried to a depth of several hundred meters by an early mare-type ridged plains surface and superposed impact craters; (4) sediments shed from the highlands formed a uniform unit over much of the southern and southeastern basin; (5) subsequent impact cratering and regional mare-type ridge formation; (6) catastrophic outflows of water from Maja Valles to the west and Kasei Valles to the northwest scoured and incised all preexisting units and resulted in additional deposition in the basin interior; and (7) the Viking Landing site was resurfaced at least in part by the deposition of sediments carried by Maja Valles and Kasei Valles.

Operational Benefits of Chryse Planitia: All potential landing sites within Chryse Planitia satisfy the primary operational requirements for the Mars Pathfinder mission: (1) low latitude = 22°N ± 2° and 46.5°W ± 5°; (2) altitude below 0 km = –1 to –3 km below datum; (3) landing ellipse free of large-scale hazards = Chryse Planitia has some of the largest expanses of low-hazard terrain on Mars. A critical advantage is that the engineering requirements for landing in Chryse are well known at lander scales. The block size distribution is known and predictable: blocks ≥1 m account for ≤4% of the surface area. Known meteorological conditions during predawn landing of Mars pathfinder indicate very low winds at the surface and aloft, and high-resolution regional images exist for local landing site selection. Based on my experience on the Viking Lander 2 site selection effort, landing ellipses are difficult to situate at large scales and these additional considerations are likely to be overriding during final landing decisions.

Science Benefits of Chryse Planitia: Different scale features require different path lengths in order to accumulate adequate "truth" (N) about that feature; the cumulative rate is an inverse exponential (to some constant, n) of traverse length (R) such that (N~ ((R)exp(1/n))/C). The proposed Mars Pathfinder rover capabilities are excellent for addressing many of the small-scale mineralogical and lithological questions raised by initial Viking Lander study, but regional lithologic questions cannot be addressed with the same rover capabilities. The probable diverse lithologies of blocks at small scale in the Chryse Basin deposited from outflow events in Maja and Kasei take advantage of the ability of Mars Pathfinder rover to make small-scale mineralogical investigations while increasing the information content of small-scale investigations during short traverse lengths.

Knowing the detailed questions that will be asked greatly increase the ability to design a successful experimental test: Viking Lander 1 raised detailed questions that Mars Pathfinder may be designed and engineered specifically to address. For example, what are the dense, coarse, and pitted lithologies? What is the origin of the block distribution? Impact? Outwash? *In situ* weathering? What is the grain size of the surface fines, sand or silt? What is the microstratigraphy of the fines? Is there a stable substrate in Chryse at lander scales of observation? Other regional geological issues remain: What is the geological unit of central Chryse, volcanic or sedimentary? Is there microscale evidence for standing water or water-derived precipitates? If these questions cannot be answered in Chryse with carefully designed experiments and some prior

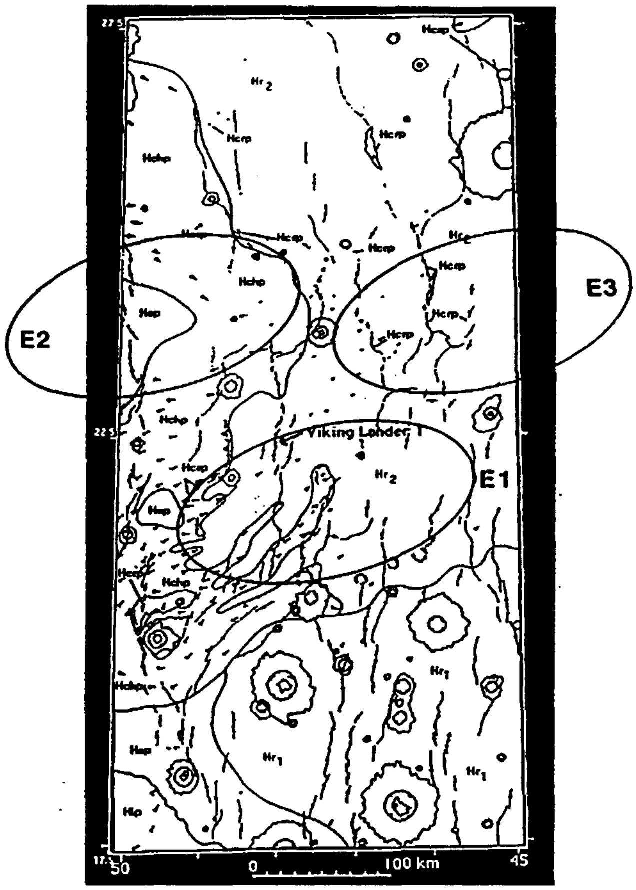

Fig. 1. Geologic map of the MTM 25047 and 20047 photomosaic sheets in the Viking Lander 1 region of Chryse Planitia. Map units: Hr_2 = upper ridged plains; Hr_1 = lower ridged plains; Hsp = smooth plains; Hcrp = channel and ridge plateau; Hchp = channel plains; Hip = incised plains. See Crumpler et al. [1] for more detailed description and interpretation of units. Numbered landing ellipses are 100 km × 200 km and indicate recommended sites: E1 = safest; E2 = less safe; E3 = intermediate level of safety based on degree of similarity to VL-1 site.

knowledge, then they will be more difficult elsewhere where the questions are unknown.

Conclusions and Site Recommendations: It is tempting to set the sights for future prospects on many of the additional interesting areas defined on Mars since the Viking mission and expand the database for ground truth to new and different terrains. This desire should be balanced with the critical need for success in planetary exploration in general and avoidance of an inconclusive mission result in particular. An important goal should be learning how to operate on Mars and addressing answerable questions. A firm start on the latter can be attained by a new mission to Chryse Planitia in the region specified, in which the existing ground truth of the Viking Lander 1 is used to constrain the engineering choices and to design appropriate instrument goals to fully utilize the lander limitations and capabilities. Three proposed sites are indicated on Fig. 1 along with the currently defined landing ellipses. Site E1 is most likely to be similar to VL-1; site E2 is less well constrained and is likely to differ from VL-1 in some respects; and site E3 is likely to be similar to VL-1, but incorporates slightly less hazardous, but slightly different terrain.

References: [1] Crumpler L. S. et al. (1994) *USGS 1:1M scale map*, submitted. [2] Craddock R. A. et al. (1994) *JGR*, submitted. [3] Schultz R. A. and Frey H. V. (1990) *JGR, 95*, 14175. [4] Stockman S. and Frey J. (1993) *Eos, 74*, 199.

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A HIGHLAND SAMPLE STRATEGY FOR PATHFINDER.
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Mission Constraints: Potential landing sites are confined to latitudes between 0° and 30°N and surfaces below 0 km elevation. The landing ellipse is 100 × 200 km oriented N74°E. The constraints essentially eliminate the slopes of Elysium Mons, Olympus Mons, Tharsis Ridge, Lunae Plaunum, all the southern highlands, and almost all the Noachian material of Arabia Terra. Those areas that remain as potential landing sites are chiefly lowland plains of Amazonis Chryse, Isidis, and Elysium Planitiae.

Siting Strategy: With only two previous Viking landing sites in widely separate locations, almost any landing will provide new data. Viking 1 landed on Chryse Planitia on a surface that is presumed to be Hesperian ridged plains material, which is interpreted to consist of volcanic flows [1]. Viking 2 landed on knobby material in Utopia Planitia, which is interpreted as eolian and volcanic materials [2]. The large landing ellipse precludes a finely targeted sampling strategy. Several site selection strategies are equally valid. Presumably, Noachian materials are more representative of the geochemical character of the planet than the volumetrically less important surficial flows and sedimentary materials.

Any attempt to sample highland material further constrains the possible landing sites by eliminating areas of Hesperian or Amazonian lavas and sediments. Materials of possible Noachian age are primarily located above 0 km elevation and at southern latitudes, except for minor occurrences in Arabia Terra and a narrow zone along the southern edge of Elysium Planitia.

One possible sampling strategy is to sample materials within those few "highland" terrains that extend to low elevations. Minor occurrences of Noachian materials are exposed at low elevations as outliers flanked by younger material within Nepenthes Mensas and Aeolis Mensas, but such areas are rugged and unsuitable for a safe landing. However, parts of western Arabia Terra extend to acceptable elevations and are reasonably smooth.

A second strategy is to sample materials at the mouth of an outflow channel that drains from the highlands. Channels may terminate in deltas, alluvial fans, or sheet deposits. For simplicity these deposits will be refered to as "fans." Fans provide materials from a large sampling area, and dissected fans offer the advantage of providing a vertical section of exposed stratification that records the history of the outflow.

On first appraisal, any fan at the mouth of a channel draining from highlands offers a potential target, but not all fans offer equal opportunities. Many outflow channels have ponded along their length; hence, any sediment carried by the discharge at the mouth is derived only from the last site of ponding [3]. Further, although catastrophic outflows are characterized by high sediment load and large caliper, the last sediments deposited during waning discharge are generally fine grained.

Potential Landing Sites: Potential landing sites include outflow channel material at the edge of Chryse Planitia and highland materials bordering southern Amazonis Planitia. The circum-Chryse channels include Kasei Valles into northwest Chryse Planitia; Bahram Vallis, Vedra Valles, Maumee Valles, and Maja Valles into western Chryse; Shalbatana Vallis into southwest Chryse; channels draining from Capri and Eos Chasmata into southern Chryse (Simud. Tiu, and Ares Valles); and Mawrth Vallis into northeast Chryse Planitia. With so many large outflow systems terminating within Chryse Basin, it is probable that any landing site within the basin (including Viking 1 landing site) will be blanketed by sediments from catastrophic outflows or outflow sediments reworked by eolian activity. Channels in southern Chryse Planitia, originating within Vallis Marineris or chaotic terrain south of Chryse Planitia, traverse Noachian material before entering the basin, but they do not provide readily identifiable fans.

Best Bets: Mawrth Vallis of the Oxia Palus region cuts Noachian cratered plateau material, which is interpreted to be largely impact breccia of ancient crust [4]. The plateau surface bordering the lower reaches of the channel, below 0 and –1 km elevation, is one of the few places on Mars where typical highland material can be found below 0 km elevation. Three landing sites are feasible. One potential site is at the mouth of the channel (29°N, 21°W); an alternate site is on the plateau surface adjacent to the valley (28°N, 18°W); and a third site is south of Mawrth Vallis and east of Ares Vallis (2°N, 2°W). The highland site adjacent to Mawrth Vallis is more likely to contain less surficial cover than the site east of Ares Vallis. If not covered by surficial material, highland sites are likely to consist of highly commuted materials; they would provide an estimate of the geochemical character of the homogenized early crust.

The mouth of Maja Canyon (18°N, 50°W), with remnant fan material cut by late-stage discharges [5,6], offers the best channel mouth target. The chief constituents here are likely to be detritus from Noachian material of the Xanthe Terra region carried by outflow that spilled onto Chryse Planitia following ponding behind a barrier massif of Noachian basement material.

Pitfalls and Predictions: The large landing ellipse and low resolution of Viking images do not allow assurance that the landing site will contain any particular anticipated material. Extremely