MARS LANDING + 50 YEARS: REPURPOSING THE FIRST VIKING LANDING SITE ON CHRYSE PLANITIA AS AN EXPLORATION ZONE FOR AUTOMATED INFRASTRUCTURE CONSTRUCTION

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Introduction: Return to America's first landing site on the surface of Mars allows a well-studied landing site in the Chryse Basin -- a level expanse with a complex geological history [1], interpreted as a volcanic plain [2] resurfaced by deposits from floodwaters and deflation from aeolian processes -- to be re-purposed as an Landing Site (LS)/Exploration Zone (EZ) well suited for automated construction of infrastructure for human habitation on Mars [3,4,5]. The proposed EZ, centered at latitude 22.3°N and longitude 48.3°W, provides a location with ground truth of available resources for human infrastructure and habitation, confirmed through analysis of imagery and experiments conducted at the first Viking Lander (VL-1) landing site decades ago [6,7,8]. Figure 1 shows the EZ against Viking orbiter images as a context image with approximate dimensions of the EZ and identified six Regions of Interest (ROIs) [9].

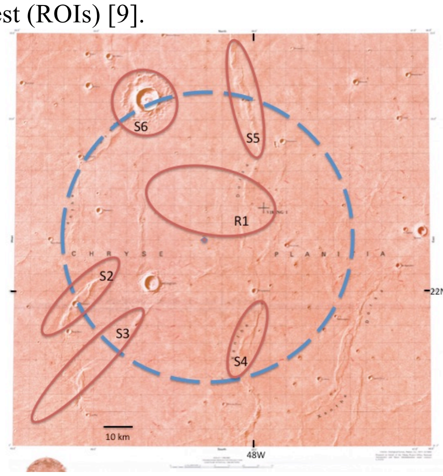

Figure 1: Context image from USGS I-1059 of Chryse Planitia EZ, showing landing site center (red diamond), EZ 50km reference margin in dashed blue, and six ROIs (R1, S2-6) described in the text as red ellipses.

Rationale: The proposed EZ on in the Xanthe Dorsa region of Chryse Planitia gives access to closely accessible scientific ROIs, including outcrops of volcanic bedrock [10], impact crater ejecta and stratified drift deposits in the immediate vicinity, a rich assemblage of petrologic samples showing evidence of trapped atmospheric gases in vesicles [11], and proximity to datable volcanic wrinkle ridges [12] and landforms shaped by water floods and later aeolian erosion [13,14]. The Chryse Planitia EZ has substantial evidence, confirmed through ground truth gathered by VL-1, that the EZ is capable of providing adequate resources for human crews: cobbles, regolith, and basalt-based silica and metal feedstocks are available in a centralized area. These resources can be readily used for LS and Habitation Zone (HZ) in-situ resource utilization (ISRU) and infrastructure construction by highly automated equipment. The proposed EZ site has the potential for readily accessible ice, and centers near an extensive resource ROI that allows for the retrieval and study of VL-1 lander hardware subjected to the Martian environment for a half-century, offering an unique insight into the impact of sustained exposure of infrastructure to conditions on the Martian surface.

The original selection and return to the VL-1 landing site and its environs has been proposed for robotic landers largely on the basis of scientific investigations for the site [15,16,17]. The proposed EZ site's five scientific ROIs collectively meet threshold criteria for trapped atmospheric gases, datable crustal units, aqueous processes and stratigraphic contacts. However, direct experiments performed on the sampled soils at the VL-1 site have not provided clear evidence of either current habitability or fossil biosignatures at the EZ site. However, this proposed EZ affords an unique opportunity to investigate the rate of weathering and morphological, meteorological and mineralogical changes to the Martian surface in the location of VL-1 in the decades since the lander's initial operations ceased in 1982 [18,19]. The extensive resource ROI that contains the VL-1 lander (Figure 1.R1) has a well-imaged surface subject to change, and could include changes to ventifacts subject to aeolian erosion, downslope movement of pebbles and clasts, dust accumulation and scouring near the VL-1 lander, dust tail orientations and pitting of coarsely granular cobbles.

The proposed EZ lies at the western margin of the Chryse Basin, a depositional plain that may retain the outflow of three significant late Hesperian channel systems in catchment areas from the distant headlands to the west and south of the EZ. Of the five scientific ROIs identified in the EZ beyond the VL-1 site, two ROIs (Figure 1.S2, S3) concern outflow channel morphologies and impact crater ramparts of "Princeton" and "Lexington", another two ROIs (Figure 1.S4, S5) explore along one of the prominent Xanthe Dorsa wrinkle ridges for evidence of early Hesperian volcanism, and a sixth ROI (Figure 1.S6) examines a substantial impact crater "Yorktown" that may have exhumed Noachian crustal material, mafic bedrock and volatiles into its ejecta field [20].

The Chryse Planitia EZ itself may center on the confluence of several channel systems whose origins have been subject to numerous interpretations, and recent analytical consensus indicates that these channel structures were created by floodwaters during the late Hesperian era, and may have terminated in a standing body of water [21]. The two outflow channel ROIs in the EZ include (1.) outflow areas of Maja Valles from the south draining Juventae Chasma, and (2.) outflow areas of Kasei Vallis from the northwest which may have had more than one episode of erosion, as well as landforms that may have been created from floodwaters from either Bahram, Vedra, or Maumee Valles flowing from the west of the EZ. Well-sorted material, which appears to include fairly well rounded pebbles, may have been deposited in the EZ area from floodwaters that coursed through these channel systems. Traversals to ROIs in the EZ could travel upstream towards the Maja fan [18] to reveal clues to the complex history of these flooding events and their deposits. Statistical variations in the numbers and types of cobbles, boulders and sediments present in each of the outflow ROIs could give clues to the timing and extent of episodic flooding events and origin of the parent rocks found in the deposits [22]. Evidence of pre-Amazonian (Noachian?) astrobiologic habitats could have been formed upstream of the Chryse Basin and placed in the EZ area as a result of floodwaters depositing detritus in downstream locations.

Engineering factors important to the EZ ISRU include: (1.) latitude near 30°N for likelihood of near surface water ice in excess of 100MT, (2.) elevation (−2 km) for sufficient atmosphere for a safe descent of robotic and human landers, (3.) relief of <100 m, for ease of construction of large planar platforms and transportation corridors, (4.) slopes of <10° for stability at touchdown of robotic and human landers, (5.) accessible rocks, drift deposits and moderate sized boulders for construction material and (6.) a load-bearing surface that shows evidence of bedrock in outcrops. The EZ is uniquely suited to provide detailed study of the VL-1 site to discern morphologic changes to the landscape and weathering changes since 1982.

Summary: The proposed Chryse Planitia EZ centered near the VL-1 landing site has evidence for adequate water ice, silica, and load-bearing bedrock surface resources to utilize as infrastructure for long-term missions to support humans. Significant scientific inquiries into environments conducive to possible astrobiosignatures, Martian surface processes and the geologic history of Mars could be enhanced through extention of investigations begun in the Viking era into the 2030's and beyond.

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