North and east in the restricted site are rough floor material and landslide material [1], the smooth distal tongues of landslides. In the nominal site, but not the restricted site, are mesas of layered material, probably volcanic or lacustrine sediments [1,9]. Mesa elevations are to 2.5 km, and some are bounded by cliffs.

Surface. Imagery of the landing surface will help elucidate recent surface-atmosphere interactions (wind) and past geological processes in Valles Marineris (sedimentary or volcanic deposition, erosion by wind and water). Characterization of the landing surface will provide ground-truth calibration for remotely sensed data from Viking color and IRTM, Phobos 2 ISM, and Earth-based spectroscopy and radar.

Sand, rocks, and dust should be accessible. The sand has little adhering dust [6], so IMP and APXS analyses of sand will include little dust component. Data on the sand, if basaltic, will help explain martian magma genesis and volcanic processes, provide tests of the origins of "martian" meteorites (via element abundance ratios [10]); and provide clues to aqueous alteration processes (especially from IMP spectra). Rocks on the landing surface probably represent local types, including basalt, sediment (layered material), and highland material from Chasma walls. Chemical and spectral data on rocks will be important in elucidating the geologic history of the Valles Marineris area, and will be relevant to all sedimentary, highlands, and volcanic terrains on Mars. There will likely be local concentrations of dust for analysis.

Scene. The IMP will have spectacular views of Chasma walls to the north (~5.5° vertical angle, 101 IMP pixels, 60 m/pixel) and mesas of layered material to the southwest (~1.5° vertical angle). Spectra from IMP will help reveal the mineralogies and compositions of highland crust (in Chasma walls), Lunae/Syria Planum resurfacing units, layering at tops of the Chasma wall, and the sedimentary layered material. IMP and synthetic stereo imagery will help clarify structures, material properties, and slope processes of the Chasma walls; tectonic structures in and around Melas; and stratigraphic, depositional, and exobiological implications of layered Valles fill.

Atmosphere. Meteorological data from Melas Chasma would be the first from an equatorial site, but local effects could be significant. Valles mists could be studied directly, and the Chasma wall and mesas could provide some calibration for airmass optical depths as a function of elevation, at least to the wall heights.

Mission Constraints II: To investigate Melas Chasma requires landing at 10°S, entailing decreases of ~10–15% photovoltaic power (vs. 15°N), and ~1 hr/day line-of-sight with Earth (vs. 0°N) [11]. To maintain safety, a landing ellipse with an aspect ratio of 2:1 and elongation on N74E must be < ~170 × 85 km. Ellipses of 100 × 200 km aligned between east-west and ~S30°E can be accommodated in Melas Chasma with no elevation above about 1 km.

Fig. 1. Nominal and restricted landing ellipses (100 × 200 km and 75 × 150 km) proposed for Melas Chasma. Scene is 8 to 12S, 67.5–80W; ellipses centered near 9.75S, 72.75W.

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CLIMATOLOGICAL TARGETS FOR MARS PATHFINDER.

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Major Climatological Questions: Did Mars have a wet, warm climate early in its history? There is evidence that water flowed across the martian surface during the Noachian [1], and a hydrologic cycle was probably required [2]. However, surface temperatures early in martian history are predicted to have been too low for liquid water [3]. An atmospheric greenhouse, with CO_2 as the major constituent, has been postulated as a mechanism to raise surface temperatures. The subsequent fate of that CO_2 remains a puzzle; 2–5 bar would have been required, equivalent to a global layer of calcite 46–115 m thick. Although bulk carbonates have recently been reported in martian meteorites [4], it is important to search for *in situ* martian carbonates.

Did the discharge of martian outflow channels produced a large ocean in the northern plains, and Hesperian and Amazonian periods of clement climate? It has been hypothesized [5] that return of CO_2 to the atmosphere could have occurred during the creation of the outflow channels, and that subsequent higher surface temperatures could have permitted a global hydrologic cycle that was responsible for formation of a vast Austral ice sheet. The outflow would have formed a northern ocean that would eventually have reprecipitated the CO_2 into carbonates, thereby ending the warm, wet periods.

Is chemical weathering proceeding at present on Mars? The reactive nature of regolith materials suggests either that reactive oxidants are present in the soil [6], or, more likely, that heterogeneous chemistry is taking place between surface materials and photochemically produced oxidizing compounds in the atmosphere [7].

Target Considerations: The ability to look into the past means the ability to look down the sedimentary sequence. The ideal landing site is one in which sedimentary units are exposed. Ideally, a mixture of clastic and chemical sediments will be present; decimeter-scale coherent igneous rocks would provide the opportunity to examine chemical weathering processes. A near-shore deposit, where local channels show evidence of having dissected units of a variety of ages, would be ideal.

We search for depressions within the allowable latitude and elevation domain, into which channels or valleys clearly flow, and which show no obvious signs of subsequent deposition, such as wrinkle ridges, or the high-albedo/low-thermal-inertia signatures of thick dust deposits.

Target materials include carbonates, nitrates, sulfates, halides, phosphates, clays, and Fe-oxides. Much of the original CO_2 inventory was expected to be locked up in carbonates somewhere in the martian regolith. Although small amounts of carbonate have been detected in airborne dust [8], no significant *in situ* deposits or coherent carbonate rocks have been identified. Nitrates are important because Ni is an element of major biological significance and has not been identified in the martian soil. Moreover, some models of the Viking Labeled Release Experiment [9] require significant nitrate deposits. The presence of sulphates, particularly in the absence of carbonates and nitrates, would constitute support for the hypothesis [10] that reactions between S-rich volcanic aerosols and precipitates may have displaced CO_2 and NO_x back into the atmosphere. Halides are not predicted to form under any circumstances [11], so indications that they exist would be an important constraint on martian geochemistry.

Available Measurements and Strategies: The APXS imager may be able to identify depositional environments; if trenching can be done with the tires, even to a very limited depth, additional information may be gained. Small-scale stratigraphy can be very revealing. During Marsokhod rover tests in the Mohave in March 1994, the presence of well-rounded, high-sphericity pebbles at 15 cm was conclusive evidence of flooding. Resolution of 1 mm should reveal evidence of fluvial transport, if any, in clastic sediments.

Measurements of atmophilic elements in sediments may shed light on the climatic conditions that existed during their deposition. Coherent rocks of any probable evaporite could probably be identified with a combination of APXS and IMP imagery. Conversely, if evaporites are present only in the fines, unique identification is problematic, although APXS data may detect constituent elements. Mass balance calculations and geochemical considerations [12] may permit identification of evaporites. Examination of any crust should be a high priority, using both APXS and IMP data.

An important test for contemporaneous heterogeneous chemistry can be carried out with any rock larger than the saltation mean free path length. Weathering reactions should produce a rind, which mantles underlying material from subsequent alteration until accumulated unit-cell mismatches and physical abrasion cause spallation. If heterogeneous weathering is occurring, the windward and leeward sides of rocks may exhibit compositional gradients in their surfaces, detectable by the APXS. Comparison of the two sides of any large rock should be considered a high priority.

Target Area: Four areas fit within the elevation and latitude constraints: Chryse, Elysium, Amazonis, and Isidis. There is geomorphic evidence that all have supported standing water. In some sense, it would be difficult to pick a landing site that had no hope of teaching us about the climatic history of Mars.

The southeast Elysium Basin (3°N, 184.5°W) provides an optimal target in which a variety of materials may be accessible in a near-shore environment [13]. The albedo of the region is moderately low, and the thermal inertia is indicative of moderate rock coverage or some consolidation of fines, arguing that the site has not been covered with eolian dust deposits.

The orientation of the landing ellipse is parallel to the inferred shoreline, which is the circumglobal highland-lowland scarp. The probability of landing in a near-shore paleoenvironment, in which small but coherent fragments of highland materials might be deposited, is increased where the paleoshore lies along the long axis of the landing ellipse.

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