Look for evidence of wetbased glacial activity. Traverse to graben: Analyze theories of origin. Compare evidence for simple glacial-passive graben interaction and the possibility of dike intrusion into the ice and phreatomagmatic explosions and eruptions. Look for country rock blocks and juvenile magmatic material on the rim and floor of the graben. Assess wall stratigraphy. (MEPAG investigations IA1, IIIA4, IIIA7). Detailed Mapping of Glacial/Volcanic Interactions. (MEPAG investigations IIIA4, IIIA6, IIIA7).

Shallow Seismic. Record depth measurements of distal smooth facies. (MEPAG investigations IIIA4, IIIA5, IIIA6, IIIA7).

Rock Sampling. Dating of distal units to provide context for duration of glacial flow. (MEPAG investigations IIIA4, IIIA5, IIIA6, IIIA7).

Application to MEPAG Goal III. Determine the evolution of the surface and interior of Mars.

Appendix 1. Candidate Mars Human Exploration Sites

Compiled by HEM-SAG with specific site suggestions and contributions by Jim Head, James Dickson, Caleb Fassett, Joseph Levy, Jim Rice, Francois Poulet, Jeff Moersch, Jen Heldmann, Charles Cockell, Peter Doran, Ralph Milliken and Rick Elphic. Initial biology prioritization also included: (Score: 1-5. EL = Extinct Life, PL = Present life. WG = biologist's 'wild guess'). See map for locations, separate entries at each site description for gamma ray spectrometer and neutron spectrometer data on hydrogen/water content. RM is one of three HEM-SAG Reference Mission sites (red dots on map). All sites would include full complement of geophysical instrumentation (active and passive seismometers, magnetometers, heat flow probes, etc.) and the selection of sites should consider how the selection would contribute to the most effective seismic networks, obtaining heat flow measurements from different terrains and terrains of different ages, and be sure to sample the full range of known magnetic anomalies. Most sites contain the average Water Equivalent Hydrogen (WEH) in weight %, courtesy of Rick Elphic. Three reference mission sites provide seismic profile from edge to middle of Tharsis (38 and 34) and opposite sides of the globe for deep seismic structure (38/34 and 1).

1. Impact Crater Near Nili Fossae: (18.4°N, 77.7°E) (WEH wt% = 4.02) Valley networks forming deltas and water-filled impact crater near edge of Isidis Basin. Valley networks, layered sediments, ancient crater walls, Isidis basin deposits, volcano or basin peak ring structure near crater rim, mineralogical alteration revealed by OMEGA and CRISM (phyllosilicates, olivine). EL 5 (valley network means water — and ancient crater might have ponded water). PL1 (unless there is geological activity there now, this looks like a place most promising for past life). RM

2. Newton Crater gully sites: (40.5°S, 157.9°W) (WEH wt% = 4.03) Potentially ice-rich lineated valley fill on crater floor, gullies, crater stratigraphy. Highest concentration of gullies in one region anywhere on Mars. EL4 (crater hydrothermal systems?). Crater might have hosted life in hydrothermal system. PL5 gullies might be sites of present-day water seeps and therefore extant life.

3. Meridiani Region: (2.0°S, 5.5°W) (WEH wt% = 7.67) MER site to investigate context and the nature of early water-rich deposits. Easily traversable terrain would enhance regional study. Mineralogically unique region of the planet. EL5 early sediments/water suggest site of high priority for early life. PL1 Now dry and geologically inactive — not so likely to harbour present-day life

4. Gusev Crater-Columbia Hills: (14.6°S, 175.4°E) (WEH wt% = 8.42) Complex stratigraphy and explosive volcanic deposits in Columbia Hills, at the MER Gusev site. Lies on the crustal dichotomy, with fluvial input from the southern highlands and volcanic deposits related to Hr (Hesperian ridged plains). EL3 crater may have hosted hydrothermal systems/ponded water for early life, although it is a large crater and the site would have to be selected carefully. PL1 Doesn't look very geologically active for present-day life.

5. Chasma Boreale:(82.6°N, 47.3°W) (WEH wt% = 41.45) North polar layered deposits and pre-PLD basal unit. Assessment of polar stratigraphy and relations to pre-polar deposits; orgin of Chasma Boreale and relationship to the northern extent of Vastitas Borealis. EL5 – If chasma was formed by water flood may be site of potential habitability early on and site of sustained water. Ice cap may have provided water. PL4 Near water ice (polar cap). Changes in obliquity may have created regions suitable for life even in recent times with oases sustained today?

6. South polar layered deposits and the Dorsa Argentea Formation:(71.8°S, 67.3°W) (WEH wt% = 35.71) Polar stratigraphy, comparison to MARSIS radar data showing ice-like layering, exploration of Hesperian DAF and possible ancient ice record. Close proximity to Amazonian ice flow features along the margins of the present day polar cap. EL5 – ancient terrains may have hosted water during the Noachian. PL4 Site of ancient permafrost – possible preservation/habitats of recent life?

7. Gale Crater: (5.1°S, 137.5°E) (WEH wt% = 6.48) Ancient crust, valley networks, central mound of volatiles. Stratigraphic analyses of crater wall material as well as sedimentary layers within the central mound, possibly of fluvial origin. EL4 Crater