GEOLOGY OF THE MER 2003 "ELYSIUM" CANDIDATE LANDING SITE; K. L. Tanaka[1], J. A. Skinner, Jr.[1], Michael H. Carr[2], Martha S. Gilmore[3], and Trent M. Hare[1]; [1]U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff AZ, 86001, USA, ktanaka@usgs.gov; [2]U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA 94025; [3]Wesleyan University, 265 Church St., Middletown, CT 06459

Introduction. The NASA Mars Exploration Rover (MER) Project is considering a landing-site ellipse designated EP78B2 in southeastern Utopia Planitia, southwest of Elysium Mons. This ellipse is centered at 11.73N, 123.96E (planetocentric coordinates) and is 155 km long and 16 km wide, has its major axis oriented N86W, and covers ~1640 km^2. The site appears to be relatively safe for a MER landing site because of its predicted low wind velocities in mesoscale atmospheric circulation models and its thin dust cover and low surface roughness at various scales as indicated by topographic, thermal, and imaging data sets. Here, we assess the geology of the site and environs and discuss the potential science results of a MER investigation to this site.

Topographic setting. The MER Elysium site, as expressed in a digital elevation model (DEM) derived from Mars Orbiter Laser Altimeter (MOLA) data, occurs in gently tilted upper slopes of southeastern Utopia Planitia below the highland/lowland boundary (HLB) along northwestern Terra Cimmeria (Fig. 1). Highland rocks appear to be broken up into a wide swath of irregular mesas and knobs known as Nepenthes Mensae. The southeastern edge of Utopia Planitia is defined by Hyblaeus Dorsa, a series of NNE-trending scarps and ridges forming a topographic divide between Utopia and Elysium Planitiae. The dorsa extend to the broad Elysium rise, capped by Elysium Mons. The central basin floor of Utopia occurs some 1400 to 2300 km north of the MER ellipse.

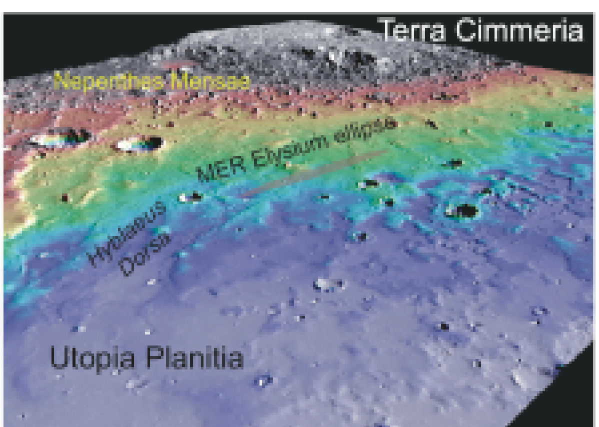

Figure 1. Perspective view of MER Elysium landing site ellipse (MOLA color shaded relief digital elevation model).

The MER ellipse is on the east edge of a bench that is 200-250 km wide (north to south) and ~1500 km long (west to east) and has a fairly narrow upper elevation range of -2200 to –2000 m where it adjoins Nepenthes Mensae and Terra Cimmeria. The bench's lower elevation ranges between –3000 and –2600 m in the region of the ellipse, where it is defined by the tops of a series of arcuate, moderately sloping scarps, demarcating a lower plain marked by complex, irregular depressions tens of kilometers wide and tens to hundreds of meters deep. The MER ellipse occurs on the east end of the bench, about where the complex lower plain disappears. Regional, basin-ward slopes along the bench range from 0.1 to 0.3°. Northward, the complex plain transitions into a smooth plain at –3300 to –3100 m.

Ellipse landforms. Landforms within and near the MER ellipse are surprisingly varied given that the site represents a relatively smooth area of the planet on the scale of the ellipse. Different aspects of surface features are revealed by Viking, MOC, and THEMIS images and various representations of MOLA topography data, including shaded relief, slope, contour, and detrended topography maps.

Wrinkle ridges are seen in most MOC images of the ellipse. Two dominantly NE-trending wrinkle ridges crossing near the center and the western part of the ellipse include broad arches 5-11 km wide. The western ridge is 80 to 140 m high. The central ridge rises a few tens of meters above the adjacent plain and consists of two NE-trending segments connected by a NNE-trending, 7-km-long segment within the ellipse. In MOC image E19-00178, the ridge displays multiple crests and crenulations. Regionally, NE-trending wrinkle ridges and scarps of southern Utopia, including those of Hyblaeus Dorsa just east of the Utopia ellipse, have overall greater relief and lengths than those trending more nearly to right angles to them.

Knobs are scattered through the central and eastern parts of the ellipse. Many of these knobs include broad pedestals up to a few kilometers wide and tens of meters high topped by circular domes a few hundred meters in diameter. We also note an exceptionally large knob south of the ellipse about 820 m high lying along and east of the central ridge. This knob includes a steep, triangular peak above a broad, gently sloping bench elevated ~200 m above the knob's base. The northern margin of the knob forms a relatively steep slope within the ellipse, with MOLA slope values ranging from <1 to 3.6°.

Large irregular depressions occur within and surrounding the ellipse. They generally range in size from several kilometers to several tens of kilometers across. Many are fully enclosed, but some only partly. North of the ellipse, the depressions in some cases are deeper with steeper walls and may be nested or inset downslope. The irregular trough within the ellipse between the wrinkle ridges steps downslope north of the ellipse along a series of gentle scarps and intervening relatively flat steps, some of which are partly enclosed. The scarps typically range from tens to a couple hundred meters in relief. The eastern tip of the ellipse extends into a roughly circular depression about 35 km in diameter and ~200 m deep. A particularly deep depression occurs 35 km northwest of the ellipse center and ranges from 400 to 600 m deep; its floor lies about 500 m below the ellipse center surface.

Scenarios of Geologic History: Interestingly, the more significant proposals of landform development and geologic history for the MER Elysium site by ourselves and other works are not entirely mutually exclusive. Thus all or some subset of these hypotheses may be expressed in the geology of the site. Here, we provide a composite history incorporating these ideas showing how they may fit in chronologically.

Late Noachian/Early Hesperian. The HLB degrades by mass wasting and collapse, producing knobs, depressions, and colluvium [1]. Sill intrusions may have aided in ground-ice melting and resultant degradation of highland material [2-3]. Volcanic resurfacing may have soon followed [e.g., 4]. Densities of craters >5 km across suggest an Early Hesperian age for the plains material in the ellipse [1]; however, these size craters are insensitive to later resurfacing of ~<200 m. Crater densities from a MOC image of the top of the western ridge suggest that this surface has remained relatively unscathed since plains formation

Early Hesperian/Late Hesperian. Tectonic contraction of boundary plains material generates wrinkle ridges. Presence of crenulations suggests mechanical discontinuity at ~2 km depth between materials of lower frictional strength overlying those of higher strength [5]. Also during this period, the occurrence of a plains-forming ocean may have deposited marine sediment and perhaps formed the bench of the south knob by wave cutting [6, 7]. Alternatively, the bench may be the result of collapse in plains materials surrounding the knob [8].

Late Hesperian/Early Amazonian. Local collapse within the central and eastern parts of the ellipse may have produced shallow depressions. Associated thin flows and low pancake domes with interior knobs may be mud or silicate volcanic features. A small channel occurring alongside a wrinkle ridge may have originated by local spring discharge along a thrust fault [5]. Densities of craters in MOC images of the central and eastern parts of the ellipse indicate Late Hesperian to Early Amazonian ages.

Late Amazonian: Bright dunes in MOC images formed within larger impact craters (>~200 m) and along the bases of scarps and of other topographic inflections. The long axis of the dunes predominantly trends east-west, indicating control by north-south winds that likely arise from slope-related currents associated with the northward-dipping HLB and boundary plains topography.

Potential MER Science Investigations. Although chosen mainly for its safety characteristics, new Mars Global Surveyor and Mars Odyssey data suggest that the Elysium site also meets basic science requirements for the MER mission involving the geologic activity of water (unless it happens to be covered by silicate volcanic material). The geology of the site is likely representative of widespread plains formation and modification processes below the highland/lowland dichotomy boundary on Mars, and therefore showcases some fundamental aspects of martian geologic evolution that may include climate change, hydrologic evolution, and magmatic and tectonic history.

A MER rover investigation at the Elysium site may be able to:

1. Sample ancient Noachian rocks dissected by pre-HLB valley networks
2. Sample Hesperian lowland plains material of colluvial, marine, alluvial, or volcanic origin
3. Assess how the HLB degraded and eroded
4. Determine if local flows and domes have a mud or silicate volcanic origin
5. Search for possible sites of spring discharge
6. Investigate the roles of thrust faulting and collapse processes in the modification of the plains surface

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