MAPPING FINELY LAYERED HIGHLAND ROCKS (FLHR) FOR MARS SCIENCE LABORATORY LANDING SITE SELECTION. A. Limaye[1], K.L. Tanaka[2], J.A. Skinner, Jr.[2], and T.M. Hare[2]; [1]Dept. of Earth and Planetary Science, University of California, Berkeley, Berkeley, CA 94720, alimaye@berkeley.edu, [2]Astrogeology Team, U.S. Geological Survey, Flagstaff, AZ 86001.

Introduction: Landing site selection is under way in anticipation of the arrival of Mars Science Laboratory (MSL) on Mars in 2010. A site that could have supported life is of prime interest [1], motivating the selection of a site that records a persistent aqueous environment. Sedimentary rocks formed in such an environment may preserve fossil organic or pre-biotic materials [2]. Water as ice and perhaps in liquid form appears active in places on the Martian surface today [3-5]. MSL will focus on older outcrops that could have formed in the presence of liquid water [6], avoiding areas likely to contain near-surface water to limit the possibility of biologic contamination [7]. Although ice-dust interactions may lead to layering [8], at least ten landing zones proposed at the first MSL landing-site selection workshop in May 2006 [9] occupy crater floors—enclosed basins particularly suited to lacustrine deposition.

After Mars Orbiter Camera (MOC) images from Mars Global Surveyor (MGS) revealed layered outcrops in great detail, the addition of spectral and high-resolution color and topographic data from the Mars Exploration Rovers, Mars Express (MEX) and Mars Reconnaissance Orbiter (MRO) is advancing our understanding of the role of water in the formation of Martian sedimentary rocks [e.g., 10]. Widely distributed ancient sedimentary rocks [11] include promising sites for detailed study by MSL, such as areas where the OMEGA spectrometer onboard MEX has detected phyllosilicate and sulfate deposits [12]. Potential landing sites were ranked for suitability at the landing site workshop, guiding the acquisition of additional high-resolution MGS MOC and MRO High Resolution Imaging Science Experiment (HiRISE), Context Camera (CTX), and Compact Reconnaissance Imaging Spectrometer (CRISM) data.

Overall, planetary protection, engineering requirements, and outcrop accessibility are essential factors in the selection of suitable landing sites. We are contributing to this effort by precisely mapping accessible, finely layered highland rocks (FLHR) that can achieve the MSL science goals.

Mapping techniques: FLHR contacts have been mapped in relation to the 463 m/pixel digital elevation model base of Mars from Mars Orbiter Laser Altimeter data in simple cylindrical projection. MOC images reveal detail in layered outcrops, while Thermal Emission Imaging System (THEMIS) visible images provide context and allow identification of geomorphic features with possible roles in FLHR formation—namely, basins and channels. In the early stages of mapping, we constructed a preliminary GIS model that evaluated the suitability of landing sites based on engineering constraints [13]. This model indicated regions of Mars that are unsuitable, on the fringe of suitability (i.e., within 100 km of suitable areas), or have uncertain suitability due to inadequate engineering data on hand. Of the 33 landing zones proposed at the first MSL landing site workshop, 27 may satisfy engineering requirements (Fig. 1). For these satisfactory zones, we have completed mapping of exposed FLHR in available MOC images (e.g., Fig. 2). In addition, we are extending the mapping into areas of interest near the proposed landing zones that will enhance contextual understanding to the FLHR, as well as possible additional places for MSL landing site consideration.

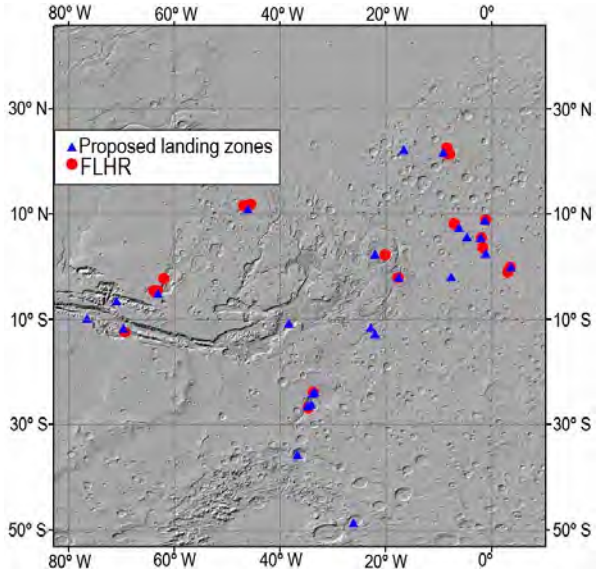

Figure 1. *Locations of finely layered highland rocks (FLHR) within and near some landing zones proposed at the first MSL landing site selection workshop [9]. (MOLA shaded-relief base.)*

Further mapping of FLHR in the proposed landing zones also is made possible by releases of new MOC, CTX, and HiRISE images. These added data sets will aid mapping by revealing color contrasts between FLHR and other materials difficult to discriminate in MOC and THEMIS images (see Fig. 3).

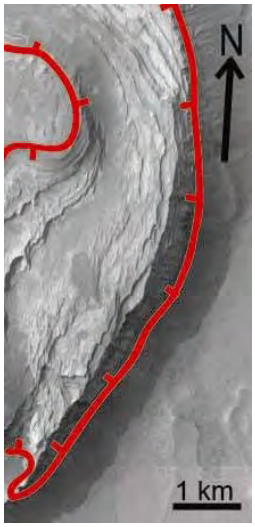

Figure 2. *Finely layered highland rocks in Terby crater (within red hachured line). (MOC image R03-00753 centered at 27.9°S, 285.6°E; 3.58 m/pixel)*

Other layered rocks: Well-exposed in Becquerel crater, light-toned materials with concentric layering (Fig. 4) appear to have formed after FLHR. The irregular topography, intricate bed geometry and stratigraphic position of these whorled features suggest that they formed in different conditions than massive, continuous beds of FLHR—possibly through short-period volatile activity [e.g., 14].

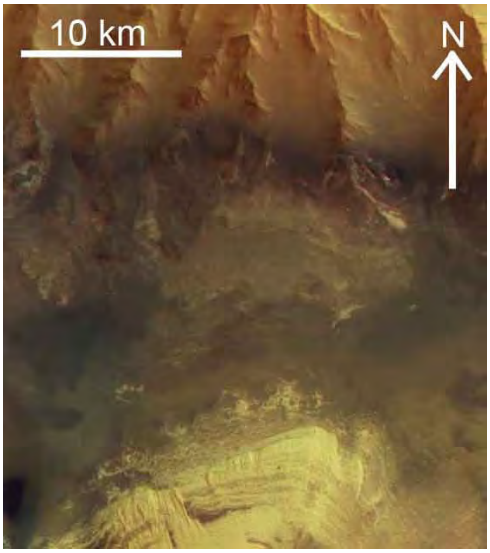

Figure 3. *Part of Candor Chasma showing light-colored finely layered deposits (bottom) readily distinguished from surrounding materials (HRSC image at 5ºS, 285ºE from orbit 0360; 40 m/pixel).*

Incorporation into GIS framework: Mapping of FLHR in trafficable locations will contribute to a scientific-interest database for landing-site selection and could motivate consideration of areas not yet proposed as landing sites. We are also mapping features such as fluvial channels and basins that they transect or terminate within, features which also suggest locations of possible lacustrine sedimentation. Integration with OMEGA and CRISM mineralogic data as well as engineering and planetary protection constraints will yield an improved GIS landing site suitability map that will enable a systematic and thorough comparison of potential landing sites for the second MSL landing site workshop in October 2007. Moreover, an expanded database of layered deposit locations and adjacent geomorphic features could yield new clues about their origins and the dynamic early history of Mars.

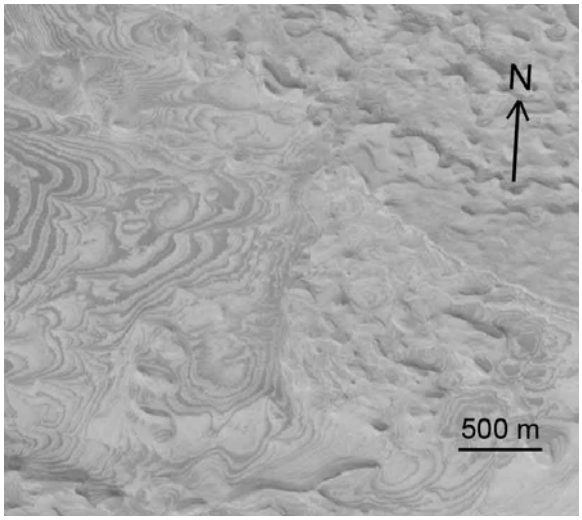

Figure 4. *Superficial concentric features with the appearance of layering in Becquerel crater. Such features commonly overlay outcrops mapped as FLHR occurring in depressions. The concentric pattern and uneven topography are strikingly different from the simpler layered appearance of FLHR (e.g., Fig. 2). (MOC image E13-01260, centered at 21.6º N, 8.3º E; 3.15 m/pixel).*

References: [1] http://marsprogram.jpl.nasa.gov/msl/overview 14 June 2006. [2] Golombek M.P. and Grotzinger J.P. (2006) 1st MSL landing site workshop. [3] Boynton W.V. (2002) Science *297*, 81-85. [4] Smith D.E. *et al*. (2001) *Science 294*, 2141-2146. [5] Malin M.C. et al. (2006) *Science, 314*, 1573-1577. [6] Jakosky B.M. and Phillips R.J. (2001) *Nature 412*, 237-244. [7] Beaty D.W. *et al.* (2005) *Astrobiology, 5*, 663-689 [8] Richardson M.I. *et al*. (2003) *LPS XXXIV* Abstract #1241. [9] http://webgis.wr.usgs.gov/msl/program_for_the_first_msl_workshop.htm [10] Squyres S.W. *et al*. (2004) *Science 308*, 1709-1714. [11] Malin M.C. and Edgett K.S. (2000) *Science 290*, 1927-1937. [12] Bibring J.-P. *et al.* (2006) *Science 312*, 400-404. [13] http://webgis.wr.usgs.gov/msl/docs/1st_LSWorkshop/Tanaka_1st_MSL_workshop.pdf. [14] Crown D.A. *et al.* (2005) *JGR (Planets) 110*, E12S22.

Acknowledgements: Thanks to Professor Kathy Eastwood (Northern Arizona University), the National Science Foundation (REU grant AST-0453611), and the U.S. Geological Survey for supporting this work.