LAKE SHORELINES: EARTH ANALOGS FOR HYPOTHESIZED MARTIAN COASTAL FEATURES. J. R. Zimbelman[1], S. H. Williams[2], A. K. Johnston[1], and James W. Head[3], [1]CEPS/NASM MRC 315, Smithsonian Institution, Washington, D.C. 20013-7012, jrz@nasm.si.edu, [2]Education/NASM MRC 305, Smithsonian Institution, Washington, D.C. 20013-7012, williamss@nasm.si.edu, [3]Dept. of Geological Sciences, Brown University, Providence, R.I., 02912, James_Head_III@Brown.edu.

Introduction: The possibility of oceans on Mars [1-3] has generated a lot of interest in the science community, but conclusive evidence supporting or refuting the ocean hypothesis has remained somewhat elusive [4-7]. Precise topographic measurements of fresh-appearing shorelines from glacial Lake Lahontan were collected recently in an effort to obtain well-constrained data for comparison with the hypothesized Martian shorelines. This report summarizes the first results of the on-going research project.

Background: The ocean hypothesis grew out of intriguing morphologic features identified in the northern lowlands of Mars [1, 3], along with global models for water transport [2, 7]. Precise elevation measurements from the Mars Orbiter Laser Altimeter (MOLA) [8] allowed the reported shorelines to be tested as an equipotential level, with only the lowest shoreline showing a good possibility of representing the level of a large body of water on the surface [4, 5]. High-resolution images from the Mars Orbiter Camera (MOC) [9] have thus far not shown definitive morphologic attributes supporting a hydrologic interpretation for the hypothesized shoreline features [6, 10]. A recent report [7] made an in-depth assessment of the complete range of relations at the morphologic boundaries that comprise the hypothesized shorelines on Mars. The present work is an effort to obtain precise topographic information of known shorelines on Earth to be used as a new basis of comparison with the enormous MOC and MOLA databases. Glacial Lake Lahontan, in central Nevada [12], is an excellent candidate for investigations of pristine pluvial landforms. The northern end of the Winnemucca Basin, between the towns of Gerlach and Nixon, preserves an impressive sequence of relatively undisturbed Lahontan shorelines (Fig. 1), generated by wind and wave action on shore materials as the lake level fluctuated [12].

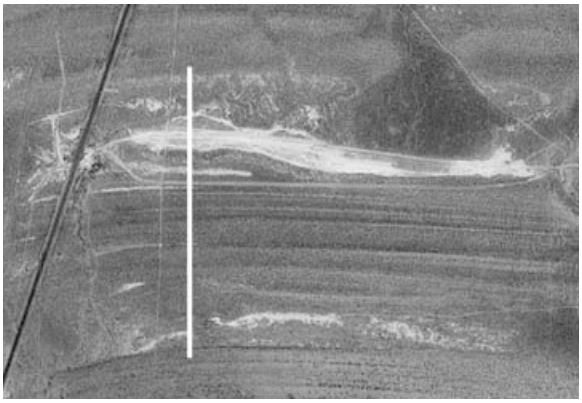

Figure 1. Aerial photograph mosaic [11] of shorelines on the northern end of the Winnemucca Basin, part of glacial Lake Lahontan. White line is location of 800-m-long DGPS survey (see Fig. 2). North is at top.

Results: In April, 2003, the Winnemucca shorelines were surveyed (Fig. 2) using a Trimble 4800 Differential Global Positioning System (DGPS) capable of providing positional information with a precision of 2-4 cm vertically and 1-2 cm horizontally [13]. The points

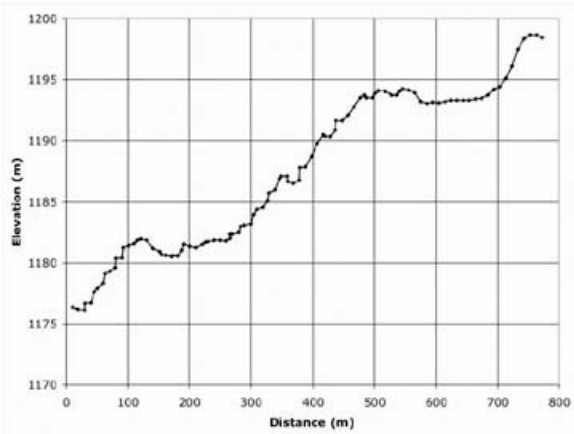

Figure 2. DGPS survey (going S to N) across several shorelines in Winnemucca Basin, Nevada (see Fig. 1).

along the survey line were flagged and also measured using a handheld tape and inclinometer, in order to assess the potential errors derived from this simpler surveying technique. Initial results indicate that the tape-inclinometer method does a good job on the horizontal spacing of surveyed points, but vertical errors can accumulate to be several meters by the end of the 800-meter line. The DGPS survey line reveals that the shoreline ridges were sufficiently impervious to subsequent overland flow so that linear playas formed upslope (north) of the largest shorelines (those with relief >1 m). The linear playas show up as white patches in aerial photographs (Fig. 1) and they have a vertical relief of <4 cm over horizontal scales of 20 to 100 meters (Fig. 2). Even if dust cover on Mars would obscure the albedo contrast of such playa features,

their distinctive topographic signature may be resolvable in MOLA data if they exist upslope of Martian shoreline ridges. The shoreline ridges are comprised of a collection of angular to sub-rounded rock fragments that range in size from granules to small cobbles (Fig. 3). The rock size and angularity are directly related to the source rocks derived from the mountains surrounding Winnemucca Basin. It seems unlikely that sediments in any Martian shorelines would show large size or composition variations detectable by spectroscopic variations, given the global prevalence of dust on the Martian surface [14, 15]. However, THEMIS images [16] may be able to detect subtle thermal inertia variations across some of the shoreline ridges if the dust cover locally is not pervasive. There is no field evidence that the various components of Lake Lahontan were extensively frozen, unlike the probable fate of large standing bodies of water in the northern hemisphere of Mars [17].

Figure 3. Vertical view of one of the shoreline ridges on the northern end of Winnemucca Basin, Nevada.

Future Work: Our next efforts will focus on taking the DGPS survey results and comparing them to MOLA data across selected examples of the hypothesized Martian shoreline features. This comparison will likely require scaling up the measured shoreline points to be comparable to the scale of features detectable in MOLA data (which have typical shot-to-shot separations on the order of ~300 m [8]), but the precision of the DGPS points should allow substantial scaling without compromising the comparison. Future field work in the Lake Lahontan region will focus on obtaining additional DGPS surveys over different shorelines, such as erosional benches on bedrock outcrops or over pre-lake surfaces different from that present in the Winnemucca Basin, as well as attempt to constrain or quantify the lateral continuity of various shoreline components (e.g., is there a relationship between the vertical scale of the landform and its lateral continuity?).

Acknowledgements: This work was supported by grant NAG5-12746 from the Mars Fundamental Research Program of NASA.

References: [1] Parker T. J. et al. (1989) *Icarus, 82,* 111-145. [2] Baker V. R. et al. (1991) *Nature, 352*, 589-594. [3] Parker T. J. et al. (1993) *J. Geophys. Res., 98*, 11061-11078. [4] Head J. W. et al. (1998) *Geophys. Res. Lett., 25* , 4401-4404. [5] Head J. W. et al. (1999) *Science, 286*, 2134-2137. [6] Malin M. C. and Edgett, K. S. (2001) *J. Geophys. Res., 106(E10)*, 23429-23570. [7] Carr M. H. and Head J. W. (2003) *J. Geophys. Res., 108(E5)*, DOI: 10.1029/2002JE001963. [8] Smith D. E. et al. (1999) *Science, 284*, 1495-1503. [9] Malin M. C. et al. (1998) *Science, 279*, 1681-1685. [10] Malin M. C. and Edgett K. S. (1999) *Geophys. Res. Lett., 26,* 3049-3052. [11] Earth Explorer web site, http://edcsns17.cr.usgs.gov (eastern central Nevada). [12] Morrison R. B. (1991) Geology of North America, Vol. K-2, (Morrison R. B., Ed.), Geol. Soc. Am, Boulder, CO, 283-320. [13] Zimbelman J. R. and Johnston A. K. (2001) Volcanology in New Mexico , *New Mex. Mus. Nat. Hist. & Sci. Bull., 18*, 131-136. [14] Christensen P. R. (1986) *J. Geophys. Res., 91*, 3533-3545. [15] Christensen P. R. (1988) *J. Geophys. Res., 93*, 7611-7624. [16] Christensen P. R. et al. (2003) *Science, 300*, 2056-2061. [17] Kreslavsky M. A. and J. W. Head (2002) *J. Geophys. Res., 107(E12)*, DOI: 10.1029/2001JE001831.