

EVIDENCE OF BURIED BASINS IN THE NORTHERN LOWLANDS OF MARS FROM THE MARSIS RADAR SOUNDER.

T. R. Watters¹, C.J. Leuschen², J.J. Plaut³, G. Picardi⁴, A. Safaenili³, S.M. Clifford⁵, W.M. Farrell⁶, A.B. Ivanov³, R.J. Phillips⁷, E.R. Stofan⁸ and the MARSIS Science Team, ¹Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560 (watterst@si.edu); ²Applied Physics Laboratory, Johns Hopkins University, Laurel, MD 20723; ³Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109; ⁴Infocom Department, "La Sapienza" University of Rome, 00184 Rome, Italy; ⁵Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston TX 77058; ⁶NASA/Goddard Space Flight Center, Greenbelt MD 20771; ⁷Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130; ⁸Proxemy Research, Laytonsville, MD 20882.

Introduction: The first subsurface data on the shallow crust of Mars are being returned by the Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) on Mars Express [1]. Initial operations of the MARSIS instrument (June-July 2005) were over the northern lowlands. The relatively featureless lowland plains of the northern hemisphere and the heavily cratered highlands of the southern hemisphere are the surface expression of the crustal dichotomy on Mars. The young appearance of the northern plains lead to the interpretation that the northern lowlands crust could be young [2-4]. This view changed when subdued quasi-circular depressions (QCDs) in the northern lowlands were revealed in Mars Orbiter Laser Altimeter (MOLA) data [5-7]. Interpreted to be buried impact craters, the QCDs suggest that the crater retention age of the northern lowlands crust is comparable to but somewhat younger than the most ancient highlands crusts [7].

MARSIS: The MARSIS instrument is a multi-frequency synthetic aperture orbital sounding radar. The instrument operates in four frequency bands between 1.3 and 5.5 MHz in its subsurface modes. The free-space range resolution is ~150 m and the cross-track and the along-track footprint range in size from 10 to 30 km and 5 to 10 km, respectively [1]. The lower frequency bands (centered at 1.8 and 3.0 MHz) are used in nightside operations to avoid interference from the ionosphere, and the higher frequency bands (centered at 4.0 and 5.0 MHz) are used on the dayside. To compensate for the high variability in the ionospheric phase distortion, we correct the time delay of the peak surface return to agree with the corresponding MOLA topographic profile along the orbit track. MOLA derived surface clutter can then be directly compared with MARSIS radargrams (time-delay renderings of the sounding data) as an aid in separating surface returns from subsurface returns.

Buried Basin in the Lowlands: Radargrams for two adjacent orbits 1892 and 1903 (Fig. 1A, B) over the lowlands of eastern Chryse Planitia show multiple parabolic-shaped echoes interpreted to be off-nadir reflections from subsurface structures because of the long delays (up to 180 μ s). If the echoes are from the

subsurface directly beneath the spacecraft, the penetration depths would be unrealistically large for the frequencies used (3 MHz band for 1892; 4 MHz band for 1903) [1]. Surface clutter models derived from MOLA for the two orbits show no parabolic-shaped clutter features (Fig. 1C, D). Projecting the 1903 and 1892 radargrams in ground-range, which assumes the buried features are at a shallow depth, the echoes appear as arcs on the surface (Fig. 2A, B). Under the hypothesis that these features are of impact origin, it is possible to infer the probable location and basin size from these arcs. Some arcs from the two orbits are collocated and overlap, suggesting that echoes are from the same subsurface features. We suggest the echoes can be accounted for by either a ~220 km-diameter basin, a ~310 km-diameter basin, or two superimposed basins. Most of the arcs in the two orbits can be encompassed by a ~220 km-diameter basin. A 310 km-diameter basin is suggested by fits to two parallel, overlapping sets of arcs the source of which could be the top and bottom of a rim wall. The remaining echoes in both cases could be accounted for by rim-wall slumps or a discontinuous peak ring structure. Many of the echoes in the two orbits approach the surface suggesting the 220 km-diameter basin is superimposed on the 310-km diameter basin. The prominent linear echo in orbit 1903 (Fig. 1A, 2A) could be from a subsurface feature directly below the spacecraft. If so, the time delay indicates a depth of 1.5 to 2.5 km. This feature may be the interface between the basin floor and the basin fill material or an intermediate layer in the basin fill. The echo power suggests a low-loss material, possibly (but not uniquely) ice-rich, partially fills the basin [1].

Radargrams for MARSIS orbits over other areas of the northern lowlands also show parabolic echoes. Ground-range projections of these sounder data suggest buried basins with a range in diameters.

Implications for the Age of the Lowlands Crust: Many of the buried basins revealed by MARSIS have little or no surface expression in MOLA topography. This indicates that the total population of buried basins in the northern lowlands is not expressed by QCDs. Thus, QCD-based crater retention ages [7] may place a lower limit on the age of the northern lowlands crust.

References: [1] Picardi G. et al. (2005) *Science*, 310, 1925-1928. [2] Scott D.H. and Tanaka K.L. (1986) *U.S. Geol. Surv. Misc. Invest. Ser. Map, I-1802-A*. [3] Greeley R. and Guest J.E. (1987) *U.S. Geol. Surv. Misc. Invest. Ser. Map, I-1802-B*. [4] Tanaka K.L. and Scott D.H. (1987) *U.S. Geol. Surv. Misc. Invest. Ser. Map, I-1802-C*. [5] Frey, H.V. et al. (2002) *GRL*, 29, doi: 10.1029/2001GL013832. [6] Head J.W. et al. (2002) *JGR*, 107, doi: 10.1029/2000JE001445. [7] Frey H.V. (2006) *JGR*, in press (2005JE002449).

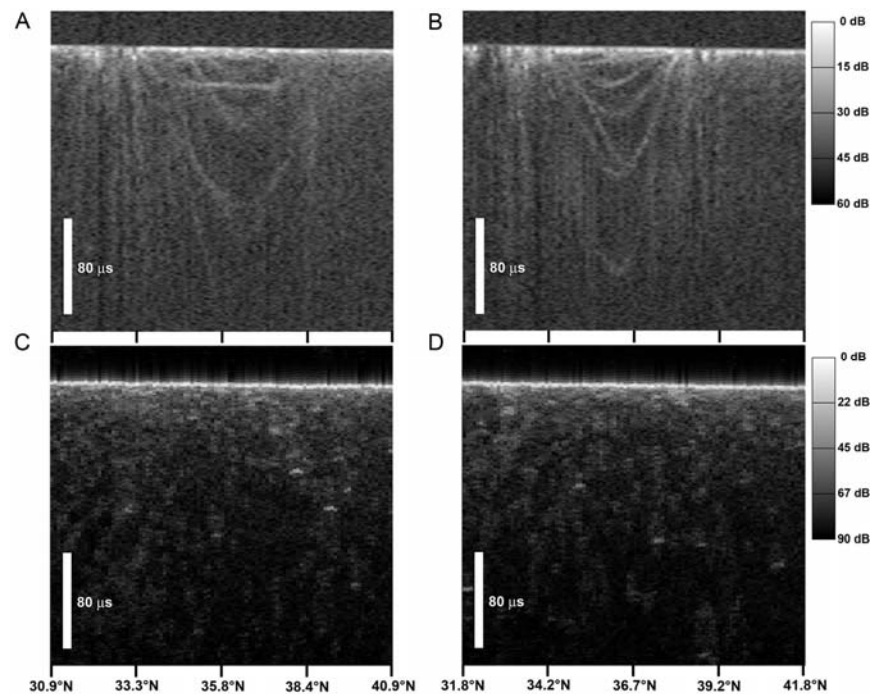


Figure 1. Radargrams showing MARSIS data for orbit 1903 (A) and 1892 (B) where echoes are plotted in time-delay versus position along the orbit. The parabolic-shaped echoes exhibit greater time-delays than the surface return. The peak surface return is adjusted to agree with the MOLA topography along the orbit track. Clutter models for 1903 (C) and 1892 (D) derived from MOLA topography.

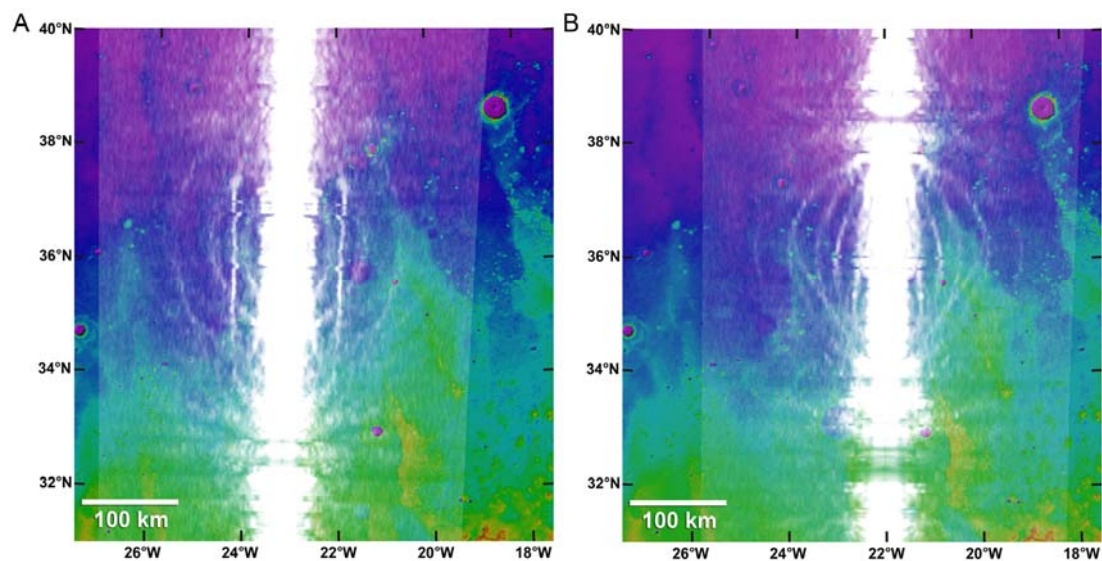


Figure 2. Ground-range projections of radargrams for 1903 (A) and 1892 (B) overlaid on MOLA color coded shaded relief of eastern Chryse Planitia. Parabolic echoes project as arcs on the surface.