MARSIS RADAR SOUNDER OBSERVATIONS IN THE VICINITY OF MA'ADIM VALLIS. O.L. White[1], E.R. Stofan[1], J.J. Plaut[2], A. Safaeinilli[2], Y. Gim[2], G. Picardi[3], and the MARSIS Team. [1]Dept. of Earth Sciences, University College London, Gower St., London, WC1E 6BT, UK (o.white@ucl.ac.uk, ellen@proxemy.com). [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, 91109, USA. [3]Infocom Department, "La Sapienza" University of Rome, 00184, Rome, Italy.

Introduction: The MARSIS radar sounder aboard ESA's Mars Express satellite has been obtaining radar profiles of the Martian subsurface since June 2005. The instrument uses a 40-meter antenna to transmit radio waves in four frequency bands (centered at 1.9, 2.8, 3.8 and 4.8 MHz, and each with a 1 MHz bandwidth) to the Martian surface. These radio waves are reflected back upwards when they encounter a boundary between materials of different dielectric constants (e.g. dry rock and ice-rich rock, or ice-rich rock and a water aquifer), and are recorded by the instrument and processed to create a 'radargram' showing horizontal distance against two-way travel time of the radio waves. MARSIS has previously succeeded in characterizing the electrical properties and mapping the thickness of the South Polar Layered Deposits [1], and in imaging buried impact basins in the plains of the northern hemisphere [2]. Here we present MARSIS observations in the vicinity of Ma'adim Vallis.

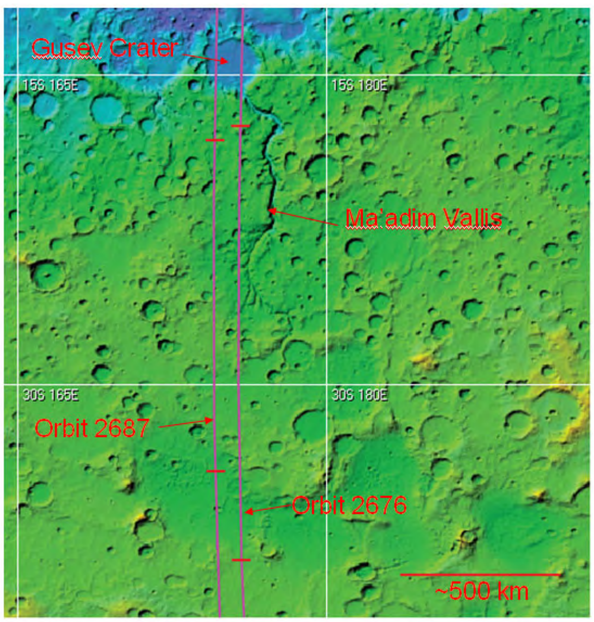
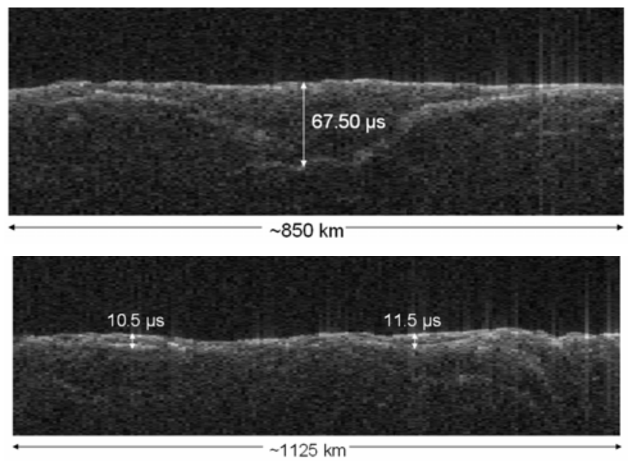


Fig. 1. Topographic relief map of the Ma'adim Vallis vicinity showing the groundtracks of orbits 2676 and 2687. The red lines crossing the groundtracks mark the boundaries of the radargrams shown in figs. 2 and 3.

Previous Research: The origin of Ma'adim Vallis has been attributed to surface runoff [3], groundwater sapping [4], or the emergence of voluminous groundwater by terrain collapse or a fissure [5]. The most recent investigation noted that Ma'adim Vallis originates at a spillway of a ~3,000,000 km^2 closed drainage basin [6]. It was interpreted that the interior morphology of this source basin included shoreline features that follow topographic contours, and it was concluded that Ma'adim Vallis was created through the catastrophic overflow of a ~1,100,000 km^2 highland lake. This would suggest that the lake's presence should now be recorded in the form of lacustrine sediments.



Figs. 2 (above) and 3 (below) showing segments of the radargrams from orbits 2687 and 2676 respectively. Both radargrams obtained at a frequency band centered at 4.0 MHz. Times shown are two-way travel times. North is to the left.

Results: Fig. 1 shows the locations of the groundtracks of orbits 2676 and 2687. A prominent reflection is seen in the radargram obtained for orbit 2687 (fig. 2). The reflection has a parabolic shape, extending ~750-800 km north-south. The radargram for the more easterly orbit 2676 (fig. 3) shows two separate shallower reflections, each on the order of 200-300 km long. MARSIS records reflections as a function of two-way travel time rather than depth (specifically, each vertical pixel = 0.68 µs two-way travel time). The velocity of the radio waves will differ depending on the dielectric contrast (ε_r) of the medium they are travelling through. Assuming a rock composition of basalt, the velocity of the radio waves in basalt (v_r) can be calculated as follows:

$v_r = c/\sqrt{\varepsilon_r}$

where c is the velocity of light in a vacuum and ε_r = 7.1 [7]. This equation gives a value of v_r of ~1.13×10^8 ms^{-1}. The depth to the reflector, d, can then be calculated as follows:

$$d = (nt)v_r$$

where n is the number of pixels between the surface and the subsurface reflector and t is the pixel one-way travel time (i.e. 0.34 μs). Assuming that the reflections are from subsurface interfaces at nadir, the following depths to the reflectors were calculated: orbit 2687 reflector: ~3800 m; orbit 2676 left-hand reflector: ~600 m; orbit 2676 right-hand reflector: ~650 m.

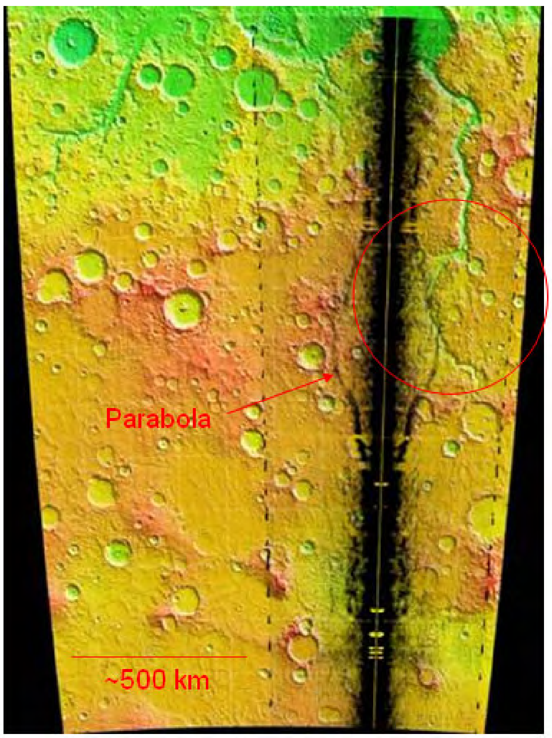


Fig. 4. Ground-range projection of the radargram from orbit 2687 on a topographical relief map. The red circle marks the approximate rim of the QCD.

Interpretation: The MAG/ER investigation performed aboard Mars Global Surveyor acquired vector magnetic field observations of the Martian crust [8]. The experiment found that the most intense magnetic crustal sources (producing a magnetic anomaly >100 nT at 400 km) lay in the Terra Sirenum region, which incorporates Ma'adim Vallis. One cannot rule out the possibility that the parabolic feature is caused by an interaction of the radar waves with the magnetic field and Martian ionosphere. Below, we assess possible causes for the reflections related to the subsurface.

Fig. 4 is a ground-range projection of orbit 2687, mapping the reflections of the radargram at the surface locations they would correspond to if they were being produced by surface clutter (the reflections are plotted on both sides of the groundtrack as there is an ambiguity as to which side of the groundtrack the reflections may be coming from). We find no evidence that the reflections are caused by surface clutter, as there appear to be no topographic features that are consistent with the reflections over the distance they span (including Ma'adim Vallis). However, the location of the parabolic reflection in orbit 2687 coincides roughly with that of the rim of a quasi-circular depression (QCD) ~500 km across, which is interpreted to be a highly eroded impact basin [9]. The reflection, if not a result of the magnetic field anomalies, may result from either a nadir or off-nadir subsurface reflection originating due to the electrical discontinuity between the material filling the basin and the substrate material.

The source(s) of the reflections in the radargram of orbit 2676 is more ambiguous, but has similar issues associated with the magnetic field anomalies. We do not interpret them to be buried portions of a previous course of Ma'adim Vallis, as no surface manifestations of such buried channels were identified through study of high-resolution images of the areas corresponding to the reflections. However, the southern reflection corresponds approximately to the position of a large basin that extends ~500 km E-W and ~250 km N-S, and which appears to be linked to other basins of a similar size to the south and west. These basins were interpreted by [6] to be the sites of "lake sub-basins" that overflowed to carve Ma'adim Vallis and isolated lake basins in Gusev crater. They cited shoreline morphology at the edges of these depressions, as well as their bowl-shaped morphology as evidence of lakes having occupied them during the Noachian. The reflections in orbit 2676 may be related to these proposed lake basins.

A repeat pass over this region will provide confirmation of the nature of the reflections. If the features are confirmed to originate from the subsurface, further mapping of this region and analysis of the MARSIS reflections will help us to refine the interpretation of these data.

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