Enigmatic northern plains of Mars

A network of ridges in this region opens a new tectonic window onto this planet.

Although the northern plains of Mars form the flattest known surface in the Solar System, they are crisscrossed by ridge features[1]. Here we test the idea that they might once have been covered by an ocean[2] by examining the topographic profiles of possible shorelines. We conclude that these candidate shorelines were more likely to have been formed by tectonic rather than oceanic processes.

Linear slope changes in the northern plains have been identified as possible shorelines of an ancient ocean formed during the middle period of martian history[2]. Figure 1 shows topographic profiles, generated from Mars Orbiter Laser Altimeter (MOLA) data[1], across two such groups of shorelines. Candidate shorelines near the Utopia impact basin are flat terraces, with a higher ridge bounding their landward, or upslope, side (Fig. 1a). Possible shorelines on the other side of the proposed ocean, near the Alba Patera volcano, are also flat terraces, with a raised ridge bounding their oceanward, or downslope, side (Fig. 1b).

We believe that this morphology is hard to explain in terms of a shoreline-formation process, as is the reversal of shoreline morphology from one side of the ocean to the other. We favour the idea that these candidate shorelines were created by tectonic activity, on the basis of recent MOLA digital terrain models of kilometre-scale horizontal resolution of the northern plains of Mars.

As seen from early images recorded by Viking (Fig. 1c), these plains are essentially flat and featureless, but MOLA data (Fig. 1d) reveal a network of ridges spanning the northern plains, some of which are the candidate shorelines of the proposed ancient ocean[2]. Most ridges appear to be related to obvious stress centres, such as the volcanic Tharsis Rise, the Utopia impact basin and the Alba Patera volcano. These ridges are generally perpendicular to the predicted directions of maximum compressive stress, which indicates that the ridges have a tectonic origin[3]. They also have the characteristic profile of wrinkle ridges formed by compressive tectonism[4]. Some ridges are close to known wrinkle ridge provinces, such as Lunae Planum, and have similar strikes; clearly, these formed with the known wrinkle ridges. Both groups of candidate shorelines have orientations consistent with their formation by compressive tectonism.

The causes of the youth and smoothness of the northern plains are still debated. This network of ridges is the only tectonic feature in this region and their discovery opens a new tectonic window onto Mars.

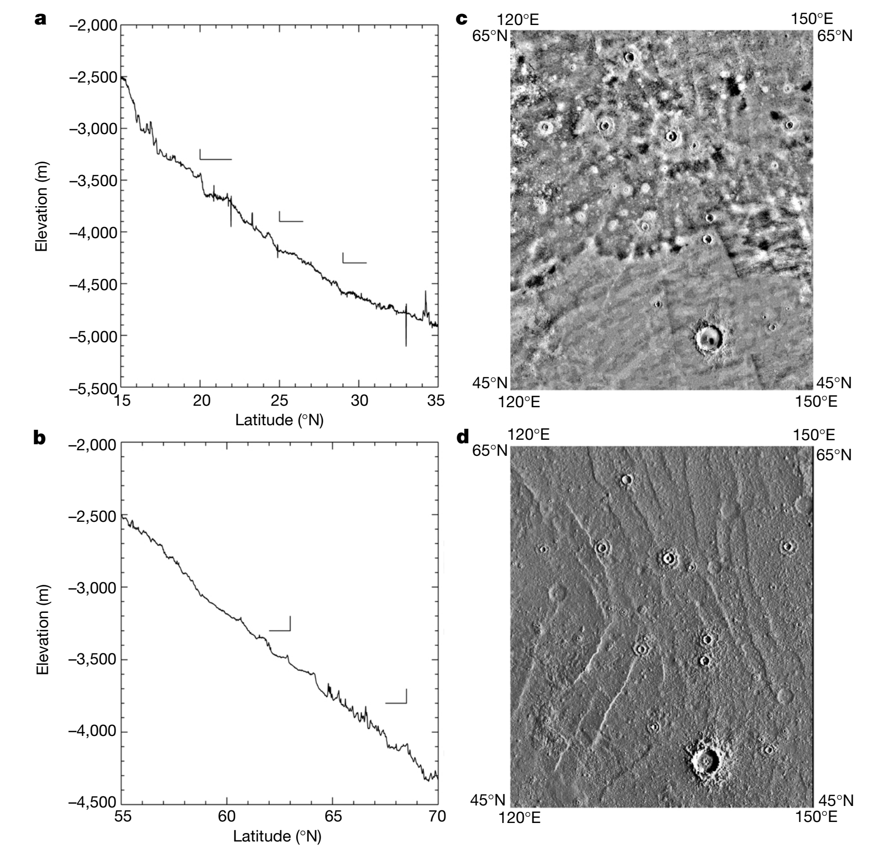

Figure 1 Martian topography. **a,** MOLA profile 10190 near the Utopia impact basin. Terraces and ridges are marked by horizontal and vertical lines, respectively. **b,** MOLA profile 10929 near the Alba Patera volcano. Terraces and ridges are marked by horizontal and vertical lines, respectively. Vertical exaggeration in **a** and **b** is by a factor of ~400. **c,** Viking photomosaic near the Utopia impact basin, Mercator projection. **d,** Shaded relief map generated from MOLA digital terrain model of the same region with the same projection. Many ridges are visible in the MOLA image that are not evident in the Viking image.

Paul Withers*, Gregory A. Neumann†‡

**Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona 85721, USA*
e-mail: withers@lpl.arizona.edu
†Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA
‡Laboratory for Terrestrial Physics, NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, USA

1. Smith, D. E. *et al. Science* **284,** 1495–1503 (1999).
2. Head, J. W. III *et al. Science* **286,** 2134–2137 (1999).
3. Banerdt, W. B. *et al.* in *Mars* (eds Kieffer, H. H. *et al.*) 249–297 (Univ. Arizona Press, Tucson, 1992).
4. Schultz, R. A. *J. Geophys. Res.* **105,** 12035–12052 (2000).

Food-web dynamics

Animal nitrogen swap for plant carbon

Predatory plants are typically found in discrete groups living under conditions of extreme nutrient stress. But we show here how a common species of boreal tree can act indirectly as a predator of arthropods living in the soil by virtue of a fungal symbiont that supplies it with animal nitrogen in exchange for the plant's carbon. If the way in which this partnership operates proves to be widespread, ideas about nutrient cycling[1,2] and food-web dynamics[3] in temperate forests may have to be modified.

Ectomycorrhizas are mutualisms between soil fungi and the roots of trees that improve plant nutrition, specifically by nitrogen, in exchange for carbohydrates[4]. Soil arthropods such as springtails and mites selectively feed on fungi, including mycorrhizal, decomposer and pathogenic groups[5].

During a routine feeding study in microcosms, however, we found that less than 5% of springtails (*Folsomia candida*, a soil-dwelling arthropod) survived after two