GEOLOGY OF THE ISIDIS BASIN, MARS

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Introduction: Building on Bridges et al. [2003], we are currently studying the general geologic history and evolution of the Isidis basin based on topographic and imaging data obtained by orbiting spacecraft such as Mars Global Surveyor (MGS) and Mars Odyssey. This study complements our recently completed analyses on Syrtis Major to the west [Hiesinger and Head, 2003] and the transition between Syrtis Major and Isidis [Ivanov and Head, 2002]. The new data allow one to get a close view of the Isidis basin, its structure, stratigraphy, geologic history and its evolution. We are interested in a number of scientific questions, for example, what are the characteristics of the Isidis rim and what caused its present morphology? What is the role and fate of volatiles in the Isidis basin and what are the characteristics of the uppermost surface layer? Does the floor of the Isidis basin primarily consist of volcanic plains as indicated by wrinkle ridges and cone-like features, material deposited by a catastrophic collapse of the rim as proposed by Tanaka et al. [2000], or of sediments deposited in an ocean as suggested by Parker et al. [1989, 1993]? What is the stratigraphy of the deposits within the Isidis basin and what processes were responsible for its present appearance?

Results: For our study we made use of the latest MOLA topography data with a spatial resolution of 128 pixel/deg. These data indicate that the basin floor is tilted towards the southwest. Southwestern parts are at about -3880 m elevation; northeastern parts of the floor are at about -3660 m elevation. This results in a slope of ~0.015 degree.

A prominent rim of the Isidis basin is absent in several locations such as the passage to the northeast into Utopia/Elysium Planitia (Figure 1). A sharp, well-defined rim is also missing where Syrtis Major lavas flowed into the Isidis basin. However, the rim is well exposed along the southern edge of the basin as well as in the north of Isidis and Syrtis Major. The topography along the rim of Isidis is relatively smooth and only the Libya Montes exhibit a rough topography with high isolated peaks that are separated by deep valleys (Figure 2). Based on gravity and topography data Zuber et al. [2000] concluded that the basin is filled with sediments and/or lavas and that the crust underneath the basin is thin. In the geologic map of Greeley and Guest [1987] the southern rim consists of rough, hilly, fractured material (unit Nplh) of moderately high relief which they interpreted as ancient highland rocks and impact breccias that were formed during the period of heavy bombardment. The units that are exposed at the north rim (Nple, Npl_2) are younger than the units of the south rim and are characterized by eolian dissection, collapse of ground ice, minor fluvial activity, and thin lava flows or sediments that partly bury underlying rocks [Greeley and Guest, 1987].

The obvious variations in elevation of the Isidis rim of almost 8000 m (Figure 2) can have several causes such as initial heterogeneities, erosion of parts of the rim, tectonic deformation or burial with Syrtis Major lavas [e.g., Wichmann and Schultz, 1988; Tanaka et al., 2002]. Despite the wide range of possible causes, the absence of the western Isidis rim has been used as an argument for the emplacement of thick (1-2.5 km) Syrtis Major lavas that covered the rim [e.g., Wichmann and Schultz, 1988].

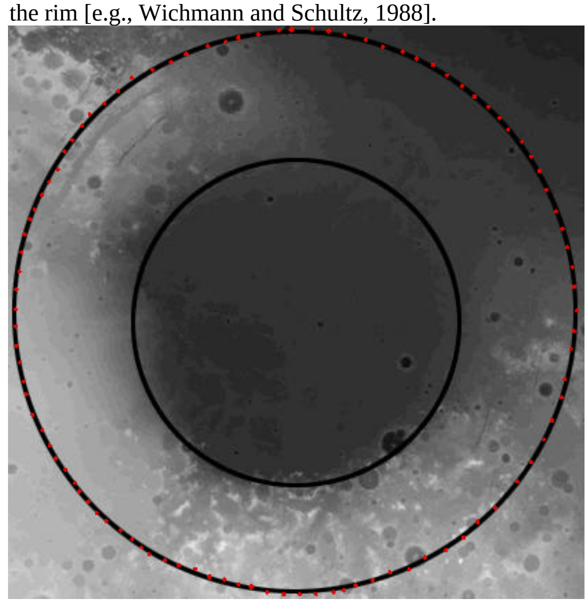

Figure 1: MOLA topography of the Isidis basin with superposed ring structures of Schultz and Frey [1990]. Red dots mark the locations of measurements for Figure 2.

Alternatively, Tanaka et al. [2001a, b; 2002] suggested that magmatic activity in the Syrtis Major region began with shallow sills that drove catastrophic erosion of friable upper crustal Noachian rocks, i.e., the Isidis rim. They proposed that these rocks were charged with water ice, water, or perhaps CO_2 ice or CO_2 clathrate, allowing large volumes of rock to be disrupted, eroded and transported for many hundreds of kilometers (also see Tanaka et al. [2001c]). According to Tanaka et al. [2001a] the eroded material would have ultimately filled the Isidis basin with tens to a few hundreds of meters of sediments. However, as mentioned above, MOLA data indicate that the basin floor is tilted to the southwest, with the lowest elevation close to the eastern edge of Syrtis Major lavas. In addition, Bridges et al. [2003] concluded that thermal inertia data are not consistent with the majority of rocks being brought into the Isidis basin from the Syrtis Major area as suggested by Tanaka et al. [2000]. They found evidence for an influx of sediments from the southern and eastern margins of the basin such as the Libya Montes region.

Based on the new 128 pixel/deg MOLA topographic data we identified two types of ridges on the floor of Isidis;

wrinkle ridges and curvilinear ridges that comprise the thumbprint terrain [e.g., Grizzaffi and Schultz, 1989].

Our preliminary results indicate that the ridges of the thumbprint terrain are on the order of 10-50 m high and less than ~5-7 km wide. These heights are much smaller than the heights (150-300 m) estimated by Grizzaffi and Schultz [1989] on the basis of shadow measurements. The elevations of the ridge crests vary along the investigated ridges and are not uniform along the ridges. Along their crests numerous ridges show isolated knobs which are the highest points of the ridges. Most of the curvilinear, subparallel-parallel ridges do not occur throughout the entire Isidis basin but are restricted to a relatively narrow range of elevations of about –3600 to –3700 m and hence do not occur in the deepest parts of the basin. Grizzaffi and Schultz [1989] mapped the curvilinear ridges in Isidis and comparing their map with the map of ring structures of Schultz and Frey [1990] we see that these ridges only occur within the innermost ring. The orientation of the studied ridges appears to be independent from the basin structure, that is, they are not parallel to any particular contour line.

Wrinkle ridges in the interior of the Isidis basin were not mapped in previous studies [e.g., Chicarro et al., 1985; Watters, 1993]. Head et al. [2002] found that the wrinkle ridges in Isidis are similar to wrinkle ridges in the North Polar basin and argued that the veneer of units Hvr and Aps is sufficiently thick to obscure the topography and morphology of the ridges in Viking Orbiter images. They proposed that the wrinkle ridges are part of the Hesperian-aged ridged plains (Hr) that formed elsewhere on Mars.

Compared to the ridges of the thumbprint terrain we found significant differences of the wrinkle ridges in Isidis Planitia. Based on our preliminary results these wrinkle ridges are much larger in height, width, and length and do not show the typical subparallel orientation of the thumbprint terrain. Rather these wrinkle ridges are oriented radially and concentric to the basin structure and form “cells” of ~180 km diameter. They occur throughout the basin floor and over a wide range of elevations. Wrinkle ridges in Isidis are on the order of 75-150 m high and less than ~70 km wide. Profiles across these ridges commonly show asymmetric cross-section, which are typical for lunar wrinkle ridges and martian wrinkle ridges of typical volcanic plains such as Lunae Planum.

Conclusions: From our study we conclude that (1) the basin floor is tilted towards the southwest with about 0.015 degree, (2) there are 2 types of ridges within the Isidis basin, (3) ridges of the thumbprint terrain are ~10-50 m high, < ~5-7 km wide, and occur at narrowly constrained elevations, (4) these ridges occur only within the innermost ring structure and most of them are not exposed at the lowest elevations, (5) wrinkle ridges are ~75-100 m high, < ~70 km wide, hundreds of kilometers long and occur over a wide range of elevations, (6) the rim of Isidis exhibits a wide range of elevations of ~7500-8000 m.

The floor of the Isidis basin has been chosen by the European Space Agency (ESA) as landing site for the first European lander on Mars. This lander, named *Beagle* after Darwin’s exploration vessel, will operate on the surface for 180 sols. It will perform a whole suite of experiments (e.g., stereo camera, microscope, spectrometers (X-ray, Gamma-ray, Mössbauer), gas analyzer, environmental sensors), while the Mars Express spacecraft will orbit the planet to acquire global high-resolution remote sensing data and to ensure data downlink from the lander to Earth. In addition, the Isidis basin is also under consideration as a potential landing site for the NASA MER rovers.

References: Bridges et al., [2003], JGR 108; Chicarro et al., [1985], Icarus 63; Greeley and Guest, [1987], I-1802-B, U.S. Geol. Surv.; Grizzaffi and Schultz, [1989], Icarus 77; Hiesinger and Head, [2003], to be submitted to JGR; Ivanov and Head [2002] Lunar Planet. Sci., XXXIII, abstract 1341; Parker et al., [1989], Icarus 82; Parker et al., [1993], JGR 98; Schultz and Frey, [1990], JGR 95; Tanaka et al., [2000], Lunar Planet. Sci., XXXI, abstract 2023; Tanaka et al., [2001a], EOS. Trans. AGU, 82(20), Spring Meet. Suppl., abstract V42A-12; Tanaka et al., [2001b], Lunar Planet. Sci., XXXII, abstract 1898; Tanaka et al., [2001c], Geology, 29, No. 5; Tanaka et al., [2002], Geophys. Res. Lett., 29; Watters, [1993], JGR 98; Wichmann and Schultz, [1988], Lunar Planet. Sci., XIX; Zuber et al., [2000], Science 287.

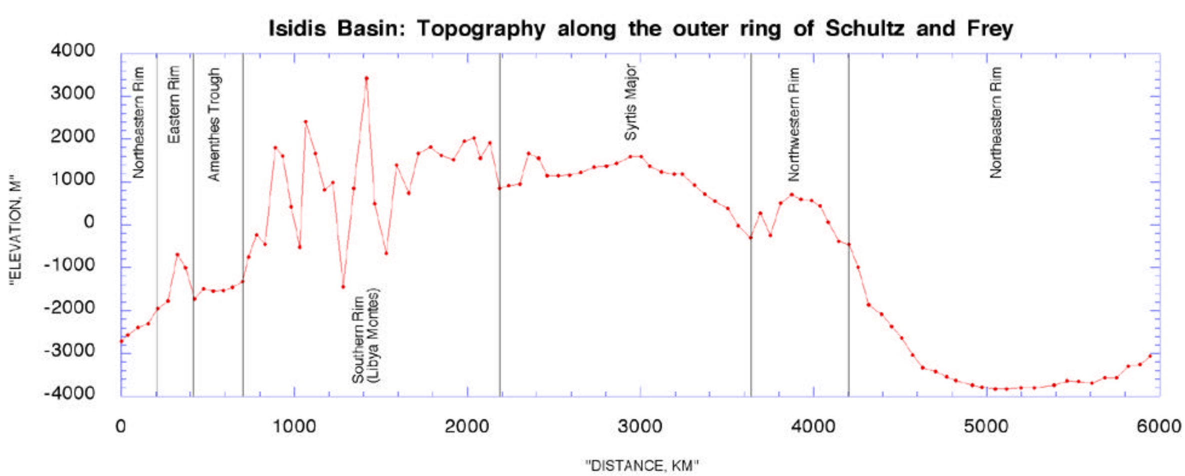

Figure 2: Topographic profile along the second ring structure of Schultz and Frey [1990] of Figure 1. Starting at 90˚ (E, right side of Figure 1), the profile shows the topography clockwise, i.e., E-S-W-N along the ring.