Geophysical Research Abstracts, Vol. 7, 04952, 2005
SRef-ID: 1607-7962/gra/EGU05-A-04952

The Martian Northern Lowlands – A Time-Stratigraphic Interpretation

S. C. Werner (1), G. Neukum (1), K. L. Tanaka (2), and J. A. Skinner (2)

(1) Institut fuer Geologische Wissenschaften, Freie Universitaet Berlin, Malteserstr. 74-100, Bldg. D, 12249 Berlin, Germany. (swerner@zedat.fu-berlin.de), (2) Astrogeology, U.S. Geological Survey, Flagstaff, AZ, USA

Introduction: Global Martian geologic mapping and stratigraphic analysis is based mainly on Viking Orbiter image interpretation (Scott and Tanaka, 1986, Greeley and Guest, 1987, Tanaka and Scott, 1987). One of the dominating features of the Martian surface is the ancient highland-lowland topographic and morphologic dichotomy superimposed by huge impact basins and volcanic regions. The lowland region is roughly centered on the north pole and covers one third of the planet at an elevation between -3000 to -6000 m. While its origin remains unclear, detailed topographic data from the Mars Orbiter Laser Altimeter and additional imagery from the Mars Orbiter Camera (both on board the Mars Global Surveyor space craft) (Tanaka et al., 2003) have provided new insights into the interpretation of the northern lowlands.

General settings: Major geographic features include the Vastitas Borealis Formation, Utopia Planitia, and Isidis Planitia. Chryse and Acidalia Planitiae are located east of the huge volcanic Tharsis rise and are characterized by old channel mouths, possible channel-related flood-plains, and chaotic material. At the base of the western flank of the Tharsis rise, Amazonis Planitia and Arcadia Planitia are located, followed westwards by the volcanic Elysium rise and the Elysium Planitia. Amazonis, Arcadia, and Acidalia Planitiae were grouped into the Arcadia Formation, distinguished on the basis of morphology, albedo, and crater densities. These regions have been remapped into new volcanic and sedimentary plains units based on post-Viking spacecraft data.

For many mapped units (Tanaka et al., 2003) representative type units were selected. A detailed study of the time-stratigraphic sequence is given here. Based on Viking MDIM 2.1 imagery, crater size-frequency measurements were performed and the resulting surface ages are discussed in this paper. For details regarding the method see Neukum et al. (2001), Ivanov (2001), and Hartmann and Neukum (2001). Special focus has been given to four different zones, which represent different characteristics and evolution within the northern plains: zone 1 (the Chryse basin), zone 2 (the Utopia basin), zone 3 (the Amazonis and Elysium region) and zone 4 (a profile line between the north pole and Alba Patera).

The Chryse region (zone 1): A system of deep, wide channels (Kasei, Maja, Shalbatana, Simud, Tiu, Ares, and Mawrth Valles) emanate from chaotic terrains. The channels originate from chaotic terrain and dissect highland plateaus and boundary plains (Noachis, Nepenthes, Lunae, and Libya unit). Most of the huge outflow channels discharge into the nearly circular structure of Chryse Planitia, a possible impact basin. These channels can be traced by scour features northward into Acidalia Mensa. The extent of Chryse Planitia is outlined by four geological units (Chryse unit 1 - 4). A few units relate directly to the outflow channel morphology (Ares unit and Simud unit). The main characteristics of this basin include the scoured features and streamlined islands associated with the outflow channels. In this zone the morphologic units are represented by 16 patches on which crater counts were performed.

Zone 2, the Utopia basin and vicinity: Zone 2 includes the Utopia basin, the Isidis impact structure, the volcanic province Syrtis Major, and volcanic flow units related to the Elysium Mons (mapped as Elysium and Tinjar unit 1 and 2). East and west of Isidis, the morphologic characteristics of the dichotomy-boundary are clearly visible. In this zone, 19 patches were chosen for crater counting. Most of the patches roughly define a profile line along the 120°E meridian.

Elysium volcanic province and Amazonis Planitia, Zone 3: Here 7 patches represent volcanic units resembling volcanic flanks of the Elysium bulge, covering part of the plain unit discussed in relation to the Athabasca Valles, and Amazonis Planitia.

Crossing the Vastitas Borealis between North Pole and Alba Patera, Zone 4: 4 patches make up a profile line between Alba Patera and the northern polar ice cap, roughly following the 270°E meridian. The selected units follow the gentle down slope to the northern lowland average elevation.

Results: As expected and already described by Tanaka et al. (2003), the oldest ages are found in the highland units, which are heavily cratered. In the geological interpretation these units are named Noachis unit (assumed to be the oldest in the Tanaka et al. (2003) and earlier interpretation). In all discussed zones they are clearly the oldest (approximately 4 Gyrs old; 1 Gyrs = 1 billion years), and belong to the highland plateau. The surface age gradually decreases towards topographic lows. In general the northern lowland units (in all zones) range in age between 3.65 and 3.55 Gyrs, with afew exceptions in zone 2 and zone 3. These exceptions are correlated to morphologic units of different geologic origin.

Within the Chryse units the elevation related decreasing age is confirmed by the crater counts, which indicate a resurfacing event about 3.66 Gyrs ago. This is roughly the upper limit of the overall lowland age and is related to a constant elevation around the basin, originally mapped as the boundary of the Vastitas Borealis Formation, which grouped four morphologic end members (Scott and Tanaka, 1986, Greeley and Guest, 1987, Tanaka and Scott, 1987). The lower most region of the Chryse basin appears to be the youngest unit of that zone, represented by a variety of units all resembling remaining flow features and other channel-related units. Subsequently no strong resurfacing activity has affected the Chryse region.

In zone 2 the Vastitas Borealis Formation surface ages have been determined to be the youngest of the investigated patches (about 2.8 Gyrs). The units related to possible rim features of the Utopia basin, represented by patches east and west of the Isidis basin (Utopia unit 1), appear to be slightly older at the eastern flank (about 3.75 Gyrs) compared to the 3.65 Gyrs at the western flank. Mapped as the single morphologic unit Utopia unit 2, the surface ages appear to better fit the surrounding unit ages than to be homogeneous within the morphologic unit. For the volcanic province Syrtis Major, crater counts indicate an age of about 3.57 Gyrs which is close to the latest stage activity of other paterae volcanic constructs.

For Elysium and Tinjar units, which have been interpreted earlier to be lava flows erupted most likely by Elysium Mons, ages of about 3.55 Gyrs have been measured. Most suffered a resurfacing episode which ended about 3.3 Gyrs ago as indicated by their crater size-frequency distributions. During this episode the craters smaller than 3 kilometers in diameter has been erased from the record. In zone 3 morphologically similar units show the same ages.

The surfaces represented by the patches in zone 1 and 2 were formed during the Hesperian, except the highland units that are of Noachian age. A few units in zone 2, which are the youngest (roughly 2.9 Gyrs old), are considered Early Amazonian.

Patches representing units in the western lowland vicinity of Olympus Mons in the Amazonis Planitia indicate ages of Middle to Late Amazonian (1.5 to 0.5 Gyrs). A distinction based on surface morphology correlated to different crater densities is observed from measurements across the entire Amazonis Planitia. Strong resurfacing visible in the eastern part of Amazonis Planitia (close to the Olympus Mons aureole) could require a reevaluation of earlier attempts, which described Amazonis Planitia as a wide, homogeneous plain. The selected Arcadia unit appears to have an overall surface age of about 3.55 Gyrs.

Between Alba Patera and the north pole region, crater counts indicate a surface age of approximately 3.6 Gyrs. There is no gradual change in age coinciding with the observed elevation level. The crater measurements closest to Alba Patera display the youngest surface age of 3.37 Gyrs.

Morphology and ages in zone 4 do not follow the typical highland-lowland boundary characteristics. It is unlikely that similar geologic processes have acted to form this sector (compared to the dichotomy sector). Units between - 30 E to about 145 E are characterized by the transition between old Noachian heavily cratered highland terrain to Hesperian aged lowland units. The Tharsis hemisphere does not show any cliff-like dichotomy-boundary characteristics. This feature either has been obscured or fully covered by volcanic (or other resurfacing) activity or never existed. The gradual decrease of observed surface ages is clearly represented by patches measured.

References: Scott, D. H. and Tanaka, K. L.(1986) Geological Map of the Western Equatorial Region of Mars (1:15,000,000), USGS. Greeley, R. and Guest, J. E. (1987) Geological Map of the Eastern Equatorial Region of Mars (1:15,000,000), USGS. Tanaka, K. L. and Scott, D. H. (1987) Geological Map of the Polar Regions of Mars (1:15,000,000), USGS. Tanaka, K. L., Skinner, J. A., Hare, T. M., Joyal, T., and Wenker, A.(2003) Resurfacing history of the northern plains of Mars based on geologic mapping of Mars Global Surveyor data, Journal of Geophysical Research 108. Hartmann, W. K., and Neukum, G. (2001) Cratering Chronology and the Evolution of Mars, Space Science Reviews 96, 165-194. Neukum, G., Ivanov, B. A., and Hartmann, W. K. (2001) Cratering Records in the Inner Solar System in Relation to the Lunar Reference System, Space Science Reviews 96, 55-86. Ivanov, B. A. (2001) Mars/Moon Cratering Rate Ratio Estimates, Space Science Reviews 96, 87-104.