MAJOR EPISODES OF THE GEOLOGIC HISTORY OF ISIDIS PLANITIA, MARS, M.A. Ivanov[1], G. Erkeling[2], H. Hiesinger[2], F.J. Hielscher[2], and D. Reiss[2], 1-Vernadsky Inst. RAS, Moscow, Russia, 2-Muenster Univ., Muenster, Germany

Introduction: Isidis Planitia, one of the largest (~1500 km) impact basins on Mars, is the region where the volcanic and fluvial/glacial landforms are abundant and where interaction of volcanic materials with water/ice likely took place [1]. The floor of the basin is one of the most important sites of development of thumbprint terrain (TPT) [2-4]. In order to assess the evolution of the Isidis basin and understand the place and role of different processes there (including formation of TPT), we undertook geological mapping in the region between 75-103°E and 1-27°N (Fig. 1). We defined and mapped units there using all available imagery and topographic data. Here, as the first step of our study, we describe morphology of the mapped units, give age estimates for them, and formulate the major steps in the geologic history of the region.

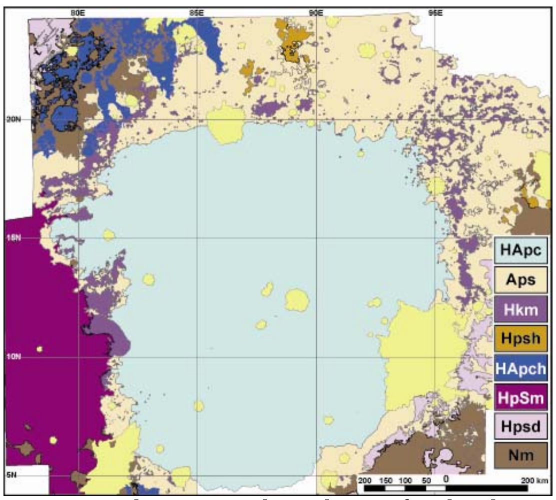

Fig. 1. Preliminary geological map of Isidis Planitia

Description of map units: The units in the map area occur in three topographic domains, the highlands (SW half of the rim of the basin), the midlands (the interior slopes of the basin and its NE half of the rim), and the lowlands (the basin floor). The following units form the highlands domain. The *mountainous materials* (Nm, Fig. 2) form high-standing, rugged, and heavily cratered massifs that comprise the S rim of the basin (Libya Mts.), surround the Amenthes Trough [5], and occur to N and S of Syrtis Major. The unit is of Noachian age, from ~4.1 to ~3.8 Ga [6,7]. Materials of two plains-forming units, *smooth dark plains* (Hpsd, Fig. 2) and *smooth plains of Syrtis Major* (HpSm, Fig. 1) embay the massifs of unit Nm. These units form highland plains with morphologically flat and sometimes heavily degraded surfaces. Within unit HpSm evidence for lava flows and tubes can be found. Unit Hpsd occurs in the NW (near Nili Fossae) and SE (at the NW edge of the Amenthes trough) portions of the Isidis' rim. In both regions the graben of either Nili or Amenthes Fossae cut the unit. Materials of unit HpSm flood the floor of Nili Fossae [8,9]. In localities where scarps and crater walls expose the interior of the units, the rough layering and specific spur-and gully pattern of erosion are visible. These features are identical to those seen in the typical volcanic regions (e.g., calderas of the large shield volcanoes [10]) and we interpret the units Hpsd and HpSm as volcanic plains. The crater age estimate of unit HpSm is ~3.3 Ga (Fig. 3). The crater statistics for unit Hpsd suggest two ages, ~3.6 Ga and ~2.3 Ga (Fig. 3). Because this unit predates emplacement of materials of Syrtis Major, we interpret the older age as the time of formation and the younger age as the time of resurfacing

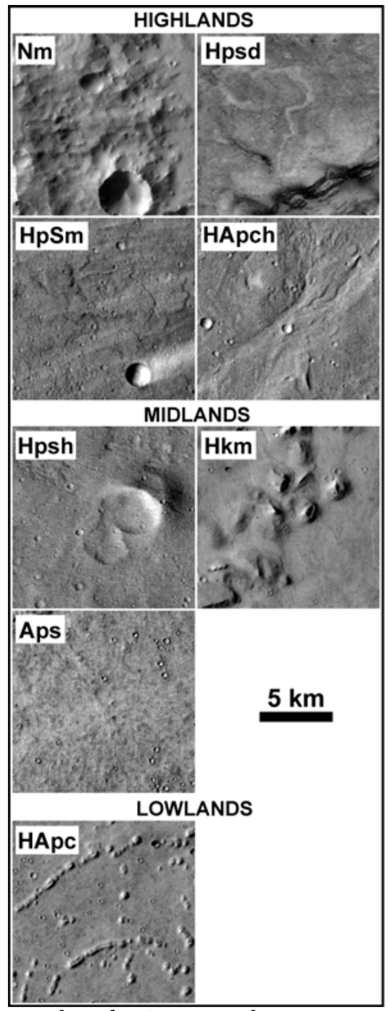

Fig. 2. Examples of units mapped

of unit Hpsd. Fluvial channels cut the surface of the next unit of the highlands, *channeled plains* (HApch, Fig. 2) that occur in the NE and S portions of the rim. The age estimates for the terminal portions of both occurrences give the large variety of ages (Fig. 3), from ~3.6 Ga (NE) to ~1.0 Ga (S, at the base of Libya Mts.).

Three units make up the midland domain. On the N and E segments of the rim of Isidis there are several small (tens of km) clusters of broad and low shield-like features with large central pits (*shield plains*, Hpsh, Fig. 2). The morphology of the shields suggests their formation due to localized volcanic eruptions. Surrounding plains embay the shields and their ages are estimated to be ~3.6 (E) and ~3.3 (E) Ga (Fig. 3). Tight groups of small (<~1km) sharp-peaked and flat-topped knobs represent one of the most important units within the midland domain (*knobby material*, Hkm, Fig. 2). This unit is widely distributed and occurs almost everywhere on the internal slopes of the basin except for the southern portion where the rim is dominated by the

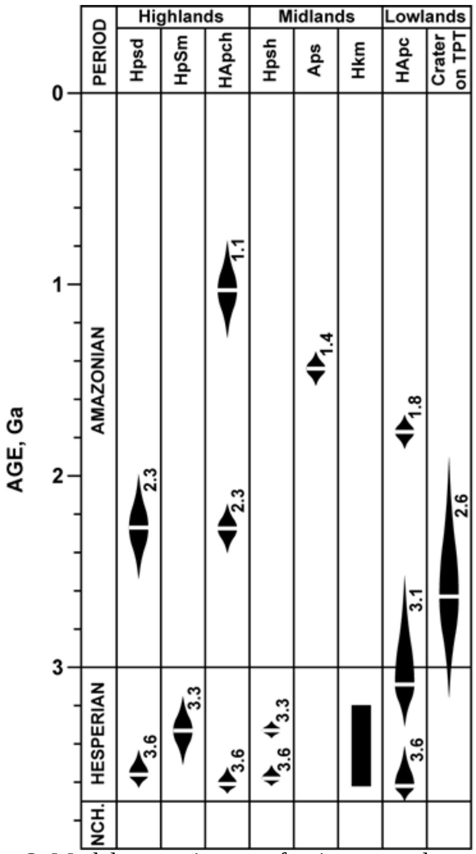

Fig. 3. Model age estimates of units mapped

Noachian terrains. The knobby unit includes remnants of both the Noachian mountainous materials (sharp-peaked knobs) and the Hesperian lava plains (mesa-like knobs). Because unit Hkm consist of disintegrated blocks, it is impossible to obtain reliable crater counts for its surface. The extensive plains units of the midlands and lowlands, which embay the knobby materials, provide the upper stratigraphic boundary of formation of the unit (Fig. 3). The most abundant unit within the midlands is *smooth plains* (Asp, Fig. 2) that have morphologically smooth and featureless surface. The unit covers the internal slopes of the basin, forms a complete collar around the lower floor of the basin, and separates it from the units of the highlands. The crater counts within smooth plains give the age ~1.4 Ga (Fig. 3).

A single unit of *coned plains* (HApc, Fig. 2) makes up the lowland domain and corresponds to the thumbprint terrain on the floor of the basin. Previously, this unit was mapped either as the Hesperian ridged plains [2] or as the early Amazonian Isidis Planitia unit [11]. The origin of TPT is unclear and there is a variety of hypotheses proposed to explain its formation [3,12,13]. Unit HApc forms very broad and flat deposit of plains-forming materials that almost everywhere exhibits a sharp contact with surrounding smooth plains. The chains of cones that form TPT occur almost exclusively within unit HApc and are identical in albedo to the main type of materials of the unit. Our crater counts within unit HApc display three ages, ~3.6, ~3.1, and ~1.8 Ga (Fig. 3).

Summary: Both the mapping results and determinations of the absolute model ages suggest that the geologic history of the Isidis Planitia region consists of four major episodes.

(1) Formation of the Isidis basin due to a major impact during the heavy bombardment epoch. The impact formed a large feature, the topography of which controlled the processes of volcanism, tectonism, denudation, and deposition in the Isidis region. The oldest materials exposed in the map are mostly related to impact processes during the Noachian. The crater counts within Libya Montes [6,7] indicate that the mountainous materials (Nm) are mid- to late Noachian (~3.8-4.1 Ga) in age.

(2) The major volcanic activity in the highland and midlands characterizes the Hesperian epoch in the map area. The current areal distribution of the clearly (Hpsd, Hpsm) and likely (Hpsh, Hkm) volcanic units suggests that the rim of Isidis basin was the site of intensive volcanism. The presence of both a mascon [14] and subdued wrinkle ridges within the basin [1] suggest that a composite layer of volcanic flows also covers the floor of the basin. The volcanic plains on the rim embay the mountainous Noachian materials, which provide the lower stratigraphic boundary of the volcanic activity. The crater statistics for the highland volcanic plains suggest that volcanic activity on the rim of Isidis continues for ~500-800 my. Fluvial activity in other parts of the rim of Isidis (NE and S [6,7]) also occurred in the beginning at the Hesperian epoch.

(3) The crater counts within TPT (unit HApc, coned plains) indicate three ages. The oldest age (~3.6 Ga) is correlated with the major volcanic episodes (Fig. 3) and it is very likely that the mesa-like knobs of the knobby unit represent remnants of volcanic plains formed during these episodes. Since coned plains are stratigraphically younger than the knobby unit, we conclude that the older age estimate for unit HApc (~3.6 Ga) corresponds to the older units underlying coned plains. There are several rampart craters superposed on the surface of coned plains. These craters establish the upper stratigraphic boundary of formation of the plains. The crater count on ejecta of one of the oldest craters is consistent with an age of ~2.6 Ga [15]. This implies that the youngest age within coned plains (~1.8 Ga) clearly postdates formation of the plains and corresponds to later resurfacing events. Thus, the most likely age of formation of coned plains (and the TPT as well) is estimate to be ~3.1 Ga (Fig. 3).

(4) The latest activity within the map region corresponds to Amazonian resurfacing events that, however, were not sufficient enough to significantly change the morphology of units formed in earlier times.

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