

**THE AMENTHES TROUGH, MARS: NOACHIAN FLUVIAL/MASS-WASTING SEDIMENTS FOR INVESTIGATION BY THE MARS '01 LANDER.** K. L. Tanaka, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001 ([ktanaka@flagmail.wr.usgs.gov](mailto:ktanaka@flagmail.wr.usgs.gov))

**Introduction:** The Amenthes trough forms a northwest-trending depression within the heavily cratered highlands of Mars. A landing site proposed here affords a well-defined geologic setting that will allow scrutiny of ancient Noachian sedimentary materials and processes. The proposed landing site, in the vicinity of 1.7°S, 246.4°W (Fig. 1), generally satisfies mission engineering requirements for the Mars Surveyor '01 lander (Table 1).

Herein I describe the rich geology of the landing site from an examination of the regional context as well as local features. I also describe some of the kinds of science that might be performed by the lander/rover instrument package in this area.

**Table 1.** Data for the proposed Mars '01 landing site in the Amenthes trough (1.7°S, 246.4°W).

<i>Data type</i>	<i>Values</i>
Viking image coverage	14-16 m/pixel (124S)
MOC images (3 nearby)	6, 8, 9 m/pixel
Topography, MOLA	~2.0 km
Rock abundance	12%
Fine component TI	7 cgs units

**Regional setting:** The Amenthes trough extends southeastward from Isidis Planitia, forming a ~100-km-wide breach in the Isidis basin rim. The trough is ~1,100 km long, and the proposed landing site is near the southeast end of the trough. The northwest half of the trough is flanked by Early to Middle Noachian massifs and rugged cratered terrain of the ancient Isidis basin rim [1]. This part of the rim is cut by several linear, wide, NNE-trending fractures of Amenthes Fossae [2]. The southeast half of the trough is flanked by Middle Noachian dissected cratered material [1]; prominent scarps of Amenthes Rupes form parts of the trough walls [1]. These scarps are thought to be contractional thrust and fold features [3]. Most of the floor of Amenthes trough is covered by smooth plains material [1] that is locally deformed by wrinkle ridges.

The new MOLA global topographic mapping [4] indicates that the floor of Amenthes trough rises slightly from ~2.5 km elevation where it connects with Isidis Planitia to about -2 km elevation near the landing site. In the vicinity of the proposed landing site, the trough floor is ~2 km and the crest of Amenthes Rupes reaches ~2 km.

**Landing site geology:** The 124S orbit of Viking images (Fig. 1) provides a high-resolution swath across Amenthes Rupes and trough. These images elucidate well the erosional history of the trough wall and the depositional history on the trough floor. Cited stratigraphic ages (Noachian and Hesperian) are esti-

mates based on morphological state.

The oldest rocks in the image swath (unit Nar) make up the rugged crest and southwest flank of Amenthes Rupes. These appear to be rugged Noachian highland materials whose morphology is dominated by (1) southwest-trending, moderately sinuous valleys 1-2 km wide and up to ~10 km long, (2) generally southwest-facing alcoves up to a few km wide, and (3) impact craters up to 2 km in diameter. This terrain is relatively steep. The general lack of connection and organization of the alcove and valley features indicates that most of these features were formed by localized, discrete erosional events, presumably driven by ground-water sapping and mass wasting. The valley walls appear to be steepest on top, and valley floors appear to have narrow channels a few hundred meters wide. Subtle northwest-trending scarps and ridges in this terrain indicate that the material was only moderately deformed (except for possible broad-scale deformation) after valley and alcove development.

Below the rugged highland material, a series of planar deposits form sloping steps in the lower part of the Amenthes trough. These deposits are progressively younger in age toward the bottom of the trough. They appear to correspond with successive levels of downcutting and deposition.

The first of these trough units (unit Nat<sub>1</sub>) embays one of the more prominent valleys in the wall material. It appears that significant erosion has removed the upper part of the older unit in places, and elsewhere the older unit is exposed and apparently embayed by the upper trough unit. Contacts between these units are mostly indistinct. Small wrinkle ridges aligned with the trough deform the unit's surface.

The upper trough unit is dissected by deep, broad (>5 km wide), long (~20 km), round-headed, flat-floored troughs filled by the next younger trough unit (unit Nat<sub>2</sub>). Some of the valleys that dissect the rupes unit (unit Nar) also dissect the upper trough unit and connect with the troughs of the second trough unit.

The next lower trough unit (unit Nat<sub>3</sub>) covers much of the broad floor of Amenthes trough across the 124S image swath, as well as the floors of connected troughs that cut the floor material (unit Nat<sub>2</sub>) of higher-level troughs. The troughs are generally 2-6 km wide. This broad unit, while planar, shows considerable fine-scale texture and morphologies. A broad, sinuous channel-like feature courses along the trend of the image swath, whereas local narrow channels trend across the swath. Small, short ridges appear to be aligned in the along-swath direction and may be dunes. The surface is densely pocked by impact craters; the larger craters display layering in their upper, interior rims and

are filled by smooth floor deposits. The crater rims and ejecta ramparts appear etched. Shallow, broad circular depressions in the unit appear to be areas where the unit has compacted above underlying crater forms.

At the southwest end of the swath, the next lower unit (unit HNat<sub>4</sub>) infills a 23-km-diameter crater and embays unit Nat<sub>3</sub>. The eastern part of the degraded crater rim is partly exposed, whereas the southwestern part is buried but marked by a prominent northwest-trending wrinkle-ridge system. Within the crater, the unit is superposed by scattered remnant mesas up to a few kilometers across made up of a younger deposit (unit HNat<sub>5</sub>).

The lower trough units (units Nat<sub>3</sub> and HNat<sub>4</sub>) also embay a rugged trough floor unit (Natr) east of the large crater. In lower resolution images, the unit appears dissected and may have contributed to the sedimentation of the lower trough unit. A narrow, sinuous channel that dissects unit HNat<sub>4</sub> in the eastern part of the large crater may emanate from the rugged floor unit.

**Lander and rover science:** The high-resolution Viking 124S image swath provides excellent visualization of part of the Amenthes trough. The proposed landing site generally fits within engineering constraints, with the possible exceptions that the topography may be rather rough in places and the ellipse must

include some large impact craters and trough walls, unless the ellipse size is reduced to about 15 km.

Perhaps the greatest strength of this landing site proposal is the degree to which the geologic context can be mapped and interpreted. Obviously, without strong geomorphic evidence, the origin of many Noachian rocks cannot be deciphered; various sedimentary, volcanic, and impact origins may be plausible. The proposed Amenthes trough site is covered by a deposit (unit Nat<sub>3</sub>) that clearly originates from ancient, uplifted crustal material (unit Nar). In addition, the alcoves and valleys above the site indicate that the deposit was emplaced by a series of sapping and mass-wasting events. The proposed landing-site materials would be ideal for site analysis of paleoclimatic and paleobiologic indicators, because they formed from ancient crustal material that had contained ground water during the Noachian.

**References:** [1] Greeley R. and Guest J. E. (1987) *USGS Map I-1802-B*. [2] U.S. Geological Survey (1982) *USGS Map I-1429*. [3] Schultz R. A. and Tanaka K. L. (1994) *JGR* 99, 8371-8385. [4] Smith D. E. et al. (1999) *Science* 284, 1475-1503.

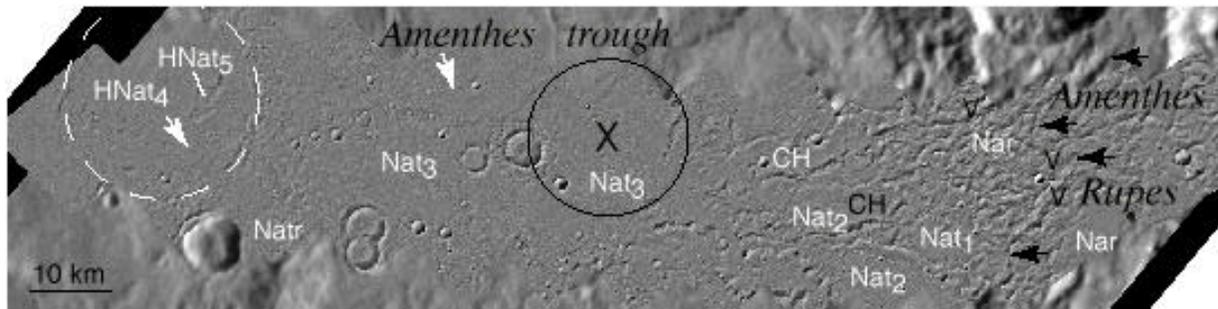


Figure 1. Part of Amenthes Rupes (right) and trough showing proposed landing site (X and 20-km-diameter circle). Geologic units described in text. Note valleys (V), alcoves (black arrows), channels (CH), partly buried crater rim (dashed line), and narrow sinuous channels (white arrows). [north at upper left; Viking images 124S1-24, 16-18 m/pixel superposed on image 381S41, 250 m/pixel]