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**PETROGRAPHY AND STRUCTURES OF NOCTIS LABYRINTHUS
(VALLES MARINERIS, MARS) - PRELIMINARY RESULTS**

Abstract: Mars Orbiter Camera (MOC) data from Mars Global Surveyor and Planetary Fourier Spectrometer (PFS) data from the Mars Express mission have been used to analyse and describe the diversification of rock forms and material of the Noctis Labyrinthus region of Mars, a complex pattern of intersecting fault systems, including fractures and graben-bounding faults. The floor of Noctis Labyrinthus canyons is structurally more diversified than the canyon walls. Large accumulation of layered deposits has been observed in the eastern part of Noctis Labyrinthus. The diversification of material tones on MOC images, from light, through intermediate, to dark, indicates the different mineral composition of the rocks. PFS spectra should be corrected for the contribution of atmospheric components to allow for determining unequivocally the presence of minerals.

Keywords: graben system, layered deposit, fault surface, MOC image, PFS spectrum, Noctis Labyrinthus, Valles Marineris, Mars

INTRODUCTION

The Valles Marineris canyon extends over 4000 km along the Martian equator. The system of Noctis Labyrinthus intersecting grabens is situated in the western end of the Valles Marineris canyon and extends for 976 km along the equator. The origin of the Valles Marineris troughs has not been explained as yet. Stratigraphic, structural and geomorphologic relations indicate that this large-scale, complex structure formed as the result of stretching and fracturing the planet crust, in response to Tharsis-centered stress (Tanaka 1997; Tanaka, MacKinnon 2000). Poorly consolidated material was easily eroded and numerous erosional landforms are present on the surface (Komatsu *et al.* 1993). Another interpretation compares the Valles Marineris canyon to a continental rift (Mége, Masson 1996). Numerous fault dislocations in the western part of Valles Marineris lead to forming a dense network of Noctis Labyrinthus grabens, few kilometers deep in some places (Tanaka 1997).

Images of Mars received during the Mariner 9 and Viking missions revealed rhythmically layered deposits within the Valles Marineris canyon (Nedell *et al.* 1987). These deposits are very important because of their relationships to the evolution of Valles Marineris canyon and their implications for depositional and erosional history of the canyon. The composition of layers allows to determine the past Martian environment. The sequences of layers might be of volcanic origin (periodical lava flows; Lucchitta 2004), or sedimentary (deposition in a standing body of water; Komatsu *et al.* 1993). MOC images show the outcrops of the Valles Marineris chasms in much greater detail; more important, they reveal many occurrences that were not previously identified (Malin and Edgett 2000). The fewest exposures are in areas where no pre-MGS examples were identified (*e.g.* Noctis Labyrinthus; *op. cit.*).

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DATA SET AND INVESTIGATION AREA

For this research there have been used Mars Orbiter Camera (MOC) data from Mars Global Surveyor and Planetary Fourier Spectrometer (PFS) data from the Mars Express mission. The MOC data set contains narrow and wide angle images of Mars, about 187 000 in number, received in the time interval from September 1997 up to now. Resolution of these images is from 1.5 to 6 m/pixel. PFS is taking infrared spectra of Mars surface and atmosphere in two spectral channels: short wavelengths (1.2-5 μm) and long wavelengths (5-45 μm), with spectral resolution of about 1.5-2 cm^{-1} and spatial resolution of a few kilometers (the vision field is 4°). The data set consists of about 1700 orbits (over 200-300 measurements/orbit). The measurements have been taken from January 2004 up to now.

From the MOC data set 1090 MOC narrow angle images have been chosen and scrutinized. These images cover the area between 0° and 15°S latitude and 90° and 105°W longitude - the Noctis Labyrinthus region. The area of the highest density of data extends from latitude 6,5° to 8°S and longitude 94,5° to 98°W (about 100 MOC narrow angle images). From this part of the data set 10 representative images have been chosen to analyse and describe the diversification of rock forms and material of both the canyon floors and walls. Most of these images have been taken in the time interval between March 2003 and March 2004.

The long wave channel infrared spectra of the PFS data set, from orbit 438 to 683, have been scrutinized and 11 orbits cross the Noctis Labyrinthus region. These measurements have been taken in the time interval between 25 May and 2 August 2004. The measurements from 3 representative orbits: 486, 497 and 508 have been analysed. Part of the orbit 486 corresponds to MOC images in the area of the highest density of the MOC data. The orbits 497 and 508 cut the western part of Noctis Labyrinthus.

RESULTS AND CONCLUSIONS

The area of the highest density of the MOC data contains partly the surface not cut by grabens, what permits a greater variety of structures to appear. Representative images show mostly the floor of the canyon (Figs. 1a; 2a, b). On most images the floor of the canyons is covered by a large quantity of bright eolian material accumulated around dark massive extended ridges, several kilometers long. Eolian wrinkles and ripplemarks often appear on the surface (Fig. 1a). Mesas, either single, large (few kilometers wide) or numerous, but relatively small (tens to hundreds meters; Fig. 1a) are another type of structures of the canyon floor. The mesas are usually darker than the material around them (Fig. 1a). The material around the mesas is strongly wrinkled. Light-toned rock layer, few meters wide, is often present around mesas, hills and massifs (Fig. 1a). On most images the canyon walls are covered by eolian material. The massive rock material sporadically appears as ridges (Fig. 1b). The walls are often fault surfaces. The floor of the canyons is structurally more diversified than the canyon walls.

The exposures of layered deposits are scarce in the area between 6,5° to 8°S latitude and 94,5° to 98°W longitude on the analysed MOC images; only single, relatively small

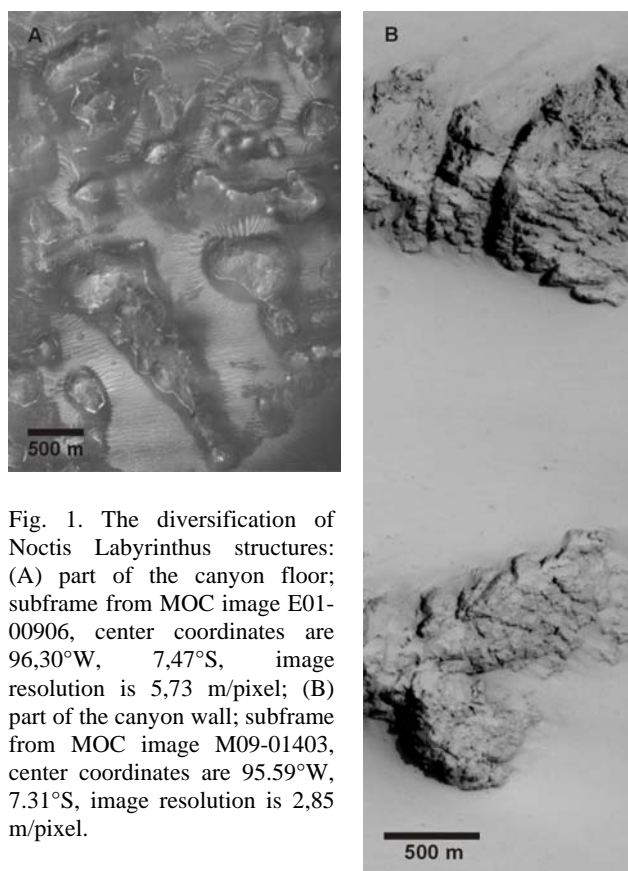


Fig. 1. The diversification of Noctis Labyrinthus structures: (A) part of the canyon floor; subframe from MOC image E01-00906, center coordinates are 96,30°W, 7,47°S, image resolution is 5,73 m/pixel; (B) part of the canyon wall; subframe from MOC image M09-01403, center coordinates are 95.59°W, 7.31°S, image resolution is 2,85 m/pixel.

outcrops (few meters) have been observed. The fact is that the whole area is not covered by MOC images. The images received up to now do not allow to determine the presence or absence of layered deposits. On the other hand, while scrutinizing all MOC images of Noctis Labyrinthus region, large accumulation of layered deposits has been observed in the area over 7°S latitude and 92°W longitude, in the eastern part of Noctis Labyrinthus. The layers have thickness varying from several to hundreds meters and their tones are light and dark (Fig. 2a, b). The layered deposits overlay the floor of Noctis Labyrinthus graben.

The rock material has been characterized mostly on the basis of its visual tone and sometimes of its structure. The diversification of material tones, from light, through intermediate, to dark, indicates different mineral composition of the rocks. The spatial resolution of PFS in most cases does not allow to identify the mineral composition of particular kinds of the rock material, so a different data set must be used to investigate this diversification. There is no clear difference between the PFS spectra of the canyons and spectra of the surrounding terrains with smooth surface (mainly Syria Planum), in the analysed data set. The analysis of PFS spectra shows that in the range of 900 to 1000 cm^{-1} wavelength there is an indication for the presence of pyroxene (presumably augite), but the spectra do not determine the mineral presence unequivocally. The same uncertainty refers to the next observed features (*e.g.* in the range of 1100 to 1200 cm^{-1}). Absorption bands of

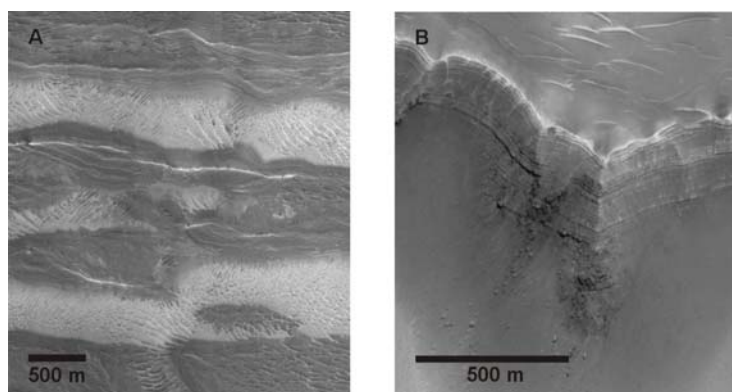


Fig. 2. The layered deposits on the floor of Noctis Labyrinthus: (A) subframe from MOC image M09-06305, center coordinates are 92,69°W, 7,12°S, image resolution is 2,86 m/pixel; (B) subframe from MOC image R11-02076, center coordinates are 92,91°W, 7,34°S, image resolution is 2,85 m/pixel.

CO₂ at around 667 cm⁻¹ show a strong signature in the spectra and preclude the observation of absorption bands of hematite and other minerals, which have characteristic absorption bands in the 500 to 800 cm⁻¹ wavelength range. PFS spectra should be corrected for the contribution of atmospheric components before further analysis of the surface composition. Mustard *et al.* (2005) performed such a correction for OMEGA spectra assuming that the surface and atmospheric contributions are multiplicative and that the atmospheric contribution follows a power law variation with altitude. A similar treatment of the PFS spectra is planned.

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