Rend. Online Soc. Geol. It., Vol. 34 (2015), pp. 5-8, 4 fig. (doi: 10.33.01/ROL.2015.28)

High resolution DEM from stereopairs: examples from Nili Fossae and Gale crater, Mars

Paolo Mancinelli, Cristina Pauselli & Costanzo Federico

Dipartimento di Fisica e Geologia, Università degli Studi di Perugia, Via A. Pascoli, 06123 Perugia, Italia.

Document type: Short note.
Manuscript history: received 14 October 2014; accepted 20 January 2015; editorial responsibility and handling by Paola Reichenbach.

ABSTRACT

In this work, we present two Digital Elevation Models (DEM) obtained from stereopairs produced by the High Resolution Imaging Science Experiment (HiRISE) camera onboard the Mars Reconnaissance Orbiter (MRO). Target regions are chosen among the most intriguing and studied of Mars and are the western trench of the Nili Fossae and the northern portion of the central peak of the Gale crater. The terrains found in the first have proven to have a significant compositional variability whose spatial distribution is related to their morphology. The canyon found in the Gale crater is important to extend the comprehension of those geologic processes observed by the Curiosity rover, up to a distance and a morphologic context (the wall of the canyon) unreachable by the rover. The high resolution of the HiRISE images (0.25 m/pixel) from which we started allowed us to produce the DEM with higher resolution and increased detail respect to the topographic model derived from the Mars Orbiter Laser Altimeter (MOLA) data.

KEY WORDS: Mars, Stereopairs DEM, Nili Fossae, Gale Crater.

INTRODUCTION

The geological investigation of a planetary surface must consider the topography and morphology in which the observed features are found. The higher the resolution of the topographic data, the more precise will be the interpretation of the geologic context. Here we present two DEM derived for two regions of Mars which were chosen among the most intriguing geological scenarios of the planet and considering HiRISE data availability.

The first target region is a portion of the western Nili Fossae (21.1°N; 74.1°E), a system of concentric grabens found in the north-western rim of the Isidis Planitia, where hydrated minerals have been found (e. g. Bibring et al., 2005; Bibring et al., 2006; Mustard et al., 2007; 2009) (fig. 1).

The second target region is the northern portion of the central peak of the Gale crater (5.1° S; 137.2° E) (e. g. Anderson and Bell, 2010; Grotzinger et al., 2013). This area is located 25 km SW from the Curiosity rover landing site (fig. 2) and was chosen because the observed canyon (fig. 2c) exposes a significant amount of layers that are traceable over a long distance.

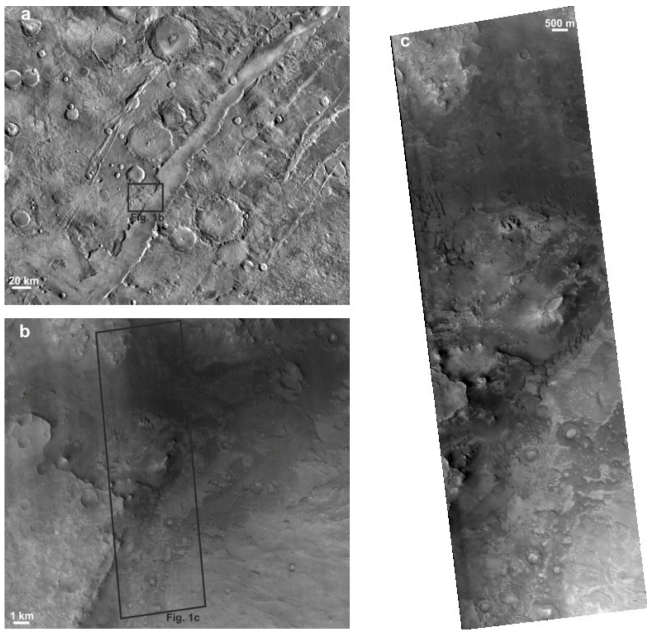

Fig. 1 – a) Nili Fossae daytime infrared emission as observed by the Thermal Emission Imaging System (THEMIS). b) Context camera (CTX) file B06_012039_2011_XN_21N285W. c) One of the two HiRISE files used for this area (PSP_003086_2015).

The aim of this work is to produce high resolution elevation models of these target regions, in order to increase the resolution and detail of topographic models of these regions and contribute to their geological characterization.

METHODS

DEM are produced using the Ames Stereo Pipeline (ASP) (Broxton and Edwards, 2008; Moratto et al., 2010), a NASA software (http://ti.arc.nasa.gov/tech/asr/intelligent-robotics/ngt/stereo/) that was integrated in the ISIS 3 software environment (http://isis.astrogeology.usgs.gov/index.html).

Once downloaded (http://www.uahirise.org/), the HiRISE images that constitutes the stereopair are calibrated, rectified and projected using the ISIS 3 software and then are processed

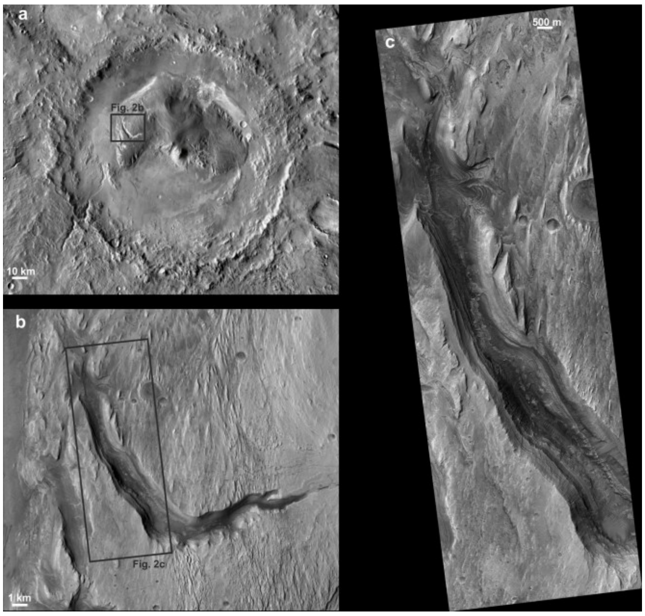

Fig. 3 – a) Gale crater daytime infrared emission as observed by the THEMIS instrument. b) CTX file G05_020054_1749_XN_05S222W. c) One of the two HiRISE files used for this area (PSP_007501_1750).

through the ASP to produce the DEM (ASP manual, see references).

The main product resulting from the ASP procedure is a 3D point cloud image that can be used to create a digital elevation model, a color hillshade map or a KML file to be imported in Google Earth.

For the Nili Fossae region the HiRISE files used to create the DEM are the PSP_003086_2015 and the PSP_003587_2015, in the Gale crater region the HiRISE stereopair is composed by the PSP_007501_1750 and the PSP_006855_1750 files.

RESULTS

The DEM produced by the ASP procedure are shown in figures 3 and 4. These products are the original output as obtained by the ASP procedure. To avoid artifacts, the DEM are computed only where both files of the stereopair overlap – i.e., if one image has a larger footprint than the other, only the area in common is used to create the DEM – and fill procedures to refine the outcomes have not been produced. The final product is projected according to the reference system set by the user. In figures 3 and 4, the color-coded DEM are superposed by 10 m interval contour lines. The contouring was produced using GIS procedures, starting from the files resulting after the ASP procedure.

Processing requires a long time because of the size of the HiRISE input files (~ 2 GB each). Moreover, several GB of intermediate products are obtained before the resulting DEM is produced (~ 4GB). However, results are significant in terms of both the resolution and the detail of the final product (fig. 3 and 4), in particular if compared to MOLA topography (Zuber et al., 1992).

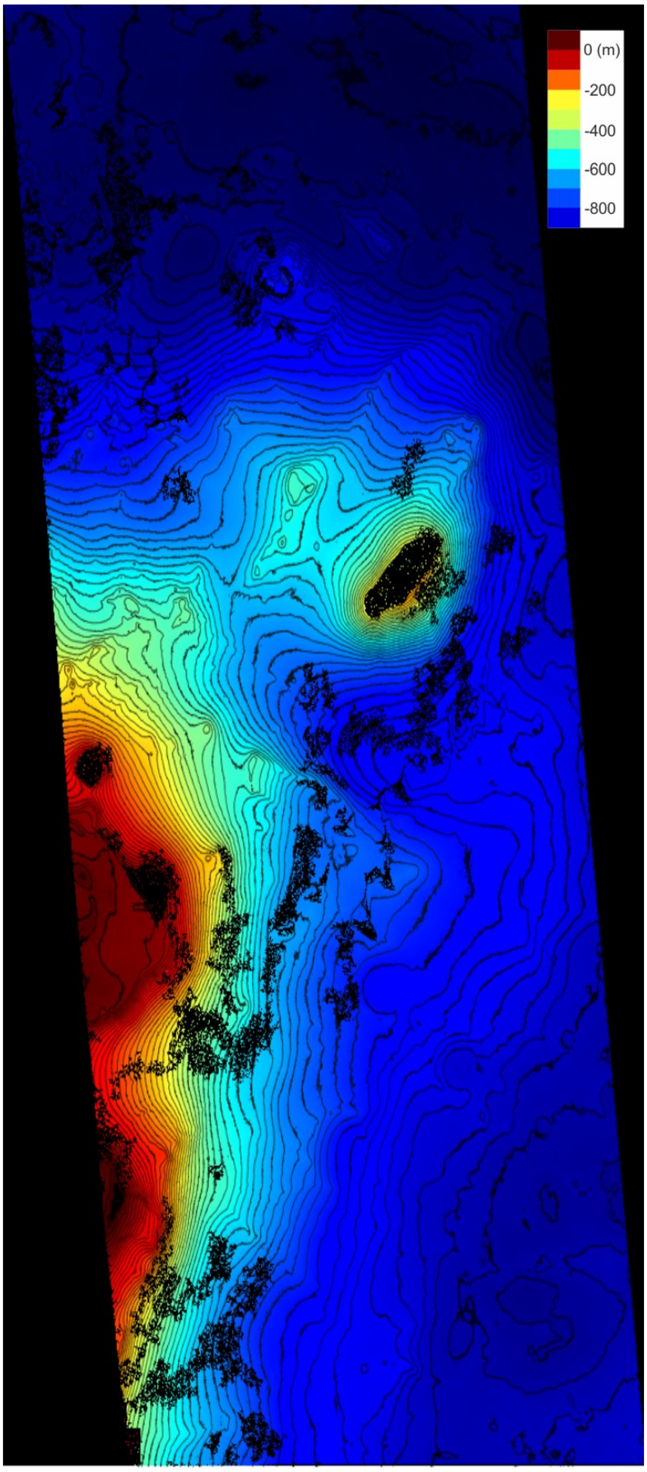

Fig. 2 – Nili Fossae DEM, obtained from the HiRISE stereopair PSP_003086_2015 and PSP_003587_2015. Black lines are 10 m interval contours.

CONCLUSIONS

The resolution of HiRISE images has allowed us to produce DEM of Nili Fossae and Gale target regions with unprecedented detail and resolution. These products will likely contribute to the geological characterization of these regions.

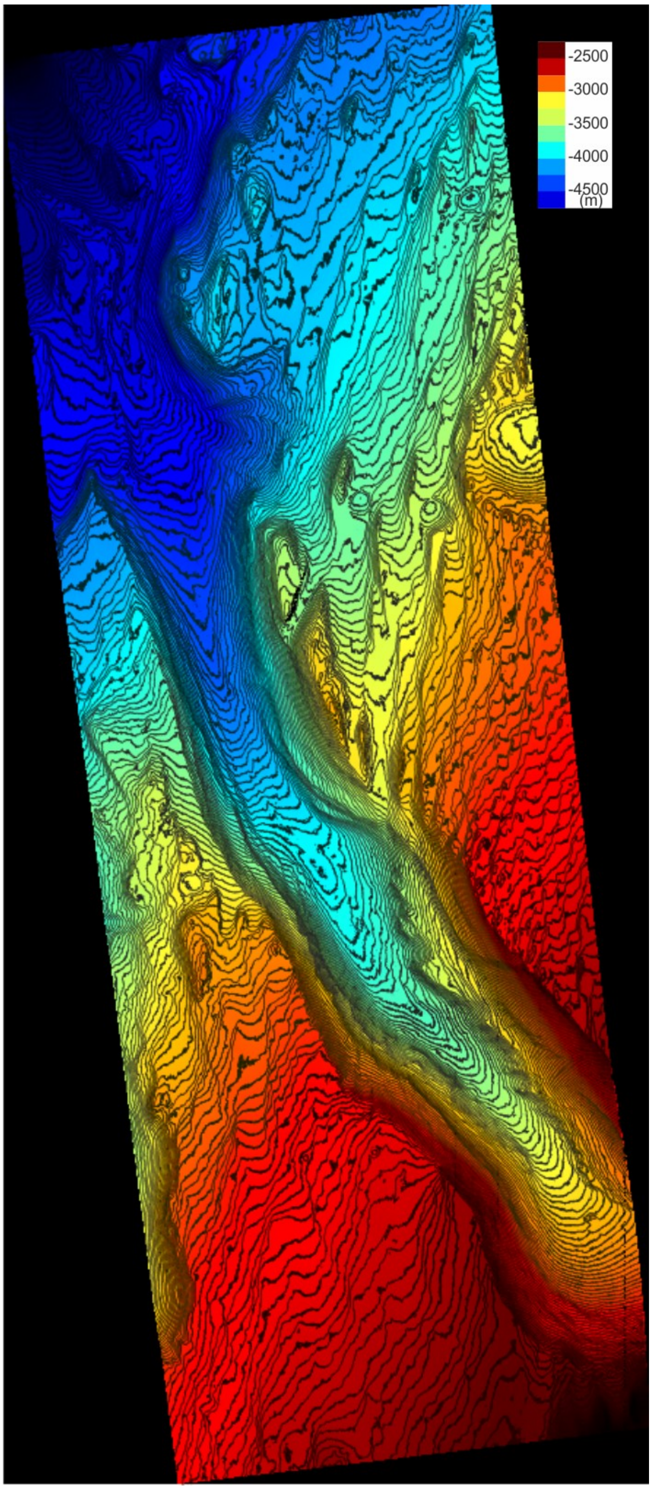

Fig. 4 - Gale crater canyon DEM, obtained from the HiRISE stereopair PSP_007501_1750 and PSP_006855_1750. Black lines are 10 m interval contours.

Producing high resolution topographic datasets represents a significant improvement in the characterization of the target regions, both considering the geologic contexts found in these regions and, in perspective, for future landing missions.

The DEMs produced here have proven to be useful tools for the characterization of the Nili Fossae and the Gale crater. In fact, in the Nili Fossae, is interesting to note that the DEMs we produced (fig. 3) show a very good correlation between the change in the topography and morphology and the mineralogical variability of the terrains (Mustard et al., 2009).

In particular is possible to observe the high variability of the topography in this region of the Nili Fossae which ranges from 0 to -700 m. The flat higher deposits are mainly composed by low-Ca Pyroxene while lower and darker terrains are composed by phyllosilicates (Mustard et al., 2007 and 2009).

In the case of Gale crater canyon, the layers highlighted by the DEM (fig. 4) are likely related to the terrains observed by the Curiosity rover 25 km NE from the canyon. The canyon is long more than 15 km, it strikes N-S cutting the deposits that constitutes the north-western flanks of the central peak of Gale crater and producing a topographic gap of ~2000 m. The high resolution of the final product allows also to highlight steeper portions of the wall of the canyon. In particular, as highlighted by the comparison of the DEM with HiRISE image (fig. 2 and 4), the albedo of these materials changes in several points of the flanks indicating that these terrains, which were deposited in a stratigraphic sequence, have different competence and composition. The terrains found at the bottom of the valley and in topographic lows in the northern regions are likely related to more recent aeolian activity.

The high resolution DEMs, coupled with a detailed analysis of data produced by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), will allow to investigate all the observed morphologies. This analysis will allow to interpret the sedimentary context through which the observed layers were deposited in an early phase and exposed later, likely with a combination of fluvial and aeolian processes.

ACKNOWLEDGMENTS

We thank Paola Reichenbach and the organizing committee of the 2014 meeting of the Geosciences and Information Technology group of the Società Geologica Italiana.

REFERENCES

Anderson R. B. & Bell J. F. (2010) - Geologic mapping and characterization of Gale Crater and implications for its potential as a Mars Science Laboratory landing site. Mars 5, 76-128, 2010; doi:10.1555/mars.2010.0004.

Bibring J.-P., Langevin Y., Gendrin A., Gondet B., Poulet F., Berthé M., Soufflot A., Arvidson R., Mangold N., Mustard J., Drossart P. & the OMEGA team. (2005) - Mars surface diversity as revealed by the OMEGA/Mars Express Observations. Science 307, 1576-1581.

Bibring J.-P., Langevin Y., Mustard J., Poulet F., Arvidson R., Gendrin A., Gondet B., Mangold N., Pinet P., Forget F. & the OMEGA team. (2006) - Global mineralogical and aqueous Mars history derived from OMEGA/Mars Express data. Science 312, 400-404.

Broxton M. J. & Edwards L. J. (2008) - The Ames Stereo Pipeline: Automated 3D Surface Reconstruction from

Orbital Imagery. Lunar and Planetary Science Conference 39, abstract #2419.

Grotzinger J. P., Sumner D. Y., Kah L. C., Stack K., Gupta S., Edgar L., Rubin D., Lewis K., Schieber J., Mangold N., Milliken R., Conrad P. G., DesMarais D., Farmer J., Siebach K., Calef III F., Hurowitz J., McLennan S. M., Ming D., Vaniman D. & alii (2013) - A Habitable Fluvio-Lacustrine Environment at Yellowknife Bay, Gale Crater, Mars. Science 343, doi: 10.1126/science.1242777.

ISIS 3 software is available at: http://isis.astrogeology.usgs.gov/index.html

Moratto Z. M., Broxton M. J., Beyer R. A., Lundy M. & Husmann K. (2010) - Ames Stereo Pipeline, NASA's Open Source Automated Stereogrammetry Software. Lunar and Planetary Science Conference 41, abstract #2364.

Mustard J. F., Poulet F., Head J. W., Mangold N., Bibring J.-P., Pelkey S. M., Fassett C. I., Langevin Y. & Neukum G. (2007) - Mineralogy of the Nili Fossae region with OMEGA/Mars Express data: 1. Ancient impact melt in the Isidis Basin and implications for the transition from the Noachian to Hesperian. J. Geophys. Res., 112, E08S03, doi:10.1029/2006JE002834.

Mustard J. F., Ehlmann B. L., Murchie S. L., Poulet F., Mangold N., Head J. W., Bibring J.-P. & Roach L. H. (2009) - Composition, Morphology, and Stratigraphy of Noachian Crust around the Isidis basin. J. Geophys. Res. 114, doi:10.1029/2009JE003349.

NASA Ames Stereo Pipeline and its manual are available at: http://ti.arc.nasa.gov/tech/asr/intelligent-robotics/ngt/stereo/

Zuber M. T., Smith D. E., Solomon S. C., Muhleman D. O., Head J. W., Garvin J. B., Abshire J. B. & Bufton J. L. (1992) - The Mars Observer laser altimeter investigation. J. Geophys. Res. 97, 7781-7797.