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Geological mapping and analysis of Daedalia Planum lava field (Mars)

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Abstract
Volcanism is the most important rock-forming processes of the planetary surfaces and represents one of the main clues to investigate the chemical composition of the interior and the thermal history of a planet. Our study has been focused on the longest lava flows of Mars, emplaced on Daedalia Planum south-west from Arsia Mons. THEMIS, MOC, HiRISE images were analyzed in order to perform a stratigraphic and morphological analysis of the area. Several features have been interpreted as related to inflation processes and the comparison with the inflated terrestrial Payen Matru flows (Argentina) seems to confirm this hypothesis. OMEGA and CRISM spectra reveal that Daedalia Planum lavas have a basaltic composition; moreover the SAMs performed on OMEGA data show several different spectral variations among the flows, which could depend on several factors, like the different surface textures.

Introduction
Tharsis region is one of the main volcanic provinces on Mars which includes the most known Olympus Mons and the other large shield volcanoes Ascraeus Mons, Pavonis and Arsia Mons. Located south-west from Arsia Mons, Daedalia Planum is a lava plain where more than 1500 km-long lava flows were emplaced, over an almost flat terrain (<0.5° and commonly <0.1°) (Smith et al., 1999). We analyzed the area from different points of view, beginning with a stratigraphic study of the flows emplaced on the field followed by a deeper investigation of the flow surface morphologies and concluding with a spectral analysis of the region.

Stratigraphic and geomorphological analysis of Daedalia Planum lava field
By analyzing Mars Odyssey THEMIS VIS and IR images and the high resolution images of Mars Global Surveyor’s MOC and MRO/HiRISE, we distinguished thirteen different geological units on the base of stratigraphic relationship and morphological characters. Moreover thanks to the high spatial resolution of images several morphological features that remember the inflation fingerprints, like tumuli, lava rises and lava ridges, were found in some lava flows, and a comparison with the Payen Matru inflated flows seems to confirm such hypothesis. These striking morphological analogies suggest that inflation process is quite common for the Daedalia field, implying that the inflation emplacement mechanism on Martian flows could be more frequent than previously supposed and, consequently, effusion rates and rheological properties of Martian lavas more variable (Giacomini et al., 2009).
Our dating by crater counting of the youngest lava flows of Daedalia gave an age of about 260 Myr. This explains the different shape between the Daedalia Planum features and the mounds of Elysium Planitia which were interpreted by Keszthelyi et al. [2008] like inflation expressions. By dating the flows in which this features occur we obtained an age of about 30 Myr, therefore the Elysium flows are much younger than the Daedalia ones which thus have been eroded for a longer time and show heavier modelled shapes. However this couldn’t be the unique explanation of the different shape between Elysium and Daedalia features. Some authors (Page, 2007; Page et al., 2009) assert that Elysium Planitia is interested by a considerable number of mudflows where several pingos fields took place. Therefore it is possible that the features detected by Keszthelyi et al. [2008] could be pingos rather than tumuli and consequently this can imply that the different shape between Elysium and Daedalia features is due to their different genesis. Although the presence of pingos can’t be completely excluded either for Daedalia, the lack of some distinctive signs indicating the presence of iced surfaces, like reshaped crater rims (Murray et al., 2005; Page, 2009), suggests that the mounds detected can be effectively tumuli, at least on the flows investigated.
**Spectral analysis of Daedalia Planum lava field**

Up to date the spectral data are not usually taken into account on planetary geological mapping, nonetheless they may have great potential to discriminate the geological units. We considered the data of both Mars Express and Mars Reconnaissance Orbiter spectrometers, OMEGA and CRISM respectively, in order to find some correlation among our stratigraphic units and the spectral characteristic of the Daedalia Planum volcanic field.

Several OMEGA and CRISM spectra have been analyzed revealing a substantial uniform composition of the lavas. The absorptions observed at about 1 and 2.3 micrometers suggest the presence of olivine and pyroxene and the spectra shapes seem to be comparable with those of terrestrial tholeiitic basalts. All these evidences support the hypothesis of a basaltic composition of the flows on Daedalia, in agreement with the studies asserting a predominance of basalts among the Martian volcanic rocks (e.g. McSween et al., 2009).

However the employment of spectra data can give information other than composition. Indeed while the mineral assemblages control the absorption bands, other factors, like grain size and surface textures, influence the overall reflectance and spectral slopes (Burns, 1993). On these bases, we tried to find possible spectral differences among the stratigraphic units detected on Daedalia Planum. Despite the low geometric resolution (100 m to 4 km per pixel) the synoptic view of OMEGA data enables an analysis of almost the entire area. On the bases of spectral signatures derived from the Omega data, a Spectral Angle Mapper (SAM) classification was performed obtaining a map of Daedalia showing several spectral differences inside the lava field. This map displays a good correlation with the previously recognized stratigraphic units. In addition the spectral map allowed the boundaries between some flows not well morphologically defined to be detected and enabled spectral subdivisions inside some stratigraphic unit. It demonstrates the great potentials of improving Martian geological maps by considering also “spectral subunits”.

**References**


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SUMMARY OF ACTIVITY

Courses:

GIANLUCA GROPPELLI: Geologia del vulcanico, Dipartimento di Scienze della Terra, Università Bicocca, Milano 2007.
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Visit to Jet Propulsion Laboratory, Pasadena (California), from 26th May to 26th June 2008.
Visit to European Space Research and Technology Centre (ESA) (Noordwijk, The Netherlands) (11th July 2008).
Participation to 37th COSPAR Scientific Assembly, Montreal, Canada (13-20 July 2008) as ESA Sponsored Student.
Visit to Open University, Milton Keynes (UK), from 14th April to 24th July 2009.