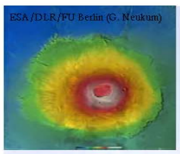
Planet Mars III
28 March- 2 April 2010
POSTERS: ABSTRACT BOOK

LES HOUCHES



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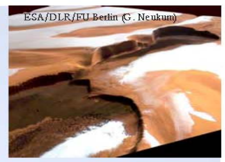

Scientific Committee & Organization

Thérèse Encrenaz, Directeur de recherche CNRS, Observatoire de Paris, Meudon, France; **Dan McCleese**, Chief scientist, JPL, USA **Jack Mustard**, Professor, Brown University, USA, **Frédéric Schmidt**, Assistant Professor, IDES, Université Paris Sud; **Jonathan Schulster**, Mission Planning, Mars Express/ESOC(VCS AG), Darmstadt, Germany; **Christophe Sotin**, Senior Research Scientist, JPL, Pasadena, USA

Olivier Witasse, Mars Express Project Scientist, European Space Agency, ESTEC, The Netherlands

Goals of the Workshop

The goals of the workshop are to integrate the main results of both the recent Earth-based observations and the missions to Mars (MarsExpress, Mars Reconnaissance Orbiter, Phoenix and Mars Exploration Rovers) into a new global picture of Mars evolution. With the same spirit of the previous similar workshops, discussions among scientists of different disciplines will be encouraged and it is foreseen that they will help refine the scientific goals of the future missions to Mars. This workshop is an opportunity for the young scientists to be updated on the most recent results and to be trained in some specific data processing techniques.

The format of the Workshop will encourage discussions. Leading scientists in the interpretation of data and in modelling processes will present their views on key topics, such as the geological history, surface properties, climate evolution, atmospheric composition, exobiology, interior, and solar wind interaction. Posters from students and scientists will be displayed and will be discussed between sessions. Dedicated sessions on data processing (e.g. hyperspectral mapping from OMEGA and CRISM) will also be organised.

List of speakers (not exhaustive): J.-L. Bertaux (LATMOS), J.-P. Bibring (Orsay), V. Dehant (Royal Observatory of Belgium), F. Forget (CNRS), B. Gondet (Orsay), J. Grebowsky (NASA GSFC), E. Hauber (DLR), O. Korablev (IKI), F. Lefevre (CNRS - Université Pierre et Marie Curie), P. Lognone (IPGP, Paris), R. Lundin (Swedish Institute of Space Physics), N. Mangold (CNRS et Université de Nantes), W. Markiewicz (MPS Lindau), M. Mischna (JPL), M. Mumma (NASA GSFC), J. Mustard (Brown University), J.J Plaut (JPL), F. Raulin (University Paris 12), S. Smrekar (JPL), S. Werner (The University of Oslo).

Deadline for application (via the web page): 15 January 2010

The number of partipants is limited due to accommodation, and early registration will be considered in case of over-subscription.

http://www.sciops.esa.int/index.php?project=MARSEXPRESS&page=planet_mars3

Le village des Houches se trouve au coeur des Alpes, dans la vallée de Chamonix. Fondée en 1951, l'Ecole de Physique est située à 1150 m d'altitude, dans un décor champêtre, face à la chaîne du Mont-Blanc. L'Ecole de Physique des Houches est rattachée à l'Université Joseph Fourier Grenoble I (UJF). C'est un service interuniversitaire commun l'UJF et à Grenoble-INP. Elle est subventionnée par l'UJF, le Centre National de la Recherche Scientifique (CNRS) et la Direction des Sciences de la Matière du Commissariat à l'Energie Atomique (CEA/DSM). Ecole de Physique des Houches, Côte des Chavants, F-74310 Les Houches.

Les Houches is a village located in Chamonix valley, in the French Alps. Established in 1951, the Physics School is situated at 1150 m above sea level in natural surroundings, with breathtaking views on the Mont-Blanc mountain range. Les Houches Physics School is affiliated with Université Joseph Fourier Grenoble I (UJF). It is a joint interuniversity facility of UJF and Grenoble-INP, and is supported by the UJF, the Centre National de la Recherche Scientifique (CNRS) and the Direction des Sciences de la Matière du Commissariat à l'Energie Atomique (CEA/DSM).

http://w3houches.ujf-grenoble.fr   Directeur du Centre de Physique : J.-F. Pinton

Recent Science Results from VMC on Mars Express

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Mars Express carries a small Visual Monitoring Camera (VMC), originally to provide visual telemetry of the Beagle-2 probe deployment, successfully release on 19-December-2003. The VMC comprises a small CMOS optical camera, fitted with a Bayer pattern filter for colour imaging. The camera produces a 640x480 pixel array of 8-bit intensity samples which are recoded on ground to a standard digital image format. The camera has a basic command interface with almost all operations being performed at a hardware level, not featuring advanced features such as patchable software or full data bus integration as found on other instruments.

In 2007 a test campaign was initiated to study the possibility of using VMC to produce full disc images of Mars for outreach purposes. An extensive test campaign to verify the camera's capabilities in-flight was followed by tuning of optimal parameters for Mars imaging. Several thousand images of both full- and partial disc have been taken and made immediately publicly available via a web blog.

Due to restrictive operational constraints the camera cannot be used when any other instrument is on. Most imaging opportunities are therefore restricted to a 1 hour period following each spacecraft maintenance window, shortly after orbit apocenter.

Power-limited seasons, such as the eclipse seasons 2009-2010 close to Mars aphelion, allow for additional VMC observing opportunities closer to pericenter, when ASPERA is off for power reasons, or preceding and following propulsive spacecraft manoeuvres.

This poster attempts to present some of the most exciting images obtained during the latest 2009-2010 season, focusing on aspects of Mars science that can be studied uniquely with the VMC properties of orbit and field-of-view.

The first inertial limb-tracking observation of Mars covering almost 120 degrees of latitude was observed in orbit 7631 on 15 December 2009, revealing cloud banks, dust and haze in the atmosphere over northern and southerly latitudes.

A series of VMC imaging opportunities between February 3 and 8th, 2010 were used to record weather formations and evolution over the Hellas basin, at various times of day from early morning to late evening.

On March 4th 2010 (orbit 7905) a long-duration observation provided a panoramic arc of images stretching from Chasma Boreale at the north pole, over Milankovic crater, Acheron Fossae, Lycus Sulci and ending at Olympus Mons. Clouds are visible with shadows over the north polar cap ice layer deposits, and the full patera of the Olympus Mons volcano.

These recent observations with the VMC on Mars Express have revealed the true potential contribution of the camera for large-scale context and time-evolving events. It is hoped that other PI teams are able to make further use of the VMC in future to contribute to their scientific investigations, within the limits of its operations constraints.

Constitution of a Mars analogues rock store and data base for space missions, the key role of Raman spectroscopy.

Nicolas Bost [1, 2], Frédéric Foucher [1], Frances Westall [1], Claire Ramboz [2], and the Orléans-Lithothèque Team*
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ExoMars has joined up with the American Max-C rover in a joint, two rover mission to Mars in 2018. The science objectives of ExoMars are to search for traces of past or present life and to document the habitable environment in terms of water and geochemistry as a function of depth in the shallow subsurface. Max-C seeks to determine the habitability of the surface of Mars with the aim of selecting and catching rocks potentially containing traces of life for the future Mars Sample Return mission. The ExoMars rover will embark a number of scientific instruments to investigate rock outcrops and subsurface materials: for observation, a variety of cameras and a close up imager, for mineralogy, Raman and IR spectrometry as well as an XRD, and GCMS and LDMS for chemical characterization of the organics. A drill will provide subsurface access to hopefully preserved organics. Max-C will be distinguished by a suite of arm-based tools for observation and mineralogical/elemental mapping.

Due to the payload's limitation, *in situ* analyses will be relatively limited. It is thus probable that the unambiguous detection of past life on Mars will be done only after the return to Earth of the samples. However, as only 500g of rocks are planned to be sent back to Earth during the Mars Sample Return mission, the selection process during the *in situ* investigations will thus be crucial. Presently, the best way to improve this selection process is to study Mars analogue rocks with laboratory and space equipment in order to facilitate the interpretation of the *in situ* analyses. With this in mind, the CNRS in Orléans (France) and the *Observatoire des Sciences de l'Univers en région Centre* are creating a collection of well-characterized rocks that will be available for testing and calibrating instruments to be flown on ExoMars missions. The characteristics of the collection's analogue materials will be described in an online database.

The preliminary selection of rocks chosen covers a range of possible lithologies found on Mars. Apart from their compositional relevance, many of the rocks were formed at a time period equivalent to the Noachian of Mars (the period when liquid water was present on Mars and when life may have appeared) and some of them contain fossil biosignatures.

The rocks are studied in the form of hand samples, thin sections and powders. They are then characterized using a wide range of instruments: optical microscopy, Raman spectroscopy, electronic microscopy, electron microprobe… In particular, the Raman spectrometer (WITec Alpha500 RA) of the CBM, in Orléans, appears to be a key instrument for the analyses. This system permits compositional mapping on a scale from tens of micrometers to up than 10 cm with a submicrometric resolution. Moreover, due to the confocality of the system, analyses can be made within the sample thickness and the mapping can be made in 3D. This precious information allows full characterization of the composition of the samples, including mineralogy and eventual microbial remains. These fully characterized samples will be used in order to test the future ExoMars equipments.

* Nicolas Bost, Frédéric Foucher, Frances Westall, Claire Ramboz, Axelle Hubert, Derek Pullan, Beda Hofmann, Elisabeth Vergès, Michel Viso, Jorge Vago, Christelle Briois, Bruno Scaillet, Michel Tagger

GLOBAL MINERALOGICAL MAPPING OF THE MARTIAN SURFACE FROM OMEGA/MEx : AN UPDATE. A. Ody[1], F. Poulet1, J.-P. Bibring[1], B. Gondet[1], Y. Langevin[1], J. Carter[1], M. Vincendon[2]. D. Jouglet3. 1Institut d'Astrophysique Spatiale,Université Paris-Sud, 91405 Orsay cedex, France 2Departement of Geological Sciences, Brown University, Providence, RI USA,3 CNES Toulouse, 31401 Toulouse cedex 09.

Aboard the Mars Express spacecraft, OMEGA has been mapping the surface of Mars since January 2004. In 2007, the observations acquired during the first 22 months of observations provided a first analysis of the global distribution of some surface materials (Poulet & al. JGR (2007)). Here, we reassess the detection of these minerals using data acquired until October 2009, which correspond to 3 Martian years, namely 7441 orbits and 7527 OMEGA image-cubes. This provides an almost complete coverage of the Martian surface with a spatial sampling from 300 m to several kms depending on the pericentre altitude of the spacecraft elliptical orbit. Global maps of the Fe^{3+} signature, nanophase oxides and mafic minerals (pyroxenes and olivines) are derived from diagnostic criteria based on spectral parameters developed and tested in the study of 2007. These parameters were adapted to take into account the aging of the detector due to radiation damage. The interannual variability of the aerosols cause strong variations of the values of criteria which were not observed on the 2007 maps acquired during one Martian year only. To reject data disturbed by dust, a threshold based on the dust opacity measured by the MERs was apllied on all data. The albedo map shows a significant increase of the OMEGA data global coverage of the martian surface since the 2007 study. Mineralogical maps indicate that the bright regions are characterized by strong Fe^{3+} and nanophase oxide signatures, while pyroxenes are mainly localized in the low albedo regions, both in southern and northern hemisphere. These results are in good agreement with the 2007 analyses. The olivine-bearing terrains are mainly scattered in the southern hemisphere. All previously identified olivine regions including Nili Fossae, Terra Meridiani, Syrtis Major and Ganges Chasma are detected. Special interest is in the presence of olivine in some craters of the northern plains. Numerous additional small deposits, especially around the Argyre and Hellas bassins, are reported.

Study of MGS magnetic data to infer the planet internal electrical conductivity

François Civet et Pascal Tarits

Our research studies aim to determine electrical properties of the deep interior of Mars using the magnetic data recorded by Mars Global Surveyor (MGS). During its mapping phase, MGS measured continuously the 3 components of the Martian magnetic field from 1999-2006 at an altitude from 380-420 km. The objective is to characterize the electromagnetic induction process originating from the external inducing magnetic field generated by the interaction of the planetary environment with the solar flux. The electromagnetically induced magnetic field is a function of the electrical conductivity of the Martian mantle.

This technique is used successfully on earth. Several studies involving satellite magnetic data (from Magsat to Champ) have shown that at least a detailed one dimensional conductivity profile may be obtained from the analysis of the induced magnetic field observed at satellite altitude. However, on earth, the source field is dominated by a simple geometry which leads to a rather simple forward solution. In contrast, the Martian magnetic environment is very heterogeneous, presents strong contrasts between day and night sides and interacts with the large static planetary magnetic anomalies. In addition, the magnetic series recorded by MGS are not fully continuous.

Because of the complexity of the Martian external field, we tested an approach involving a quasi-continuous external proxy to be introduced in the space and time spectral analysis of the magnetic data in order to obtained accurate estimates of both internal and external spherical harmonics coefficients of the induced and inducing magnetic field. The generation of this proxy is currently tested on Earth synthetic data. These data were generated by Kuvshinov et al. (2006) to prepare the future ESA magnetic constellation mission SWARM.

We present a series of approaches developed to calculate with a proxy the spherical harmonic coefficients of the spherical harmonic expansion for the magnetic field from satellite's observations. We are currently testing two methods, one with the Dst index and one with a proxy derived from the satellite data themselves

Reference:

Earth Planets Space, 58, 417–427, 2006
3-D electromagnetic induction studies using the Swarm constellation: Mapping conductivity anomalies in the Earth's mantle, Alexei Kuvshinov, Terence Sabaka, and Nils Olsen, Earth Planets Space, 58, 417–427, 2006

IDENTIFICATION AND DISTRIBUTION OF PHYLLOSILICATES RICH DEPOSITS ON THE SURROUNDING PLATEAUS OF VALLES MARINERIS. J. Flahaut[1], L. Le Deit[2], C. Quantin[1] and P.Allemand[1] . [1]Laboratoire des Sciences de la Terre, UMR CNRS 5570, Ecole Normale Supérieure de Lyon/ Université Claude Bernard, 2 rue Raphaël Dubois, 696222 Villeurbanne Cedex, France (jessica.flahaut@ens-lyon.fr). [2]Institute of Planetary Research, German Aerospace Center (DLR), Rutherfordstr. 2, 12489 Berlin, Germany.

Introduction: Previous analyses of OMEGA and CRISM data revealed several thousands of Fe/Mg-phyllosilicates rich outcrops in the southern highland Noachian terrains [1-6]. We also recently identified Al-phyllosilicates rich deposits widely spread around the chasmata of the outlet of Valles Marineris. Several tens exposures of light-toned deposits (LTDs) located on the surrounding plateaus were therefore investigated to assess their mineralogy, their distribution and their stratigraphy.

Method: In order to describe the morphological and mineralogical characteristics of the light-toned deposits, we analyzed the available HiRiSE and CRISM hyperspectral data between 40°S and 0°N in latitude, and 70°W and 30°W in longitude so far. CRISM data were processed as in [7]. For each couple of images, we reported the morphology and mineralogy of light-toned deposits, and classified their spectral features.

Results: *Al-phyllosilicates rich deposits:* The Al-phyllosilicates rich deposits correspond to massive, rough light-toned deposits that are exposed as superficial deposits on the surface of the plateaus south of Coprates-Capri-Eos Chasmata, and west of Ganges Chasma. Their distribution is limited in space and time, since all outcrops investigated so far are only present over Npl2 Noachian terrains, and generally close to the rims of Valles Marineris chasmata. Associated spectra display absorption bands at 1.4 µm, 1.9 µm, and a narrow band at 2.2 µm. These spectral characteristics are consistent with Al-smectite or kaolinite spectra [8].

Fe/Mg-phyllosilicates rich deposits: The Fe/Mg-phyllosilicates rich LTDs are characterized by light-toned outcrops of various morphologies but are clearly distinct from that Al-type LTDs. The associated spectra exhibit absorption bands at 1.4 µm, 1.9 µm, and 2.3 µm, which are best fitted by Fe/Mg smectite spectra in most of cases [8]. Fe/Mg-phyllosilicates rich LTDs occur in various geological contexts and outcrop in terrains of various ages, indicating different mechanisms and times of formation. Many of them are located in central peaks and pits [9] of impact craters on plateaus that suggests these LTDs correspond to old excavated buried layers. An extensive superficial layer of Fe/Mg phyllosilicates has also been identified over the whole Noachis Terra area [10]. Fe/Mg rich phyllosilicates are also found in association with late valley and crater infillings, such as in Ladon Vallis and in Shalbatana Vallis.

Stratigraphy: Al-phyllosilicates rich deposits are located stratigraphically above some Fe/Mg-phyllosilicate-rich deposits where they both occur, at the very top of a wall cross-section, near Coprates Catena [5]. The occurrence of Al-phyllosilicates rich deposits on the plateaus and of Fe/Mg-phyllosilicates rich deposits in and around impact craters is consistent with this stratigraphic sequence. Some Fe/Mg-phyllosilicates rich deposits, as the one corresponding to valley and crater infillings, are younger than that the ones outcroping along escarpments.

Moreover, on one observation, west of Gangis Chasma, Al-phyllosilicates are covered by Hesperian layered deposits (LDs) rich in opaline silica and sulfates [11,12]. These deposits could mark a transition in the stratigraphic record.

Conclusion: The previous stratigraphic sequence reveals environmental changes in the history in the region of Valles Marineris. The earliest events of this sequence include the deposition of Al-phyllosilicates over Fe/Mg-phyllosilicates, what has already been observed in other location of the planet Mars, as in Marwth Vallis [13]. This transition between the two cationic compositions could register an evolution of the environmental conditions between the two episodes of depositions, or during the alteration processes. A difference in composition of the primary rocks, considering more acide basaltic rocks at the top, as in a differentiation sequence, could also explain the stratigraphic profile observed. We could then register an evolution in the type of volcanism of Mars.

References: [1] Bibring J.-P. et al. (2006) Science, 312, 400-404. [2] Poulet et al. (2007) *7th Int. Conf. on Mars,* Abstract #3170. [3] Gondet et al. (2007) *7th Int. Conf. on Mars,* Abstract #3185. [4] Mustard J. F. et al. (2008) *Nature, 454,* 305-309. [5] Murchie S. L. et al. (2009) *JGR, 114,* E00D06. [6] Carter J. et al. (2009) *LPSC XXXX,* Abstract #2028. [7] Flahaut J. et al. (2010), *submitted to JGR* [8] Ehlmann B. et al. (2009) *JGR, in press* [9] Quantin C. et al. (2009) *LPSC XXXX,* Abstract #1651 [10] Buczkowski D. et al. (2009) AGU Fall Meeting, Abstract#P21C-03 [11] LeDeit L. et al. (2010)

Observations of Water Vapour and Carbon Monoxide in the Martian Atmosphere with the SWC of PFS/MEX

Giuseppe Sindoni and Vittorio Formisano
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In the history of the Mars exploration its atmosphere and planetary climatology has from time aroused particular interest. In the study of the minor gas abundance in the Martian CO_2 atmosphere, the water vapour assumes particular importance, both because it is the most variable trace gas, and because it is involved in several processes characterizing the planetary atmosphere.
The water vapour photolysis regulates the Martian atmosphere photochemistry, and so it is strictly bounded to the carbon monoxide. The CO study is very important for the so called "atmosphere stability problem" (the whole CO_2 atmosphere should be destroyed in 6000 years by photolysis), solved by the theoretical modelling involving photochemical reactions in which the H_2O and the CO gases are main characters.
The Planetary Fourier Spectrometer (PFS) on board of ESA Mars Express (MEX) mission can probe the Mars atmosphere in the infrared spectral range between 200 and 2000 cm^{-1} (5-50 μm) with the Long wavelength channel (LWC) and between 1700 and 8000 cm^{-1} (1.2-5.8 μm) with the Short wavelength channel (SWC). Although there are several H_2O and CO absorption bands in the spectral range covered by PFS, we chose to use the 3845 cm^{-1} (2.6 μm) band for the water vapour and the 4235 cm^{-1} (2.36 μm) band for the CO analysis, because these ranges are less affected by instrumental problems respect to other ones. The gaseous abundances are retrieved by using a particular algorithm developed for this purpose. The analysis procedure is based on the best fit between the measured averaged spectrum and a synthetic one appositely generated in each step of the fitting loop.
The averaged water vapour mixing ratio results to be about 130 ppm, while the averaged carbon monoxide mixing ratio results to be about 1000 ppm, but with strong seasonal variations at high latitudes. The seasonal water vapour map reproduces very well the known *seasonal water cycle*. In the northern summer the water vapour and CO show a good anticorrelation most of the time, i.e. water has its maximum and carbon monoxide has its minimum mixing ratio over the north pole. This behaviour is due to the carbon dioxide and water sublimation from the north polar ice cup, which dilutes noncondensible species including carbon monoxide. An analogous process takes place during the winter polar cup, but in this case the carbon dioxide and water condensation causes an increase of the abundance of noncondensible species. Therefore, the carbon monoxide mixing ratio varies in response to the mean seasonal cycle of surface pressure.

Martian Valley Networks: What We Know, What We Think We Know, And What Is Left To Discover, Robert A. Craddock, Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560 craddockb@si.edu

What We Know. Mars valley networks represent the best evidence that liquid water was once stable on the surface of Mars. Attempts to age-date the valley networks using higher resolution imagery data and a variety of techniques converge on the fact that most valley networks ceased formation around the early Hesperian, but there are some notable exceptions.
Valley networks are also concentrated around the equatorial region of Mars, which indicates that climate conditions were also the most favorable in this area.

Quantitative estimates of discharge rates that were determined for some valley networks where a central channel has been preserved indicates that valley networks took a hundreds to perhaps a couple of thousand years to form, so the climatic optimum associated with valley networks was short-lived.

What We Think We Know. Whether valley networks formed from groundwater sapping or surface runoff has been a long-standing controversy. Analyses of putative sapping canyons on the Earth is providing evidence that lithology is the primary control on valley network morphology. Typically sapping canyons occur in units that are closely spaced, horizontally layered and lithologically the same (e.g., Hawaii) or in units that are nearly horizontal where a more competent geologic unit overlies a less competent one (e.g., Utah). In either case, the erosion is controlled primarily by overland flow, which may often been ephemeral, but intense (i.e., flashy).

The other features indicative of past fluvial process on Mars are modified impact craters. The size range of affected craters and the various degrees of modification exhibited by craters in the same areas indicates that crater modification was a long-lived process. However, only a few craters have been breached by valley networks. This suggests, again, that valley networks formation was a short-lived process that appears to have occurred near the end of a more favorable climate in the Noachian.

What's Left? Despite having decent topographic data for nearly a decade, it's surprising that more quantitative analyses haven't been performed from these data. Most of the emphasis has been on simply determining the drainage densities of the valley network, which has been a contentious issue because software package that extract drainage basin information from digital elevation data must adjust for the fact that valley networks are no longer active, and the present topography has been heavily affected by impact cratering. Mapping valley networks by hand, however, is subjective, and it is a painstaking process to measure morphometric characteristics this way.

It is still a mystery as to why there are so few valley networks systems with smaller order, space-filling tributaries. The lower gravity and variations in the local lithology could mean that a larger contributing area is necessary to initiate incision, or it is possible that the smaller tributaries were buried, but these ideas need to be explored.

While most valley networks date to the early Hesperian, there is evidence for some systems that are much younger. Potentially climatic conditions deteriorated gradually allowing some intermittent episodes of favorable conditions, but it is not clear why younger systems are so unique.

Studying the Mars atmosphere using a SOIR Instrument

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SOIR (Solar Occultation InfraRed spectrometer) is an echelle infrared spectrometer on board the Venus Express orbiter (VEx). SOIR probes the Venus atmosphere by solar occultation, operating between 2.2 and 4.3 microm with a resolution of 0.15 cm-1. This spectral range is suitable for the detection of several key components of planetary atmospheres, including H2O and its isotopologue HDO, CH4 and other trace species. The Acousto-Optics Tunable Filter (AOTF) allows a narrow range of wavelengths to pass, according to the radio frequency applied to the TeO2 crystal; this selects the order. The advantage of the AOTF is that different orders can be observed quickly and easily during one occultation. The SOIR instrument was designed to have a minimum of moving parts, to be light and compact. To obtain a compact optical scheme, a Littrow configuration was implemented in which the usual collimating and imaging lenses are merged into a single off-axis parabolic mirror. The light is diffracted on the echelle grating, where orders overlap and addition occurs, and finally is recorded by the detector. The detector is 320×256 pixels and is cooled to 88 K during an occultation measurement, to maximise the signal to noise ratio.

SOIR on VEx has been in orbit around Venus since April 2006, allowing us to characterise the instrument and study its performance. These data have allowed the engineering team to devise several instrumental improvements. These will be outlined briefly, with regard to the improvement they will offer for the observations. We will focus on the capacity of an improved instrument to perform nadir observations as well as solar occultation measurements. We will show Mars data as could be observed by a SOIR instrument to demonstrate what SOIR would be capable of in Mars orbit.

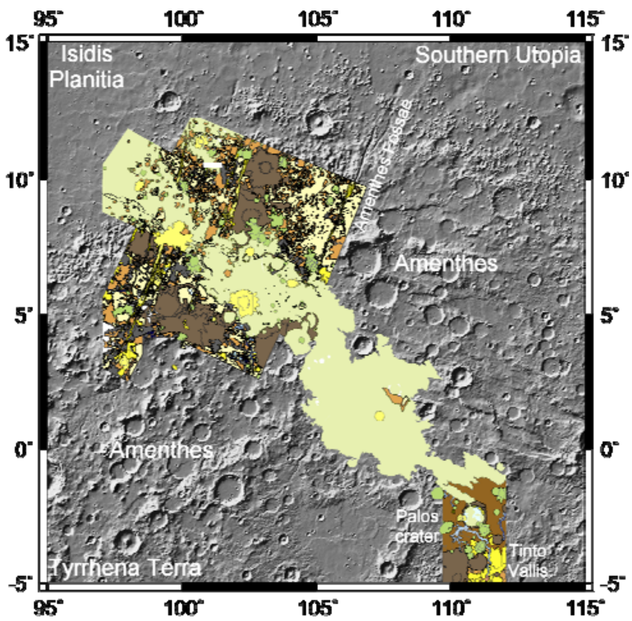
STRATIGRAPHY OF THE AMENTHES REGION, MARS: TIME LIMITS FOR THE FORMATION OF TECTONIC, VOLCANIC AND FLUVIAL LANDFORMS G. Erkeling[1], H. Hiesinger[1], D. Reiss[1], R. Jaumann[2], M. A. Ivanov[3] [1]Institut für Planetologie, Wilhelm-Klemm-Straße 10, 48149 Münster, WWU Münster, Germany, (gino.erkeling@uni-muenster.de / +49-251-8336376) [2]Institute of Planetary Research, DLR, Berlin, Germany [3]Vernadsky Inst. RAS, Moscow, Russia

Introduction: The Amenthes region, located in northern Tyrrhena Terra between 95˚/115˚E and 15˚N/5˚S, has been affected by a large variety of geologic processes. It consists of a broad trough-like topographic depression (Amenthes Planum) that shows evidence for a tectonic origin [1] and represents a transition between the topographically higher northern edge of the volcanic province of Hesperia Planum and the low-lying plains of the Isidis impact basin. The relief of the Amenthes region indicates that the trough connects Hesperia Planum and the Isidis basin and could have served as the main path of distibution for various types of materials from the neighboring cratered terrains and Hesperia Planum to Isidis Planitia [2,3].

We present the results of our morphologic and stratigraphic investigations (Fig.1,2) in the Amenthes region where our observations suggest, that volcanic and possibly water-related processes (including the deposition of ice-saturated materials [3]) appeared either simultaneously or sequentially. Our study of the Amenthes region aims to address the following questions: 1) What are the time constraints for the formation of volcanic and fluvial deposits in the Amenthes region? 2) How do they relate to major episodes of the neighboring volcanism (e.g. Syrtis Major [4]), the geologic history of Isidis [5] and water activity (e.g., Libya Montes [6,7])?

Fig. 1: Regional context of the Amenthes region. Our morphologic map (in progress) is superposed on MOLA shaded relief. Amenthes Planum corresponds to the green unit (AHs).

Data sets and methods: Our morphologic mapping and the crater counts were performed on High Resolution Stereo Camera (HRSC) [8] and Context Camera (CTX) images [9].



Our morphologic mapping builds on the classification of [10]. Absolute model ages for the surfaces were derived from the current Mars cratering chronology model of [11].

Summary: Based on the morphology and our crater counts, we propose that

1) the Amenthes trough and the surrounding highlands were formed in the Noachian and modified by tectonic processes (Amenthes Fossae),

2) the formation of the Amenthes Fossae occurred before ~3.6 Ga,

3) Tinto Vallis is formed later than ~3.6 Ga by Hesperia Planum lava flows

4) the surfaces of Amenthes Planum were formed between ~3.3 and ~2.7 Ga, are most likely of volcanic origin and are superposed on Amenthes Fossae as well as fluvial deposits from the highlands south of the trough,

5) the channels identified in the trough are formed between ~3.0 and ~2.7 Ga and indicate Late Hesperian to Early Amazonian fluvial activity that postdates the formation of the Amenthes volcanic plains.

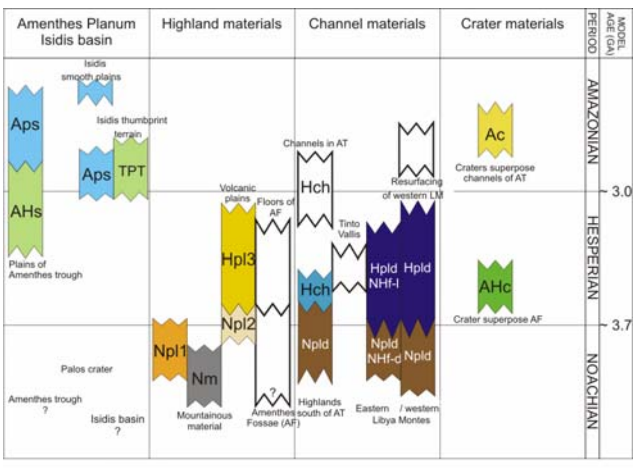


Fig. 2: Stratigraphy of the Amenthes region and time constraints for the formation of surfaces in the Libya Montes [6,7] and the Isidis basin [12].

Acknowledgements: This research has been supported by the Helmholtz Association through the research alliance "Planetary Evolution and Life".

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Uncertainties in the Martian airglow models, and their influences on the precision of future mesosphere-upper atmosphere retrieval systems

Gronoff, Mertens, Simon, Lilensten

The Martian upper atmosphere has huge seasonal variations. In a recent paper, Forget et al. 2009 has shown that the density above 100 km could undergo variation up to twenty times. To understand these variations, and therefore be able to model correctly the atmosphere of Mars we must be able to retrieve precisely the composition, the density, and the temperature of the mesosphere-upper atmosphere of the planet.
To perform that work, the best solution should be a NASA (Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics) TIMED-like mission to Mars. To develop the retrieval system of such a satellite, and its selection of spectroscopic channels, we must understand the influence of model uncertainties on the inverse problem. In this work, we show the advance of our modeling, using a new generation of Trans* models to compute the line intensities, and their uncertainties. Moreover we show the need for some improvements in the existing cross sections measurements in laboratory, and the need for some molecular UV band databases.

Modelling Mars Chemistry and Meteorology with the GEM-Mars GCM

Lori Neary

The GEM-Mars model is a three-dimensional global climate model (GCM) for the Martian atmosphere. The dynamical core is based on the GEM (Global Environmental Multiscale) operational weather forecast model for Canada (Cote et al., 1998). The model has been adapted for Mars (Moudden and McConnell, 2005) and includes a water cycle with a 14-layer regolith slab and bulk ice clouds (Akingunola, 2008). Heating includes absorption and scattering of radiation by seasonally and latitudinally varying dust in the atmosphere. Carbon dioxide condensation and sublimation are also included. The current chemical scheme is comprised of 13 species, 15 photolysis reactions and 31 chemical reactions (Garcia-Munoz et al., 2005) as opposed to the chemical scheme of Moudden and McConnell (2007).

Results will be shown from simulations at a horizontal resolution of 4x4 degrees with 102 vertical levels up to approximately 140 km. Model results will be compared to selected observational datasets for meteorology and chemistry.

Modeling and optimization of loaded electrical antennas dedicated to deep Martian subsurface sounding by a bistatic HF GPR operating from the surface

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In the frame of the ESA's ExoMars mission, the EISS ground penetrating radar (GPR) has been designed and developed by LATMOS to perform deep soundings of the Martian sub-surface from the surface. EISS was designed to take advantage of the potential for bistatic radar investigations of the Martian subsurface between the fixed station (Lander) and the mobile rover. Using this approach, EISS can be used to characterize the 3-D structure and stratigraphy of the subsurface at depths ranging from 100 m to a few kilometers out to a 1-km radius around the Lander.

EISS is an impulse radar operating at HF frequencies (~ 2-4MHz). EISS can operate in four modes, including: (1) surface impedance, (2 & 3) subsurface monostatic and bistatic, and (4) passive (i.e., atmospheric monitoring) mode. EISS makes use of an electrical dipole antenna made of two 35m resistively loaded monopoles, to transmit (and also receive in mono-static mode) the signal. The resistive profile of each monopole is carefully optimized to transmit the pulse without noticeable distortion and avoid ringing. The two monopoles are deployed on the surface in nearly opposite directions, at an angle which, when EISS is used in bistatic mode, ensures good volume coverage around the Lander. Electromagnetic simulations have been used to optimize the value of this angle based on its impact on the radiation pattern of the two monopoles.

EISS's most innovative capability is its potential for bistatic operation, made possible by the placement of a small magnetic sensor on the ExoMars Rover which can be rotated to measure all 3 components of the propagation vector of the reflected signal transmitted by EISS, whatever the direction and orientation of the Rover. EISS's bi-static performance has been explored using both FDTD simulations and analytical models -- investigations that have yielded important results regarding antenna optimization, the impact of the angle between the two deployed monopoles, and the coupling between the antennas and ground. Finally, a method to retrieve the direction of arrival for each detected echo will be presented that allows the 3-D location and orientation of buried reflecting interfaces.

Nevertheless EISS can also take advantage of the existence of a single stationary platform and perform monostatic soundings of the terrestrial subsurface, estimate the near subsurface properties. Potential applications on Earth are, for example, the search for deep liquid water reservoirs in arid environments or the mapping the bed-rock buried under thick layers of ice. After the last redesign of the original ESA's 2016 ExoMars mission, the whole lander payload was removed; EISS (in its monostatic version) will be also proposed for the ESA EDL (Entry, Descent and Landing) demonstrator (2016) which will maybe provide the next future opportunity for EISS to fly to Mars.

Automated methods for the identification and characterization of Martian surface features, by Saraiva J.

Considering the high volumes of data (namely visual) provided by the current lunar and planetary missions, it is readily apparent that there is a need for automated methods capable of detecting and to some extent characterizing any surface features present on the images acquired. Even if not absolutely accurate, such methods can be used as important tools for the analysis of features that are relevant for the improvement of our understanding of the geological evolution of planets. They can save a vast amount of time, permit the fast collection of data on large numbers of individual features and the analysis of their relations, whenever desired. Furthermore, they can be subject to improvements that will make them more powerful, saving human operators from the tedious task of counting and measuring by hand and freeing them to do the interpretative work needed to transform data into information.

The work developed has focused on the creation of methods for the automated detection and characterization of a number of features that commonly occur on the surface of Mars, namely impact craters, polygonal terrains and dune fields.

In the case of craters, several different approaches were tried, using techniques from the fields of Image Analysis and Pattern Recognition. The aim was to develop an algorithm that could accurately determine the location and dimensions of impact craters on images of Mars, whatever the spatial resolution of the image. It is easy to recognize that no such method can be perfect, but the results obtained so far point the way for improvements and the establishment of this approach as a powerful tool for a first analysis of the distribution (density and pattern) of impact craters on new areas of planetary surfaces.

The research into polygonal patterns was focused on the mapping of the networks and the collection of geometric and topological parameters that can characterize the networks and allow for the recognition of similarities and differences between them. This can in turn be related to their origin and evolution. The method is based on the application of the watershed transform, and permits the quick processing of large images with many thousands of individual polygons, thus acquiring a volume of data that would be virtually impossible for a human operator to collect.

Dunes are also a common feature on the surface of Mars, and provide another adequate target for application of automated methods for their detection, mapping and characterization. Though this is still in a preliminary phase, the goal is to identify the area covered by dunes in an image, and later to classify them in one of the already defined types.

ALTERATION MINERALS IN IMPACT-GENERATED HYDROTHERMAL SYSTEMS. WHICH, WHERE, WHEN – AND HOW IMPORTANT?

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Introduction: Independent of surface conditions, impact cratering can establish hydrothermal systems even where water may otherwise be completely locked up in a frozen state or in minerals; the energy of the impact heats the target unlocking bound water as a consequence [1,2]. Evidence for impact-generated hydrothermal systems has been found in several terrestrial craters [e.g., 3–6]; and thermal models of those systems on Earth [e.g., 7, 8] and Mars [1, 9] indicate that they can be long-lived. Therefore, mineralogical alteration will likely result from the hot water circulating through the highly fractured target rock.

Which? Thermochemical modeling results of alteration phases allow important insights for geologic exploration and provide constraints on formation conditions of the new minerals [10]. Dependent on water to rock ratio (W/R) three types of alteration can be distinguished: "Metamorphic", if the water to rock ratio (W/R) is low, "hydrothermal" at intermediate W/R and "leaching" at very high W/R. If the target rock is a lherzolithic shergottite [10] serpentine, chlorite and amphibole are the main constituents at low W/R. At intermediate W/R a nontronite-hematite assemblage dominates; at high W/R the precipitate is hematite accompanied by some pyrite and diaspore. If the target rock contains more feldspar, the resulting mineral assemblage will have secondary feldspar as well as zeolithes, but no serpentine [11]. If the altered rock is a dunite, a serpentine-magnetite assemblage results [11]. High amounts of CO_2 lead to carbonate formation at the expense of hydrous silicates [12]. Higher S contents, as found in Martian soil [13], lead to the formation of pyrite at the expense of hematite and iron bearing hydrous silicates and to the formation of anhydrite instead of Ca-bearing silicates [14].

Where? The W/R dependence causes different assemblages to occur in specific locations in the crater: The rock beneath the crater is intensely fractured. Fracturing is most prominent in and around the central peak and in the inner crater wall with the highest water flow occurring there [1]. Water flow outside the fractures depends on rock permeability with highly permeable rocks being altered more intensely [15]. Because permeability shows high spatial variability, alteration may vary on a small scale. The initial temperature distribution and the inwards movement of the temperature zones with time [1] make the innermost parts of a complex crater the most likely places to find the high temperature alteration and the most heavily altered rocks.

When? Looking at the Martian surface, it becomes clear that the Noachian terrains are disrupted by frequent impacts [16–18] that may have created thousands of hydrothermal systems. Moreover, evidence for liquid water activity, including morphological features (e.g., rampart craters [19]) and hydrous silicates such as nontronite [e.g., 20], are found in the Noachian and fade out or are absent in the Hesperian and thereafter.

How important? With lifetimes up to several Ma for basin-sized events [1], impact-generated hydrothermal systems provided frequent, long-lived, zoned, steadily cooling, hot-water environments that were largely independent of surface conditions. The systems are capable of providing a wide variety of alteration minerals, dissolving the target rock, changing its chemical and physical properties and liberating ions into the aqueous phase. The sum of those processes can supply nutrients and energy for life, if it ever existed on Mars. Moreover, clay minerals as seen in the models and in Martian craters, are discussed as one possible step from organic chemistry to biology [21]. Recently, orbiter missions found evidence for clay minerals and zeolites in the inner crater walls and central uplifts of several Martian craters on Noachian terrain [22–24]. With the intense cratering during the Noachian [16–19] this can be taken as evidence for frequent, planet wide, impact-generated hydrothermal alteration, with the same processes potentially happening on the contemporary Earth.

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Chemical Pathway Analysis of the lower Martian Atmosphere

J.W. Stock

The atmospheric composition of terrestrial planets is critically controlled by trace species, which operate in catalytic cycles (e.g. Bates and Nicolet, 1950; Crutzen, 1970). These cycles can provide more efficient routes for the production or consumption of highly abundant species (e.g. CO2 on Mars (e.g. McElroy and Donahue, 1972; Parkinson and Hunten, 1972)). Identifying such cycles is in general a challenging task.

In order to investigate such chemical processes in the lower Martian atmosphere, we introduce a new analysis tool (Pathway Analysis Program - PAP), which was originally developed by Lehmann (2004) and applied to determine ozone and methane cycles in Earth's stratosphere. The implemented algorithm determines and quantifies all significant pathways by treating each species one after another as a branching point. Pathways are formed by connecting shorter pathways producing those branching point species with pathways consuming it. Rates are assigned to the pathways proportional to the branching probabilities. Hence operating catalytic cycles can be identified automatically.

In this contribution, we will outline the methodology of the analysis program. By applying PAP to the CO2 dominated atmospheric chemistry of Mars, important cycles affecting the chemical composition of the lower Martian atmosphere can be identified and discussed.

Ground-based monitoring of H_2O and H_2O_2 on Mars from infrared imaging spectroscopy

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Since 2001, we have developed a monitoring program for mapping both H_2O and H_2O_2 on Mars using the TEXES imaging spectrometer at IRTF in the 8-micron thermal range. This program has led to the first infrared detection and mapping of H_2O_2 on Mars. A strong seasonal variability is observed, with mixing ratios ranging from 40 ppb (Ls = 206°) to 10 ppb or less (Ls = 80°, 110°, 352°). The observed variability supports the heterogeneous chemistry model developed by Lefevre et al. (2008). TEXES water vapor maps are in good agreement with the GCM predictions at some seasons (Ls = 80°, 110°, 206°) but show significant discrepancies at other occasions (Ls = 335°). These results will be discussed and future plans will be described.

Geophysical Research Abstracts
Vol. 12, EGU2010-13725-1, 2010
EGU General Assembly 2010

Possible seasonal activity of gullies on an sand dune (Russell crater, Mars)

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Recent work has shown that gullies are among the most youthful features on Mars (Malin and Edgett, 2000; Costard et al., 2002; Reiss and Jaumann, 2003, Malin et al., 2006). Here we show that the gullies located on the Russell Crater dune are not only extremely youthful but also seem to be still actives. Various geomorphological features consistent with a seasonal activity suggest reactivated flows over the last three terrestrial years.
Moreover, using an assemblage of 26 HiRISE images over a 31 month period (November 2006-May 2009) and superposed with MOLA tracks, we performed a quantitative analysis of the sinuosity and branching of the gullies on the shallow slope of the Russell crater. These geomorphologicals features suggest that debris flow have been formed by a fluid flow. As pure water generally is not thought to be stable on the surface of Mars under current conditions, these gullies could be indicative of a highly localized zone of meta-stability heretofore unidentified in the literature or by a highly mineralized water. Equally, the occurrence of the gullies on a dune may point to a near-surface source, i.e. near surface permafrost (Vedie et al. 2008), that could have been emplaced under conditions associated with late Amazonian obliquity excursions (Costard et al., 2002). Nevertheless, the precise composition of the fluid (CO_2, mineralized water,...) is still unknown.

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CRISM STUDIES OF INTERIOR LAYERED DEPOSITS IN ARABIA TERRA, MARS.

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Introduction: Interior Layered Deposits (ILD) have the potential to reveal a history of climate variation on Mars. We are studying them by characterizing cyclicity and making comparisons to the North Polar Layer Deposits (NPLD) and between different ILD e.g. Arabia Terra mounds and Valles Marineris. Here we report the results of a study using CRISM to assess the role of water in their formation and compare between different deposits.

ILDs are mainly found in equatorial regions, usually in topographic lows, such as large impact craters (Becquerel Crater 22^0N, 353^0E has one of the best sedimentary sequences within the Arabia Terra region) or Valles Marineris. Layering is visible on the metre scale as recent HiRISE results demonstrate and partial erosion reveals intricate patterns between geological layering and the topography.

The processes which lead to ILD are as yet unknown, with various formation models proposed; including a lacustrine event, wind-blown sediments or a similar mechanism to the NPLD [1, 2, 3]. It is the regularity of the light-dark layer alteration observed in examples of ILD, such as Becquerel sediments, and marked similarity to the current NPLD which suggests a climatic control dominated by orbital forcing [2, 3].

CRISM can help determine the likelihood of such a model and assess the role of water by looking for clay and other water bearing minerals on Mars. One of the questions we seek to address is were hydrated minerals within ILD deposited at the same time as the layers or as a result of later brine activity?

Data: CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) is a visible-near infrared (VNIR) and infrared (IR) imaging spectrometer on the Mars Reconnaissance Orbiter (MRO) spacecraft [4]. In targeted mode, CRISM can map a region of interest at full spatial and spectral resolution (15-19 m/pixel, 362-3920 nm and at 6.55 nm/channel over 544 channels).

The focus of the study was on 6 ILD sediment mounds within craters of the Arabia Terra region (Fig. 1a) which were compared as a group to 4 NPLD and a comparable group of 6 ILDs found within Valles Marineris (Fig. 1b) .

Method: Data processing has been conducted using the freely available CRISM Analysis Tool [5] in conjunction with ENVI. The spectral data has been processed to account for all instrumental effects and reduced to radiance from which I/F are calculated. This data is corrected for photometric and atmospheric effects and CRISM Clean is applied to filter the data and reduce the effect of noise before the data is map-projected.

Data Analysis. The spectral trends within the chosen CRISM scenes were studied by extracting spectra, averaged over ~100 pixels, from regions of interest selected through the use of mineral indicator maps. The 1.9 µm absorption band was selected for comparison across both the NPLDs, ILDs and spectral signatures of smectite detected in Nili Fossae and gypsum in the North polar dunes, to assess the strength of the hydration band in Fig.1.

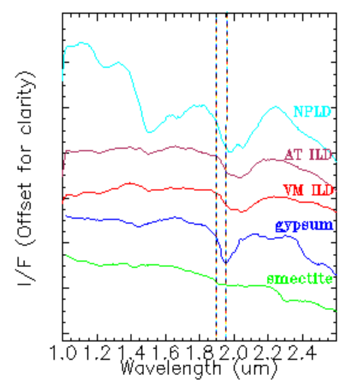

Fig. 1 – Comparison of hydrated 1.9 & 1.94µm absorption bands in extracted spectra of ILDs in Arabia Terra (AT ILD, 3245), Valles Marineris (VM ILD, 9A1B), dust-rich layer NPLD (C299), gypsum in polar dunes (285F, -119.5^{0}E, 80.1^{0}N) & smectite in Nili Fossae (64D9, 74.2^{0}E, 21.1^{0}N).

Discussion: The ILD spectral signatures studied so far show a ferric oxide dust coating, indicated by the iron mineralogy parameter maps, for Becquerel in particular. However small absorption features at ~1.9 µm on NPLD and ILD surfaces suggest the presence of hydrated minerals. Hydrated sulphate e.g. gypsum and kieserite, has been identified in some ILD or Light Tone Layered Deposits in Valles Marineris [6, 7]. Our results to date suggest that the ILD within Arabia Terra, Valles Marineris and the NPLD have locally variable amounts of hydrated minerals such as sulphate. The ILD across Mars may share a common origin analogous to NPLD but at times of high obliquity. The variable concentrations of sulphate and other hydrated minerals being identified in ILD by CRISM and OMEGA may be due to localized low temperature brine activity after the layers were deposited.

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Determination of the first level image processing of the Chemcam RMI Instrument for the Mars Science Laboratory (MSL) Rover.

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Introduction. ChemCam is one of the 10 instrument suites on the Mars Science Laboratory, a Martian rover being built by Jet Propulsion Laboratory (JPL), for the next NASA mission to Mars (MSL 2011).

Figure 1 : ChemCam Mast Unit

ChemCam is an instrument package consisting of two remote sensing instruments: a Laser-Induced Breakdown Spectrometer (LIBS) and a Remote Micro-Imager (RMI). LIBS provides elemental compositions of rocks and soils, while the RMI places the LIBS analyses in their geomorphologic context.

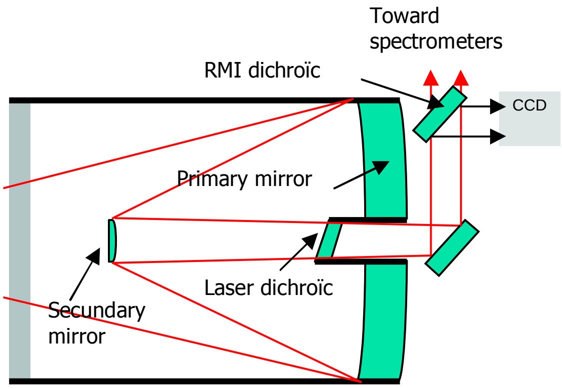

Figure 2 : light path in the telescope

Light from the scene enters the telescope and is focused to the CCD matrix thanks to a set of lenses and mirrors (fig.2). Two dichroïc dioptres have been used to separate the various optical paths. The Laser dichroïc reflects light around 1067 nm (LIBS laser beam), while other rays (visible and UV light emitted by the plasma) pass through it with no attenuation. The RMI dichroïc reflects only 20% of the visible radiation.

The RMI camera, previously developed for Roseta mission, has been provided by the IAS. It is a precise imager (78-105µrad for a field of view of 22mrad), and will be used as a microscope to see tiny details such as LIBS impacts, as well as to have a larger view of the rocks.

But RMI pictures are marred with defects, some of them due to the camera technology, and others to the instrument optics. Among all these picture deteriorations, some are negligible, while others are penalizing. After a brief description of these defects, this abstract describes how we used data from experimentation to build overall algorithms which will be used by JPL to correct images.

Idiosyncrasies. Six main defects are studied on our system. For each of them, we explained the physical phenomenon, we quantified its impact on the total image and we determined the different parameters in function of which its appearance evolves. The CCD technology, and the particular frame transfer CCD used creates a first kind of defects.

- Raw images present an offset called bias corresponding to a false zero of each pixels. It depends mostly on temperature.
- Obscurity current due to thermal signal increases pixels value. To isolate the optical flux, we must subtract this signal depending on temperature and integration time.
- A pixel answers a value proportional to the luminosity received on a particular range. Above a maximum value, we reach a non linear zone, and then saturation. Moreover, these characteristics depend on each pixel.
- The data transfer technology imposes a charges displacement on the matrix. As there is no shutter on the instrument, this displacement creates the smearing, white drag below luminous spots (fig.3).

The optical path followed by the beam in the instrument implicates variations in the final picture.

- The transmittance of the series of mirrors and lenses crossed by light rays evolves depending on the distance with the centre of the field of view. So a flat-field does not match with a constant value on the matrix : the image appearance depends strongly on the distance of the target. This succession of lenses and mirrors creates also distortion.
- An intrusive reflection (called the ghost) on the last dioptre before the CCD duplicates the scene on the final image, and must be deleted not to hide the net area.

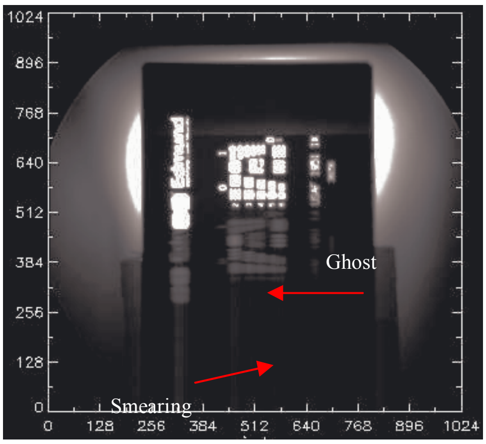

Figure 3 : Picture of the USAF target. Light intensity multiplied by 5 to show ghost and smearing.

Data processing. Some of the defects described do not need any correction. The distortion has been evaluated at less than 0.2%, the CCD already has an anti-blooming, the direct light received by the CCD can not be evaluated, and thus, can not be corrected on in-flight pictures.

To correct some other defects, we do not need further information than what is contained in the picture. The smearing and the ghost corresponds to some light received by the sensor, at least temporarily and the luminous intensity is related to the intensity of another point in the matrix. These information, added to picture information such as integration time, is enough to calculate the intrusive intensity pixel by pixel. The correction depends only on the luminous intensity of the picture itself, and a simple algorithm allows to correct it.

To compensate the last defects (dark and flat), a data bank is required. Indeed, they depend either on the distance between the target and the instrument, or on temperature and integration time. Anyway, as only a finite number of points is available from measurements, we have to interpolate these points to be able, once on flight, to rebuild necessary darks and flats whatever the distance and temperature are.

Four deformations will be mainly corrected in our images. But the treatments order is really important : for instance, ghost creates smearing, so we must remove smearing before ghost. In fact, treatments must be applied in the exact reverse order from the creation of the defects in the picture taking (fig.4).

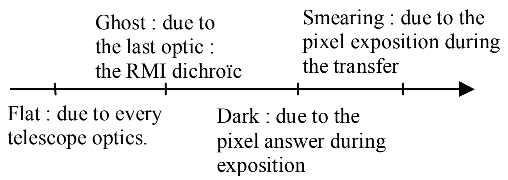

Figure 4 : Apparition of the defects in the image creation process.

The ghost and the flat are specific to our instrument, while the others are generic.

Ghost. At the rear of the telescope, the incident ray is split by a separator dioptre: a fraction of light goes toward the spectrometers, and another arrives on the RMI CCD (fig.5). In spite of the optical surface coating of the dioptre, a fragment of the ray is reflected by the second face of the dioptre, and creates an intrusive reflection called “ghost”. We worked on particular pictures to determine the position of this ghost, and the ratio between its intensity and the luminous intensity of the pixel located 190 lines above. These pictures are RMI of a target called ‘USAF’ and allowed us to build the algorithms necessary to remove the ghost.

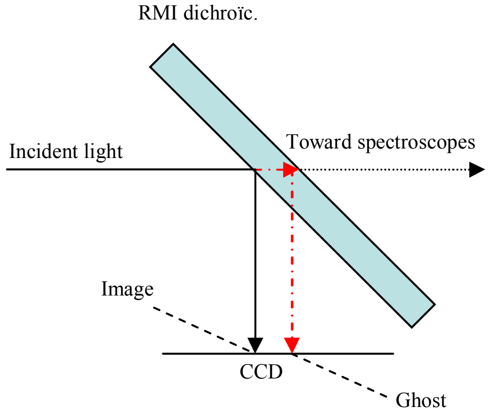

Figure 5 : light rays on the RMI dichroïc

Flat. The flat is the RMI picture of an uniform lighting (fig.6). The rims of the picture received a lower luminous intensity than its centre. It characterizes the optical system transmission on all the field of view. The treatment aims to raise the pixel values on the rims so that the average by zone is a constant on all the matrix. Construction of these Flat pictures is experimental. With an integrating sphere, an uniform light source, we took pictures for several distances. After basic correction (removal of the thermal and electronic noises, correction of smearing and ghost), we compared the different pictures and showed that Flats were really dependent on distance. But once on flight, we will not be able to take anymore flat, and, to process a picture, we will need the flat at the same distance : we must find a solution to build a Flat from a databank filled before launching. Finally, we showed that treating a picture by the linear interpolation between the two closest flats in the database gave much better results than treating it by the closest flat. The standard deviation of the residual error after applying this method (interpolation) was 0.5% compared to 2% with the first treatment (closest flat), and 40% before treatment.

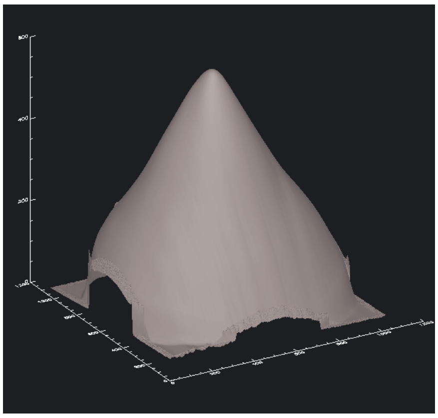

Figure 6 : Flat in 3 Dimensions

Future work. Today, we have already computed the different parameters needed to correct RMI pictures, working on specific targets. The next step will be to process pictures of rocks and stones to validate the treatments.

References. [1] Maurice et al. (2009), *Characterization of Chemcam (MSL) Imaging Capability*.

Poster by Achim Morschhauser

1) Introduction

The composition and evolution of the Martian atmosphere is an important aspect of planetary habitability and sensitively influences the climatic conditions on the planetary surface. Atmospheric evolution is driven by loss processes and volcanic outgassing, which in turn is linked to the production of partial melt in the Martian mantle. Therefore, the atmospheric evolution of Mars is directly coupled to the planet's thermal evolution.
New data concerning the enrichment and concentration of radioactive elements in the Martian crust has been gathered using the gamma-ray spectrometer onboard the Mars Odyssey spacecraft and radioactive elements have been found to be more strongly enriched in the Martian crust than previously assumed. Furthermore, laboratory experiments on the creep behaviour of olivine indicate that the relatively higher iron content of the Martian mantle with respect to Earth's mantle reduces mantle viscosity on Mars by approximately one order of magnitude.
Both of these new findings promote crustal recycling in models of the Martian thermal evolution and the Martian mantle will be replenished with crustal material. This in turn enhances crustal production rates and reinforces volcanic outgassing, potentially having an important influence on the evolution of the Martian atmosphere.
Therefore, we have recalculated the Martian thermal and chemical evolution taking crustal production and outgassing into account. The evolution of the Martian atmosphere is calculated using the obtained volcanic outgassing rates and neglecting all erosive loss processes except strong hydrodynamic escape in the early Noachian. Finally, we address the question of whether a CO2 dominated greenhouse effect would allow for episodes of stable liquid surface water on Mars in the late Noachian and Early Hesperian periods.

2) Methods

In this study we use one-dimensional thermo-chemical evolution models to study atmospheric outgassing on Mars. The model solves the energy balance equations in the stagnant lid, mantle and core and treats mantle energy transport using scaling laws for stagnant lid convection. Crustal production rates are calculated by comparing the mantle temperature profile to the peridotite solidus and liquidus. Crustal recycling is treated by reducing crustal thickness and remixing crustal material into the mantle whenever the stagnant lid becomes thinner than the crust, a process which is facilitated by the basalt-eclogite phase transition occurring at around 1 GPa. Once the crustal production rate has been computed, the amount of outgassed CO2 is obtained by multiplying the mass of extracted melt with the melt CO2 concentration at every time-step and integrating over the entire evolution. The concentration of CO2 in the melt depends on the thermochemical conditions in the melt region, i.e., temperature, pressure and oxygen fugacity. To compute melt concentrations of CO2 we use the model developed by Holloway et al., which was adapted to Mars by Hirschmann and Withers. Moreover, we assume that intrusive volcanism does not contribute to atmospheric outgassing and set the fraction of extrusive volcanism to 1/7.

3) Results

Crustal thickness was calculated for models having mantle reference viscosities ranging from 1E18 Pas to 1E21 Pas, where viscosities between 1E18 and 1E19 Pas correspond to a wet mantle rheology. Initial mantle temperatures were varied from 1700 K to 2000 K. Wet mantle rheologies and high initial mantle temperatures were found to promote crustal recycling. Higher initial mantle temperatures favor higher crustal production rates in the beginning of the evolution, but more crust is recycled back into the mantle for these models. Crustal recycling therefore constrains today's crustal thickness to a value independent of the initial mantle temperature and today's crustal thickness is about 80 km for reference viscosities of 1E18 Pas and 105 km for viscosities of 1E19 Pas. For dry mantle rheologies this value ranges from 80-110 km depending on the initial mantle temperature.

Crustal erosion also impacts the evolution of the atmospheric pressure as it promotes strong volcanic outgassing after the formation of the earliest crust. Atmospheric pressures were calculated for the late Noachian (3.8 Gyr ago) and early Hesperian (3.2 Gyr ago) periods, a time where the presence of fluvial features on the surface indicates that liquid water was stable in the Martian environment. Hydrodynamic escape during the early evolution was assumed to have stripped Mars from its entire early atmosphere. After the loss of the early atmosphere, models with a wet mantle rheology and high oxygen fugacity outgas more than 500 mbar of CO_2 until the late Noachian. For a dry mantle rheology, it is hardly possible to outgas enough CO_2 even until the early Hesperian unless special conditions are assumed.

4) Discussion

New spacecraft and lab data indicate that crustal recycling could have been an important process in the volcanic outgassing history of Mars. Particularly models with a wet mantle rheology facilitate crustal recycling, leading to a late peak of volcanic outgassing after 500 Myr. For this reason, these models best explain surface pressures which could allow for liquid water in the LN/EH periods. Furthermore, models using a wet mantle rheology generally produce the bulk of the crust in the early Noachian period, which is consistent with isotopic data. Whether these models can also account for the observed late Amazonian volcanism remains to be investigated.