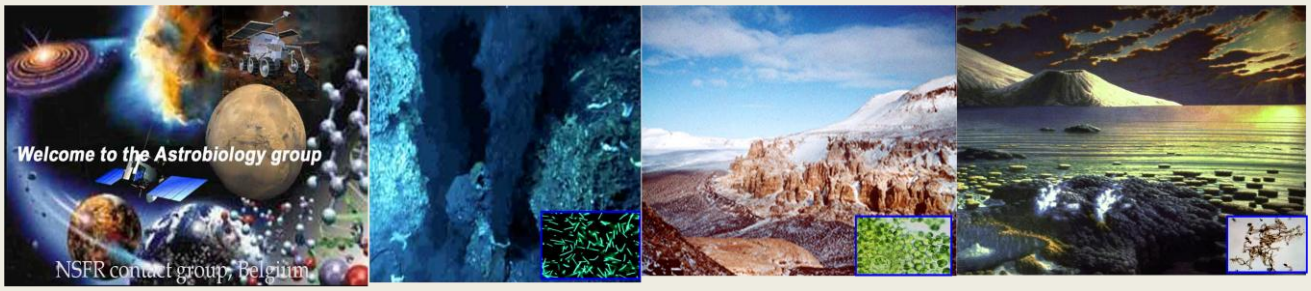

The FNRS/NFSR "ASTROBIOLOGY: FROM STARS AND PLANETS TO EXTREME LIFE" contact group
invites you to participate to its annual workshop
following the EU COST CM805 the chemical cosmos meeting "carbon in the solar system" (http://www.busoc.eu/cost/programme.php)

December 8th 2010 (10:30-16:00)
"Salle Méridienne"of the Royal Observatory of Belgium
rue circulaire/Ringlaan, 3, Brussels

Invited Speakers

Dr Robin Wordsworth, Université Paris 6
"Habitability on the outer edge: Climate studies of Noachian Mars and GJ581d"

Dr Augustin Chicarro, ESA Solar System Missions Division
"The European robotic exploration of the planet Mars"

Dr Emmanuelle Gérard, Institut de Physique du Globe de Paris
« Three dimensional raman/molecular fluorescence microimaging of modern stromatolites "

Organization: V. Dehant (ORB) & E. Javaux (ULg)
with the support of the FNRS, ORB, SRSL
Registration (free lunch) & Abstract deadline: December 3rd
(contact: ej.javaux@ulg.ac.be); Details at http://astrobio.oma.be/
Access: http://www.astro.oma.be/EN/info/praktisch.php

ORB – KSB

FNRS

SRSL Société Royale des Sciences de Liège

Université de Liège

Program

	Speakers	affiliation	
10h30-10h40	**E Javaux-V Dehant**	FNRS Contact group	**Welcome coffee**
10h40-11h20	**R Wordsworth (Invited speaker)**	Univ Paris 6	**Habitability on the outer edge: Climate studies of Noachian Mars and GJ581d**
11h20-12h00	**A Chicarro (Invited speaker)**	ESA, Solar System Missions Division	**The European robotic exploration of the planet Mars**
12h00-12h20	**V Dehant**	ORB	**Mars Geophysical Observatories (Mars-GeO) are in line with habitability studies**
12h20-14h00	**LUNCH**		
14h00-14h40	**E Gérard (Invited speaker)**	IPGP Paris	**Three dimensional raman/molecular fluorescence microimaging of modern stromatolites**
14h40-15h00	**A Wilmotte**	ULg	**Cyanobacterial diversity close to the South Pole (Antarctica)**
15h00-15h20	**E Javaux**	ULg	**Traces of early life in 3.2 Ga old mud: an analog for the search for life on Mars**
15h20-15h40	**C Muller**	BUSOC	**History of spontaneous generation and extraterrestrial life in Belgium from van Helmont to Minckelers and Quetelet and its end in Pasteurian times**
15h40-16h00	**General discussion**		

Abstracts

(by order of presentation)

HABITABILITY ON THE OUTER EDGE: CLIMATE STUDIES OF NOACHIAN MARS AND GJ581D

ROBIN WORDSWORTH

Université Paris 6:

We describe modelling of planets on the outer edge of the habitability zone. In the first part of the talk, three dimensional simulations of Mars up to 4 GYa are presented, and the plausibility of a warm, wet scenario for Early Mars is discussed. Next, we present results for the exoplanet Gliese 581d. We show that the planet will support liquid water for a range of atmospheric scenarios even when problems like spin-orbit resonance are taken into account, and we discuss some of the observational criteria that will be necessary to distinguish these scenarios from other possibilities.

THE EUROPEAN ROBOTIC EXPLORATION OF THE PLANET MARS

AUGUSTIN F. CHICARRO

European Space Agency, Solar System Missions Division, ESTEC/Code SRE-SM, Postbus 299, 2200 AG Noordwijk, The Netherlands (agustin.chicarro@esa.int).

The ESA Mars Express mission was launched in June 2003 and has been orbiting Mars for over six years providing data with an unprecedented spatial and spectral resolution on the surface, subsurface, atmosphere and ionosphere of the red planet. The main theme of the mission is the search for water in its various states everywhere on the planet by all instruments using different techniques. A summary of scientific results is given below.

The High-Resolution Stereo Colour Imager (HRSC) has shown breathtaking views of the planet, pointing to very young ages for both glacial and volcanic processes, from hundreds of thousands to a few million years old, respectively. The IR Mineralogical Mapping Spectrometer (OMEGA) has provided unprecedented maps of H_2O ice and CO_2 ice in the polar regions, and determined that the alteration products (phyllosilicates) in the early history

of Mars correspond to abundant liquid water, while the post-Noachian products (sulfates and iron oxides) suggest a colder, drier planet with only episodic water on the surface. The Planetary Fourier Spectrometer (PFS) has confirmed the presence of methane (also seen in ground-based observations), which would indicate current volcanic activity and/or biological processes. The UV and IR Atmospheric Spectrometer (SPICAM) has provided the first complete vertical profile of CO_2 density and temperature, and has discovered the existence of nightglow, as well as that of auroras over mid-latitude regions with paleomagnetic signatures and very high-altitude CO_2 clouds. The Energetic Neutral Atoms Analyser (ASPERA) has identified solar wind scavenging of the upper atmosphere down to 270 km altitude as one of the main culprits of atmospheric degassing and determine the current rate of atmospheric escape. The Radio Science Experiment (MaRS) has studied the surface roughness by pointing the spacecraft high-gain antenna to the Martian surface. Also, the martian interior has been probed by studying the gravity anomalies affecting the orbit, and a transient ionospheric layer due to meteors burning in the atmosphere, was identified by MaRS. Finally, results of the ionospheric and subsurface sounding radar (MARSIS) indicate strong echoes coming from the surface and the subsurface allowing to identify buried tectonic structures, as well as layers of water-ice and the very fine structure of the polar caps. Also, probing of the ionosphere reveals a variety of echoes originating in areas of crustal remnant magnetism. Mars Express is flying at the closest distance ever of Phobos (less than 100 km), allowing to determine the mass of Phobos with great accuracy, to sound its interior with a radar for the first time, to obtain the sharpest images ever, to observe the satellite in the visible, UV and IR, and to monitor the solar wind interaction with its surface.

Mars Express will be followed by ESA's new Exploration Programme, starting in 2016 with an Orbiter focusing on atmospheric trace gases and in particular methane. The ExoMars rover will follow in 2018 to perform geochemical and exobiological measurements on the surface and the subsurface. Later, potential missions may include a Network of 3-6 surface stations (possibly together with an orbiter), in order to investigate the interior of the planet, its atmospheric dynamics and the geology of each landing site. All these Mars Exploration missions will be carried out jointly with NASA.

Such network-orbiter combination represents a unique tool to perform new investigations of Mars, which could not be addressed by other means. In particular, i) the internal geophysical aspects concern the structure and dynamics of the interior of Mars including the state of the core and composition of the mantle; the fine structure of the crust including its paleomagnetic anomalies; the rotational parameters (axis tilt, precession,

nutation, etc) that define both the state of the interior and the climate evolution; ii) the atmospheric physics aspects concern the general circulation and its forcing factors; the time variability cycles of the transport of volatiles, water and dust; surface-atmosphere interactions and overall meteorology and climate; iii) the geology of each landing site concerns the full characterization of the surrounding area including petrological rock types, chemical and mineralogical sample analysis, erosion, oxidation and weathering processes to infer the geological history of the region, as well as the astrobiological potential of each site. To complement the science gained from the Martian surface, investigations need to be carried out from orbit in a coordinated manner, such as i) global atmospheric mapping to study weather patterns, opacity and chemical composition; ii) a detailed map of the crustal magnetic anomalies from lower orbit (150 km); iii) study of these magnetic anomalies need to be studied in light of the magnetic field induced by the solar wind interaction with the upper atmosphere of the planet. The Network Mission concept is based on the fact that some important science goals on any given terrestrial planet can only be achieved with simultaneous measurements from a number of landers located on the surface of the planet (primarily internal geophysics, geodesy and meteorology) coupled to an orbiter.

The long-term goal of Mars robotic exploration in Europe remains the return of rock and soil samples from the Martian surface before Humans go to Mars. For further details on Mars Express science results: **http://sci.esa.int/marsexpress/**

MARS GEOPHYSICAL OBSERVATORIES (MARS-GEO) ARE IN LINE WITH HABITABILITY STUDIES.

VERONIQUE DEHANT & THE MARSGEO TEAM.
Royal Observatory of Belgium

A vision on future geophysics missions to Mars MarsGeO (Mars Geophysical Observatories) will be presented with particular focus on furthering our understanding of the interior, rotation and orientation of this terrestrial planet. We explain how geophysical instruments (seismometer, heat flow, geodesic, and geomagnetic measurements) can be used to study the deep interior of Mars.

The question of whether life exists or could have existed on other planets than Earth is not just limited to the search for life but it also requires an understanding of the habitable

planetary environments, which is the purpose of MarsGeO. Stability of liquid water on the surface of a planet is generally used as criterion to define a habitable zone around a star. We here further consider other factors that determine the habitability of a planet, related to the internal dynamics, the presence or absence of a magnetosphere, the characteristic and evolution of a planet's atmosphere, and the presence of energy sources.

Future landers as those envisaged in the MarsGeO mission address these objectives. With the aim to determine interior properties of Mars, we propose a mission related to the understanding of the evolution of a planet involving processes in planetary interiors.

THREE DIMENSIONAL RAMAN/MOLECULAR FLUORESCENCE MICROIMAGING OF MODERN STROMATOLITES

EMMANUELLE GERARD[1], BENEDICTE MENEZ[1], ESTELLE COURADEAU[1,2], DAVID MOREIRA[2], KARIM BENZERARA[1], PURIFICACION LOPEZ-GARCIA[2]

[1] Equipe Géobiosphère actuelle et Primitive, IPGP/IMPMC, 4, place Jussieu, 75252 Paris cedex 05, France; emgerard@ipgp.fr

[2]Unité d'Ecologie, Systématique et Evolution, CNRS UMR8079, Université Paris-Sud 11, bâtiment 360, 91405 Orsay, France; puri.lopez@u-psud.fr

To explore the role of microorganisms in mineral formation or dissolution at microscale, we are developing a method coupling 3D mapping of both, molecular fluorescence emitted by labeled or unlabeled microorganisms and Raman scattering from minerals. For this, we use a confocal laser scanning microscope coupled with a Raman spectrometer allowing, identifying and co-locating microorganisms and minerals. We applied this method to study stromatolites from the alkaline lake Alchichica, Mexico. These modern stromatolites are considered as analogue for the Precambrian stromatolites. By analyzing morphology and pigment content of the dominant photosynthetic microorganisms through their intrinsic fluorescence, we identified 9 cyanobacterial types belonging to Oscillatoriales, Chroococcales, Nostocales and Pleurocapsales, as well as several diatoms and other microalgae. Cyanobacteria of the genera *Rivularia, Calothrix, Pleurocapsa, Gloeocapsa* and especially *Leptolyngbia* produced large amount of extracellular polymers that trapped mineral particles. To characterize the organization of the biofilm and acquire Raman maps of associated minerals, we stained stromatolite fragments with DAPI and Calcein (forming

fluorescent complexes with some bivalent ions like Mg^{2+} or Ca^{2+}), that were embedded in resin before being cut transversally to the surface. The oldest parts of the highly abundant *Pleurocapsa* colonies were always mineral-encrusted, whereas the smaller younger cells, located towards the exterior, were not, suggesting mineral precipitation in the inner part of the biofilm. Raman analysis showed the encrusting material to be made of aragonite crystals together with an organic phase related to the *Pleurocapsa* cells, some encrusted cells are furthermore surrounded by hydromagnesite crystals. We conclude that aragonite is biologically precipitated in these modern stromatolites. The combination of 3D maps of molecular fluorescence and Raman signal hold promise to tackle the mechanisms of biologically induced mineral formation.

CYANOBACTERIAL DIVERSITY CLOSE TO THE SOUTH POLE (ANTARCTICA)

FERNANDEZ-CARAZO, R.[1], NAMSARAEV, Z.[1], HODGSON, D.[2], CONVEY, P.[2], WILMOTTE, A[1]

1. Centre d'Ingénierie des Protéines, Institut de Chimie B6, Université de Liège, 4000 Liège, Belgique
2. British Antarctic Survey, Madlingey Road, Cambridge CB3 0ET, UK

For the first time, the cyanobacterial diversity in biotopes of the Transantarctic Mountains and Shackleton Range (80-82ºS) was studied by molecular and microscopic approaches. Two perennially ice-covered lakes were sampled: Forlidas Pond in the Dufek Massif (Pensacola Mountains) and Lundström Lake (Shackleton Mountains). These are amongst the most southerly locations where freshwater-related ecosystems are present, and cyanobacteria are the dominant phototrophs in these extreme environments. These lakes are ca 400 kms apart, but separated by a chain of mountains. Samples from Forlidas Pond were taken along a gradient going from a saline slush at the bottom of the lake, an aquatic mat in the littoral zone and 'cabbage-like' terrestrial mats in the vicinity. There is a continuity between close-by habitats that share some OTUs (groups of 16S rRNA sequences with more than 97,5% of similarity). The diversity in the centre of the continent appears lower (3 to 7 OTUs per sample) than in coastal lakes (4 to 12 OTUs per sample). A high degree of cosmopolitanism was observed among the total of 12 OTUs. The OTUs in Forlidas Pond and

Lundström Lake were different, maybe reflecting the fact that Forlidas was more saline (due to different evaporation histories). Two samples from a locality furthest South was recently obtained, coming from Mt Lowry, 84°S 63°E, at about 1000 m. altitude. The microscopic observation of a large desiccated terrestrial mat and a wet sample from a lake moat showed the presence of a quite rich diversity of cyanobacteria.

TRACES OF EARLY LIFE IN 3.2 GA OLD MUD: AN ANALOG FOR THE SEARCH FOR LIFE ON MARS

JAVAUX, EMMANUELLE J.
Department of Geology, University of Liège

Possible traces of life reported in Archean sediments suggest a diverse microbial community in a range of habitats from evaporitic lakes and open-marine shallow-water settings to deep hydrothermal systems. However, ambiguities and controversies persist regarding the biogenicity, endogenicity and syngeneity of the record older than the Late Archean. We report the discovery of a population of large (up to 298 µm in diameter) carbonaceous spheroidal microstructures in 3.2 Ga shales and siltstones of the Moodies Group, South Africa, the Earth's oldest siliciclastic alluvial to tidal-estuarine deposits (Javaux et al, 2010, Nature 463, 934-938). These microstructures are interpreted as organic-walled microfossils based on petrographic and geochemical evidence for their endogenicity and syngeneity, their carbonaceous composition, cellular morphology and ultrastructure, occurrence in populations, taphonomic features of soft wall deformation, and the geological context plausible for life, as well as lack of abiotic explanation falsifying a biological origin. The cell size of the microfossils population is larger than any other reported Archean sphaeromorphs, but comparable in size to the oldest unambiguous organic-walled microfossils (acritarchs) reported from the late Paleoproterozoic, extending their record in fine-grained siliciclastic sediments by more than 1 billion years. The Moodies Group provides an unusual window into ecology of Mesoarchean ocean, demonstrating the early evolution of a moderately diverse ecosystem in the photic zone of 3.2 Ga marginal marine siliciclastic environments, where large recalcitrant organic-walled unicells or colonial envelopes lived contemporaneously with earlier reported benthic microbial mats. This study demonstrates that

early Earth fine-grained siliciclastics do preserve traces of early cellular life, suggesting an interesting analog target for the future ESA and NASA exobiological missions on Mars.

HISTORY OF SPONTANEOUS GENERATION AND EXTRATERRESTRIAL LIFE IN BELGIUM FROM VAN HELMONT TO MINCKELERS AND QUETELET AND ITS END IN PASTEURIAN TIMES.

CHRISTIAN MULLER

BUSOC

Jan-Baptist van Helmont in the seventeenth century quantified the apparition of parasites in several media including the air. He went as far as to give a 21 days delay for an experimental set-up containing dirty laundry to generate mice. He conducted also experiments in the spontaneous fermentation of beer and derived principles which are still used by Brussels artisanal breweries.

The van Helmont theories led eighteenth and nineteenth century astronomers and geoscientists think that life would occur in any favourable environment. They led also to the production and use of methane by For most nineteenth century scientists, including Adolphe Quetelet, life on the terrestrial planets was evident and they were sure that instrumental progress would prove it. This was substantiated by more controlled early experiments on the fermentation of wine by Gay-Lussac in 1810 after the Appert sterilization process had been tested and quantified. A history of strategies to search for life on planets as soon as spectroscopic observations in the nineteenth century were available will be described. In biogeosciences, the 19th century theories relating oxygen, ozone and other oxidants to pathogen generation on atmospheric miasmas will be described also.

The experiments made by Louis Pasteur during his career to prove that none of the previous experiments were a proof of spontaneous life generation will be described together with its conclusions and the influence they had on the further developments of wine-making and generally food industry.

More generally, the twentieth century consequences on astrobiology and environmental sciences of Pasteur postulate that “life can only originate from life” will be exposed.