Astrobiology 2017 & IAP Planet Topers joined meeting
Program

February 3rd 2017 in Brussels
(room DB5.236, building D, niveau 5, campus du Solbosch, ULB)

- **9:30-10:00 registration, welcome coffee**

Invited talk (30 + 10 min questions)
- **10:00-10:40 D. Defrère**(1), A. Léger(2), J.L. Grenfell(3), M. Godolt(3), A Garcia Munoz(3), H. Rauer(3), and F. Tian(4)
(1) University of Liège, Belgium; (2) University of Paris-Saclay, France; (3) TU Berlin, Germany
(4) Tsinghua University, Beijing, China
"Proxima Cen b: theoretical spectral signatures for different atmospheric scenarios"

Contributed talks (15 + 5min questions)
- **10:40-11:00 Artem Burdanov** and Michael Gillon
AGO, UR STAR, ULg
"SPECULOOS: exploring the nearest ultracool dwarfs for terrestrial exoplanets"

- **11:00-11:20 Kyriaki I. Antoniadou** and Anne-Sophie Libert
NaXys, Department of Mathematics, University of Namur
"To what extent do habitable planets co-exist with giants on eccentric orbits?"

-**11:20-11:40** D. Defrère, **A. Léger**, and O. Absil
(1) University of Liège, Belgium; (2) University of Paris-Saclay, France
"How to characterize habitable planets in the alpha Centauri system?"

- **11:40-12:00 Lena Noack**; Attilio Rivoldini and Tim Van Hoolst
Royal Observatory of Belgium
"Volcanism and outgassing of stagnant-lid planets: Implications for the habitable zone"

-12:00-12:20 R.M.G. Armytage[1], V. Debaille[1], A.D. Brandon[2], C.B. Agee[3]
[1]Laboratoire G-Time, CP 160/02, Université Libre de Bruxelles, Ave Fr. Roosevelt 50, 1050 Bruxelles, Belgium.
[2]Earth and Atmospheric Sciences, University of Houston, Houston, TX, 77204, USA [3]Institute of Meteoritics, University of New Mexico, Albuquerque, NM, USA
"The meteorite NWA 7034 and constraints on the early differentiation history of Mars"

-12:20-12:40 M. van Ginneken[1], J. Gattacceca[2], P. Rochette[2], C. Sonzogni[2], A. Alexandre[2], V. Vidal[2], M.J. Genge[3]
[1]VUB/ULB, Belgium. 2CNRS/Aix-Marseille Université, CEREGE UM34, Aix-en-Provence, France. [3]Imperial College London, UK.
"The parent body controls on cosmic spherule texture: Evidence from the oxygen isotopic compositions of large micrometeorites"

12:40-13:40 lunch (sandwiches)

Invited talk (40 + 10 min)

-**13:40-14:30 Hervé Martin**
Université Clermont-Auvergne, Sciences de la Terre
« Why Archaean TTG cannot be generated by MORB melting in subduction zones : Implications for the evolution of life”

Contributed talks (15 + 5min questions)

-**14:30-14:50 Luc André**[1], Kathrin Abraham[2,1,5], Stephen F. Foley[3,5], and Axel Hofmann[4]
1. Earth Sciences Department, Royal Museum for Central Africa, Leuvensesteenweg 13, Tervuren, B-3080, Belgium.; 2 University of Oxford, Department of Earth Sciences, Oxford, United Kingdom; 3 Dept. Earth and Planetary Sciences and ARC Centre of Excellence for Core to Crust Fluid Systems, Macquarie University, North Ryde 2109, Australia; 4 Department of Geology, University of Johannesburg, South Africa.; 5 Institut für Geowissenschaften, Universität Mainz, Becherweg 21, D-55099 Mainz, Germany.
“Silicon isotopes as markers for the onset of surface products recycling in the Archean”

-14:50-15:10 A.N.Wainwright[1]*, V. Debaille[1], J. Berger
[1]Laboratoire G-Time, Université Libre de Bruxelles, Belgium, *awainwri@ulb.ac.be
[2]Géosciences Environnement Toulouse, Université Paul Sabatier, Toulouse, France
“Constraints from the West African Craton on Archean mantle dynamics”

-**15:10-15:30 Lucas Demaret**, Cedric Malherbe, Emmanuelle Javaux, Gauthier Eppe
MolSYS, ULg ; UR GEOLOGY, ULg
“Analytical approach for the detectability of organics in mineral powders by Raman spectroscopy in preparation for future Mars exploration missions”

- **15:30-15:50 Yohan Cornet**[1]*, J. Beghin[1] , B K. Baludikay[1] , C. François[1] , J.-Y. Storme[2], P. Compère [3], E.J. Javaux
[1] Palaeobiogeobiology-Palaeobotany-Palaeopalynology, University of Liège, [3] Department of Biology, Ecology and Evolution, University of Liège
“Microanalyzes of remarkable microfossils of the Late Mesoproterozoic–Early Neoproterozoic”

- **15:50-16:10 coffee break**

-**16:10-16 :30 Camille François** [1], B. K. Baludikay [1], D. Baudet [2], JL Birck [3], JY Storme [1], JL Paquette [4], M. Fialin [5], V. Debaille [6] & E. J.Javaux [1]

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How to date a sedimentary serie: Different approaches to better constrain the diversification of early eukaryotes in Central Africa (Mbuji-Mayi Supergroup, Proterozoic, DRCongo)

-**16:30-16:50 Marie Catherine Sforna** [1,*], M. Daye[2], P. Philippot[3], A. Somogyi[4], M. A. van Zuilen[3], K. Medjoubi[4], E. Gérard[3], F. Jamme[4], C. Dupraz[5], O. Braissant[6], C. Glunk[7], P. T. Visscher[8]

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Patterns of metal distribution in hypersaline microbialites: Implications for the fossil record

-**16:50-17:10 Séverine Robert** & AC Vandaele

BISA

"Scientific preparation for nomad nadir measurements".

- **17:10-17:30 Maria Valdes** & Vinciane Debaille

Laboratoire G-Time, Université Libre de Bruxelles, Brussels, Belgium

« Investigating the Moon’s early differentiation using calcium Isotopes”

-**17:30-17:50 Camille Cartier**[1], Olivier Namur[1,2], Bernard Charlier[1]

[1]Department of Geology, University of Liege, 4000 Sart Tilman, Belgium; [2]Institut für Mineralogie, Leibniz Universität Hannover, 30167 Hannover, Germany

“Inner planets, reduced planets? The case of Mercury”

-**17:50-18:10 Cedric Gillmann**[1], Gregor Golabek[2], Paul Tackley[3], Sean Raymond[4]

(1)Royal Observatory of Belgium; (2)University of Bayreuth, Germany; (3)ETH Zürich, Switzerland; (4)Laboratoire d’Astrophysique de Bordeaux, France

« Changes in surface conditions and mantle convection due to impacts on Venus and Mars »

-18:10-18:20 Christian Muller

BUSOC, former EANA secretary

A brief history of astrobiology in Belgium.

-**18:20** EANA Belgian representative selection

18:30: end of meeting

Abstracts (by alphabetical order)

Invited talks

D. DEFRÈRE[1], A. LÉGER[2], J.L. GRENFELL[3], M. GODOLT[3], A GARCIA MUNOZ[3], H. RAUER[3], AND F. TIAN[4]

[1] AGO UR STAR ULG University of Liège, Belgium
[2] University of Paris-Saclay, France
[3] TU Berlin, Germany
[4] Tsinghua University, Beijing, China

Proxima Cen b: theoretical spectral signatures for different atmospheric scenarios

Proxima Cen b is possibly the nearest rocky exoplanet orbiting in the habitable zone of its star and might represent by consequent a formidable opportunity for astrobiology. In this presentation, we discuss several possible atmospheric compositions and present the corresponding infrared spectrum computed with modern planetary atmosphere models. To be specific, we consider (1) a bare planet, which has lost its atmosphere; (2) a water-ocean planet; (3) an Earth-analog planet; and (4) a planet similar to Earth but with a lower O2 pressure (< 1mbar) that produces a false positive for the triple signature (H20, O3, and CO2). We discuss the information contained in each infrared spectrum and the possibility to constrain the nature of the planet by remote sensing. We end this presentation by describing an instrumental concept recently proposed to ESA and optimized for this task.

HERVÉ MARTIN

Université Clermont-Auvergne, Sciences de la Terre

Why Archaean TTG cannot be generated by MORB melting in subduction zones : Implications for the evolution of life

Contributed talks

LUC ANDRÉ[1], KATHRIN ABRAHAM[2,1,5], STEPHEN F. FOLEY[3,5], AND AXEL HOFMANN[4]

1. Earth Sciences Department, Royal Museum for Central Africa, Leuvensesteenweg 13, Tervuren, B-3080, Belgium. ;2 University of Oxford, Department of Earth Sciences, Oxford, United Kingdom; 3 Dept. Earth and Planetary Sciences and ARC Centre of Excellence for Core to Crust Fluid Systems, Macquarie University, North Ryde 2109, Australia ; 4 Department of Geology, University of Johannesburg, South Africa. 5 Institut für Geowissenschaften, Universität Mainz, Becherweg 21, D-55099 Mainz, Germany.

Silicon isotopes as markers for the onset of surface products recycling in the Archean

1. Introduction

Geodynamic processes in the Archean Eon were probably very different from the modern ones, essentially due to hotter mantle conditions. The Archean witnessed the production of early continental crust, the nature of which has evolved from a highly mafic bulk composition before 3.0 billion years ago to a felsic bulk composition by 2.5 billion years ago. This compositional change was attended by a fivefold increase in the mass of the upper continental crust due to addition of granitic rocks, suggesting the onset of global plate tectonics at ~3.0 billion years ago (Tang et al., 2016). In order to corroborate this hypothesis, it is essential to pinpoint with adequate isotopic proxies the timing of the onset of resurfacing events that could recycle large parts of the upper continental crust into mantle conditions, which would be associated with generating more differentiated crustal components. Here, we propose a model to better constrain these early recycling processes as well as the nature and the amount of the recycled components using silicon isotopes as a proxy.

2. Rationales

The rationales of using this proxy are based on the fact that low-temperature weathering and precipitation of secondary silica tends to significantly fractionate the Si isotopes. Precipitation of secondary clays tends to enrich the rock by desilicification in lighter isotopes of Si resulting in residual water with a relatively heavy isotopic composition (e.g. Cardinal et al., 2010; Hughes et al. 2013). Weathering-induced desilicification has been recently confirmed to be widely effective during the Mesoarchean showing that surface processes under anoxic conditions in the Archean also tends to significantly fractionate the silicon isotopes (Delvigne et al., 2016).

3. Results

We report silicon isotopic data on Archaean granitoids from the Barberton granitoid-greenstone terrane (Kaapvaal craton), which range in age from 3.55-3.11Ga. The older generations (3.55 – 3.22 Ga) belong to the TTG (Tonalite-Trondhjemite-Granodiorite) suite, whereas the youngest (3.11 Ga) form a potassic GMS (Granite-Monzonite-Syenite) suite. The oldest plutons have Si isotopes in the igneous array (δ^{30}Si: -0.17 to -0.10‰), whereas younger generations show a significantly heavier isotopic signature (δ^{30}Si: -0.08 to +0.05‰). This is explained by melting of recycled silicified basalts and cherts (δ^{30}Si:~+1‰, Abraham et al., 2011), which were common surface rocks in the oceans at the time, beginning between 3.3 and 3.2 Ga.

4. Discussion

Mass balance calculation shows that about 20-25% of combined chert and silicified basalts in a mixed source region are required to achieve the heavier Si isotope composition of the younger (<3.3Ga) generations of TTG and GMS magma. This is reasonable in a subduction scenario, as silicified sedimentary and volcaniclastic rocks are common in the Paleoarchaean, Barberton greenstone succession, making up more than 10% of the volcanic succession. The mixture of these components in the source before melting means that the high SiO_2 content of the subducted cherts and silicified basalts does not carry over into increased SiO_2 in the melt, because of quasi-eutectic melting.

References

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Cardinal D., Gaillardet J., Hughes, H. J. Opfergelt S. and André L. (2010). Contrasting silicon isotope signatures in rivers from the Congo Basin and the specific behavior of organic-rich waters. Global Biogeochemical Cycles, 19, GB2007, doi:10.1029/2004GB002364.

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KYRIAKI I. ANTONIADOU AND ANNE-SOPHIE LIBERT

NaXys, Department of Mathematics, University of Namur, 8 Rempart de la Vierge, 5000, Namur, Belgium

To what extent do habitable planets co-exist with giants on eccentric orbits?

Dynamical analyses are essential to determine, whether a given planet can remain stable in the habitable zone for long time spans, in order for its biosphere to evolve. The periodic orbits act as a diagnostic tool, which ascertains information regarding the phase space in planets' dynamical vicinity and provides clues about their survival. In this talk, we address the question of the possible existence of terrestrial planets with a giant companion on an eccentric orbit, and explore the extent of the stability regions, when both the eccentricity of the inner terrestrial planet and the semi-major axis of the outer giant planet change

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The meteorite NWA 7034 and constraints on the early differentiation history of Mars

Introduction: Shergottites are the largest group of martian meteorites currently represented in our collection. On the basis of their bulk incompatible trace element compositions and Sm-Nd systematics, shergottites form a compositional continuum that can be subdivided into enriched, intermediate, and depleted subgroups. However, the broad variety of textures exhibited by the shergottites, and indices of differentiation such as Mg# do not correlate with these subgroups, making it difficult to explain the compositional continuum in terms of simple crustal assimilation and fractional crystallization [e.g. 1,2]. In addition the correlation between the initial□□^{143}Nd and □^{187}Os in shergottites is hard to replicate using the crust as an end-member [3]. The favoured interpretation in recent times based on ^{142}Nd-^{143}Nd systematics has been is that the compositional variation reflects mixing between distinct, ancient mantle source regions, likely established during magma ocean solidification, though this requires a protracted magma ocean on Mars [1-3]. Despite the dominance of shergottites in our collection, recent rover and orbital data of the martian surface have highlighted how unrepresentative shergottites actually are of the crust [4]. Until the discovery and identification of NWA 7034 (and its pairs e.g. NWA 7533) as martian regolith breccias [5-8], the crustal end-member in shergottite mixing models was somewhat hypothetical and usually defined based on shergottites themselves. Modelling of the trace element profiles in NWA 7533 carried out by [6] suggested that the crust could be the enriched end-member for the shergottites. To investigate the relationship between NWA 7034, representing the a crustal reservoir, and the enriched end-member for shergottites, we collected ^{147}Sm-^{143}Nd, ^{176}Lu-^{176}Hf and high precision ^{142}Nd data on NWA 7034.

Method: The three fragments (~0.1g) were digested in HF-HNO_3 in Parr Bombs due to the possible presence of zircons [6]. Aliquots to measure spiked Sm-Nd and Lu-Hf, and trace elements were both removed from the initial dissolution. Ion-exchange chromatography was used to separate Hf and Nd for isotopic analysis. The Nd isotopic data was collected on a TritonPlus, while the Hf isotopic ratios and the spiked aliquots were measured on a NuPlasma HR, both at ULB.

Results and Discussion: Although there is some variation in the trace element profiles among the three aliquots, there is no resolvable variation in the Nd isotopic composition and the average □^{142}Nd=□□47 ± 5(2SD) and □^{143}Nd= □17.5 ± 0.3 (2SD) are in good agreement with previous data [5,8-9] for this sample. The Hf isotopic data show a bit more variation with□□^{176}Hf ranging from □66 to □58. For □^{143}Nd$_{150Ma}$ or □^{176}Hf$_{150Ma}$ vs La/Yb, NWA 7034 plots as the enriched end-member on a two component mixing hyperbola for shergottites, with a calculated mixing curve (between NWA 7034 and the depleted shergottite Tissint) plotting nearly on top of a hyperbola fit to the data. The sources of the shergottites also appears to show this coupling as NWA 7034 falls on a hyperbolic mixing curve fit through it and the shergottites. However, a calculated mixing curve between NWA 7034 and the DMM (depleted martian mantle) composition of [1], does not accurately model the shergottite ^{146}Sm/^{144}Nd-

$^{176}Lu/^{177}Hf$ source trend. This rules out any simple binary mixing with the crust as the enriched source. Even a more complex mixing scenario as modeled in [10] requires an enriched end-member that is the residue of magma ocean crystallization. Therefore the $^{147}Sm/^{144}Nd$-$^{176}Lu/^{177}Hf$ systematics of the shergottites appear to be inconsistent with the "crust", as represented by NWA 7034, being the enriched end-member. However, as NWA 7034 clearly falls on the mixing curve for the shergottites it is likely to also represent some degree of mixing of the same mantle reservoirs that have generated the shergottite sources.

References: [1] Borg L. E. and Draper D. S.(2003) *Meteoritics & Planet. Sci., 38*, 1713-1731. [2] Debaille V. et al. (2007) *Nature 450***,** 525-528 [3] Brandon A. D. et al. (2012) *Geochim. Cosmochim. Acta*, *76,* 206-235. [4] Mc Sween Jr. H.Y. et al. (2009) *Science, 324*, 736-739. [5] Agee C. B. et al. (2013), *Science, 339*, 780-785 [6] Humayun M. et al. (2013), *Nature, 503*, 513-516. [7] Santos A. R. et al. (2015), *Geochim. Cosmochim. Acta*, *157,* 56-85 [8] Nyquist L.E. et al. *Meteoritics & Planet. Sci., 51*, 1-16 [9] Kruijer T.S. et al. *LPS XLVII,* Abstract #2115. [10] Debaille V. et al. (2008) *EPSL, 269,* 186-199

ARTEM BURDANOV AND MICHAEL GILLON

AGO UR STAR ULG University of Liège, Belgium

SPECULOOS: exploring the nearest ultracool dwarfs for terrestrial exoplanets.

The first detailed atmospheric characterizations of exoplanets similar in size and temperature to Earth are eagerly awaited. Theoretically, transit techniques represent a possible path to this breakthrough. Still, the extreme size- and brightness-ratios between an Earth analog and its stellar host make virtually impossible its atmospheric characterization with existing and next-generation astronomical facilities... except if the planet transits a nearby "ultracool dwarf" star, i.e. a Jupiter-sized star at the extreme bottom of the main-sequence. Unfortunately, these mini-stars, despite being very frequent in the Galaxy, have been mostly unexplored for planets so far. In this context, we present here the status of our project SPECULOOS, a new transit survey based on a network of robotic telescopes targeting the ~1000 brightest ultracool dwarfs. We describe the concept and status of SPECULOOS, some results of its prototype ongoing since 2011 in Chile, and our current efforts to extend the project to the Northern hemisphere.

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Inner planets, reduced planets? The case of Mercury

Mercury has always held the distinction of being the terrestrial planet most unlike the others. It is the smallest terrestrial planet of our Solar system, the closest to the Sun, and is made of the densest materials (its core constitutes about 3/4 of the planet's radius). These extreme features have inspired various theories to explain its formation: high temperature condensation/evaporation processes, dynamical mixing in the accretion disk, or a giant impact stripping off most of the silicate mantle after the planet had differentiated. However, these models individually cannot explain both the high metal/silicate ratio of the planet and its volatile-rich nature, as revealed by the MESSENGER spacecraft. Very recently the space telescope Kepler collected geophysical data for hundreds of multi-planet exosystems. These data reveal a quasi-systematic correlation between density and heliocentric distance of planets that belong to the same solar system. This suggests that iron enrichment in inner planetary systems may well be a universal trend, and Mercury would not be an isolated case.

Geophysical and geochemical measurements by MESSENGER have refined our understanding of the internal structure and geological history of Mercury. In particular, measurements of low iron and exceptionally high sulfur contents in lavas support the idea of a highly reduced planet. Further, the existence of a magnetic field requires a partially molten metallic core. In this talk, we will present our estimate of Mercury's mantle redox conditions, and the importance of such redox conditions on the early history of the planet, in particular during core formation. The potential formation of a sulfide layer at the top of the core and its role in the thermal history of Mercury, as well as its volatile content, will be discussed.

Y. CORNET[1], J. BEGHIN[1], B K. BALUDIKAY[1], C. FRANÇOIS[1], J.-Y. STORME[2], P. COMPÈRE[3], E.J. JAVAUX[1]

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Microanalyzes of remarkable microfossils of the Late Mesoproterozoic–Early Neoproterozoic

The Late Mesoproterozoic–Early Neoproterozoic is an important period to investigate the diversification of early eukaryotes (Knoll *et al.,* 2006). Following the first appearance of red algae in the Late Mesoproterozoic, other (morphological or molecular) fossils of crown groups are recorded during the Early Neoproterozoic, including green algae, sponges, amoebozoa and possibly fungi. Other microfossils also includes unambiguous eukaryotes, including several distinctive forms for that time period, such as the acritarchs (~820–720 Ma) *Cerebrosphaera buickii,* (1100-720 Ma) *Trachyhystrichosphaera aimika, T. botula*, and the multicellular eukaryotic *problematicum* taxon (1100–?720 Ma) *Jacutianema solubila*. To further characterize the taxonomy of these microfossils and to test hypotheses about their possible relationships to crown groups, we combine analyzes of their morphology, wall ultrastructure and microchemistry, using optical microscopy, Scanning and Transmission Electron microscopy, and Raman and FTIR microspectroscopy respectively.

Cerebrosphaera populations from the Svanbergfjellet formation, Spitsbergen, and from the Kanpa Formation, Officer Basin, Australia, include organic vesicles with dark and robust walls ornamented by cerebroid folds (Butterfield *et al.,* 1994). Our study shows the occurrence of complex tri or bi-layered wall ultrastructures, confirming the eukaryotic nature of these microfossils, and a highly aromatic composition (Cornet *et al.,* in preparation). The genus

Trachyhystrichosphaera includes various species characterized by the presence of a variable number of hollow heteromorphic processes (Butterfield *et al.,* 1994). Preliminary infrared microspectroscopy analyzes performed on two species, *T. aimika* and *T. botula,* from the 1.1 Ga Taoudeni Basin, Mauritania, and from the ~1.1 - 0.8 Ga Mbuji-Mayi Supergroup, RDC, indicate a strong aliphatic and carbonyl composition of the wall biopolymer, with some differences linked to thermal maturity between the two locations. Transmission electron microscopy is performed to characterize the wall ultrastructure of these two species. Morphometric analyzes are also ongoing to constrain the large morphological diversity of processes of these acanthomorphic acritarchs. Various morphotypes of the species

Jacutianema solubila from the Svanbergfjellet Formation, Spitsbergen and from the Taoudeni Basin, Mauritania, are also characterized with infrared and Raman microspectroscopy as well as with transmission electronic microscopy, permitting to test a previous hypothesis proposing that *Jacutianema* represents part of the life cycle of a Vaucherian alga (Butterfield, 2005).

Deciphering the identity of these distinctive microfossils will improve our understanding of the timing and pattern of eukaryote stem and crown group diversification in the mid-Proterozoic, prior to large "snowball Earth" glaciations and during time of changing ocean chemistry.

This PhD project is supported by the ERC Stg ELITE project "Early life Traces and Evolution, and implications for Astrobiology".

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D. DEFRÈRE[(1)], **A. LÉGER**[(2)], AND O. ABSIL[(1)]

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How to characterize habitable planets in the alpha Centauri system?

As our nearest rocky exoplanet, Proxima Cen b might represent a formidable opportunity for astrobiology. Following the previous talk on the possible nature of this planet, we present in this talk the main observational challenges to overcome in order to study the atmospheric composition of this planet and review what will be possible with current and/or planned facilities. We also describe an instrumental concept recently proposed to ESA and optimized for this task. In the second part of this presentation, we present another promising near-future opportunity to get the first image of an habitable exoplanet with ESO's VLT/VISIR that will soon be upgraded and equipped with a Vortex coronagraph developed at the University of Liege.

LUCAS DEMARET[1, 2], CEDRIC MALHERBE[1], EMMANUELLE JAVAUX[2], GAUTHIER EPPE[1]

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Analytical approach for the detectability of organics in mineral powders by Raman spectroscopy in preparation for future Mars exploration missions.

For the first time, Raman spectrometers will be part of the scientific rover payload on board two forthcoming missions to Mars with the objectives of describing the geochemical composition of Mars (surface and subsurface down to 2 meters) and detecting organic molecules potentially preserved on Mars. Qualitative descriptions for geochemical samples, amongst them Mars analogue samples, were successful using Raman instruments. However, quantitative analyses were not sufficiently reported in the literature. It is indeed very important to evaluate the smallest quantity of organics which will be detectable in crushed minerals relevant to the exploration of the Martian surface by Raman spectroscopy. Quantitative approaches would support the interpretation of Raman data returning from Mars when the rovers will be exploring the red planet.

Applying the operating parameters proposed for the Raman Laser Spectrometer (RLS) on board the ExoMars 2020 mission to Mars, we planned to develop analytical approaches to evaluate the limit of detection of an organic molecule within a crushed mineral matrix. This project will be articulated into 4 mains parts: (a) the preparation of reference materials relevant to Mars; (b) the development of analytical methods for low signal detection (with a given confidence level) and quantification using lab instruments; (c) the adaptation of the developed methods to miniaturised instruments designed for space missions, including a RLS prototype instrument; (d) the study of Mars analogue samples such as biogeological crust (possibly comprising recent molecular biosignatures) and ancient carbonaceous shale (comprising ancient fossils). The entire project will reinforce the databases and contributes to the understanding of new media which host and/or preserve organics.

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How to date a sedimentary serie: Different approaches to better constrain the diversification of early eukaryotes in Central Africa (Mbuji-Mayi Supergroup, Proterozoic, DRCongo)

The Mbuji-Mayi Supergroup, DRC, is located between the Archean-Paleoproterozoic Kasai Craton and the Mesoproterozoic Kibaran Belt. This sedimentary sequence is unaffected by regional metamorphism and preserves a large diversity of well-preserved microfossils, evidencing the evolution of complex life (early eukaryotes) for the first time in Meso-Neoproterozoic record of Central Africa (*Baludikay et al., 2016*). A total of 49 taxa belonging to 27 genera were identified, comprising 11 species of unambiguous eukaryotes, 10 species of possible eukaryotes or prokaryotes and 28 species of probable bacteria.

The lithostratigraphy consists of two distinct successions:

- BII Group: an unconstrained upper carbonate sequence intercalated with shales. Basaltic lavas topping the Mbuji-Mayi Supergroup were dated around 950 Ma (*Cahen, 1974; Cahen et al., 1984*)
- BI Group: a lower siliciclastic sequence (ca. 1174 Ma to ca. 1055 Ma (*Cahen, 1954; Cahen, 1974; Delpomdor et al., 2013; Holmes & Cahen, 1955; Raucq, 1957*) unconformably overlying the ca. 2.82-2.56 Ga granitoid Dibaya Complex (*Cahen, 1972; Delhal et al., 1976; Holmes, A., & Cahen, 1955*).

The diagenesis of BI Group was dated by LA-ICP-MS and Electron MicroProbe (on xenotime, monazite and zircon) between 1030 and 1065 Ma (*François et al., 2016*). Nevertheless, no diagenetic minerals were found in the BII Group which contains the more diverse fossiliferous levels.

Thus, we perform Re-Os dating (Laboratoire de Géochimie des enveloppes externes, IPGP, Paris, France) on fossiliferous shales with the method developed by Birck et al. (1997), to better constrain the age of this BII Group and the age of organic-walled microfossils in the Meso-Neoproterozoic interval.

We also plan to re-evaluate the age of basaltic lavas overlying the Mbuji-Mayi Supergroup (previously dated around 950 Ma (*Cahen, 1974; Cahen et al., 1984*) with Ar-Ar technique

(Laboratoire G-Time, ULB, Bruxelles, Belgium & Centre & Dept of Applied Geology, Curtin University, Perth, Australia) to constrain the end of deposition of this Supergroup.

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Changes in surface conditions and mantle convection due to impacts on Venus and Mars.

We study how impacts modify the evolution of terrestrial planets and their atmosphere, using a coupled numerical model. Mars and Venus are the main targets of our simulations. We focus on volatile exchanges and their effects on surface conditions.

Mantle dynamics, volcanism and degassing processes lead to an input of gases in the atmosphere and are modeled using the StagYY code. Volatile losses are estimated through atmospheric escape modeling. It involves two different aspects: hydrodynamic escape (0-500 Myr) and non-thermal escape. Hydrodynamic escape is massive but occurs only when the solar energy input is strong. Post 4 Ga escape from non-thermal processes is comparatively low. The resulting state of the atmosphere is used to the calculate greenhouse effect and surface temperature, through a one-dimensional gray radiative-convective model (in the case of Venus, that exhibits globally homogenous surface temperatures).

Large impacts are capable of contributing to (i) atmospheric escape, (ii) volatile replenishment and (iii) energy transfer to the mantle. We test various impactor compositions, impact parameters (velocity, location, size, and timing) and eroding power. Various scenarios are tested from cases arbitrarily chosen to test the interactions between multiple impacts to more realistic histories from accretion simulations (Raymond et al., 2013).

Small impactors (0-50km radius) have a negligible effect on long term evolution unless one considers the erosion by the swarm of smallest and most numerous objects that can deplete the early atmosphere. Larger impactors have two main effects on the atmosphere. They can (i) create a large input of volatile from the melting they cause during the impact and through the volatiles they carry. This leads to an increase in atmosphere density and surface temperatures. However, early impacts can deplete the mantle of Venus and (assuming strong early escape) ultimately remove volatiles from the system, leading to lower late degassing and lower surface temperatures.

Large impacts also destroy older crustal material and are able to drive convection for millions of years after the event on a global scale. They can mobilize the upper mantle and deplete it very efficiently, which in turn limits subsequent volcanic degassing and atmosphere replenishment. The Late Veneer period is especially prone to have these events occur.

CHRISTIAN MULLER

BUSOC, former EANA secretary.

A brief history of astrobiology in Belgium.

The first characterisation of gases and their relation to biology was made by van Helmont in the early 17th century one hundred years before their chemical composition was investigated. Methane, its biological origin and its production from coal were investigated by Minckelers at Louvain University. Quetelet, as other scientists of the nineteenth century held extra-terrestrial life as certain in his public course. Van Helmont theories of spontaneous generations were explicitly refuted if not mocked by Pasteur and the principle that life comes only from life was generally accepted.

However, it was only in the 20th century that the identification of carbon radicals in the cometary spectra by Pol Swings led to a renewal of interest in biological molecules which led to design observation programmes and space missions to observe molecules related to life in other planets and in the interstellar space. Similarly, progresses in the study of the early evolution and exploration of extreme environments on the earth changed the envelope of life and made it more possible on other planets. The number of planetary systems discovered in the last 20 years increase even the possibility of future life detection. Several Belgian scientists present in this meeting contributed to these recent progresses which lead to the current EXOMARS mission.

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Volcanism and outgassing of stagnant-lid planets: Implications for the habitable zone

Rocky exoplanets are typically classified as potentially habitable planets, if liquid water exists at the surface. The latter depends on several factors like the abundance of water but also on the amount of available solar energy and greenhouse gases in the atmosphere for a sufficiently long time for life to evolve. The range of distances to the star, where surface water might exist, is called the habitable zone. Here we study the effect of the planet interior of stagnant-lid planets on the formation of a secondary atmosphere through outgassing that would be needed to preserve surface water. We find that volcanic activity and associated outgassing in one-plate planets is strongly reduced after the magma ocean outgassing phase, if their mass and/or core-mass fraction exceeds a critical value. As a consequence, the effective outer boundary of the habitable zone is then closer to the host star than suggested by the classical habitable zone definition, setting an important restriction to the possible surface habitability of massive rocky exoplanets, assuming that they did not keep a substantial amount of their primary atmosphere and that they are not in the plate tectonics regime.

S. ROBERT, AC VANDAELE

IASB

Scientific preparation for NOMAD nadir measurements

NOMAD (Nadir and Occultation for MArs Discovery) is one of the four instruments onboard the ExoMars Trace Gas Orbiter (EMTGO). It consists of a suite of three high-resolution spectrometers – SO (Solar Occultation), LNO (Limb, Nadir and Occultation) and UVIS (Ultraviolet and Visible Spectrometer). At the end of 2016, EMTGO started orbiting around Mars. Maneuvers will soon take place in order to reach the final 400 km circular orbit. These will last until April 2018. Meanwhile the scientific preparation is in full swing.

Based upon the characteristics of the channels and the values of Signal-to-Noise Ratio obtained from radiometric models, the expected performances of the instrument in terms of sensitivity to detection have been investigated. The analysis led to the determination of detection limits for 18 molecules.

Another study was carried on to evaluate how synergy with two instruments would increase the science return. Synergistic retrievals were performed on synthetic spectra. We have simulated spectra of a Fourier transform spectrometer and of a grating spectrometer. As control runs, non-synergistic retrievals were performed as well. Two molecules of interest in the Martian atmosphere were chosen to test this method: carbon monoxide and methane.

The impacts of these studies will be discussed. A status of NOMAD will be given, as measurements have been performed during the Mars Capture Orbit.

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Investigating the Moon's early differentiation using calcium Isotopes

Calcium (Ca) isotopes are ideal tracers of the evolution of the interiors of rocky planets and can help us explore the role of fractional crystallization and crystal segregation in the establishment, mixing, and possible overturn of lunar mantle reservoirs after the hypothesized Moon-forming giant impact. Not only does Ca, a refractory lithophile element, allow us to circumvent any issues related to impact-induced volatilization (which fractionates more volatile isotopes (e.g. Zn [1]), Ca is also a major element and highly abundant in some samples, even those that are particularly depleted in trace elements commonly used to investigate planet interiors. Thus, it is ideal for studying the fate of the Moon after the giant impact.

Notably, Ca, along with many other elements (e.g. Mg, Fe; [2-3]) has recently been shown to exhibit mass-dependent isotopic fractionation among co-existing minerals within terrestrial mantle xenoliths. Chen et al. (2014) showed that $\delta^{44/40}$Ca values for bulk mantle xenolith samples vary from 0.81 to 1.25 ± 0.10 ‰ (2sd) and that olivine and orthopyroxene in xenoliths are isotopically much heavier than co-existing clinopyroxene [4]. Kang et al. (2016) recently corroborated these results [5].

Given these recent observations, we aim to investigate the mineral control on mass-dependent fractionation of Ca isotopes among mantle reservoirs in order to trace LMO reservoir development and evolution. As a pilot study, we measured the Archean Guelb el Azib ultramafic-mafic-anorthosite (UMA) layered complex in the West African craton of Mauritania. The co-genetic layers of this complex represent a full crystallization sequence and parallel the sequence of layers hypothesized to have initially evolved out of the LMO: ranging from ultramafic (olivine and pyroxene-rich harzburgites) to highly felsic (plagioclase-rich anorthosites). We measured bulk aliquots from each layer and found clear evidence for inter-mineral isotopic fractionation, with their Ca isotopic signatures defining a $\delta^{44/40}$Ca range of 3.25‰, from -2.25‰ to 1‰. There is a pronounced and systematic Ca isotopic variation with CaO content, and thus, we can conclude, with mineralogy and degree of melt crystallization. Our Ca isotopic analyses provide a detailed picture of how crystallization affected the isotopic evolution of this particular layered complex, which in turn lends to a deeper understanding of lunar interior evolution.

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Patterns of metal distribution in hypersaline microbialites: Implications for the fossil record

Metals, which are widely used by all microorganisms, could act as indicators in the rock record of past microbial activity if we are able to distinguish the influence of microorganisms on metal distribution and speciation from the influence of abiotic processes. For understanding the distribution observed in the rock record it is thus essential to understand the processes controlling the initial metal(loid) incorporation and early diagenetic processus occuring in living microbialites. We report the distribution of metals and the organic fraction within the lithifying microbialite of the hypersaline Big Pond Lake (Bahamas). By combining synchrotron X-ray microfluorescence, confocal and biphoton microscopies, Raman spectroscopy with traditional geochemical analyses, we show that the initial cation sorption at the surface of an active microbialite is governed by passive binding to the organic matrix, resulting in a homogeneous metal distribution. During early diagenesis, the metabolic activity in deeper microbialite layers slows down and the distribution of the metals becomes progressively heterogeneous, resulting from remobilization and concentration as metal(loid)-enriched sulfides, which are aligned with the lamination of the microbialite. The similarity of the metal(loid) distributions observed in the Big Pond microbialite to those observed in the Archean stromatolites of Tumbiana (2.72 Ga) provides the foundation of a conceptual model of the evolution of the metal distribution through initial growth, early diagenesis, and fossilization of a microbialite, with potential application to the fossil record.

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The parent body controls on cosmic spherule texture: Evidence from the oxygen isotopic compositions of large micrometeorites.

Introduction: The high-precision measurement of oxygen isotopes by laser fluorination coupled with mass spectrometry is a powerful proxy to the determination of the parent body of mi- crometeorites [1]. However such measurements require microme- teorites (MMs) with a minimum mass of about 0.3 mg, i.e. a di- ameter of about 560 µm. In view of the typical size distribution of MMs, such large objects are extremely rare and can be found only in very large MM collection. The dry conditions coupled with the old age of the Atacama Desert make it a very favorable area for the recovery of meteorites [2; 3]. We collected several thousands of MMs from the soil of the Atacama desert, and se- lected 23 micrometeorites with mass > 250 µg to measure their oxygen isotopes after non-destructive characterization.

Material and methods: Raw soil was samples over a 1 m2 area, sieved (200-800 µm), and submitted to magnetic separation. MMs were then hand-picked from the magnetic fraction using a binocular microscope. This technique yielded over 2000 magnet- ic cosmic spherules (CS), lacking the non-magnetic glass CSs. The present study focuses on 23 CSs. The oxygen isotope com- position of the CSs was determined using laser fluorination coupled with mass spectrometry at CEREGE (see [1] for the ana- lytical details). The physical properties of 18 of these CSs were determined by X-ray computed microtomography (µCT).

Results: The physical properties of 18 of these 23 CSs have already been reported in [4]. µCT show that analyzed CSs in- clude mainly cryptocrystalline (C) and barred-olivine (BO) subtypes, and one porphyritic olivine showing well-defined skeletal olivine crystals several tens of µm in length. Pervasive dissolution of oli- vine resulting from terrestrial weathering is almost non-existent in the studied CSs, thus we assume that weathering products will not affect the oxygen isotope composition of CSs.

Discussion: The oxygen isotope compositions of cosmic spherules from the Atacama Desert are consistent with those of cosmic spherules from the Transantarctic Mountains [1], showing a global distribution for micrometeorites >500 µm in size and not distribution due to local anormal events. About 85% of BO CSs plot below the terrestrial fractionation line (TFL), suggesting that they are mainly related to carbonaceous chondritic materials. Similarly, most C CSs and all porphyritic olivine (Po) CSs plot above the TFL, suggesting that they are related to either ordinary chondritic chondritic materials or to unknown parent bodies [1]. The texture of stony CSs (excluding V-type CSs) seems to be mainly controlled by the nature of the parent material and less so by other factors (i.e. atmospheric entry parameters and bulk composition of the precursor). In conclusion, the textures of CSs provide a mean to identify quickly their parent body.

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Constraints from the West African Craton on Archean mantle dynamics

Determining the extent of mantle mixing during the Hadean-Archean is an integral factor in our understanding of early geodynamic processes and degree of mantle homogenisation. If a dynamic convecting mantle was the predominant regime it would be expected that early formed isotopic anomalies would be quickly homogenised, whilst in a stagnant lid regime these anomalies might last for hundreds of millions of years [1]. Using the short-lived ^{146}Sm-^{142}Nd chronometer, any ^{142}Nd anomalies that formed only during the first 500 Ma of Earth's history is subsequently remixed with the bulk mantle. Both positive and negative ^{142}Nd anomalies have been observed in rocks ranging from 2.7-3.9 Ga [2]. However, to determine whether these were local anomalies or are representative of the entire Earth requires that Archean rocks from other localities are also investigated. As such, we will present ^{142}Nd data on the 2.8-3.3 Ga ultramafic-TTG suite of the West African Craton.

The Amsaga area of the West African Craton is host to both silicic and mafic suites. The mafic amphibolites display typical flat incompatible element patterns, indicating little fractionation or secondary metamorphic enrichment. The silicic TTGs have typical incompatible element patterns with an enrichment in the most incompatible elements, due to their more evolved nature. The amphibolites yielded a ^{147}Sm-^{143}Nd isochron age of 3353±75 Ma, with initial εNd compositions ranging between +5.0 and +6.2 and zircon dating indicates an age of 2.6-2.9 Ga for the TTGs [3,4]. A positive initial εNd for the amphibolites suggest that the magmatic protolith evolved from an already differentiated source, making these samples a prime candidate for a ^{142}Nd investigation. The ^{142}Nd isotopic composition will provide constraints on timing of mantle mixing, as the ages observed throughout the suite will enable us to track the homogenisation of the local mantle through time.

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