Early Earth and ExoEarths: origin and evolution of life

Warsaw, Poland| 3-7 April 2017

Book of abstracts

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The organizers of the *Early Earth and ExoEarths: origin and evolution of life*, Warsaw, Poland 3-7 April, 2017 conference wish to express their thanks to:

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The City Marketing Office (Biuro Marketingu Miasta) for of promotion materials for the conference participants

Conference Programme

April 3rd, Monday

15.00-19.00 Registration in the Pałac Staszica (the location of the conference).
19.00 Ice breaking party in the Pałac Staszica (the location of the conference).

April 4th, Tuesday

8.30-9.00: Opening of Conference – welcome speeches :

Vice-President of the Polish Academy of Sciences : ***Paweł Rowiński***

Chair of the COST Action : ***Muriel Gargaud***

Director of the Institute of Geological Sciences : ***Ewa Słaby***

1) Session WG1-a: Structure and evolution of planetary systems – chaired by *Ewa Szuszkiewicz*

9.00-9.30: ***Papaloizou John, UK:*** Planet formation and the early evolution of planetary systems

9.30-10.30: **3 CT of 20' each**

1) **Bizzarro Martin, Denmark:** Early formation of planetary building blocks inferred from Pb isotopic ages of chondrules

2) **Gallet Florian, Switzerland:**Tidal dissipation in rotating low-mass stars and implications for the orbital evolution of close-in planets

3) **Gros Claudius, Germany:** Terrestrial life for habitable oxygen worlds

Coffee Break : 10.30-11.00

2) Session WG1-b: Interior, surface and atmosphere of exoplanets – chaired by *Florian Gallet*

11.00-11.30: ***Jørgensen Uffe, Denmark:*** Do habitable zone exoplanets have water?

11.30-12.00: ***Bolmont Emeline, France:*** Habitability around ultra-cool dwarfs

12.00-13.00: **3 CT of 20' each**

1) **Noak Lena, Belgium:** Habitable zone limitations for massive rocky planets

2) **Schulze-Makuch Dirk, Germany/USA:**The Challenges of Detecting a Truly *Earth-like* Planet

3) **Grenfell John Lee, Germany:** Effect of cosmic rays on atmospheric biosignatures in Earth-like atmospheres

13.00 - 14.30 lunch break and informal discussion

3) Session WG2-a: Complex molecules in space – chaired by *John Robert Brucato*

14.30-15.00: ***Testi Leonardo, Germany:*** Complex organic molecules with ALMA: tracing the origin of chemical complexity

4) Session WG2-b: The Prebiotic to Protolife Trajectory – chaired by *Terence Kee*

15.00-16.00: **3 CT of 20' each**

1) **Ashkenazy Gonen, Israel:** Emergence of Native Peptide Sequences in Early Chemical Evolution

2) **Clarke Paul, UK:** Potentially Prebiotic One-Pot Synthesis of 2-Deoxy-D-Ribose

3) **Greiner Andrea, Germany:** Adenosine Monophosphate Catalyzes Molecular Self-Assembly: Temporal Nanoconfined Water as a biochemical reaction vessel

16.00-16.30: coffee break

MC meeting: 16.30-19.30

16.30 Sightseeing old town Warsaw
20.00 informal dinner

April 5th, Wednesday

5) Session WG2-b: The Prebiotic to Protolife Trajectory – chaired by *Gonen Ashkenazy*

8.30-9.00: ***Powner Mathew, UK:*** System Chemistry: Selection Overcoming Prebiotic Clutter

9.00-10.40: **5 CT of 20' each**

1) **Pross Addy, Israel:** A Roadmap toward Synthetic Protolife

2) **Saladino Raffaele, Italy:** The mechanism of prebiotic meteorite-catalyzed nucleosides formation under proton irradiation

3) **Szymański Jan, UK:** Emergent properties of life-like vesicles produced by a photoinitiated membrane-forming polymerization process

4) **Kee Terence, UK:** Chemical transformations in silica hydrogel media

5) **Monnard Pierre-Alain, Denmark:** Evolution of membrane building blocks and their functions

Coffee Break: 10.40-11.10

5) Session WG3-a: Biogeochemistry: from the origin of life to extreme environments – chaired by *Emmanuelle Javaux*

11.10-11.40: ***Finster Kai, Denmark:*** Biogochemistry: from the origin of life to extreme environments

11.40-12.10: ***Amils Ricardo,Spain:*** The dark biosphere, metabolic challenges of the subsurface anaerobic world

12.10-13.10: **3 CT of 20' each**

1) **Pohorille Andrew, USA:** Flexible proteins at the origin of life

2) **Kotnik Tadej, Slovenia:** Assessing abiotic HGT as a driver of early evolution

3) **Lopez-Garcia Puri, France:** Exploring microbial life in the multi-extreme environment of Dallol, Ethiopia

13.10 - 14.30 lunch break and informal discussion

6) Session WG4-a: Habitability of Mars – chaired by *Akos Kereszturi*

14.30-15.00: ***Changela Hitesh, China:*** Affinities between Abiotic Organic Material from Chondrites and Natural Organic Material from Earth: Disambiguating Potential Biomarkers from Mars

15.00-16.00: **3 CT of 20' each.**

1) **Ciesielczuk Justyna, Poland:** How spheroidal hematite was formed on Mars: an experimental study

2) **Dębniak Krzysztof, Poland:** Water in the past of Ius Chasma (Valles Marineris, Mars): evidence from geomorphological mapping

3) **Kromuszczyńska Olga, Poland:** Water in the past of Hebes Chasma (Valles Marineris, Mars): evidence from landslide deposits' geomorphological investigation

Coffee Break : 16.00-16.30

7) 16.30-18.00: Early Career Investigator Session: 6 CT of 15' each – chaired by *Lena Noak*

1) **Cornet Yohan, Belgium:** Early eukaryote evolution: microanalyses of remarkable microfossils of the Late Mesoproterozoic–Early Neoproterozoic

2) **Loron Corentin, Belgium:** An exceptionally preserved and diverse assemblage of organic-walled microfossils from the Proterozoic of Arctic Canada.

3) **Sforna Marie Catherine, Belgium:** Metal distribution patterns in modern stromatolites: Keys to understand the fossil rock record

4) **Profitis Eleftherios, Belgium:** Image processing techniques for the autonomous mineral and pattern identification in planetary exploration

5) **Mazankova Vera, Czech Republic:** FTIR diagnostics of nitrogen-methane atmospheric glow discharge used for a mimic of prebiotic atmosphere

6) **Birski Łukasz, Poland:** The use of TEM and FTIR spectroscopy in isotope research of apatite from Archean Barberton Greenstone Belt.

18.00 - 20.00 poster session (see poster schedule below) + dinner buffet

April 6th, Thursday

8) Session WG3-b: Archean and Paleoproterozoic phosphorous cycle and phosphorite – chaired by *Ewa Słaby*

8.30-9.00: ***Albarede Francis, France:*** Water in the Earth-Moon system and the early cycle of nutrients

9.00-9.20: ***Lepland Aivo, Norway:*** Triggers of the first global phosphorite formation two billion years ago

9.20-9.40: ***Wirth Richard, Germany:*** Microbially mediated apatite nucleation:TEM applications

9.40-10.00: ***Giera Alicja, Germany:*** Many secrets of Archean apatite – hydrogen isotopic study of apatite from Isua, SW Greenland

Coffee Break : 10.00-10.30

9) Session WG4-b: Solar System Exploration – chaired by *Elias Chatzitheodoridis*

10.30-11.00: ***Leszek Czechowski, Poland:*** Enceladus subsurface ocean and possible thermodynamic aspects for life there

11.00-11.30: **Pohorille Andrew, USA:** What would constitute evidence for life on icy moons?

11.30-12.30: **3 CT of 20' each**

1) **Kaczmarek Łukasz, Poland:** Can tardigrades theoretically survive on Mars?

2) **Keresztury Akos, Hungary:** Paleo-environment indicators of Mars – focus points for next astrobiology missions

3) **Losiak Anna, Poland:** Small amounts of ephemeral liquid water in polar regions of Mars

12.30 - 14.00 lunch break and informal discussion

14.00 - 18.00 excursion to The Royal Castle (Old Town) and a summer residence of the last Polish king Stanisław August Poniatowski – Łazienki
19.00 (Wilanów) Conference dinner

April 7th, Friday

10) WG5: "Societal issues in astrobiology" – chaired by *David Dunér*

9.00-9.30: **Waltmathe Michael, Germany:** Beyond the surly bonds of Earth: Religion and the Challenges of Human Space Exploration

9.30-10.00: **Lazcano Antonio, Mexico:** The RNA Word: stepping out of the shadows

10.00-10.40: **2 CT.**

1) **Milligan Tony, UK:** Anxiety about Discovery

2) **Capova Klara Anna, UK:** Astrobiology and Society in Europe today

Coffee Break: 10.40-11.10

11.10-12.30: European Astrobiology Institute discussion and Conference closure

12.30 – 14.00 Lunch

<u>Poster session schedule:</u>

Daszykowski Grzegorz, Poland: PW-Sat2 - Polish student satellite project

Demaret Lucas, Belgium: Raman spectroscopy investigation of fossil fumaroles: from bulk material to crushed powder analysis in preparation for ExoMars 2020

Dessimoulie Lucile, France: Iron isotopes composition of the oceanic lithosphere during fluid-rock interactions

Ferrari Franco, Poland: Is ionizing radiation of cosmic origin (Galactic Cosmic Radiation and Solar Energetic Particles) an obstacle for the exploration of the Solar system by human missions?

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

Haidău Cătălina, Romania: Preliminary data on the microbal diversity of two underground ice blocks

Holinger Seraina, Netherlands: Studying the Effect of UV-Radiation on Organic Carbon in Meteorites

Hrušák Jan, Czech Republic: Towards theoretical description of state-selected reaction $[CH_4 + O \rightarrow CH_3 + OH]^+$

Kaźmierczak Józef, Poland: Archean eukaryotes from South Africa: A farewell to some paradigms of precambrian paleobiology?

Krcma Frantisek, Czech Republic: Application of PTR-MS for determination of compounds formed in Titan like gaseous mixtures by electrical discharges

Kruszewski Łukasz, Poland: Coal fires – Titan – interstellar medium – life: what do they have in common? Potential gaseous bio-precursors in burning mining heaps

Laine Pauli, Finland: The evolution and distribution of complex molecules and their implications to the earlies point of life in the Universe (working title)

Letho Kirsi, Finland: Origin of Life - promoting conditions on the early Earth

Lopez-Garcia Puri, France: Microbial eukaryotes in the Movile Cave chemosynthetic ecosystem

Piast Radosław, Poland: Origin of Life and the Phosphate Transfer Catalyst

Roszkowska Milena, Poland: Monitoring of mitochondria activity during desiccation: Is the anhydrobiosis a key to colonization of waterless exoplanets and moons?

Stavrakakis Hector-Andreas, Grece: An electrokinetics concept for handling underground water on Mars

Strbak Oliver, Slovakia: Magnetotaxis and early life forms (Why geomagnetic navigation matters)

Świeżyński Adam, Poland: In search for the deepest philosophical background of contemporary origin of life theories

Tautvaišienė Gražina, Lithuania: Spectroscopic and Photometric Survey of Northern Sky for Exoplanetary Research

Trixler Frank, Germany: Nucleotide Catalysis of Molecular Self-assembly in Mineral Nanoconfinements of Water

Trunec David, Czech Republic: Kinetic model for chemical reactions in CH_4-N_2 mixture with oxygen containing admixtures for study of prebiotic atmosphere

Žabka Jan, Czech Republic: Anion Chemistry in Titan: systematic studies of the growth and stability of large negative ions

Zalewska Natalia, Poland: Laboratory experiments of Martian Cryogenic processes.

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Water in the Earth-Moon system and the early cycle of nutrients

Albarede F.[1]

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It is now clear that the Moon formed early, i.e., within the first 60 Ma after the birth of the Solar System (Barboni et al., 2017) and therefore that the major event fractionating terrestrial volatile from refractory elements took place another 50-100 Ma later. In addition, the discrepancy between the amounts of volatile elements present in the Moon and in the Earth is a strong indication that most of the terrestrial H, C, N, and to a lesser extent less volatile elements such as S, were brought to Earth by the accretion of a small number of large objects, possibly one single body similar to the water-rich satellites of the outer planets of the Solar System. Evidence of Sr and Zn isotopes and geological observations indicate that prior to the Great Oxygenation Event 2.4 Ga ago the surface area of continents above sea level was small compared to modern continents, at least over long periods of time. Such a situation exerted a tight control on the chemistry of the ocean and the environment in which life may have sprung out. For the pH of the ocean to be high enough for carbonate to precipitate and for amino acids to be functional, a continuous flux of alkalinity through the ocean is needed, which is provided today by the combined chemical and mechanical erosion of subaerial continents and carbonate precipitation. Likewise, life survival relies on steady fluxes of nutrients to the ocean, especially those of phosphate, which are also fed by the erosion of subaerial continental and volcanic expanses. Hydrothermal vents are widely seen as a source of H_2 and as a potential site for early life. It must therefore be emphasized that the water boiling point in hydrothermal systems rapidly increases with water depth while the pH of hydrothermal solutions decreases. Warm and near-neutral vents spouting hydrothermal solutions into nutrient-rich seawater represent the most favorable environment for the emergence of life. An additional requirement is that this environment must be geologically stable. These constraints suggest that, in the absence of large expanses of subaerial continents, the first biotic activity appeared on long-lived oceanic shoals with abundant hydrothermal activity, presumably fore-arc basins and oceanic plateaus, and therefore that plate tectonics was instrumental in the emergence of life.

The dark biosphere, metabolic challenges of the subsurface anaerobic world

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Although Darwin predicted the existence of deep subsurface ecosystems almost two hundred years ago, the first study of a basalt aquifer was reported only two decades ago. The new frontier in biology is continental subsurface geomicrobiology, it seeks to determine whether life can be sustained in the absence of solar radiation. Subsurface ecosystems are also interesting astrobiological models, useful in the re-creation of early life scenarios or to ascertain its possible existence on other planets. Despite the progress made in recent years, information concerning diversity, microbial abundance and sustainability in deep subsurface hard rock systems is still scarce, mainly due to methodological limitations.

Most of the geomicrobiological results of deep subsurface drilling studies have been generated by a combination of techniques (ionic and gas chromatography, elemental analysis by ICP-M and TXRF, mineral identification by XRD, stable isotope fractionation, enrichment cultures, 16S rRNA gene cloning, massive sequencing, metagenomics, immunological detection), many of which require a substantial amount of sample for the analysis, providing only global environmental information. Bulk information cannot provide insight into the possible coexistence, for instance, of competitive metabolic activities such as methanogenesis and acetogenesis. Only in micro-niches can the diverse optimal conditions, required by these metabolisms to function, exist in close proximity. Fluorescence in situ hybridization techniques are in this case much more informative as they facilitate the visualization of these micro-niches and the operation of biogeochemical cycles.

The recently completed Iberian Pyrite Belt Subsurface Life Detection project (IPBSL) identified and characterized the high level of metabolic diversity associated to this ecosystem, responsible for the origin of the extreme acidic conditions found in Río Tinto, a geochemical and mineralogical terrestrial analogue of Mars. In the IPB subsurface, H_2 is one of the most important sources of energy, allowing most important biogeochemical cycles (C, N, S, Fe) to operate at different depths. These results are not only of interest to understand how the subsurface ecosystems operate but for the design of future exploratory missions to Mars.

Acknowledgments:
To the IPBSL team for their outstanding work and the IPBSL ERC grant 250350 that make it possible.

Emergence of Native Peptide Sequences in Early Chemical Evolution

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The synthesis of specific protein sequences in living cells is accomplished via an elaborate machinery, which was obviously not applicable during amino acid polymerization on the early Earth. Scientists are consequently striving to identify mechanisms by which functional polymers were selected and further amplified from complex prebiotic mixtures. Using our peptide β-sheet self-assembly and self-replication system [1-5] we report the instrumental role of non-enzymatic replication in the enrichment of certain product(s) within prebiotically relevant mixtures. We present the complex web of reactions, focusing on the effects of the initial conditions, the stability of the intermediate compounds, and template-assisted replication. Remarkably, we have recently found that the formation of several products in a mixture is not critically harmful, since efficient and selective template-assisted reactions, driven by these products, serve for error correction, thus keeping the concentration of the peptide containing the native backbone equal to, or even higher than, the concentrations of the other products. We suggest that these new findings may shed light on molecular evolution processes that led to current biology.

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The use of TEM and FTIR spectroscopy in isotope research of apatite from Archean Barberton Greenstone Belt

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Although, there were numerous papers focused on the problem of origin of water and other volatiles on the Earth, especially on D/H ration of various water reservoirs, e.g. comets and meteorites (Pinti, 2005), topic still remains a matter of controversy. The newest research are focused on D/H and $^{37}Cl/^{35}Cl$ ratios of terrestrial apatite crystals from Archean Greenstone Belts as a mineralogical indicators of volatile evolution of the Earth (Giera et al., 2016). Unfortunately, since analyzed apatite crystals are very old, with a long history of post-formation processes, it is crucial to have knowledge on growth and transformation textures. It has to be proved that the structure is unaffected by such processes before any interpretation might be made. This study presents research made on apatite crystals from different environments from Barberton Greenstone Belt using TEM, FTIR and Raman spectroscopy. TEM observations made on apatite crystals of mantle origin revealed lack of porosity or solid and fluid inclusions. Only single dislocations were noticed. Furthermore, Raman spectra revealed presence of carbonate band (Awonusi et al., 2007). The height of the peak indicates concentration of CO_3^{2-} of about 0.03 wt. %. FTIR spectra of OH-band region revealed presence of bands of OH_{Cl}, OH_F, OH_{OH} and of Mn-OH_F and probably of Sr-OH_F or Mn-OH_{OH} in some of the crystals. Moreover, quantified using IR calibration of Wang et al. (2011) hydrogen content was 0.06 – 0.20 wt. %. TEM observations of apatite crystals from cherts and BIF present wide range of features. In case of some samples fluid inclusions and, associated with pores, highly elongated iron sulfide inclusions, a clear indicators of secondary alterations, were observed, whereas in other samples only micro- and nano-size inclusions of iron oxide and growth features such as parallel dislocations and low angle grains boundaries were noticed. FTIR spectra revealed presence of strong band of OH_F and much weaker of Mn-OH_F and of Sr-OH_F or Mn-OH_{OH}, and OH_{OH} in case of some crystals. Quantified hydrogen content was 0.14-0.16 and 0.04-0.05 wt. % in case of BIFs and cherts, respectively. For comparison apatite crystals of clearly hydrothermal origin were also examined using TEM. Observation revealed presence of REE-phosphate inclusions, as well as porosity, dissolution zones and, created by migrating fluids, channel-like structures. Furthermore, analyses indicate very low content of both hydrogen and chlorine, and high of fluorine in case of apatite crystals of hydrothermal origin.

Acknowledgments:
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Early formation of planetary building blocks inferred from Pb isotopic ages of chondrules

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In the standard model, the formation of planets occurs in stages where small dust particles coalesce into 10-100 km diameter planetesimals, which collide to form planetary embryos and planets over timescales of 50 to 100 millions years (Myr). Recent astronomical observations of young protoplanetary disks suggest much more rapid timescales for the growth of planetary cores. Indeed, detailed imaging of the <1 Myr HL Tau protoplanetary disk has revealed the presence of ring structures that are interpreted to reflect the early stages of planet formation [1]. These rapid timescales are in keeping with newer models of planet formation where planetary growth is fuelled by pebble accretion [2]. In the solar system, a record of the earliest stages of planet formation may be preserved in chondrites, which are fragments of asteroids that avoided melting and differentiation. The most abundant constituent of chondrites are chondrules, millimetersized glassy spherules formed as free-floating objects by transient heating events in the solar protoplanetary disk. Recent simulations indicate that the main growth of asteroids can result from the gas-drag-assisted accretion of chondrules [3], a process analogous to pebble accretion. In these models, the largest planetesimals of a population with a characteristic radius of ~100 km undergo run-away accretion of chondrules forming Mars-sized planetary embryos within a timescale of ~3 Myr. If chondrules represent the building blocks of planetary embryos and, by extension, terrestrial planets, understanding of their chronology and formation mechanism(s) is critical to determine at which time in the solar system evolution were conditions favourable to forming planetary bodies.

Our data-set of U-corrected Pb-Pb dates of 22 chondrules define ages ranging from 4567.61±0.54 to 4563.24±0.62 Ma, with ~50% of chondrules having formed <1 Myr after Solar System formation at 4567.30±0.16 Ma [4]. An abundance of chondrules with ages within 1 Myr of Solar System formation suggest that the production of chondrules may have been more efficient at early times. The chondrule ages are correlated to their their initial Pb isotope compositions, with younger chondrules recording evolved compositions indicative of a complex thermal pre-history relative to older chondrules. We infer that primary chondrule production was restricted to the first million years of disk evolution whereas the younger chondrules reflect remelting and recycling of first generation chondrules for ~3 Myr. This is consistent with astronomical observations indicating that replenishment of fresh dust to the disk is limited to the embedded stage of star formation lasting <1 Myr [5]. The energy responsible for chondrule production and subsequent recycling may have shifted from shocks associated with spiral arms in a young gravitationally unstable disk to planetary bow shocks and collisions at later times. Our new chronological framework is in keeping with chondrules being a key ingredient driving the efficient and early formation of planetary bodies.

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Habitability around ultra-cool dwarfs

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The very recent discovery of planets orbiting very low mass stars such as Proxima-b (Anglada-Escudé et al., 2016) and the TRAPPIST-1 system (Gillon et al., 2016, 2017) sheds light on these exotic objects. Planetary systems around low-mass stars and brown dwarfs (or ultra-cool dwarfs) are very different from our solar system: the planets are expected to be much closer than Mercury, in a layout that could resemble the system of Jupiter and its moons. The recent discoveries point in that direction with, for example, the system of Kepler-42 (Muirhead et al., 2012) and especially the system of TRAPPIST-1 (Gillon et al., 2017) which hosts planets in a mean motion resonance configuration comparable to the one of the moons of Jupiter.

Ultra-cool dwarfs are thought 1) to be very common in our neighborhood and 2) to host many planetary systems (e.g., Bonfils et al., 2013). As is the case for TRAPPIST-1, we expect that ultra-cool dwarfs can host a suite of small rocky planets. The planets orbiting in the habitable zone of these objects thus represent one of the next challenges of the following decades. Understanding the dynamical evolution of such systems and investigating their possible climates is now necessary. Indeed, planets in the habitable zone of ultra-cool dwarfs are the only planets of the habitable zone whose atmosphere we will be able to probe (e.g., using transit spectroscopy with the JWST).

Acknowledgments:
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Astrobiology and society in Europe today. The white paper on societal implications of astrobiology research in European context

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The talk presents recent work of Working Group 5 Philosophy and History of Science, of COST Action Life-ORIGINS TD1308 and introduces the latest draft of the White Paper on societal implications of astrobiology research in European context, ‘Astrobiology and Society in Europe Today.’

The talk introduces the latest version of the White Paper, version 4, and gives a detailed overview of sections added in 2016. This include, but are not limited to, contributions of astrobiology to society, advancement of science in Europe, environmental protection and the quest for sustainability, as well as societal challenges from astrobiology, and potential conflicts of interest between astrobiology and commercial use of space.

Furthermore, it will illustrate the contemporary perceptions of astrobiology by general public and the timely role of an organised initiative in astrobiology education and popularisation of science.

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The editors would like to acknowledge the members of the Life-ORIGINS TD1308 who contributed to the Astrobiology White Paper to date.
The White Paper is edited by Klara Anna Capova, David Duner (Department of Arts and Cultural Sciences, Lund University, Sweden) , and Erik Persson (Center of Theological Inquiry, Princeton, USA; and The Pufendorf Institute of Advanced Studies, Lund University, Sweden).

Affinities between Abiotic Organic Material from Chondrites and Natural Organic Material from Earth: Disambiguating Potential Biomarkers from Mars

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Chondrites are samples of early planetesimals. The major form of organic material delivered to Earth and Mars by early planetesimals is insoluble organic matter. Insoluble organic matter is macromolecular organic material. It comprises 70-99 wt. % of the total organic carbon in chondrites (Pizzarello et al., 2006). It also makes up the major fraction of organic carbon in the Earth's crust. In primitive chondrites, insoluble organic matter occurs within their matrices as micron to nanoscopic-sized particles intermixed with inorganic materials (e.g. Le Guillou et al. 2014).

Aqueous alteration and mild thermal metamorphism involving chondritic organic material both describe the geophysical and geochemical evolution of organic material on early planetesimals (e.g. Cody et al., 2008; Changela et al., 2015). We have been characterizing the morphology, functional chemistry and microscopic setting of chondritic solid organic material *in situ* using coordinated synchrotron X-ray and electron microscopy techniques (Changela et al., 2014; Changela et al., 2015). Chondritic organics display some geochemical affinities with natural organic material from Earth, such as kerogen from both shales and early microfossils. For example, chondritic organic material displays some chemical affinities (Bernard et al. 2012) and thermal maturation trends (Bower et al., 2013) similar to those found in these Earth based natural organic materials.

The delivery of organic material to the surface of Mars exogenous in origin is evident; its surface is peppered by impact craters produced mostly by fragments of early planetesimals. Furthermore, the flux of chondritic material delivered to the surface of Mars when compared with that of the Earth is higher (Bland and Smith, 2000). The need to therefore disambiguate biogenic organic material from that formed via either abiotic processes on the surface of Mars or delivered directly by early planetesimals is paramount in the search for biomarkers from the red planet.

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How spheroidal hematite was formed on Mars: an experimental study

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Hematite spherules ('blueberries') are commonly found lying on the Mars surface, gathering at the bottoms of, e.g., the Meridiani Planum, Aram Chaos, Chryse Planitia, Eagle, Endurance, and Victoria Craters (Calvin et al., 2008 and references herein). They were found and investigated by Mars Odyssey, Mars Global Surveyor, Mars Exploration Rover and other Marsian missions. The mechanism of their formation on Mars is still not explained in detail and there is no single terrestrial analog that is consistent with all that is known about the blueberries. We have noted morphological similarities with hematitic spherules formed during fires in coal-waste dumps

In the self-heated and self-ignited Marcel dump in Silesia, Poland, exhalated hematite is ubiquitous. Most of this hematite occurs in botryoidal clusters filling cavities. It is associated with hydrated sulphates and chlorides of K, Na, Al, Ca, Mg and NH_4. Some occur in the form of discrete spherules that mirror the morphology of those photographed on Mars, except that spherules are smaller even than "mini"-spherules observed inside the Eagle Crater (Calvin et al., 2008).

Experiments conducted to the formation of hematite with spherulitic shapes involved acid-sulfate brines synthesized at temperatures up to 200ºC (Golden et al. 2007). Our experiments centered on goethite, a major and widespread source of iron in the coal-waste dumps. To enable the replication of experimental conditions, synthetic goethite, α-FeOOH, was produced according to the reaction: $FeCl_3 + 3\ KOH = Fe(OH)_3 + 3KCl$. The precipitate was washed with distilled water to remove chlorine ions and dried. Some 30 experiment' variants of the experiment were performed to determine if hematitic spherules could be generated. Open-system heating was carried out at temperatures of 150ºC, 450-500ºC, 600-650ºC, 700ºC and 900ºC over time periods of 24 and 90 hours, and 7 days. Sal ammoniac, phtalimide, elemental sulphur, iron sulphide, naphthalene, coal waste, and water were included as additives. Closed-system heating was carried out under pressure in the presence of water and $AlCl_3$ or NaCl at 200ºC for 7 and 14 days. Nickel, manganese and ferric salts were added to these reactive mixtures. Minute hematite spherules were formed only when nickel was added. In terrestrial environment Ni is associated with basic rocks and ores associated with them. Also Marsian spherules show a minor NiO impurity. Many of the individual 'blueberries' and waste-dump nodules are characterized by single (peach-like) sutures. This feature may indicate progressive enclosure and final complete encapsulation of a spherical nucleus of some sort.

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Potentially Prebiotic One-Pot Synthesis of 2-Deoxy-D-Ribose

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In this lecture we report that esters and nitriles of proteinogenic L-amino acids promote the selective formation of 2-deoxy-D-ribose over 2-deoxy-D-threopentose from acetaldehyde and D-glyceraldehyde under aqueous conditions. The one-pot formation of 2-deoxy-D-ribose from formaldehyde, glycolaldehyde and glyceraldehyde, promoted by esters of proteinogenic L-amino acids has also been demonstrated. Thus for the first time, we report a plausible, one-pot, two-step potentially prebiotic pathway to convert simple interstellar building blocks into 2-deoxy-D-ribose.

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Early eukaryote evolution: microanalyses of remarkable microfossils of the Late Mesoproterozoic–Early Neoproterozoic

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The Late Mesoproterozoic–Early Neoproterozoic is an important period to investigate the diversification of early eukaryotes, prior to large "snowball Earth" glaciations and during time of changing ocean chemistry and supercontinent formation and breakup. Proterozoic fossils related to crown group eukaryotes include red algae, green algae, amoebozoa, putative fungi, and the first animals (Knoll et al, 2006; Butterfield, 2015). However most Proterozoic microfossils of unambiguous eukaryotes remain unidentified, and include biomineralized scales, vase-shaped microfossils, macroscopic remains, and microscopic organic-walled vesicles (acritarchs). The latter includes distinct forms such as ~820-720 Ma *Cerebrosphaera buickii,* 1100-720 Ma *Trachyhystrichosphaera aimika, T. botula*, and the multicellular 1100-720 Ma *Jacutianema solubila*. To characterize the taxonomy of these microfossils and test hypotheses about their paleobiology, and possible relationships to crown groups, we combine analyzes of their morphology, wall ultrastructure and microchemistry, using optical microscopy, Scanning and Transmission Electron microscopy (SEM, TEM), and Raman and FTIR microspectroscopy respectively.

Cerebrosphaera from the Svanbergfjellet Fm, Spitsbergen and the Kanpa Fm, Officer Basin, Australia, include organic vesicles with dark 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.

The genus *Trachyhystrichosphaera* includes species characterized by the presence of a variable number of hollow heteromorphic processes (Butterfield *et al.,* 1994). FTIR microspectroscopy analyzes performed on the two species from the 1.1 Ga Taoudeni Basin, Mauritania, and the ~1.1-0.8 Ga Mbuji-Mayi Supergroup, RDC, indicate a strong aliphatic and carbonyl composition of the wall biopolymer. TEM permits to characterize the wall ultrastructure on these two species and morphometric analyze constrain their morphological diversity and plasticity.

Various morphotypes of the species *Jacutianema solubila* from the Svanbergfjellet Fm, Spitsbergen and from the Taoudeni Basin, Mauritania, are also characterized using microspectroscopy and electronic microscopy techniques to test previous hypothesis proposing that *Jacutianema* represents part of the life cycle of a Vaucherian alga (Butterfield, 2005).

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Enceladus as a cradle for the life in the Solar System

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Introduction.

Enceladus is a medium sized icy satellite (MIS) of Saturn. MIS are built of mixtures of rocks and ices. Enceladus with its radius of 250 km is the smallest geologically active body in Solar System. We consider the interior of early Enceladus as a possible cradle of the life.

Conditions in early core of Enceladus.

Czechowski (2014) considered the process of core forming in Enceladus. He found that the result of differentiation is a lukewarm core of loosely packed grains with water between them. It makes the process of serpentinization possible. After Abramov and Mojzsis (2011) it could be: Mg_2SiO_4 + $MgSiO_3$ + $2H_2O$ -> $Mg_3Si_2O_5(OH)_4$. Czechowski (2014) indicates that the total mass of silicate in Enceladus is ~6.97 $\times 10^{19}$ kg.

The serpentinization is probably an important source of energy for primitive life. According to Russell et al. (2010): "For life to have emerged […], a sustained source of chemically transducible energy was essential. The serpentinization process is emerging as an increasingly likely source of that energy" (see also Izawa et al., 2010).

The pressure in the center of Enceladus is ~2.3 10^7 Pa, therefore the entire its core was permeable for liquids and gases - Czechowski (2014). This could lead to formation of hydrothermal convective systems. Note that in Enceladus the most of silicate could be serpentenized. For dozens of Myr conditions in the core were preferable for the origin of life.

Proliferation of the life.

The volcanic activity could transport organisms from the core to the surface of early Enceladus. The form of this activity could be essentially the same as the present. The existence of E-ring proves that cryo-volcanic jets eject gas and solid particles (possibly with primitive organisms) into orbit around the Saturn.

The gravity assist could be responsible for acceleration of solid particles from the orbit around the Saturn into orbit around the Sun. The existence of several satellites of Saturn increases the probability of this mechanism.

On the orbit around the Sun the small grains could decelerate as a result of Poynting-Robertson mechanism. Other mechanisms, like gravity assist, could be responsible for deceleration of larger bodies. Deceleration leads the particle to move closer to the Earth and other terrestrial planets.

The particle with small ratio of mass to their cross section could decelerate in upper atmospheres of terrestrial planets without substantial increase of temperature. Larger bodies during deceleration could partly evaporate that reduce their temperature increase.

In terrestrial condition the primitive organism could evolve into present forms of life.

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PW-Sat2 – Polish student satellite project

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Deorbitation of satellites is now increasingly hot topic because of still grownig amount of "space debris" in orbit. These so-called space junk includes spent rocket stages, old satellites, and small fragments from the collision of satellites (such as the one in February 10, 2009, when there was a collision between functioning satellite Iridium 33 and inactive satellite Kosmos 2251). As a result of such event a lot of small parts are deployed into space, which are a great threat for operating spacecrafts. Adaptation of deorbitation systems into all the spacecrafts would prevent such unfortunate events.

The PW-Sat2 mission is to test two innovative engineering solutions for deorbitation system and sun sensor device. Satellite is made of several subsystems: Thermal Control System (TCS) – responsible for general heat management in the satellite (in a lack of convection).

Electrical Power System (EPS) is responsible for power conversion from solar panels, energy storage in battery and power distribution to other subsystems. It is designed and it will be built by the EPS team of the PW-Sat2 project. Solar arrays are the main source of energy of PW-Sat2.

Communication (COM) Team has the task of preparing our satellite to send and receive signals from ground station. Communication module will contain 2 omnidirectional half-duplex antennas for VHF and UHF frequencies and a unit controlling data transfer. Antennas will be used to receive telecommands by the satellite, sending information about the state of the satellite, data from Sun Sensor and photos made by on-board cameras.

Everything is controlled by On-board Computer (OBC). It processes commands received from Earth, monitors power budget, automatically does tasks based on built-in schedule and receives data from camera(s).

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Water in the past of Ius Chasma (Valles Marineris, Mars): evidence from geomorphological mapping

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Ius Chasma is a 850-km long trough located in the western part of Valles Marineris, Mars. Among twelve chasmata constituting the Valles Marineris system, only Ius and Echus Chasmata do not contain fully developed Interior Layered Deposits (ILDs) of aqueous origin. Instead of ILDs' mounds, Ius Chasma is the host of numerous planar bright, layered deposits located within walls and floor of the trough, as well as is surrounded by Light-toned Layered Deposits (LLDs) on the adjacent plateau. The bright deposits display visible layering and high erodibility. The geomorphological inventory of water-related features found in Ius Chasma includes also sixty-six sinuous, finger-shaped sapping channels (of large, simple, and remnant types), several fluid leakages on the northern chasma wall (probable Recurring Slope Lineae), three alluvial plains with sinuous and branched channels, and lacustrine benches located in the southern chasma graben. Geomorphological investigation of Ius Chasma demonstrates at least two episodes of glacial activity in the past of the trough. The older valley glaciers produced trimlines, basal escarpments, and glacial benches in the central part of the trough. The western area of Ius Chasma contains younger glacial deposits, including moraines, till plains, and outwash plains, which flowed into the chasma from Noctis Labyrinthus. All water-related features indicate a complex and long aqueous history of Ius Chasma (Dębniak et al. 2017).

Presented results are based on geomorphological mapping. The mapping was performed on the background dataset composed of one hundred images from Mars Reconnaissance Orbiter Context Camera. The images were mosaiced in Integrated Software for Imagers and Spectrometers. The mapping procedure was conducted in ArcGIS.

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Raman spectroscopy investigation of fossil fumaroles*: from bulk material to crushed powder analysis in preparation for Exomars 2020*

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In preparation for the forthcoming exploration missions to Mars, a selection of terrestrial samples is thoroughly investigated. These samples are representative of the Martian conditions and known as Mars analogues. Amongst them, hydrothermal sites have been proposed as relevant analogues of past aqueous Martian environments (Schulze-Makuch *et al.*, 2007). The geological and mineralogical description of hydrothermal features (hotsprings, fumaroles, geysers) is important as their activity is compatible with some hypotheses on prebiotic chemistry and the emergence of early lifeforms. Especially, fumaroles have not been widely described in the literature, though they are reported on Earth as an extremophile rich-habitat and they are suggested to be present on Mars (Hausrath *et al.*, 2013). We propose to provide a comprehensive description of fossil fumarole samples (from Spanish marine sediments of upper Miocene) (Frias *et al.*, 1992). These fossil materials are representative samples of ancient hydrothermal sites in which we are searching for organic signatures and potentially preserved biomarkers. The sample substrate is a marl (carbonates-clays), which is an interesting combination of (a) a hydrothermal carbonate material identified previously as a sedimentary rock reference (Bost *et al.*, 2013) and (b) a clay-bearing deposit relevant to the mineralogy of landing sites proposed for future exploration mission to Mars. The sample characterisation is performed by Raman spectroscopy and supported by SEM imaging which brings molecular and mineralogical, and textural information respectively. Eventually, the fumarole will be crushed into a homogeneous powder to assess the information retained when multipoint scanning measurements are performed on the surface of the crushed sample, which is representative of the operation procedure of the ExoMars Raman Laser Spectrometer (RLS) (Lopez-Reyes *et al.*, 2013).

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Iron isotopes composition of the oceanic lithosphere during fluid-rock interaction

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Fluid-rock interactions at mid-oceanic ridges, due to seawater infiltration, lead to major changes in the chemical composition and redox conditions of seawater (becoming hydrothermal fluids), and mafic (basalts and gabbros) to ultramafic rocks (mantle peridotites) that compose the oceanic lithosphere.

Iron is one of the major elements that are affected by fluid-rock interaction processes. Present in very small amounts in the ocean (ppm), it is a good tracer of the hydrothermal activity (Johnson and Beard, 2006). The iron isotope composition of a system strongly depends on the redox conditions and the type of reactions that affect it, e.g. oxidation fractionates preferentially the heavy Fe isotopes (Johnson et al, 2002). Therefore, understanding the behavior of iron isotopes during alteration of the oceanic lithosphere, and more precisely during serpentinization of mantle peridotites, would be a key in reconstructing the redox conditions during oceanic rocks formation and subsequently the behavior of iron in subduction zone (Debret et al., 2016).

The South West Indian Ridge (SWIR) is one of the slowest ridges on Earth (4mm/yr). Its magmatic activity is nearly inexistent, which allows the study of serpentinization processes without a magmatic influence (Cannat et al., 2008). A selection of 19 samples coming from the SMOOTHSEAFLOOR campaign (2010) was characterized petrographically and geochemically. The petrographic and bulk-rock chemical data indicate that most of these rocks are serpentinized harzburgites, a few are serpentinized dunites. Primary minerals were partially or totally replaced by mesh and bastite serpentine, along with magnetite and clays. Sulfides, mainly present as pentlandite and millerite, hematite, metallic iron, and carbonates complete the secondary mineral assemblages.

Bulk rock iron isotopes compositions reveal that most of the serpentinites belong to the range of abyssal peridotites, as defined by Craddock et al. (2013). However, some of them show a stronger enrichment in ^{56}Fe, with δ^{56}Fe values up to 0.21‰. Those serpentinite samples underwent the strongest alteration, according to their Fe^{3+}/Fe_{total} ratio. This would be consistent with the study of Rouxel et al. (2003) reporting an enrichment of the oceanic crust in heavy Fe isotopes.

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Is ionizing radiation of cosmic origin (Galactic Cosmic Radiation and Solar Energetic Particles) an obstacle for the exploration of the Solar system by human missions?

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Ionizing radiation poses a serious threat to manned space missions outside the magnetosphere of the Earth. In this poster missions to the Moon, Mars and Near-Earth Objects will be considered. The results of a research aimed to characterize the doses of ionizing radiation that could be absorbed during missions of this type and their effects are presented. Certain gaps in knowledge that presently militate against mounting viable human exploration in deep space due to the inherent health risks are identified. Recommendations of how to fill these gaps with the help of international cooperation and how to mitigate the hazards to human health due to energetic particle irradiation and galactic cosmic rays beyond low earth orbit/BLEO are proposed.

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Biogeochemistry: from the origin of life to extreme environments

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Is life a singularity or does it emerge in a continuum under the right environmental conditions? This is one of the key questions that astrobiologists dream of solving by exploring the solar system as well as exoplanets of which the first was discovered about 25 years ago.

The search for life in the universe goes hand in hand with studying the emergence of life on Earth, one of the great enigmatic questions of mankind. Already Aristotle was speculating about the origin of life and proposed the spontaneous generation of eels from mud, a logic conclusion as the life cycles of eels was unknown 2500 years ago and only adult eels had been observed. Later it became evident that organisms need organisms to reproduce, and it were the studies of Pasteur that demonstrated that even microbes, the most primitive of all organisms, could only originate from microbes. Pasteur rejected the idea of spontaneous generation by his famous swan-neck-bottle experiment. Nevertheless, knowing now that the universe came into being by what we call the "Big Bang" and did not existed forever, also life must have had its Big Bang and most have appeared out of the mists of organic and inorganic chemistry.

This leaves us with the question:" How, where and when did life originate?" Religions are founded on the assumption that a supernatural being initiated the origin of life by a single act of creation. Science to the contrast does not except supernatural interference but builds on the assumption that the origin of life has to be in agreement with the laws of physics and the rules of chemistry and can therefore be studied, understood and in principal reconstructed in vitro.

In this lecture entitled "Biogeochemistry: from the origin of life to extreme environments" I will present some of the recent ideas about the origin of life and discuss their basic assumptions. I will introduce Gilberts "RNA world" [(1)] and Russells "Sulphur World"[(2)] and discuss the concepts in relation to the role of extreme environments in the origin of the last universal common ancestor (LUCA).

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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)

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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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Tidal dissipation in rotating low-mass stars and implications for the orbital evolution of close-in planets

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Close-in planets represent a large portion of the population of confirmed exoplanets. To understand the dynamical evolution of these planets, star-planet interactions must be taken into account. In particular, the dependence of the tidal interactions on the structural parameters of the star and its rotation should be treated in the models. In this work we estimated how the tidal dissipation in the convective envelope of rotating low-mass stars evolves as a function of their mass, evolutionary phase, and rotation rate from the pre-main sequence up to the red-giant branch at solar metallicity. We also investigated the possible consequences of this evolution on planetary orbital evolution.

We coupled the method described in Mathis (2015) to the stellar evolution code STAREVOL for rotating stars ranging from 0.3 to 1.4 M⊙. In addition, we generalized the work of Bolmont & Mathis (2016) by following the orbital evolution of close-in planets using these new tidal dissipation predictions for advanced phases of stellar evolution and also investigated the effect of a change of stellar metallicity on this evolution.

The evolution of the dissipation strongly depends on both the evolution of the internal structure and rotation of the star. During the lifetime of the star, it varies over several orders of magnitude, which has a strong consequence for the orbital evolution of close-in massive planets. These effects are the strongest during the pre-main sequence, which means that the planets are mainly sensitive to the star's early rotation history.

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Many secrets of Archean apatite – hydrogen isotopic study of apatite from Isua, SW Greenland

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The study of the earliest ecosystems, and in particular the study of abiotic processes, is crucial for understanding how life has shaped the Earth and also, perhaps, other planets. Examination of the oldest minerals should bring new light on this topic. Therefore, early Archean apatite, which has yet to be investigated as a source of information on volatiles on Early Earth, is the object of our research. In sedimentary environments apatite $Ca_{10}(PO_4)_6(OH,Cl,F)_2$ forms from a Ca phosphate precursor, while magmatic apatite crystallizes directly from a magma. One of the oldest geological formations in which apatite crystals are abundant is the Isua supracrustal belt (>3.7 Ga), located in SW Greenland (Lepland *et al*. 2003). Representative rock samples from banded iron formation (BIF), metachert, metacarbonate, and mafic dyke were collected in the least deformed part of the belt with well-preserved primary igneous and sedimentary features.

D/H ratios in apatite crystals extracted from rocks were analyzed *in situ* using a Cameca 1280-HR secondary ion mass spectrometer. δD values for all samples fall within the range from -93 to -56 ‰ relative to the VSMOW value. Extreme D/H ratios were determined in apatite crystals from rocks of different origin and metasomatic history. Garnet-growth structures (Rollinson 2003) show that a low-strain domain of Isua records a single metamorphic event at 3.69 Ga, while other domains have experienced two or three Archean metamorphic episodes. There is also evidence of post-metamorphic carbonate metasomatism (Rosing *et al.* 1996). Metasomatic apatite from a metacarbonate layer in a chlorite-dominated mafic rock is strongly deuterium-depleted (δD = -93 ‰) in comparison to sedimentary apatite from BIF (δD = -56 ‰). MgMn-siderite and Fe-dolomite are the main components of this metacarbonate rock, but Fe-dolomite was also identified as a minor phase in BIF. However, graphite inclusions, commonly found in metacarbonate and which formed from a thermal decomposition of siderite, have not been identified in BIF sample (Lepland *et al*. 2003; van Zuilen *et al.* 2003). This indicates that post-metamorphic processes influenced both BIF and metacarbonate, but to differing intensities.

It appears that our metacarbonate sample has been completely reset during younger geologic events, whereas the BIF sample appears to, at least in part, retain some of its pristine composition. D/H ratios determined in this study parallel the results of earlier research on Archean serpentines from Isua (Pope *et al.* 2012), where those minerals that have undergone minimal late-stage metasomatism preserve the highest δD values.

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Adenosine Monophosphate Catalyzes Molecular Self-Assembly: Temporal Nanoconfined Water as a biochemical reaction vessel

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Adenosine Monophosphate (AMP) is one of the most important biomolecules in every living cell. It is essential for many biological processes like energy production and consumption, signal transduction and protein biosynthesis as being the core structure of molecules like NAD+, FAD, Acetyl-CoA and cAMP. Furthermore, AMP is among the five nucleotide monomers constructing DNA and RNA. Regarding these numerous roles in cell biology AMP must have played a crucial part in the chemical evolution towards the origin of life, influencing also non-living or "not yet living" processes such as molecular self-organisation and self-assembly.

Our research on chemical evolution focuses on physico-chemical phenomena in temporal nanoconfinements of water between mineral surfaces such as Casimir-like fluctuation induced forces, dewetting in hydrophobic cavities and organic solid-solid wetting (Eberle et al., 2017). In previous studies we have revealed that the interplay of such phenomena can induce e.g. the self-assembly of organic molecules such as heteroaromatic PAHs and Porphyrines on mineral surfaces despite the insolubility of such molecules in water. In the search for strategies to enhance the efficiency of solidsolid wetting we detected indications for catalytic activities of phosphates to this type of selfassembly. Since many biomolecules, like nucleotides, contain phosphate groups we made comparative studies regarding pure water, inorganic phosphates and nucleoside phosphates.

Our results demonstrate that AMP shows significantly the highest ability to catalyse solid-solid wetting self-assembly among a the group of other nucleoside monophosphates, other phosphate containing biomolecules like Phospholipids and the various derivatives of AMP, like cAMP or NAD+. This outstanding property of AMP within temporal nanoconfinements and the exceptional number of different roles of this molecule in living cells let us suspect that catalytic reactions in temporal nanoscopic confinements of water may have played an important part in chemical evolution with AMP as a crucial actor.

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Effect of cosmic rays on atmospheric biosignatures in Earth-like atmospheres

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We investigate the effects of cosmic rays upon gas-phase biosignature species in Earth-like atmospheres using a coupled convective-climate-photochemical stationary column model coupled with an air shower approach. Our scenarios include Earth-like planets placed in the Habitable Zone of cooler M-dwarf stars for differing levels of stellar activity. We analyze in particular photochemical responses in which cosmic rays generate hydrogen- and nitrogen-oxides which can destroy biosignatures such as ozone in gas-phase catalytic cycles.

Terrestrial life for habitable oxygen worlds

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Abiotic oxygen builds up in substantial quantities on terrestrial planets whenever the stratosphere is wet and a massive photolysis of water allows hydrogen to escape to space. This will happen in particular during the initial runaway greenhouse state of M dwarf planets (Luger et al, 2015), such as ultracold TRAPPIST-1 system (Bolmont et al., 2017). The presence of early abiotic oxygen is however likely to preempt prebiotic evolution (Sies, 2013) and consequently also the development of life (Ruiz-Mirazo et al, 2014). Even potentially habitable oxygen planets may hence to be devoid of life.

Reversing the point one may ask if there is a realistic prospect for humanity to initiate evolutionary processes on potentially habitable exoplanets. The question would then be whether it is technically feasible and ethically acceptable to plan for Genesis-type interstellar missions carried out by autonomous and miniaturized interstellar spacecrafts (Gros, 2016). Slow cruising probes aiming to establish ecospheres of uni-cellular organisms on yet lifeless exoplanets could be propelled by arrays of laser and decelerated passively on arrival (Merali, 2016), where an on-board gene laboratory would synthesize in-situ bacteria and unicellular eukaryotes.

Oxygen worlds around M dwarfs resulting from an ocean-worth loss of initial water content could posses extreme oxygen partial pressures of the order of hundreds of bars and strongly varying final water contents (Luger et al, 2015). Terrestrial life on earth is adversely affected by elevated oxygen levels, primarily as a consequence of the subsequent build-up of hydrogen peroxide within the cells (Baez et al, 2014), with presentday bacteria tolerating, in contrast to eukaryotes, up to a few bars of oxygen. It is then conceivable that suitable cultivation techniques may prepare selected terrestrial bacterial strains for the conditions encountered on oxygen planets with high but not too extreme oxygen levels.

Going one step further one may consider to reprogram the genetic code of terrestrial life forms, including higher eukaryotes (Lajoie et al, 2016), e.g. by going from codons made of triplets of nucleotides to a quadruplet code (Chin, 2012). New functionalities are expected to result from the insertion of non-native amino acids, which could in turn allow terrestrial life to adapt to a wide range of exoplanetary conditions. In this contribution we point out that it may be worthwhile in this context to study the perspectives for the future evolution of life potentially present in our cosmic neighborhood.

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Preliminary data on the microbial diversity of two underground ice blocks

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Due to their isolation from the surface, caves deposits (ice blocks, stalagmites) preserve unaltered a broad range of proxies that can be used for past climate change reconstructions. In this context, cave ice microbiota is starting to gain interest since it is believed to be a proxy to climatic and environmental changes, correlations between bacterial abundance and seasonal variations being highlighted (Yao et al., 2008). Reconstruction of past environmental conditions is important because understanding them and their evolution can be helpful in predicting the near future climate and environmental changes as a result of anthropogenic activities such as pollution, tourism etc.

Moreover, our study also reflects the present interest in exobiology, in general, and in the existence of life on Mars, in particular.

The potential life-friendly conditions (protection against UV and other radiations as well as against other harsh atmospheric conditions) recently discovered on special geomorphic regions on Mars (caves; ice in polar areas) make Earth caves and the underground ice blocks hosted here the perfect models to study such sites (Rummel et al., 2014).

Thus, we chose for our study two ice caves: Demänovská Cave of Liberty and Dobšinská Ice Cave (Slovakia). Dobšinská Ice Cave is one of the largest ice caves in Europe, hosting an 110.000 m^3 ice block in places thicker than 25 m, while Demänovská Cave of Liberty is part of the longest cave system in Slovakia.

This study aims to assess the microbial diversity of the two underground ice blocks. Using classic molecular approaches based on the 16S sequences, we highlighted the presence of Achaea and bacteria in the ice/drip-water samples. Here, we present a preliminary metagenomic characterisation of the ice-embedded and drip water microbiota in close relation with the physical and chemical features of the two caves.

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Studying the Effect of UV-Radiation on Organic Carbon in Meteorites

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Infalling meteoritic material, mostly micrometeorites from interplanetary dust resembling carbonaceous chondrites in composition, are estimated to deliver ~2400 tons of organic matter per year to the surface of Mars (Flynn, 1996). However, organic molecules have not been detected at landings sites of Viking and Phoenix lander missions (Biemann, 1979). Curiosity detected chlorohydrocarbons, an end-product of the reaction of indigenous perchlorates and organics, within the organic detection instrument (Freissinet et al., 2015). From these measurements, amounts of organics on Mars are difficult to quantify. Organic compounds are further expected to be degraded on the surface of Mars by processes including photodegradation by ultraviolet light from the Sun, oxidation processes in the subsurface and interaction with galactic cosmic rays (ten Kate, 2010; Keppler et al., 2012; Poch et al., 2013). Photolysis by ultraviolet radiation (UV) is a potentially important degradation mechanism of meteoritic organic matter on the surface of Mars (ten Kate et al., 2005). The aim of this project is to quantify UV-radiation induced methane emission from Murchison (CM2) meteorite bulk material. A quantitative analysis can provide an estimate for emission rates under Mars-like conditions in order to evaluate the contribution of this source to a global methane concentration in the Martian atmosphere. Isotope analysis of methane will be performed at various stages throughout the emission process to monitor changes over time. After irradiation of single grains of bulk material, depth profiles will be made using NanoSIMS to identify changes in carbon content, as well as in isotopic composition of carbon between the surface and the interior of the grains, allowing for the quantification of UV penetration depths in meteoritic material. The results may help identify the chemical composition of various carbonaceous phases most prone to release methane upon UV exposure.

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Towards theoretical description of state-selected reaction $[CH_4 + O \rightarrow CH_3 + OH]^+$

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A relaxed guided scan for the reaction $[CH4 + O \rightarrow CH3 + OH]^+$ has been performed along an intuitive and chemically reasonable trajectory. 19 lowest electronic states were considered in the State-Average MCSCF calculation to identify the asymptotes CH_4 and O^+ (^4S, ^2P, ^2D),. The trajectory calculation is based on synoptical atom manipulation and when linearized, it allows visualization of the qualitative features of the reaction profile.

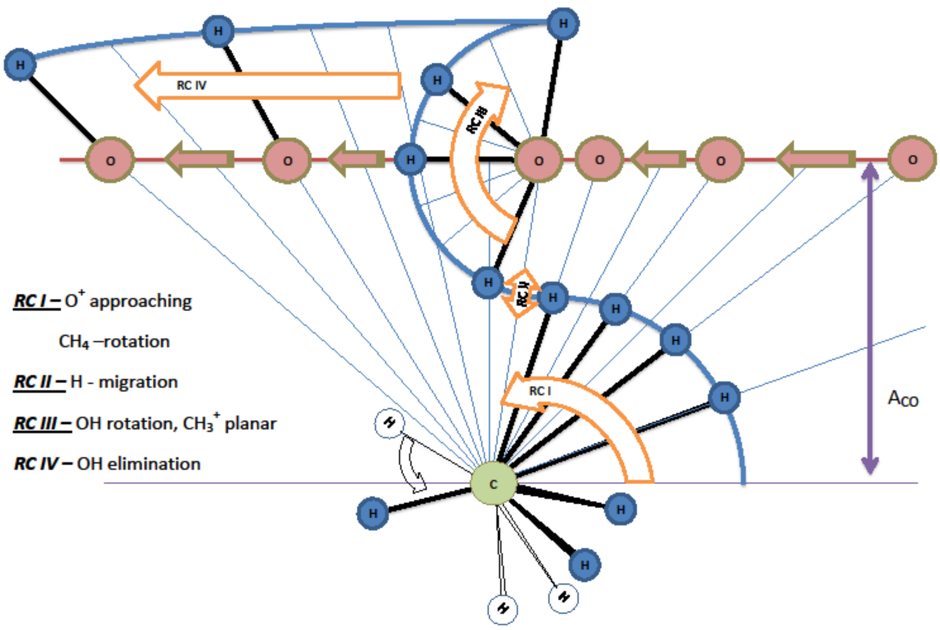

Fig. 1 A two dimensional projection of transition moments predicts a decay of the O^+ excited states already at long CO-distances.

Do habitable zone exoplanets have water?

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The habitable zone is often defined as the orbital distance where water on a planet similar to the Earth will be in liquid form (not frozen as on Mars and not thermally escaping as on Venus). But very little knowledge exist about the probability of actually having water at all on such habitable zone exoplanets. The origin of water on our own Earth is only poorly understood, and no self-consistent theory exist that is able to explain all major aspects of the origin of Earth's water. I will review the different theories for how water can have originated on Earth and the very sparse hints we have about water under formation in exoplanetary systems.

Can tardigrades theoretically survive on Mars?

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It is known, that some microorganisms like bacteria, Archaea, algae or fungi can survive in harsh conditions which are present on other planets and/or moons (e.g. on Mars). But would it be also possible in respect of higher organisms, like animals? More precisely, a microscopic invertebrates - tardigrades?

Mars, with almost lack of atmosphere, very low atmospheric pressure and temperatures, the lack of liquid water and high doses of cosmic, ionizing and UV radiation, is rather a hostile place for Earth invertebrates. On the other hand, it is still probably the most friendly place (excluding the Earth) for terrestrial organisms in the Solar System. As it was shown in numerous studies in the past, the best candidates, to survive in Martian conditions, belong to a few groups of cryptobiotic invertebrates i.e. nematodes, rotifers and of course **tardigrades**.

The Phylum Tardigrada (water bears) consists of over 1,200 species (Degma et al., 2009–2017) that inhabit almost all terrestrial, freshwater and marine environments throughout the world from the ocean depths to highest mountains (Nelson et al., 2015).

Tardigrades, as one of the toughest metazoans on Earth and a model multicellular organisms are often used in studies on survivability in the extreme conditions (Guidetti et al., 2012). Tardigrades owe this remarkable resistance to adverse conditions to their ability to enter into cryptobiosis. During this state, metabolic processes significantly decrease or even completely stop. Many experiments showed that water bears have significant resistance to a number of environmental stressors like lack of liquid water, low and high temperatures and pressures, irradiation and many chemicals. **Now can we ask, is this enough to survive on Mars?**

Acknowledgments:

Studies also have been conducted in the framework of activities of BARg (Biodiversity and Astrobiology Research group).

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Archean eukaryotes from South Africa: A farewell to some premises of Precambrian paleobiology

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The discovery of 2.8 to 2.7 Ga-old microfossils in South Africa (Omdraaivlei Fm, Kaapvaal Craton), identified as remains of mineralized tubular organisms closely related to geologically much younger and modern siphonalean microalgae (Kaźmierczak et al., 2016), has a profound consequence for several current widespread concepts of early life evolution. Some of these concepts, formulated and accepted by the majority of leading Precambrian paleobiologists and geobiologists (for review Knoll et al., 2016), serve almost as dogmas. We propose a critical review and refutation of some of these assumptions.

PREMISE 1: NO EUKARYOTIC LIFE IN THE ARCHEAN BIOSPHERE.
Arguments for refutation: This premise is founded on the absence of credible eukaryotic fossils or indigenous eukaryote-associated geopolymers in Archean deposits, but also on the results of most advanced bio-molecular studies pointing at the appearance of first eukaryotes at c. 1.8 to 1.6 Ga, corresponding with findings of accepted eukaryote-like microfossils (Parfrey et al., 2011; French et al., 2015). Our finding denotes an almost one billion year correction of these estimates.

PREMISE 2: NO, OR TRACES OF OXYGEN IN THE ARCHEAN ATMOSPHERE.
Arguments for refutation: All living siphonalean algae are oxygenic obligatory aerobes living in well-oxygenated shallow waters. Simply through this, further claiming of wholly anoxic Archean atmosphere seem to be baseless (see also Ohmoto, 2004; Planavsky et al., 2014).

PREMISE 3: MAJOR PROGRESS IN THE ARCHEAN EVOLUTION OF LIFE HAPPENED IN MARINE ENVIRONMENT.
Arguments for refutation: Lacustrine location of the Archean siphonalean microalgae suggests that non-marine habitats, like volcanic lakes or post-impact crater lakes with their temporal hydrochemical transformations might have been the sites at least equally attractive as marine environments.

PREMISE 4: FIRST BIOMINERALIZATION PHENOMENA IN LIVING SYSTEMS APPEARED NEAR THE END OF PRECAMBRIAN.
Arguments for refutation: The presence of silicate envelopes precipitated in vivo and/or early post mortem on the cell walls of the siphonous thalli of the African Archean microalgae indicate that biomineralization processes started almost two billion years earlier than currently documented, and probably much earlier (Nutman et al., 2016).

In the light of the above arguments, rejection or at least a cautious application of these premises in the research praxis is advised along with critical evaluation of contents of the many textbooks, compendia and encyclopedia concerned with the evolution of early life.

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Chemical transformations in silica hydrogel media

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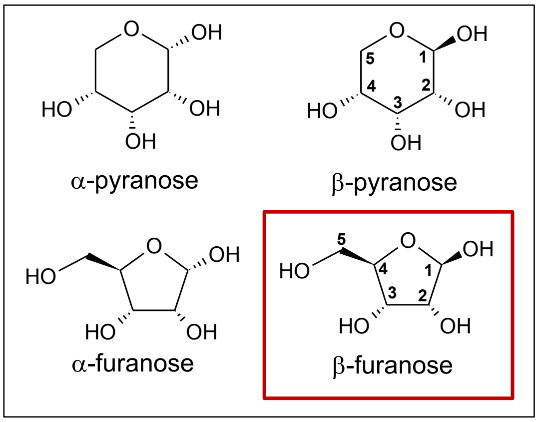
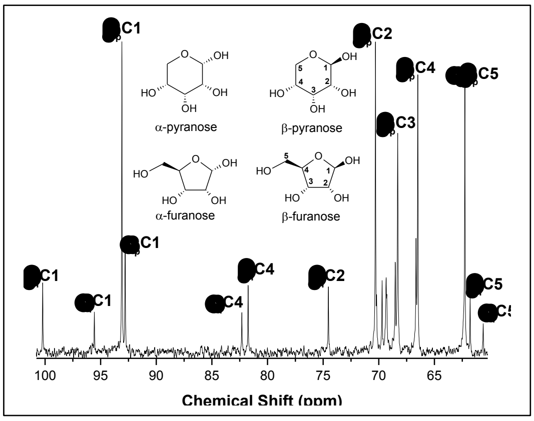
Sugars are one of the most important class of life molecules, but some sugars are unstable in solution, such as D-ribose ($C_5H_{10}O_5$)[1]. This sugar is also highly important in life science because it constitutes the carbohydrate part of DNA and RNA. For example, at pH 9 and 60°C, the half life of ribose is *ca*. 50 h; in more physiological conditions, at pH 7 and 37°C, it should be around 500 h if one extrapolates from the data of Miller and co-workers[2]. In solution, D-ribose exists as an equilibrium mixture of four cyclic isomers: α-pyranose, β-pyranose, α-furanose, β-furanose.





The main forms in water solution are the pyranose species (83 %). In order to understand the presence of D-ribose in these biopolymers, it is essential first to stabilize the molecule and secondly to explain the selectivity for incorporating the β-furanose cycle. Minerals, particularly porous materials as clays, could lead to chemical stabilization from degradation processes [3]. Minerals present a second advantage in that some surfaces are able to promote chemical reactions such as condensations.[4, 5] However, a different class of materials is only recently becoming recognized as highly relevant for prebiotic chemistry; the hydrogel phase.[6] The ultimate relevance is that, despite differences of opinion over the relative merits of certain contingent chemical frameworks, the most primitive forms of life are generally agreed to have been an anaerobic unicellular organism, and as such would have been a gelular, soft-matter system. Surprisingly therefore, relatively few studies have explored chemical processes within a hydrogel environment. Hydrogels have a significant role to play also in shaping geological rock forming environments. Silica gel for example is a key intermediate phase en route to silicate rocks and has the potential to act as a form of inorganic vesicle, a primitive inorganic cell. Beyond the stabilization of molecular species in such environments, molecular mobility must be maintained within the gel phase, in order to preserve their ability to react. We here describe the incorporation of ribose in a silica hydrogel matrix and an investigation of the diffusion characteristics, and the chemical or thermal stability in that phase compared to an aqueous phase. ^{13}C NMR (DOSY sequence) was succesfully used to characterize the mobility of ribose in the hydrogel. A classical sequence was applied to characterized the isomerization of ribose in the gel. It is found that ribose in the hydrogel phase preserves *ca*. 90% diffusional mobility compared to ribose in water. Moreover, in the hydrogel, the isomerization pattern of ribose changes somewhat; generally resulting in a greater preference of β over α forms. *In situ* NMR and Raman spectroscopy have been applied in order to evaluate the thermal behavior of ribose in the hydrogel, under hydrothermal conditions. Preliminary results seems to show a better thermal stability of the sugar within the hydrogel environment. All these results open the door for future prebiotic reactions in silica hydrogels.

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Paleo-environment indicators of Mars – focus points for next astrobiology missions

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The reconstruction of past environmental conditions is important to estimate astrobiology potential and support the targeting of future missions for Mars. Reviewing those observable features (e.g. paleo-environment indicators) that helps such reconstruction is important, as they provide focus for current and next research both in remote and in-situ missions, just like Earth based laboratory analysis and simulation. Under the international (COST TD1308 and COOP-NN-116927 projects) these indicators are collected and characterized, focusing on the available data, uncertainties, missing information and targets of future work.

Such indicators could be classified as surface morphological (km spatial scale, water and ice related surface structures like fluvial channels, alluvial fans, banks etc.), sedimentary features (m-mm spatial scale, especially in vertical columns), lithological (rock type, composition), mineralogical (mineral types, OH content) and isotopic classes. Although several pieces of information could be extrapolated from these data regarding the liquid water or frozen ice volume and temperature during the formation of certain features, information on pH and salt content just like temporal issues could be poorly estimated. Mineral paragenesis and different type of information used together support further the interpretation, while the missing data of certain environmental conditions that point to future directions of research. The current state of the indicators is presented and opened for commenting and discussion.

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Assessing abiotic HGT as a driver of early evolution

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Horizontal gene transfer (HGT) is now recognized as a major contributor to genetic variability of prokaryotes, and there also seems to be a growing consensus that HGT has played this role since the earliest stages of evolution (see e.g. Fig. 3 in Doolittle 1999, Fig. 1 in Smets and Barkay 2005, and Fig. 1 in Koonin 2009). Still, all three common mechanisms of HGT among prokaryotic organisms – competence, conjugation, and transduction – are biotic, employing proteins, implying that each of these evolution-accelerating mechanisms is itself a product of evolution. This raises a rather obvious, yet still mostly uninvestigated question: *How could HGT have proceeded before any of its biotic mechanisms had developed?*

In 2013, I tried to revive the discussion, started hesitantly in the 1990s, on the possible role of lightning, triggering DNA release (electroextraction) from donor organisms and electrotransformation of recipient organisms by this released DNA, as an abiotic HGT mechanism that could have acted from the very onset of membrane-bound life; I've argued this is both plausible theoretically and supported empirically, albeit indirectly, by single-pulse electrotransformation results in labs (Kotnik 2013a, Kotnik 2013b). In 2016, with Jim Weaver from the Massachusetts Institute of Technology, we took a broader view, exploring also the possibilities of HGT driven by freeze-and-thaw cycles, particularly in polar waters and upper layers of permafrost, and by agitation by sand and gravel, particularly at the foreshores and riverbeds (Kotnik and Weaver, 2016).

Conservative estimates we derived suggest that under contemporary conditions, per year, at least 10^{24} prokaryotic organisms are affected by freeze-and-thaw cycles, at least 10^{19} are agitated by sand, and at least 10^{17} are subjected to conditions suitable for lightning-triggered electrotransformation. Evidently, only a fraction of these organisms release DNA, and likely an even smaller fraction are transformed by this DNA, remain viable, and divide. Thus, better estimates of even the contemporary importance of abiotic HGT will require carefully planned and comprehensive experimental work.

Clearly, early Earth and early prokaryotes differed considerably from contemporary ones; e.g., lightning strokes were more frequent with intense volcanic activity, and natural permeability of early membranes to DNA fragments may have been higher. An assessment of the importance of abiotic HGT during early evolution will thus require extensive quantitative knowledge and understanding of the geology, meteorology, and biochemistry on early Earth – a daunting task, but one with potentially paramount implications for understanding of life.

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Application of PTR-MS for determination of compounds formed in Titan like gaseous mixtures by electrical discharges

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The Proton Transfer Reaction Quadrupole Mass Spectrometry (PTR-QMS) was used for the determination of gaseous products formed by electrical glow discharge at atmospheric pressure operating in nitrogen-methane gas mixtures related to the Titan's atmosphere. The aim for this analytical technique use is to determine many species generated by the discharge simultaneously without (or with very reduced) fragmentation in contrary to standard GC-MS analyzis. The main detected nitrile compounds were molecular structures containing nitrile groups (–CN), amino groups (–NH_2, –NH–, and –N<), and/or imino groups (–C=N–), namely HCN, CH_3CN and C_2H_5CN in current experiments. Hydrazine, methanimine, methyldiazene, ethylamine, cyclohexadiene, pyrazineacetylene, ethylene, propyne and propene were identified as minor compounds. The peaks at masses 21 and 37 are not listed there because they correspond to D_2HO^+, and H_3O^+-H_2O ions originating in the ionization source. Small amounts of hydrocarbons like acetylene, ethylene, propyne, propene, 2-butene and cyclohexadiene were detected. Observation of these species is in agreement with our previous experiments [1,2] as well as other publications [3, 4, 5]. The major products are nitrile compounds. Hydrogen cyanide HCN (protonated mass = 28) and acetonitrile CH_3CN (protonated mass = 42) were the two major products but also other nitrile compounds like methanimine, methylamine, hydrazine, ethenamine, methyldiazene, ethylamine, propiolonitrile, propenenitrile, proparylamine, 2-propanamine, butanenitrile, 4-methyl-pyrazole, 2,5-dimethlpyrazole and nonanenitrile were detected, too. Ammonia (protonated mass is 18) was not observed because the molecular mass is lower than 21 that is the lowest limit for used PTR-MS analytical device. The yield and generation rate of nitriles are of the following relationship: HCN > CH_3CN > C_2H_5CN > C_3H_7CN > C_4H_6N > C_6H_9N > $C_9H_{17}N$. The new experimental series carried out at the same conditions uses the proton transfer reaction time of flight (PTR-TOF) mass spectrometry. The main goal of this new technique application is to verify its applicability for this research. The advantage of PTR-TOF is in faster response and better mass selectivity allowing distinguishing species with similar masses.

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Water in the past of Hebes Chasma (Valles Marineris, Mars): evidence from landslide deposits' geomorphological investigation

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Hebes Chasma is one of the depressions composing Valles Marineris – the largest trough complex in the Solar System. Hebes Chasma is a closed depression of an approximately elliptical shape, measuring 315 by 126 km, covering an area of about 25,200 km^2. It is located ~55 km from the northern margin of Ophir Chasma. Hebes Chasma is one of the deepest trough on Mars with a maximum depth of ~8 km. This trough is a host of numerous landslides. Large-scale landslide scars are visible on both walls of Hebes Chasma and slopes of Interior Layered Deposits' (ILDs') mound, Hebes Mensa, located in the central part of the trough.

The study results were obtained through geomorphological mapping of Hebes Chasma landslide deposits conducted on the basis of CTX dataset. Twenty CTX images with reduced spatial resolution to 12 m/pxl were used to create a mosaic in Integrated Software for Imagers and Spectrometers (ISIS).

The results of detailed geomorphological observations of Hebes Chasma landslide deposits led to conclusion that a part of the trough interior history was related to lacustrine conditions. Hebes Chasma, which is the only trough devoid of connection with any outflow channels, might have hosted a lake recharged by either rainfalls or groundwater influx. The water from Hebes Chasma could not escape in catastrophic releases, therefore it must have evaporated forming a large ILD mound. The presented scenario is only hypothetical series of past events, because our level of knowledge is still far from certainty.

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Coal fires – Titan – interstellar medium – life: what do they have in common? Potential gaseous bio-precursors in burning mining heaps

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Coupled usage of the (1) unique, portable GASMET DX4000 FTIR gas analyser of OMC ENVAG for *in situ* measurements, with (2) gas chromatography analyses (GC – MS, EC and FID modes, University of California) and (3) rough indicatory tube determinations within gas vents in 4 burning coal-mining heaps of the Upper Silesia, Poland, allowed to measure and detect many organic and inorganic compounds. The presence of compounds like methane, ethane, propane, CO, CO_2, H_2O, and even acetylene, was rather obvious. However, the detailed study of residual FTIR spectra allowed to pinpoint many, although usually weak to very weak, bands. Among the band attribution proposals are compounds that – interestingly – have both been confirmed or suggested to exist in various extraterrestrial environments and are known as possible precursors to amino acids. This is especially true for nitriles which are, e.g., known to exist in the atmosphere of the Saturn's moon Titan (e.g., Gautier et al., 2011 and refs. therein). Nitriles and other compounds occurring in both Titan and the heaps include acetonitrile (e.g., sample RBR08A, from Rybnik; attribution base: Cho & Cho, 2009), HCN (5 ppm at the PSG6 vent in Pszów), NH_3, benzene, acetylene, ethene, ethane, propene, and propane (common in the heaps). HCN is a possible precursor of amino and nucleic acids (Al-Azmi et al., 2003); is was detected in the comae of at least two comets (Zubritsky & Neal-Jones, 2014). Dicyanoacetylene and its C_3NCN isomer were also identified in few heap samples; the first compound also takes part in condensation-evaporation cycle in the Titan's atmosphere (Samuelson et al., 1997). 2-propynylidyne, a known interstellar compound (Wu et al., 2009) may be present in 3 samples from Rydułtowy. Dibenz[*a*,*h*]anthracene is just an example Polycyclic Aromatic Hydrocarbon suspected to be a life precursor associated with some stars and exoplanets (Hoover, 2014); it may also be responsible for the band at 1512 cm^{-1} in the RD03 sample from Radlin. Among the quantitatively analyzed heap gases are phenols and formaldehyde (FTIR) and ethylbenzene (GC). According to Gusse et al. (2006), the *Phanerochaete chrysosporium* white-rot fungus may degrade phenol-formaldehyde polymers. Rabus & Widdel (1995) note, that ethylbenzene may act as a growth medium for *Cladophialophora* funghi and *Aromatoleum aromaticum* bacteria. Interestingly, white fungi-like segregations are quite common among many vents under scope.

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The evolution and distribution of complex molecules in interstellar medium – impossibility or prerequisite for life?

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It seems that life started on Earth as soon as conditions were suitable enough. First signs of life are about 3.8 billion years old, about 700 million years after the Solar System formed (Sleep, 2010; Bouvier and Wadhwa, 2010). Is life something that always appears when the right ingredients are in the right environment for the right time? There are basically two alternatives in the question of 'right ingredients': if the origin of life requires exobiogenesis, i.e. delivery of 'organic' molecules from interstellar processes, it would have taken much more time than if all organic molecules are created locally. On the other hand, could all the necessary building blocks have been created endogenously in plain planetary processes in such a 'short' time as happened on Earth? However, there is no evidence that the building blocks of life would be formed in the interstellar space. Even if it did, the complex building blocks would be also easily destroyed by the cosmic radiation. They could be possibly formed on rocky bodies, that would protect them from radiation, but then, the entry down to the surface of a suitable habitable planet would be a challenge: They do not survive the process of planetary formation, neither any large impacts. This paper will review these two alternatives ('long' formation via exobiogenesis/'shor' formation via endogenesis), their benefits and their challenges.

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The RNA Word: stepping out of the shadows

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Although as late as 1942 the possibility that bacteria were endowed with genetic material was held in doubt, the molecularization of biology led several scientists both in the USSR and in other European countries to acknowledge the key role that RNA molecules play in major biological processes and to discuss the idea that RNA could have preceded DNA as genetic material. It was not until the late 1960s when Woese, Orgel and Crick suggested argued that RNA molecules could exhibit catalytic activity, as is now well established – but did life start with an RNA World? The discovery of catalytically active RNA molecules has provided considerable credibility to these suggestions that the first living entities were largely based on ribozymes, in an early stage called the RNA world. There is convincing evidence suggesting that the genetic code and protein synthesis first evolved in such an RNA world, but at the time being the hiatus between the primitive soup and the RNA world is discouragingly enormous. Bioinformatics and comparative genomics provide important insights into some very early stages of biological evolution, but it is difficult to see how their applicability can be extended beyond a threshold that corresponds to a period in which protein biosynthesis was already in operation, i.e., the RNA/protein world. The evidence suggesting that ribonucleotide-derived coenzymes, alarmones and histidines and other imidazole-bearing compounds can be considered vestiges of such early epochs will be discussed.

Origin of Life – promoting conditions on the early Earth

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The smallest reduced compound of carbon and nitrogen, i.e. HCN, together with reduced phosphorus and elemental or reduced sulfur, were most likely the "seeds of abiogenesis" that drove abiogenetic chemical processes. These compounds were produced within energising conditions either on the young planet or in its vicinity, with energy derived e.g. from lightning, meteorite impacts, UV-light, volcanic eruptions or hydrothermal systems (Bada 2013, Britvin et al. 2015). These processes can produce e.g. nucleosides (even 3'2' pyrimidine cNTPs), numerous amino acids, aldehydes and lipids (Patel et al., 2015; Pino et al., 2015). Dry conditions in presence of phosphites or phosphides can also drive phosphorylation of nucleosides (Lönnberg 2016, Gull et al, 2015). The polymerisation reaction can proceed via the stacking and "click-like" polymerisation reaction of the 3'5' cNMPs in concentrated aqueous solution (Costanzo et al., 2012), or via condensation reaction of dry nucleosides in the presence of sulfur and phosphite ions (Lönnberg 2016). Production of large repertoires of various RNA polymers could give rise to simple hairpin RNA ribozymes (Costanzo et al. 2012) which, via random ligation and recombination, could lead to larger libraries of longer RNAs.

Mulkidjanian et al., (2012) describe a prebiotic scenario where the small reduced compounds together with magmatic water steam rose from the volcanic undergrounds, ventilated out from fumaroles, and accumulated into the evaporative pools. This environment provided also the soluble minerals (K^+, Mn^{2+}, Zn^{2+}) that still are ubiquitous and conserved constituents of modern cells.

We further suggest that the hot volcanic terrains and the eroded clay and sand sediments provided suitable concentrating grounds to drive the chemistry. Formamide remained as a polar liquid solvent at higher temperatures than water and moved up and down by gravity and capillary pull in the sediments. In doing so, it concentrated specific molecular sizes (precursors, nucleosides, amino acids and lipids) by chromatographic sieving effect, each in their respective soil layers. This produced adequate accumulation, purity and homogenity of the precursors to drive subsequenct chemistry.

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Triggers of the first global phosphorite formation two billion years ago

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Early Paleoproterozoic time (2.5-2.0 Ga) marks the period in Earth's history when modern-style aerobic conditions were established worldwide, as archived in a suite of interlinked mineralogical, geochemical and isotopic anomalies in the rock record. The appearance of the oldest significant phosphorites at c. 2.0 Ga is a consequence of those processes. It has been proposed that the the rise of atmospheric oxygen and related profound biogeochemical events during Paleoproterozoic led to an enhanced riverine supply of phosphate to the oceans thereby boosting biological productivity and hence phosphogenesis. However, the P-rich deposits are 100-300 million years younger than those events highlighting the need for a critical evaluation of mechanisms triggering the oldest phosphogenic episode. Phosphorite intervals in organic-rich rocks from vent/seep influenced settings of c. 2.0 Ga Zaonega Formation, Karelia, NW Russia preserve a phosphatized and fossilized consortium of sulfur-oxidizing bacteria and methanotrophic archaea (Lepland et al., 2014). Such sulfur bacteria, commonly in association with methanotrophs, inhabit the (sub)oxic-sulfidic redoxcline in sediments of venting areas and upwelling zones, and mediate modern phosphogenesis. Using the modern analogues, it can thus be hypothesized that the Zaonega rock record preserving phosphatized microbial community tracks the initial establishment of sedimentary environments with a steep(sub)oxic-sulfidic redoxcline that provided a habitat for sulfur-oxidising bacteria. Such environments facilitating biologically mediated phosphogenesis were during Paleoproterozoic established in response to the oxygenation of Earth.

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Microbial eukaryotes in the Movile Cave chemosynthetic ecosystem

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Located near the coast of the Black Sea on the Dobrogea Plateau in Mangalia, Romania, the Movile Cave is a unique underground cave ecosystem. This karstic cave is thought to have been sealed off from the outside world for several million years. Discovered in 1986, several studies have been carried out to study troglodytic metazoa but also the diversity of bacterial and archaeal communities responsible for carbon fixation in this chemosynthetic ecosystem. However, the presence of microbial eukaryotes (generally, protists) has never been investigated. Compared to animals, plants or fungi, the diversity of protists remains poorly known. Molecular studies based on 18S rRNA gene markers in natural communities have unveiled unexpected protist diversity in many different environments in the past decade. Gaining information about poorly sampled clades and about new protist clades with early diverging positions may be particularly useful to improve phylogenetic reconstructions and improve the resolution of the eukaryotic tree of life. Here, we present the first results about the diversity and activity of microbial eukaryotes in the unique ecosystem of Movile Cave by using a dual approach. We used metabarcoding approaches based on 18S rRNA gene amplicon sequencing using high-throughput techniques (Illumina) to characterize protist diversity and we have also generated metatranscriptomic data in order to i) identify active lineages and ii) carry out phylogenomic analysis of these microbial eukaryotes using concatenated marker genes.

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Exploring microbial life in the multi-extreme environment of Dallol, Ethiopia

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The Danakil depression at the Afar region in Ethiopia is one of the most unique and extreme environments on Earth. At the confluence of three tectonic plates in the East African rift (Triple Afar Junction), the Afar Depression is the only place on Earth where the transition from continental to oceanic crust (rift-to-drift process) can be observed on land. Several types of extreme environments co-exist in this area, including highly acidic hydrothermal springs linked to the local volcanic activity at the Dallol dome, as well as desert evaporites and hypersaline lakes that resulted from the intense evaporation of an ancient enclosed sea. Although there have been more than 50 years since the area was first explored, information about its chemistry and geology is limited, and its biology remains completely unknown. In January 2016 and in January 2017, after several years of preparation, we organized two interdisciplinary expeditions to the Dallol area in order to explore the presence of life and mineral-microbe interactions under these geochemical extremes. To do so, and in combination with geochemical and mineralogical studies, we are applying molecular analyses based on 16S rRNA gene sequences, metagenomic and cultural approaches. Here, we will present preliminary results on the presence of life and microbial diversity identified in several sites of this multi-extreme environment.

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An exceptionally preserved and diverse assemblage of organic-walled microfossils from the Proterozoic of Arctic Canada

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The transition from Mesoproterozoic to Neoproterozoic is recognized as a key interval for the evolution of Earth and life, especially for eukaryotic organisms. Diversification of organic-walled microfossils, including acritarchs, filamentous and multicellular microorganisms, happened during a time of profound Proterozoic environmental, biological and ecological changes. In this PhD project we investigate the diversity and the paleobiology of those microfossils for the late Mesoproterozoic and early Neoproterozoic of several successions in Northwestern Canada. Analyzes includes a combination of different microscopic and microchemical methods, such as optical microscopy, SEM, TEM, RAMAN and FT Infra-red microspectroscopy, and fieldwork. Preliminary results reveal exceptionally preserved assemblages, comprising numerous eukaryotes, prokaryotes and other taxa that are not yet assigned taxonomically. We record original new taxa, increasing the total known acritarchs diversity for this time of the Proterozoic. Comparisons with other published Precambrian assemblages show that this new material shows a high eukaryotic diversity relatively to other pre-Ediacaran assemblages. This research project is part of the ERC Stg ELITE project "Early life Traces and Evolution, and implications for Astrobiology" (E Javaux, PI) and part of a collaboration with the multidisciplinary and international Agouron project "Eukaryote evolution in the Proterozoic of Arctic Canada" (G Halverson, PI; R Rainbird, H Turner, T Schulski, J Brocks, N Butterfield, C Hallman, E Javaux, co-PIs).

Small amounts of ephemeral liquid water in polar regions of Mars

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There are at least two processes that can currently lead to formation of small amounts of ephemeral liquid water in polar regions of Mars. Firstly, solar irradiation may be sufficient to melt pure water ice located below a layer of dark dust particles lying on (or just below) the steepest sections of the equator-facing slopes of the spiral troughs within Martian North Polar Residual Cap (e.g., Catling et al. 2006, Niles and Michalski 2009, Masse et al. 2010, Mohlmann 2010, Kaufmann et al. 2013, Losiak et al. 2015). Under current orbital conditions, liquid water existence on the surface (or close to the surface) is very rare (up to couple times for up to couple of hours during summer), but it is repeated in the same area characterized by a proper latitude, albedo, slope inclination etc.).

Secondly, small amounts of ephemeral liquid water can be formed during formation of impact crater on ice-rich targets (as modeled by Reufer et al. 2010). Small impact craters are constantly forming on Mars (Daubar et al. 2013) – including on the North Polar Residual Cap and on North Polar Plains. Those impacts interact with the surface or underground ice (Dundas et al. 2014). Recent field studies of small terrestrial impact structures (Losiak et al. 2016) suggests that locally, the base of the proximal ejecta may be heated to temperatures ~300-350°C what on Earth results in formation of charcoal. Although the exact mechanism of this process is not clear yet, it is probable that a similar heating of proximal ejecta may occur on Mars leading to formation of liquid water lasting from few minutes up to few tens of minutes. The existence of small amounts of liquid water close to the surface, even under current Martian conditions, has important implications for estimating the astrobiological potential of Mars.

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FTIR diagnostics of nitrogen-methane atmospheric glow discharge used for a mimic of prebiotic atmosphere

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This work extends our previous investigation of nitrogen-methane (N_2-CH_4) atmospheric glow discharge for simulation chemical processes in prebiotic atmospheres. We present results obtained by Fourier Transform Infra Red spectroscopy (FTIR). The theory of the evolution of life was given by Oparin and it is based on the possibility of the synthesis of organic compounds by abiotic processes from inorganic species. Possible energy sources for these processes include UV radiation, electric discharges, shock waves, radioactivity, cosmic rays, solar wind, volcanoes or hydrothermal vents [1]. Sixty years ago, the Miller Urey experiment showed that many biologically important organic compounds, including sugars and amino acids, could be formed by methane, hydrogen, ammonia and water to spark discharge. They detected products like HCN, aldehydes, ketones and the ammonia in liquid water [2].

This work is focused on experiments with water (H_2O) addition to the atmospheric glow discharge fed by N_2-CH_4 mixture and diagnostic of this discharge by FTIR. The discharge was created between two stainless steel electrodes separated by a 2 mm gap. The electrode system used the standard configuration of the gliding arc discharge but due to the low applied power as well as low gas velocity the discharge is not moving along the electrodes. The discharge was operated with an applied voltage of 400 V and current in range 15 mA to 40 mA in pure nitrogen enriched by 1−5 % of CH_4 at the total flow rate of 100 sccm and H_2O vapour admixture (2%). Flow rates of all gases through the reactor were regulated using mass flow controllers (Bronkhorst). There was connected bottle gas washing with the high purity water just before the entrance to the reactor.

All recorded spectra were processed, hydrogen cyanide (HCN) was found to be the most abundant product at wavenumbers of 720 cm^{-1}. Ammonia (NH_3) was identified at 966 cm^{-1}. The other major products were acetylene (C_2H_2) as well as carbon monoxide (CO) and water (H_2O). These products were recognized in all gas mixtures. The products concentrations are strongly dependent on the gas mixtures composition.

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Anxiety about Discovery

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A series of surveys (Alexander 1994; Vakoch and Lee 2000; Roper 2002; Peters 2003; Survata 2013) seem to indicate that religious adherents across key denominations do not believe that the discovery of extraterrestrial life would in any way shake core religious convictions. In spite of the reasonable (cautionary) methodological concerns that may be raised in relation to the surveys, this *may* be close to an accurate reflection of the self-assessment of members of the denominations in question. Somewhat less reassuringly, it may equally well be read as the reflection of a desire for 'invulnerability to Discovery' that seems to be present across denominations. Identification of such a desire would not warrant the assumption that adherents of such denominations have actually achieved the invulnerability in question. Indeed, when thought of in the light of such a desire, the data seems to indicate the widespread presence of something close to a state of cognitive dissonance: (i) belief in the invulnerability of personal faith in the face of new 'reconfiguration requiring' data; coupled with (ii) a clear patterning of denominational belief in the likelihood of such Discovery that maps suspiciously well onto the varying levels of anxiety that we might expect to find given the varying levels of theological 'reconfiguration' likely to be required. Broadly, the greater the required theological reconfiguration, the less likely members of the denomination are to believe that Discovery will occur. While various denominations have weathered the impact of previous shocks (such as consensus about Darwinian evolution) without resorting to denial, and while there is no indication of the likelihood that Discovery will lead to any widespread denominational collapse, a deep level of anxiety about discovery does seem to be resilient in the face of overt affirmations of core faith. An analysis of support for space e proration by Joshua Ambrosius (Ambrosius 2015) suggests that especially those groups that have not weathered a previous shock are less supportive of space exploration and scientific research in general. This can be one of this reasons for the widespread belief that Discovery will not shake core religious beliefs, as scientific data is seen as generally suspicious. On the other hand, Ambrosius shows that the role of the individual pastor and his or her relation to science has a strong influence within these groups. While religious adherents may feel the way the studies show, a different view by the religious professionals may on the other hand cause problems for a far wider group. Thus maybe the data provided by the studies mentioned in the beginning of this abstract need to be refined to focus more on the opinion of the religious professionals as they would shape the perception of a larger group of adherents.

Evolution of membrane building blocks and their functions

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That compartmentalization is necessary for life is unquestionable. Contemporary cell identity and functions are preserved and mediated via encapsulation in membrane bound volumes. The questions in the relation with the emergence of life are however when compartmentalization became unavoidable and which building blocks were available to form primitive compartments. In the absence of proteins and other sophisticated membrane bound molecules that perform membrane related functions today, primitive membranes must have also exhibited additional functions either performed by their building blocks themselves or by associated simple chemicals.

The search for plausible "prebiotic" compartment building blocks has focused on amphiphile molecules, in particular fatty acids and their derivatives, once it was demonstrated that the formation of contemporary membranes still relies on spontaneous self-assembly of their lipids, which are not defined by genetic information, but related to the dual nature (or amphiphilic nature) of the lipid molecules. Fatty acids were chosen because of evolutionary continuity considerations as these molecules are composing the hydrophobic moiety of phospholipids, modern membrane building blocks that represent up to 75% membrane molecules in mammalian cells.

In this presentation, we will discuss "prebiotic" syntheses of novel phosphorus containing amphiphiles and their involvement in the formation of primitive compartment boundaries. We will show that resulting mixed compartment boundaries containing these amphiphiles and other co-surfactant exhibit improved chemico-physical characteristics, potentially possess essential functions essential to the co-emergence of biomolecules or their precursors, and, finally, could have been formed under many plausible environmental conditions on the early Earth, maybe with the notable exception of high ionic strength media.

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Habitable zone limitations for massive rocky planets

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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.

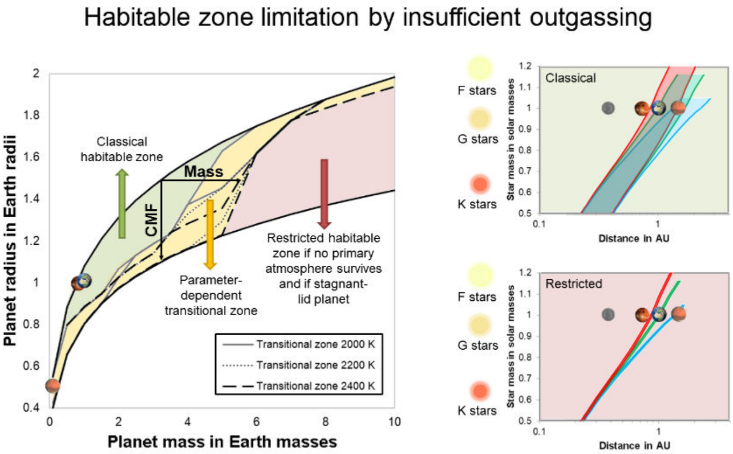

Fig. 1. *Left*: Sketch of a mass-radius diagram indicating the mass-radius range, where the classical HZ definition can be applied (green area), the range where the HZ may be restricted due to limited outgassing (red area) and the transitional regime in-between (yellow area). Black arrows indicate the influence of mass and core-mass fraction (CMF) on the transition from classical to restricted HZ definition. *Right*: Habitable zone without constraints (top) and without greenhouse gases (bottom) at different stellar ages 0 Gyr (red lines), 4.5 Gyr (green lines) and 10 Gyr (blue lines). The green and red background colors correspond to the coloured areas in the left plot.

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Planet formation and the early evolution of planetary systems

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Extrasolar planetary systems have been found to exhibit great diversity in mass and orbital architecture. We review some recent work on understanding how giant planets, Neptunes and super-Earths may form in protoplanetary disks. This involves the interplay of many physical processes including gravitational instability, the growth of planetesimals, the accumulation of solid cores and their accretion of gas. Finally interaction with the protoplanetary disk results in orbital migration that together with tidal interaction with the central star and long term orbital evolution is important for determining the final system architecture.

Origin of Life and the Phosphate Transfer Catalyst

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Phosphate chemistry is so ubiquitous in living organisms that it is hard to imagine life without it. Phosphates are our energy currency, activation agents in production of most of anabolic processes and indissoluble part of nucleic acids. Influences of phosphates are so deep in a process of life that phosphate metabolism must have been developed on the very early stage of life. Unfortunately most of chemical reactions involving phosphate transfer are in the domain of enzymes only and no chemical catalysts are known to catalyze these reactions.

Because all synthetases and kinases share common enzymatic mechanism and peptide bond is one of possible products of abiotic reactions we propose an existence of early, peptide based, metalo catalyst able to catalyze transfer of phosphate residues utilizing pyrophosphates as both substrates and energy sources. This *Phosphate Transfer Catalyst* would provide a variety of different products such as phosphoryl amino acids, nucleosides, polyphosphate nucleotides, nucleic acids, and aminoacylated nucleic acids overcoming bottlenecks about chemical production of variety of life building blocks that Origin of Life sciences are facing now.

Flexible proteins at the origin of life

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Almost all modern proteins possess well-defined, relatively rigid scaffolds that provide structural preorganization for desired functions. Such scaffolds require sufficient length of a polypeptide chain and extensive evolutionary optimization. How ancestral proteins attained functionality, even though they were most likely markedly smaller than their contemporary descendants, remains a major, unresolved question in the origin of life. On the basis of evidence from experiments and computer simulations, we argue that at least some of the earliest water-soluble and membrane proteins were markedly more flexible than their modern counterparts. As an example, we consider a small, evolved in vitro ligase, based on a novel architecture that may be the archetype of primordial enzymes. The protein does not contain hydrophobic core or conventional elements of secondary structure characteristic of modern water-soluble proteins, but instead is built of a flexible, catalytic loop supported by a small hydrophilic core containing zinc atoms. It appears that disorder in the polypeptide chain imparts robustness to mutations in the protein core. Simple ion channels, likely earliest membrane protein assemblies, also could be quite flexible, but still retain their functionality, again in contrast to their modern descendants. This is demonstrated in the example of antiamoebin that can serve as an excellent model of small peptides forming ancestral ion channels. Common features of the earliest, functional protein architectures discussed here include not only their flexibility, but also a low level of evolutionary optimization and heterogeneity in amino acid composition and, possibly, the type of peptide bonds in the protein backbone.

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What would constitute evidence for life on icy moons?

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For the first time since Viking, NASA is considering missions that would include life detection as a primary objective, making it critical to develop and evaluate a diverse set of strategies for seeking evidence of life. The central question is: what should be the target of our search that, if found, would constitute a near-certain evidence for life? Since life on icy moons might be quite different from terrestrial life, we should concentrate on features of biological systems that are considered universal and are unlikely to emerge through abiotic means.

We argue that evidence for life should be evaluated in its totality rather than on the basis of a single property or molecule. We propose two strategies for distinguishing biological and abiotic samples of extraterrestrial origin. One relies on analyzing the number, chemical diversity and chirality of building blocks and small fragments of proteins or protein-like polymers, which are likely universal catalysts of metabolic reactions. If life exists on icy bodies, it is not expected to contain the same suite of amino acids as life on Earth, but their number and chemical diversity is not expected to be markedly different. Homochirality of polymers is required for adopting well-defined structures, which in turn are the requisite for efficient and specific catalytic activity. Thus, homochirality is a strong signature of life, although abiotic synthesis of homochiral polymers cannot be excluded.

An alternative strategy is to analyze mass spectrometry (MS) pattern of a sample of all organic material collected in a mission. The goal is to distinguish reliably complex MS patterns of abiotic and biological origin. This is a very difficult, high-dimensionality problem that can be effectively handled with the aid of machine-learning (ML) techniques. The advantage of this still unproven approach is that sample processing is considerably simpler and the amount and diversity of the analyzed material is markedly larger. We are evaluating whether challenges associated with this approach can be overcome or will create an overwhelming obstacle that requires the use of different techniques.

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System Chemistry: Selection Overcoming Prebiotic Clutter

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Biology is the most complex chemical system known to exist, yet exploits only a small constellation of universally conserved metabolites to support indefinite evolution. The conserved chemical simplicity belying biological diversity strongly indicates a unified origin of life. Thus, the chemical relationship between metabolites suggests that a simple set of predisposed chemical reactions predicated the appearance of life on Earth. Traditional prebiotic chemistry produces highly complex mixtures, which implies that the feasibility of elucidating life's origins is an insurmountable task. Prebiotic systems chemistry, however, has recently been exploiting the chemical links between different metabolites to provide unprecedented scope for exploration of the origins of life, and an exciting new perspective on a 4 billion-year-old problem. At the heart of the systems approach is an understanding that individual classes of metabolites cannot be considered in isolation. This lecture will highlight several recent advances suggesting that the canonical nucleotides and proteinogenic amino acids are predisposed chemical structures.

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Image processing techniques for the autonomous mineral and pattern identification in planetary exploration

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In the last decades, computer science has rapidly developed image processing and analysis techniques, which have become extremely popular. We these techniques we aim at measuring significant geometrical properties (i.e., area, perimeter, maximum and minimum lengths) in two dimensional microscopic images of rocks. An additional strength is found in measuring and identifying three dimensional objects with real time processing of remotely imaged patterns, such as geological features.

In geological sciences, imaging methods and novel software based on mathematical methods has created new paths. The calculation for geometrical properties of grain minerals, collectively known as form, has attracted the interest of petrologists. The term form includes the fabric (size, shape, degree of crystallization) and the texture (orientation, spatial distribution, compactness, deformation and recrystallization degree) of the minerals in the rocks. During image processing, the input data are comprised of colored or grayscale images in macro- and micro-scale (remote rock formations, hand specimens, rock thin sections, SEM images, etc.), usually having distinct texture. The main purpose of these measurements aims to the automated recognition and calculation of the most significant mineral properties via clustering methods, including k-nearest neighborhood, region growing, edge detection, watershed transform, and others. It has been shown that a combination of more than two methodologies are necessary for more precise and reliable results.

Furthermore, the study of rock thin sections under the petrographic microscope is a very vital procedure in order to characterize and identify a rock and infer its crystallisation history. Minerals show a variety of optical properties with the use of the polariser (opacity, colour, pleochroism, cleavage, relief) and the analyser (isotropy, polarising colours, twinning) thus a series of steps, similar to which a petrologist would use, must be followed for the automated mineral separation and recognition. The results can be improved by calibrating the microscope (source illuminant, lenses, etc.) and the camera conditions (white balance, ISO, etc.) relying on the mineral's optical properties. Finally, with the use of two λ/4 plates perpendicular to each other for producing circularly polarised light, isotropic phases (pores, volcanic glass, cubic crystals) can be separated from anisotropic ones, improving thus the final results.

The above introduced tools give rise to various applications in the geosciences but also in remote planetary exploration with robotic vehicles. Examples of possible work are, the automated recognition of a rock in macro- and microscale according to the kind and shape of the minerals, the porosity detection in sedimentary and volcanic rocks and its relation to the mechanical properties and the petrogenesis of the rock, but also for organic mineral mining (gas, oil), the detection of linear features in macroscale, such as layering of sedimentary rocks, lineation and schistosity, for remote rover applications for space missions. It is suggested that with these methods the large volume of information coming from remotely taken images on planetary surfaces can assist in faster and better in situ and ex situ interpretation and optimum exploration patterns using autonomous vehicles. In this work, imaging methods and tools, as well as their results, will be presented, focusing on their use for autonomous interpretation during planetary exploration.

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What is Life and How Did it Emerge?
(public lecture)

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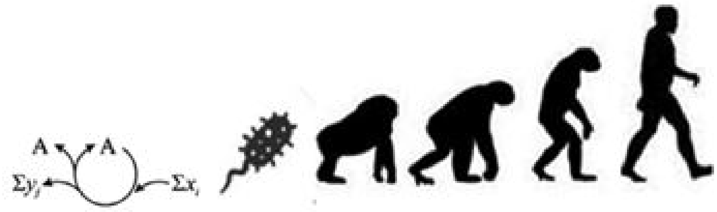

The nature of life and how it was able to emerge from inanimate matter remains one of the great scientific mysteries of all times. How was 'dead stuff' able to become living? A modern scientific approach to this problem commenced about one century ago and in this lecture the main ideas and how they developed will be described. It will be shown that the chemical process by which life emerged and the biological process of Darwinian evolution, are now thought to be two phases of one single continuous process, that some 4 billion years ago, a simple chemical system was transformed over time into a biological one. Central to that transformation was the chance emergence of a replicator - a simple chemical system able to make copies of itself. For reasons that have a logical basis, this replicator then proceeded to complexify. Finally, through a better understanding of the factors underpinning the emergence and evolution of life, we obtain deeper insight into questions that have puzzled mankind for millennia – what is it, and is it likely to exist elsewhere in the universe?

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A Roadmap toward Synthetic Protolife

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The origin-of-life problem remains one of the major scientific riddles of all time and the difficulties in attempts to synthesize simple protolife reflect yet one additional facet of this long-standing problem. In this lecture it will be argued that a strategy for the synthesis of protolife requires the characterization of the physicochemical state of life's primordial beginnings, not just its material composition. It is through the concept of dynamic kinetic stability (DKS) that key elements of that state can be specified – replicative, dynamic, non-equilibrium and energy- fueled. With the recent dramatic discovery that DKS systems are experimentally accessible and show remarkably different physical and chemical characteristics to regular chemical systems, the door to the possible synthesis of simple protolife now appears to be open.

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Monitoring of mitochondria activity during desiccation: Is the anhydrobiosis a key to colonization of waterless exoplanets and moons?

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Anhydrobiosis is an astounding strategy that allows certain organisms including plants and invertebrate animals to survive severe drought (including physiological one) in their habitat. Thus, anhydrobiosis denotes a tolerance against almost complete drying (desiccation) manifesting as the ability to survive desiccation without sustaining damages. As such, the capability can be very useful for possible colonization of other planets or moons of very harsh environmental conditions. Among animals capable of anhydrobiosis tardigrades are notable for being perhaps the most known ones and for application as a model in the phenomenon studies including astrobiology. The Tardigrada phylum currently consist of about 1200 terrestrial, freshwater and marine species. The terrestrial tardigrades need a film of water to be active and this group of tardigrades includes most of the species undergoing successful anhydrobiosis whereas aquatic tardigrades are less capable of the phenomenon. The successful anhydrobiosis includes entering, permanent and leaving stages corresponding to the dehydration, tun and rehydration stages, respectively.

At present, anhydrobiosis is still far from explanation and the only available true evidence of its successful proceeding is recovery from the tun stage to the active stage. According to common hypothesis, anhydrobiosis consists in metabolic shutdown and consequently is regarded as a form of an ametabolic state that suggests mitochondria preclusion. However, simultaneously, it is evident now that mitochondria, known to be crucial for cell survival, guarantee the proper tun formation although the underlying mechanism and their contribution to the stage survival has not been addressed till now. Thus, further studies on mitochondria are required to better understand the mechanism of successful anhydrobiosis. Therefore, we monitored functionality of mitochondria in living and anhydrobiotic tardigrades by application of the cell-permeant, cationic, lipophilic fluorophore tetramethylrhodamine methyl ester (TMRM) transported into mitochondria in the presence of the inner membrane potential. The presented conclusions are based on the resulting fluorescence observed under fluorescence microscopy.

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The mechanism of prebiotic meteorite-catalyzed nucleosides formation under proton irradiation

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The one-pot formation of nucleosides from formamide (FA, NH_2CHO) was reported (Saladino, 2015) but its mechanism was not characterized. The experimental set-up consisted of NH_2CHO, of different meteorites as catalysts, and of a 170 MeV proton beam as energy source modelling the solar wind radiation. In these conditions, the formation of cytidine, uridine, adenosine, and thymidine was observed without isolation and purification of any specific intermediates, among with that of a large variety of organic compounds including nucleobases (cytosine, uracil, adenine, guanine, and thymine), sugars (noticeably, ribose and 2'-deoxy-ribose), aminoacids and carboxylic acids.

We have determined the mechanism leading to the one-pot synthesis of ribo- and 2'-deoxyribo nucleosides from sugars and purine nucleobases under proton irradiation in the presence of meteorite NWA 1465 of the chondrite type. This experimental set-up simulates the presumed conditions on an early earth fluxed by slow protons from the solar wind, thus potentially contributing to a plausible prebiotic scenario. This one-pot reaction does not require pre-activated precursors nor intermediate purification and concentration steps, and it is based on a well defined radical mechanism. Noticeably, the yield of nucleosides is enhanced by NH_2CHO and NWA 1465 with respect to the reaction in dry state, and it is characterized by a meteorite related selectivity. Poly-glicosylation processes affording to nucleoside derivatives similar to present day products of modification of double-strand DNA were also observed as side-reactions.

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The Challenges of Detecting a Truly *Earth-like* Planet

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The number of confirmed exoplanets now exceeds 3500 and nearly weekly we hear about the discovery of a new exoplanet similar in mass to Earth and located in the Habitable Zone (HZ) around its host star. Each new discovery is greeted with excitement, which is understandable given our desire to find a second Earth. However, the claim can only be to have some crude similarity to Earth based on a few selected geophysical parameters that current technology is incapable of measuring. Further, many earlier detections of promising planets could not be confirmed from additional observations or analyses. Gliese 581d and 581g exemplify these uncertainties by showing that the previously identified potentially habitable terrestrial planets (Vogt et al., 2010), particularly the promising 581g (Von Bloh et al., 2011), may not exist and just be an artifact of stellar activity (Gregory, 2011; Robertson et al., 2014). But even if detections are confirmed, only a very small fraction of these planets will likely be genuinely Earth-like. *Earth-like* implies multiple environmental habitats, presence of a sizable biosphere and complex ecosystems, without which Earth, as we experience it, would not exist (Schulze-Makuch and Guinan, 2016). Even if the exoplanet is in the HZ, it does not mean that it is actually habitable, and habitable planetary conditions do not mean that life exists on this planet. There very well may exist a vast number of habitable but uninhabited planets in the universe. The environmental conditions that give rise to the origin of life are likely much more constrained than those for the persistence of life once it has arisen (Schulze-Makuch et al., 2015), a point which is underscored by the enormous adaptation potential shown by microbes on Earth. Thus, scientific misconceptions and exaggerations about the likelihood of life on exoplanets should be avoided. Rather it should be clearly communicated that we are probably still many years away of having the technological capability to detect an *Earth-like* planet or Earth 2.0 with adequate certainty.

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Metal distribution patterns in modern stromatolites: Keys to understand the fossil rock record

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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 here the distribution of metals and organics within lithifying microbialite from the hypersaline coastal Big Pond lake (Bahamas). This microbialite shows a progressive increase of the carbonate fraction and a decrease organic carbon fraction with depth, underlining the progressive diagenesis that affects the microbialite. This microbialite is thus an excellent target to investigate the effect of the progressive diagenetic processes on the concentration and the distribution of the metals within a microbial mat.

By combining synchrotron X-ray microfluorescence, confocal and biphoton microscopies, Raman spectroscopy with traditional geochemical analyses, we show that Fe, Cu, Zn, Mn, Br and As distribution the metal distribution in the active microbialite is homogeneous and controlled by by passive binding to the organic matrix. As the early diagenesis settles and the micrtobial activity decreases in deeper layers, the metal distribution becomes progressively heterogeneous, resulting from remobilization and concentration as metal(loid)-enriched sulfides aligned within the lamination. We also identified globules showing significant Mn, Cu, Zn and As enrichments potentially produced through microbial activity.

When compared to the metal distribution in the Archean stromatolites of Tumbiana Formation (Pilbara Craton, Australia), we see similar pattern distributions that allows the building of a model of the evolution of the metal distribution pattern within microbialites through their growth, early diagenesis and fossilization.

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An electroosmosis and electrokinetic concept for remobilising water masses on Mars

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Mars is a planet that in the last few decades is under scrutiny through a large fleet of orbiters and lander vehicles, with the intention to be once colonized. This is because Mars is the only planet that could be easier terraformed and adapt to our living conditions. To the best of our knowledge, water is the most essential ingredient for the existence of life, and luckily, it seems that it has been very active on Mars in the past while it still exists as ice caps or permafrost in transient liquid brines in the upper layer of the Martian soil [1]. ExoMars 2020 mission will deploy a drill with an IR spectrometer which will penetrate two meters in the Martian regolith for *in situ* characterisation of soils and for soil extraction. Water plays the most significant role for secondary processes and reactions that alter the regolith and form that soil, making favourable environments for life to exist on the planet [2].

Focusing on future colonisation, the control of these water aquifers on Mars seems essential. Electroosmosis and electrokinetics are two scientific and technological disciplines in geosciences which have great potential in inducing hydraulic water flow and resulting in aquifers of clean water for human consumption [3]. It can also be used to cement soil volumes in order to stabilise certain structures.

Currently, we are running small scale experiments using different natural materials (*i.e.*, clays, sands, volcanic powders) to investigate that possibility. We automate the process with programmable controllers and sensors in order to control or measure the most important physical parameters, such as soil humidity, soil conduciveness, and pH. Electrokinetics and electroosmosis have already found significant technological applications on Earth and there might be a huge potential in applying this method on Mars.

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Magnetotaxis and early life forms
(Why geomagnetic navigation matters)

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The only permanent condition under which the life on Earth has evolved is the Earth's magnetic field. The recent study has revealed that the Earth's magnetic field is at least 4 billion years old (Tarduno *et al.* 2015), while the oldest known fossils are almost 3.5 billion years old (Noffke *et al.* 2013). It is generally accepted that geomagnetic field formation was a crucial condition in origin of life in our planet. It protects the Earth from the high energy cosmic rays. However, using a geomagnetic field for navigation to more convenient environments could be also a necessary step in evolution of some early life branches. Indeed, the geomagnetic field navigation is quite widespread in currently living forms, especially in migratory species including higher organisms as fishes, birds, and mammals (Kirschvink *et al.* 2010). Probably the most ancient group of currently living organisms that use an ambient geomagnetic field to direct them into more convenient environments, are microbes known as magnetotactic bacteria (MTB). MTB are Gram-negative prokaryotes that passively align and actively swim along the geomagnetic field lines (Yan *et al.* 2012). For navigation they use "magnetosome" structures, which consist of magnetite (or greigete) nanocrystals coated by a lipidic membrane with associated proteins. Magnetotaxis of MTB is defined as preferred motility based on the geomagnetic field. It is not truly taxis, because does not involve sensing mechanism, and does not result in active cellular response to a stimulus. Recent findings of Lefevre *et al.* 2013 suggest that magnetotaxis originated monophyletically in the Proteobacteria phylum and that the common ancestor of all Proteobacteria was magnetotactic. It supports the idea of evolutionary advantage of early life forms navigation in geomagnetic field. I discuss the physical parameters of protocell model in regard to ability to perform the magnetotaxis. A starting point is the interaction of geomagnetic field with magnetic moment of magnetite nanocrystals, which allows alignment of protocell along the geomagnetic field lines. Thermal random motion, as well as viscous torque are taken into consideration. Simulated magnetic and gradient field of magnetite nanocrystal is shown in Fig. 1 (Strbak *et al.* 2013). A magnetic moment μ_{mag} = 1.8 x 10^{-17} Am^2 of simulated magnetite nanoparticle with size of 20 nm is in agreement with Kornig *et al.* 2014 (1.6 x 10^{-17} Am^2).

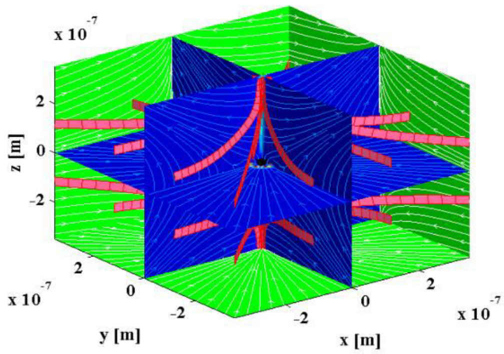

Fig. 1. Single magnetite nanoparticle (black box, *a* = 20 nm) field visualization. Green planes represent the edges of the simulated space, with gradient field lines (white). Central planes (blue) define the magnetite nanoparticle magnetic field intensity. Pink fibres demonstrate the space orientation of the magnetic field lines and their rotation.

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In search for the deepest philosophical background of contemporary origin of life theories

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The contemporary natural-scientific biogenesis is the collection of numerous particular protobiological theories – the proposition on the gradual, process way of the emergence of life in the Universe, being realized through the gradual and complex physico-chemical transformations – is common for all of them. Depending on where the particular stages of this process take place, we may talk about the earthly, cosmic or bilinear biogenesis. Therefore, they differ in their natural-scientific level, particularly in the place of the process of the emergence of life, while the same theoretical element may occur in each of them. That is why, taking into account the content of particular theories of the origin of life, we may distinguish three fundamental types of theoretical (philosophical) level underlying the natural-scientific views (the implications from them), hence, it is possible to propose three variants of biogenesis theory: (1) meta-information biogenesis – the theories, which refer to some form of universal integration principle, i.e. to “the design”, “the eternal order”, the law governing the course of all the processes within the Universe or the theories assuming the eternal existence of biological information (e.g. G. Wald – theory of designed Universe; H. D. Kenyon – biochemical predestination; C. Portelli – theory of meta-information sources; P. Fong – static-dynamic theory); (2) mechanistic-chance (eventist) biogenesis – the theories based on the assumption of the chance emergence of the first living thing, because of the lucky coincidence of natural circumstances and physico-chemical regularities favorable for the emergence of life (e.g. H. M. Muller – theory of chance-beginning of gene; G. Schramm – theory of the accidental formation of the self-replication; A. C. Elitzur – theory of the first living molecule); (3) biogenesis as a self-organization of matter – theories which adopt the evolutional way of understanding the emergence of qualitatively new systems and which point to regularities governing the process of their development, among which the crucial element is the natural tendency of matter to organize itself into more and more complex structures(e.g. H. Kuhn – theory of self-organization of proto-biological systems; M. Eigen – theory of self-organization of matter; B.-O. Küppers – theory of the origin of biological information); S. A. Kauffman – theory of the self-replicating molecular systems; Ch. de Duve – thioester world theory).

I am going to demonstrate, with examples, that these three mentioned variations of contemporary theories of biogenesis have a deeper philosophical background. This background means a general understanding by the authors of the origin of life theories how the nature functions, and in particular what are so called the laws of nature.

Considering understanding regularities of nature and their ontological basis, we should pay attention to the fact that various conceptions of law of nature may be distinguished. They are based on certain metaphysical structure of the matter and on some philosophical assumptions, depending on the approach adopted. Thus, the following may be enumerated: (1) the conception of the law of spontaneous function; (2) conception of a given (imposed) law; (3) essentialist conception of law of nature. These conceptions constitute the attempt to explain the regularities of material beings functioning within the world and, in consequence, the regularity of phenomena, events and processes explored by science.

Therefore, I try to link the mentioned type of concepts of biogenesis with the particular understanding of the regularity of nature and show that there is a close relationship between them. This allow to justify the claim that philosophical premises play an important role in the construction of theories of the origin of life as “theoretical level”. Furthermore I give reasons for the thesis that only acceptance (in a conscious manner) the fundamental premise of the research on biogenesis, i.e. the claim for the ability of matter to organize itself (self-organization), and consequently the essentialist conception of law of nature as the philosophical background, allow for answering the question on origins of life, consistent with modern scientific and naturalistic point of view.

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Emergent properties of life-like vesicles produced by a photoinitiated membrane-forming polymerization process

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For each of the three most important characteristics of extant living systems (membrane boundary, metabolism, information-carrying polymers), there exists an origins-of-life school of thought positing that one of them preceded the others along the path from non-life to life. The interconnectedness makes, however, exploring any of the three in the absence of the rest extremely difficult.

In this contribution, we present some results regarding looking instead at a pair of properties, namely membrane and metabolism, working in concert. The experimental approach involves formation of amphiphilic block copolymers from simpler precursors catalyzed by a transition metal-based redox pair. Using a protocol which allows for an aqueous reaction under mild conditions, we observe the macroscale consequences of amphiphilic polymer synthesis and the resulting molecular self-assembly using fluorescence microscopy. The polymerization process is photoinitiated by blue light granting complete control of the reaction, including on the microscope stage.

The self-assembly process leads to giant vesicles with radii larger than 10 microns, exhibiting several emergent, life-like properties, including periodic growth and collapse as well as phototaxis. Although the chemical constituents of our system are strictly inorganic, the interaction between them could offer insights into prebiotic membrane formation en route to first living systems on the early Earth.

Spectroscopic and Photometric Survey of Northern Sky for Exoplanetary Research

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Every planet search space mission needs a comprehensive input catalogue characterizing its targets as much as possible. In the nearest future the ESA-PLATO, NASA-TESS, and other space missions will use the Gaia data to build their input catalogs. However, Gaia will not be able to deliver all the necessary information on stellar variability and chemical composition. Other catalogues like HIPPARCOS (ESA, 1997), Geneva-Copenhagen Survey (Nordström et al., 2004), RAVE (Steinmetz, 2006), Gaia-ESO Survey (Gilmore et al., 2012) also do not contain all the necessary information. E.g. the RAVE and Gaia-ESO surveys are mostly done in the southern hemisphere and/or they have brightness limitations that are incompatible to the particular space mission needs. We estimated that only up to 30% of necessary information from high-resolution spectroscopy is available for the brightest targets. E.g. it is known that stellar variability can perturb signals of photometric observations and that may cause the false-positive detections of planets in the PLATO mission.

In our scientific project „Spectroscopic and Photometric Survey of Northern Sky for the ESA-PLATO space mission" we aim to provide additional observational data to be used together with the Gaia space mission results. We conduct the necessary spectroscopic and photometric observations using instruments of the Molėtai Astronomical Observatory of ITPA VU: the high-resolution VUES spectrograph (400 – 880 nm; R = 60 000; Jurgenson et al., 2014) that is installed on the 1.65 m. Cassegrain-type telescope and the CCD photometer installed on the 51 cm wide field Maksutov-type telescope. We already determined the main atmospheric parameters and chemical composition of up to 32 elements for 200 stars in the PLATO STEP02 field. The study is done in accordance with the Gaia-ESO survey standards and techniques used by the Vilnius node (Smiljanic et al., 2014). The accomplished photometric observations already allowed us to discovered 15 previously unknown long-duration variables in several northern PLATO fields. The first insights of the analysis are presented in this contribution.

Acknowledgments:
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Complex organic molecules with ALMA: tracing the origin of chemical complexity

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In astronomical terms, Complex Organic Molecules are molecules containing C and at least six atoms. Such definition may seem “minimal”, but, as will illustrate, the detection of these basic molecules is already challenging in astrophysical environments. The development of molecular complexity in the interstellar space requires high density environments, well shielded from high energy radiation. These environments are consequently very cold. Molecular complexity develops from species originating in the solid phase (ices on dust grain surfaces). This phase is difficult to observe directly, and, in most cases, observations of molecules are only possible in gas phase through rotational line transitions, mostly in the millimeter and submillimeter parts of the electromagnetic spectrum, his makes ALMA the prime instrument to study molecular complexity in the interstellar medium. I will review recent ALMA results on complex organic molecules in the interstellar medium, emphasizing the evolution of the chemical complexity from the diffuse medium to the protostellar cores and disk formation. I will also discuss the current uncertainties and future directions in this area aimed at understanding the chemical complexity of the material that may be incorporated in the planetary atmospheres.

Nucleotide Catalysis of Molecular Self-assembly in Mineral Nanoconfinements of Water

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Confined between nanoscale separated hydrophobic surfaces, water behaves very different compared to its bulk properties. Such nanoconfinements create a type of natural reaction vessel where physico-chemical phenomena occur as dewetting-induced hydrophobic collapse, fluctuation induced forces and organic solid-solid wetting. Our previous studies revealed that the interplay of these phenomena can induce the supramolecular self-assembly of organic molecules such as polycyclic (hetero)aromatic hydrocarbons (PAHs) and porphyrines on mineral surfaces despite of their insolubility in water (Eberle et al., 2017). In the search for strategies to enhance the efficiency of growing such molecular networks we got experimental indications for catalytic effects of some nucleotides for this type of self-assembly.

Results of our comparative studies show that the nucleotide Adenosine Monophosphate (AMP) has significantly the highest ability to catalyse organic solid-solid wetting self-assembly among the group of other nucleoside phosphates and various derivatives of AMP like cAMP or NAD+ as well as other phosphate containing biomolecules like phospholipids. This outstanding property of AMP within temporal confined water between hydrophobic crystals and the exceptional number of many different roles of AMP in living cells (bulding block for DNA and RNA, essential for energy production and consumption, signal transduction and protein biosynthesis) let us suspect that catalytic reactions in temporal nanoconfinements may have played an important role in the chemical evolution with AMP as a crucial actor at the borderline between chemistry and biology, influencing also non-living or “not yet living” processes such as molecular self-assembly, self-organisation and synthesis.

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Kinetic model for chemical reactions in CH_4-N_2 mixture with oxygen containing admixtures for study of prebiotic atmospheres

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We developed kinetic model for prebiotic atmospheres for chemical reaction in $N_2 + CH_4$ mixture. The content of CH_4 was set to 2%, the total pressure was set to 101 kPa and the gas temperature to 300 K. It was assumed that 2% of nitrogen was dissociated to nitrogen atoms in the ground state, the CH_4 was fully dissociated into 90% of CH_3 and 10% of CH_2. This was taken as initial conditions for the calculations and the kinetic equations were solved numerically for time from 0 to 10 s.

The kinetic model uses the set of chemical reactions and their rate coefficients from Loison et al [1]. In this model 189 different particle types and 986 chemical reactions was taken into account. Also reaction with oxygen and oxygen containing species were involved in the model, although the calculations were performed firstly without any oxygen. The initial conditions were as described above. The calculations were also repeated with different initial conditions (different concentrations of nitrogen atoms, CH_3 and CH_2 radicals). The different initial conditions resulted in small changes in the product concentrations, however, the main discrepancies between the model and experimental results were not solved. Also the calculation with initial nonzero oxygen concentration was performed.

It follows from these results that the surface reaction (e.g. on electrode surfaces) are important and these reactions could explain the increased ammonia concentrations observed in the experiment. Finally the results from different experiments with discharges in $N_2 + CH_4$ mixtures were compared with our results. It was found that our results are in agreement with the results of Ramirez el al [2], who used corona discharge. At corona discharge the surface reaction should not play important role and thus the agreement between model and experiment is better.

Acknowledgments:
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Beyond the surly bonds of Earth: Religion and the Challenges of Human Space Exploration

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The history of religion in human space-exploration shows that religious authorities will support the idea of space-exploration if their rules and traditions are compatible with it. When return to Earth is part of a mission, artifacts from or in space and stories of religious experiences can show the tradition's adaptability.

But what happens when humans leave Earth for other planets? The Mars One initiative has been advertising a hypothetical one-way trip to Mars for some time now. A return mission to Earth is not planned, they aim to emigrate to Mars.

The General Authority of Islamic Affairs and Endowment of the United Arab Emirates has compared this mission to suicide and issued a fatwa against it, arguing that suicide is forbidden in Islam. An analysis of the fatwa will show its theological bias toward Earth as the place for humanity in the Cosmos, although different theological views could be just as plausible.

A similar example can be found in Christianity ,as shown by Joshua Ambrosius in his research on religious support for human spaceflight. "Evangelical Christians are indeed less knowledgeable (...), interested, and supportive of space/space policy than the population as a whole and/or other religious traditions." he points out. The theological reasons for this and the specific religious groups Ambrosius' findings apply to will be discussed in the paper. Basically these Christian opposition to spaceflight also argues from a theology that is also Earth-centered.

The paper will give possible solutions to some of the theological and philosophical problems of human origins as the common denominator for religious opposition to human spaceflight. Both examples show a theology with a strong bias toward Earth as the place for human life. The paper will argue for academic analysis as a tool needed to understand the connection between religion and space-exploration and reach out to the respective religious communities in their own words. The paper will close with a way to address religious opposition to space-exploration. This should be done in a way that approaches the religious groups on their own terms, as an outreach initiative that addresses their structure and beliefs to further support for space-exploration within the religious communities.

Microbially mediated apatite nucleation: TEM applications in Geobiology

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Transmission electron microscopy TEM is a very powerful tool to study microbially mediated nucleation and crystallization of minerals in rocks. Focused ion beam (FIB) based TEM sample preparation allows to prepare site-specific electron transparent TEM foils from rocks or biological samples that can be investigated in TEM without further carbon coating. The superior capability of these techniques will be demonstrated with several examples in rocks and in geobiology:

- The influence of sulphur bacteria on Paleoproterozoic phosphogenesis [1];
- Blue Algea Precambrian Acritarchs within rock matrix [2];
- Influence of biological additives in bio-inspired magnetite nanoparticles synthesis [3];
- Cyano bacterium;
- A vacuole-like compartment concentrates a disordered calciuum phase in a coccolithophorid algae [4].

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Anion Chemistry on Titan: systematic studies of the growth and stability of large negative ions

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Cassini CAPS-ELS spectrometer revealed the presence of large negative ions in the ionosphere of Titan [1]. Recently, a mechanism has been proposed for the possible formation of these ions, in which cyanoacetylene, HC_3N, played a key role [2]. The reaction itself and CID experiments were studied using Waters Quattro Premier TM tandem quadruple mass spectrometer operating in negative ion mode and VG ZAB2-SEQ mass spectrometer. CID mass spectra of these anions, as well as their ion/molecule reactions with HC_3N support the previously proposed reaction scheme [2,3]. Quantum chemistry calculations revealed details of ion structures, energetics and reaction mechanisms. High-energy CID spectra of $(HC_3N)_x.C_yN^-$ anions showed a complexity of ionic and neutral products, whose formation can be expected by the high-energy ion precipitation observed at Titan [4].

Presented experiments show that in spite of its low abundance in Titan's atmosphere [5], the cyanoacetylene is probably one of the most important species in ionospheric chemistry of Titan.

The second part is experimental study of reactions of these negative ions (C_xN^-) with O_2. In the case of reaction of CN^- with O_2 the observed product was CNO^-, an anion existing in the interstellar medium, which was also predicted by theoretical calculations [6].

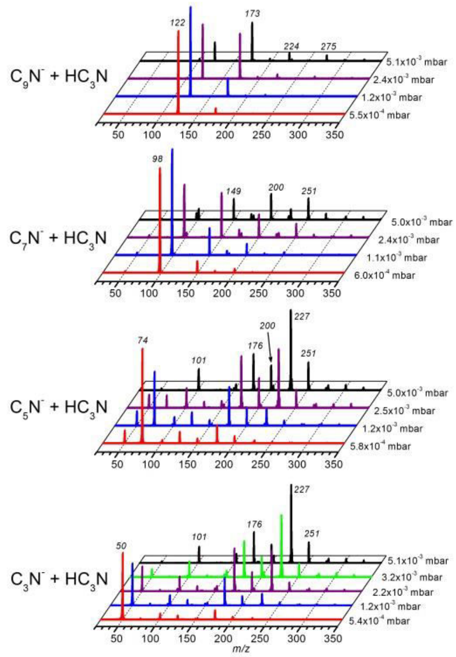

Fig. 1 Pressure dependent mass spectra of reactions of C_xN^- anions (x =3,5,7,9) with HC_3N.

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Laboratory experiments of Martian cryogenic processes

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Considering the latest high resolution images from HiRISE and their insight to the surface of Mars, one can notice that Mars was under constant climatic changes during its entire geological history. On this basis one can conclude that cryogenic processes in the arctic regions of Mars take place all the time which is closely related to the possibility of occurrence of life. Four experiments were conducted in the Climats chamber. Parameters of the chamber were carefully matched to simulate Martian day and night. Climats chamber (type R404A) parameters didn't allow for getting below 50 mbar pressure. Samples were placed in the 40x50x10 cm container for 12 hours in the temperature of +20°C and for another 12 hours in the temperature of -70°C. Whole cycle lasted 5 days. First experiment consisted of placing a layer of water ice between layers of dry sand (0.3-0.6 mm). Second experiment was putting water ice between layers of sand soaked with water, Third experiment involved using frozen brine (150 grams of NaCl per liter). The last fourth experiment involved using dry ice (CO_2) between quartz sand (1mm grains). Forms that appeared on the surface of samples resembled morphologically forms from arctic regions of Mars in microscale. Experiment result correlate with seasonal CO_2 and H_2O changes on northern and southern arctic regions of Mars. In the first two experiments after the whole cycle collapsed oval-shaped structures appeared showing layer interruptions and cavities were formed under the surface. Additionally in soaked sand sample sinuous surface cracks from thawing appeared. In the experiment with brine the surface showed no collapses as it was consolidated by crystallized salt but under the surface cavities formed. In the last experiment after CO_2 sublimated the surface collapsed in such a way that characteristic polygonal structures formed but without breaking the surface layer. Distinct fine-grained structures that appeared may confirm Martian phenomenon associated with the sublimation of CO_2 which forms characteristic silt dusty plumes. First two experiments can be correlated with cryogenic phenomena of H_2O on arctic regions of Mars. Because of thawing and freezing of subsurface layer of ice characteristic collapsed forms are apparent such as observed by HiRISE telescope: ESP_014413_0930; ESP_013609_0980; PSP_004239_1060. These studies have been continued.

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