Platinum Jubilee

Physical Research Laboratory

MetMeSS-2021

Symposium on *Meteoroids, Meteors and Meteorites: Messengers from Space*

Programme

30th November, Tuesday

Session-6: Planetary Analogue: Similar Environment of Dissimilar World!

Session Chairs: V. J. Rajesh & Satadru Bhattacharya

Abstract #	Time	Speaker	Title
Invited	15:00-15:15	Saibal Gupta	Overview of Planetary analogue
S6-01	15:15-15:25	Sarajit SenSarma	Origin of the extremely high-silica terrestrial igneous rocks: Implications to understanding Lunar and Martian high silicic magmatism
S6-03	15:25- 15:33	Souvik Mitra	Jarosite formation at Kachchh provides water-limited weathering window onto Mars.
S6-04	15:33-15:41	Anil Chavan*	Theatre headed valleys in Deccan traps: a potential analogue for the Martian studies.
S6-05	15:41-15:46	Subham Sarkar *	Characterizing Tapovan Hot Spring from a Martian Analogue Perspective.
S6-02	15:46-15:51	Anindita Das	Application of a Modified Drake-Seagre Equation to Microbes in Astrobiological Systems – Some Contributions to Impact Process Analogues.

Origin of the extremely high-silica terrestrial igneous rocks: Implications to understanding Lunar and Martian high silicic magmatism

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Introduction: Understanding silicic magmatism in the Moon and Mars are of immense interest. The crystallized zircon-hosted melt inclusions in lunar meteorite (NWA 10049) dated at ~4.38 Ga are silica rich and iron poor (~80–90 wt% SiO_2), suggest presence of silicic magmatism [1]. Density calculation on the hackle fracture pattern in quartz and the volume of quartz and fracture space in granitoid fragment in lunar regolith indicate a molar volume contraction from tridymite/cristobalite, suggestive of low pressure-high temperature SiO_2 polymorph crystallization in lunar granitoid. Granitic fragments from the Apollo rocks containing up to 0.7 wt % TiO_2, is consistent with high-temperature origin [2]. Presence of tridymite (>870°C) in a drill sample in Gale crater, Mars is the first in-situ mineralogical evidence for Martian silicic volcanism, with tridymite (14%) occur as ~40 wt% crystalline and ~60 wt% amorphous material, and has minor TiO_2 and $Fe_2O_3^t$ (~5 wt%) [3].

Significance of work: The study of origin of high-silica (SiO_2 >73 wt%) terrestrial igneous rocks though debated, i.e., whether fractional crystallization of basalts or crustal partial melting or some other processes(s), may be useful analogues to bring important constraints on Martian and lunar silicic magmatism. Although melts ultra-rich in SiO_2 (>80 wt.%) are extremely rare in terrestrial record too, few exceptions include quenched silicic glass in melt inclusions (SiO_2 81.10 wt%) in quartz-rich xenoliths in lavas/pyroclastic rocks in the Vulcano Island, Italy [4], rhyolitic glass (SiO_2 >80 wt%, TiO_2 0.19 wt%, FeO^t 0.31 wt%) in the ~2.5 Ga high silica rhyolites (HSR) in the Dongargarh-Kotri (D-K) bimodal LIP, India [5], and the ~2.15 Ga 'quartz reefs' (SiO_2 83.7 – 95.5 wt%), having positive topographic relief in the Bundelkhand craton, India [6].

Main text; Qualitative Raman observations on the Vulcano glass confirm extremely high-silica melts were formed at high temperature (980°-1100°C) and pressures in presence of water, at middle-lower crust, by melting of basement metamorphic rocks and entrapped at different times within quartz grains. In the Bundelkhand 'quartz reefs', few data show elevated Ti (TiO_2 1.07 wt%, 0.67 wt%) and variations in $Fe_2O_3^t$ (3.6-0.34 wt%), and Al_2O_3 (<3 wt.%), attributed to tectonically controlled polyphase hydrothermal silica-rich fluid, though fluid source(s) remain unclear. Sporadic high Ti-content might indicate higher temperatures too. Interestingly, despite being extremely SiO_2-rich, the samples show up to 20 times chondritic flat REE pattern to LREE/HREE >1 and could be co-genetic to microgranites. The low-grade metamorphosed deformed extremely HSR in the D-K LIP comprise quartz+K-feldspar+albite±anorthoclase+biotite+zircon+Fe-oxides; high Fe/Mg, Zr, Ga, Y, and REE (except Eu), low CaO, Ba, Sr contents and high Ga/Al; temperature of ~900°C is estimated. The REE patterns broadly similar, yet sometimes cross each other, unique to the HSR. Interaction of mantle-derived mafic and deeper crustal melts better explains $\delta^{18}O$ (4.4 to 7.6 ‰) and low initial $^{87}Sr/^{86}Sr$ (0.7031 and 0.7057) in the HSR, though limited UCC input seem plausible. So, basaltic magmas are involved in the origin of the HSR, both physically and chemically. Fluid introduction likely occurred during brittle fracturing of the crust and/or crust-mantle interaction in a caldera setting ([7]). Secondary silicification, on the other hand, may have led to HSR (SiO_2 77–80 wt%) in the Amalia tuff (USA) in the Questa caldera [8].

Conclusion: Diverse petrogenetic processes suggested for terrestrial HSR origins may provide important constraints and clues to understanding silicic lunar and Martian rocks.

References

[1] Zeng, x. et al. 2020. *Geophys. Res. Lett.*, **47**, e2019GL085997, doi.org/ 10.1029/2019GL085997

[2] Seddio, S M.et al. (2015). *Amer. Mineral*. **100**, 1533–1543.

[3] Morrisa, R V. et al. (2016). *PNAS* **113 (2),** 7071–707
[4] Frezzotti, M-L, et al., (2004) *J. Petrol*. **45(1**), Doi: DOI:10.1093/PETROLOGY/EGG080
[5] Sensarma, S. et al. (2004). *J. Earth Syst. Sci. (Springer)* **113** 619-648.
[6] Pati, J K et al., 2007, *J. Earth Syst. Sci.* 116, No. 6, 497–510
[7] Sensarma, S. and Gaur, R. (2021) *Jour. Earth Sys. Sci. (springer*) (***in press***)
[8] Lipman, P W., (1983) In *Proceedings on the Denver Region Exploration Geologists Society Symposium*, 133-147.

Application of a Modified Drake-Seagre Equation to Microbes in Astrobiological Systems – Some Contributions to Impact Process Analogues

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Quantification of several astrobiological and geobiological issues, often require substantial bridging between apparently unrelated branches. Linking genomics data to geophysical or astronomical issues has always been challenging, though not impossible. Deep-abyssal red clays of the Central Indian Basin exhibited strange linkage to ocean floor heat-flux, possible photonic emission and abundance of phototrophic microbial genera [1, 2]. While attempting to solve the complex model by a compartmentalized approach, the Drake and Drake-Seagre Equations were modified and applied. The Drake equation is the famous extraterrestrial intelligence equation [3]. Sara Seagre modified this to detect habitable zones in space and detect biosignatures in space. Frank and Sullivan altered the Drake's equation to find out the probability of technological species in cosmic history [4, 5]. Both of these work removed the 'length of time component' for reasons defended as appropriate. In this work, 'number of stars' and their subsets are replaced by 'number of microbial genes in sediments' and their subsets. The common analogy between stars and microbes is the large astronomical scale of numbers in both cases, allowing the possible modification. The present work proposes to modify the Drake-Seagre Equation with and without the time component. Uncertainty levels are high in the Intelligence Equation. Nevertheless, it serves as an adequate starting point to connect the absolutely dark gaps between geophysical and geomicrobial scales. The original Drake equation, the Drake-Seager equation and the modified Drake-Seager equation (this work) are:

a. **Drake equation** $N = R_{*}. f_p.n_e. f_l. f_i.f_c. l$
b. **Drake-Seager equation** $N = N^{*}.F_Q. F_{HZ}. F_O. F_L. F_S$
c. The Present Work:- **Modified Drake-Seager Equation** to estimate microbial phototrophic potential in abyssal ocean floor

$$\mathbf{N'=N^{*\prime}.F_Q'. F_{HZ}'. F_O'. F_L'. F_S'} \quad \textbf{Or,} \quad \mathbf{N'=N^{*\prime}.F_Q'. F_{HZ}'. F_O'. F_L'. F_S'L'}$$

N' = Number of photon absorbing OTUs (Operational Taxonomical Units)
N*' = Total Number of OTUs
F_Q' = Number of quiet OTUs that perform no photon absorption
F_{HZ}' = Fraction of OTUs contributing to photon absorption
F_O' = Fraction of observed genera contributing to photon absorption
F_L' = Fraction of cells that may absorb photons
F_S' = Fraction of biomass that could actually signal absorption of photons
L'= the Length of time for which such microbial communities release photons

Impact related processes are liable to show a time-release factor for geobiological energy. Utilization of probability, uncertainty and fractal concepts would help to quantify outcomes of extreme pulsed or continuous cascade processes like Microbial Response or Resilience to Impact events and theoretically calculate Primordial Origin of Life situations just after an impact.

Reference:

1. Singh T., Kshirsagar P. R., Das A., et al. (2019) Geochem Geophys Geosyst, **20 (2),** 708-729.
2. Das A, Singh T, LokaBharathi P.A., et al., (2017) LSSR,**12,** 39-50.
3. Sagan, C. and Drake, F. D. (1975).Sci. Am. **232**, 80–89
4. Seager et al. Sci. Adv. (2015);**1**:e1500047
5. Frank A. and SullivanIII W.T. (2016) Astrobiology **16(5)** 359–362.

Jarosite formation at Kachchh provides water-limited weathering window onto Mars

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Abstract:

The hydrous sulfate mineral jarosite is believed to be formed in a highly acidic and oxidizing condition [1]. Its presence on Mars was first confirmed from the Opportunity rover data [2] that indicated the restricted environment and surface water activity on past Martian environment [3]. Understanding the possible geochemical conditions for restricted environment appropriate terrestrial analog locations are suitable and economical. Recent studies reported the analog site of mars with similar basaltic setting in association with acidic hydrous sulfate mineral 'jarosite' on the overlying sediments at Kachchh [4]. The mode of occurrences and stratigraphic units of jarosite occurrences varies with pre- and post-Deccan eruption era in different localities at Kachchh. Plaeocene succession appears to have dominance of jarosite layers in turn early and mid Eocene successions contains small lenticular patches [5]. Subsequent ages of stratigraphic successions don't have any signature of jarosite. In Matanumadh area jarosite is found in association with alunite and gypsum [4], in rest of the locations gypsum is common. Identifications of these hydrous sulfates were performed with FTIR and VNIR analyses and supplemented with XRD results [4]. Geochemical analyses corroborate the hydrous sulfates formation and the weathering of basalt has been occurred in restricted condition. XRF and ICPMS analyses were conducted for both basalt and hydrous sulfate samples to understand the major and trace element pattern and their source for formation [5]. Sulfur isotope analysis has been conducted to understand the source of sulfur for different hydrous sulfate minerals. Considering the different parameters the Kachchh localities therefore can be inferred an appropriate terrestrial analog to understand the geochemical environment of mars in particular jarosite in basaltic setting.

References:

[1] Brown, J. B. (1971), *Min. Dep.* **6(3)**, 245-252 [2] Klingelhöfer et al. (2004), *Sci.*, **306(5702)**, 1740-1745. [3] Madden M.E.(2004) *Nature*, **431(7010)**, 821-823.[4] Bhattacharya et al. (2016), *JGRP*, **121(3),** 403-432. [5] Mitra et al. (2017), *48th LPSC*, 1344-1345.

Theatre headed valleys in Deccan traps: a potential analogue for the Martian studies

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Abstract

The comprehensive mapping of Mars has almost concluded, and studies focusing on detailed analysis at the regional to outcrop level have started to come up. Martian geology and surface geomorphic features are grouped under Noachian, Hesperian, and Amazonian eras, based on the crater retention ages and resurfacing ages by crater densities. Understanding that the Martian surface is carved by the changes in climatic, tectonic, and volcanic conditions through hydrological and geomorphic investigations of the landscape and further comparing the same with the analogues on Earth and in particular with the analogues from Deccan traps gives us confirmative answers as to how the Martian surface was sculpted. Comparing the similarities and differences between Martian and terrestrial analogues promotes an understanding of how surface processes operated on both planets.

The geological history of an area, including information of the structures and surficial conditions, can be deciphered from the study of drainage patterns [1]. In the present study, basic morphometric analysis for the Terrestrial basin and the Martian basin has been performed to understand the terrain modulation and probable causes of the differential geomorphic features. The valley observed on the Deccan plateau has similarities with the valleys carved within the Echus plateau on the Martian surface. The rock types are similar at both places, i.e., basalt [2]. The basic morphometric parameters are calculated based on the dataset discussed above, for the terrestrial and Martian valleys. These parameters include qualitative analysis such as stream ordering (Strahler method for ordering drainages), bifurcation ratios, drainage densities, total stream length for main streams, river sinuosity, basin asymmetry factor, valley floor width to height ratios, rose diagram for the first, second and third-order stream. The analysis was done based on the ratios and magnitude-dependent parameters calculated for both the valleys on Earth and Mars to understand the detailed morphological characterization of an area. The ground-truthing of the geomorphic features was done by extensive fieldwork in the analogue valley. On a broader scale, both the basins have experienced tectonism and catastrophic flooding through time. This leads us to believe that variation in climate, subsequent volcanic activity, and tectonics, which have played a significant role in shaping the present-day scenarios on Earth, can aid in assessing Martian geomorphology.

References:

[1] Schumm S. A. et al. (1987) United States: N.n p., 1987. Web. [2] Chapman M. G. et al. (2010) Earth and Planetary Science Letters 294, 256–271.

Characterizing Tapovan Hot Spring from a Martian Analogue Perspective

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Terrestrial Hot Spring localities provide all the necessary components useful for existence of life and are thus considered to be the cradle for primordial life on Earth [1]. However, the process of origin of life and ecological constraints affecting the stability and sustainability of high temperature microbiomes at these harsh conditions have not been fully understood till date. In this context, proper understanding and thorough characterization of different terrestrial Hot Springs will provide us an insight about the life forming processes and aid the search for extraterrestrial life on different planetary bodies.

Figure: Field photograph of collection of temperature data from one of the hot spring conduit

In this study, we are presenting Visible Near Infrared spectroscopic characterization of mineral assemblages found in the vicinity of Tapovan Hot spring located on Malari-Joshimath Road, around 15 km south-east of the Joshimath town in the state of Uttarakhand, India [2]. It is part of numerous circum neutral hydrothermal vents situated within Dhauliganga valley in the Garhwal Himalayas [2].

Continuously boiling water is emerging from the conduits (as shown in Figure) with temperature of the water measured to be as high as 86 °C. The average altitude of the region is around 1900 m and thus lower atmospheric pressure at such high altitudes causes the water to continuously boil. The main minerals found at this area are different phyllosilicates (muscovite, biotite), clay minerals (montmorillonite, kaolinite) and calcite. These secondary minerals are formed due to alteration of the granitic host rock caused by the hydrothermal fluid Various spectroscopic studies already suggest the presence of these altered minerals on Mars. Thus, these characterization can help us to formulate the paleo-environmental and geochemical conditions leading to their formation and to find similar hydrothermal deposits on the surface of the Red planet.

References:

[1] Cockell, Charles S., T. Bush, C. Bryce, S. Direito, M. Fox-Powell, J. P. Harrison, & H. Lammer., et al. (2016) *Astrobiology*, **16**(1), 89-117. [2] Ghosh, W., Roy, C., Roy, R. (2015) *Nat. Sci. Rep.*, **5:12179**.

VAIDURYA- Conceptualized Igneous Microbial Processes contemporary to Tarantian Age

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The enigmatic Sanskrit/Pali word "Vaidurya" embraces mysticism, mystery, message and medicine, with puzzling dictionary answers like peridot, olivine, tourmaline, chrysoberyl, emerald, lapis lazuli and more. Gemstone nomenclature of Victorian Age remained confused in the elegant green-yellow radiance of chrysoberyl, beryl (containing Beryllium) and chrysolite (olivine), much of which is overcome by modernity. The Microbial lessons are very different!

The Serpentinization reactions (olivine group), spilitization/albitization reactions (basalt group) and mixed reactions (gabbro group) are associated with the origin of primodial archaea, bacteria and the methylotrophs, respectively, since the Last Universal Common Ancestor (LUCA). The simple signatures often go unnoticed, in our anxiety for natural wealth extraction.

Evolutionary complexities of synthetic and degradative processes have overlapped with extreme geological events including impact catastrophes. In this work, igneous microbial processes contemporary to two very interesting stages of the Tarantian Age are highlighted. The first stage, the Sangamonian Interglacial stage overlaps with the termination Eemian Last Interglacial and onset of the Wisconsin Glacial, from 85,000-75,000 years before present [1]. Here, the potential of eccentric throw of mantle derivatives laterally [2] and the superimposition of the Bruhnes-Matuyama Magnetic reversal [3, 4] marks the beryllium enriched interval with high Be/Al ratio common in Marine isotope stage 5. The apparent lack of biological indicators is due to a subtle sequence of cascading primordial microbial processes. A window-pane to the mantle-derivatives and a witness of Toba super-explosion, this interval is an analogue of meteorite impact on sea-floor. The spin of the mantle fluids fuels the microbial niche dominant HC-degrading methylotrophic microbes and methanogens since the last interglacial stage.

The second stage occurred around 50,000 years ago, marking the culmination of the late Wisconsin Glaciation. Understanding microbial proxies at 50,000 years interval could demarcate a mini-ice age microbial behavior. The scrutiny in the case of the Central Indian basin is more challenging. We thus followed a multi-directional comparison and analysis involving samples from absolutely different spots from the same Age. The hot springs and paleolakes of Ladakh with an active sulphur cycle were examined. These sub-environments hold microbial mosaics that explain multiple planetary analogues of Lunar, Mars, Venus and Meteorite Impacts.

Reference:

1. Mascarenhas-Pereira M.B.L. et al. (2016) J Volcan Geotherm Res. **316**, 85–100.
2. A.C.M. Correia et al (2011) Astrophys J Letts. DOI: 10.1088/2041-8205/744/2/L23.
3. Simon Q, et al (2018) Earth and Planetary Science Letters, **482,** 510-524.
4. Shaar R., Feinberg J.M. (2013) Geochemistry, Geophysics, Geosystems, **14(2)**, 407-21.

Secret Gorges of Clay-Carbonate interaction from sediment cores to meteoritic chondrites (SHALIGRAM)

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Earth's deepest gorge, the Kali Gandaki valley, Central Himalayan belt, Nepal [1], hosts the K-Pg boundary ammonite fossils largely venerated as the Shaligram. The witness of a massive geocatastrophe and age transition, the Shaligram is an embodiment of mysterious reverence, making mankind surrender to Nature while seeking the Origins.

The geochemical mechanisms of clay-carbonate interactions are widespread, from marine sediments, to mantle pipes, interstellar dust and meteorite chondrites, across sedimentary, igneous and metamorphic systems, with system-distinct signatures and some unified principles. Extremes of habitability are investigated by many routes. They include interaction of mantle/core derivatives with clay-materials, dissolution of olivine and other serpentine alterations, deposition of carbonate/phosphate globules in low temperature near neutral to alkaline waters [2], replacements of silicates, carbonates and sulphates and many more. Geochemically, Formose or Butlerov reaction which form sugars from formaldehyde, Haber-Bosch *ab intio* synthesizing ammonia, hydrogenation of calcium carbonate in presence of Palladium (Pd) or Iridium (Ir), dissolution of carbonates by weak organic acids like formic or acetic acid, are some very important reactions participation in these processes [3-6].

Carbonaceous oozes from a seamount-top near Calcite Compensation Depth (CCD) of Central Indian Basin were examined for clay-carbonate interactions. Siliceous oozes and ooze-free pelagic red clays both below the CCD were cross-examined. Carbonaceous veins in Opliolitic systems of Nidar, and hot and cold near-neutral to alkaline systems of hotsprings, palaeolakes lakes, evaporates were all analyzed to understand glimpses of the complex mechanism. The Mukundapura Carbonaceous Chondrite data and its impact-related mechanisms [7-8] are utilized as reference data substantiating the interactions.

Microbial Carbon fixation and Adenosine Triphosphate (ATP) were measured in seamount cores TVBC-37 (2005) SVBC-37 (2007). The core recorded chronological signatures up to Marine Isotope Stage 11, along with interglacials MIS 5 and 9 [9]. The Microbial parameters mentioned were measured differentially as whole sediments, and clay and shell-fractions separated centripetally by light vortexing, a simple in-vitro technique mimicking impact rebounds that form many stratified paleo-structures. Surprisingly, the clay and shell-fractions individually neither summed-up nor subtracted from one another to quantify the whole sediment reading. At the interglacial interval the clays sequestered more carbon and carbonates did reverse. The carbonaceous shell fraction produced one order more ATP than the clay fraction expect at the onset of MIS 9, where the situation reversed. This behavior is unclear as yet. The dissolution and bioreactor mechanisms of new microbial origins are ample at such extreme intervals and other types of samples mentioned. The signature awaits more critical understanding comparatively with celestial entities like Mukundapur chondrite.

1. Carosi, R., et al. 2014. J. Virtual Explorer, Electronic Edition, ISSN 1441-8142, **47**, paper 7.
2. Treiman, A.H. (2021). Astrobiology. (2021), **21(8),** 940-953.http://doi.org/10.1089/ast.2020.2306
3. Orgel, Leslie E. (2000). "Self-organizing biochemical cycles". PNAS. **97(23),** 12503–12507.
4. Shimamura et al (2016) Scientific Reports **6**:38953 DOI: 10.1038/srep38953
5. Tamilselvi S.M. et al., 2016 Front. Plant Sci., https://doi.org/10.3389/fpls.2016.01828
6. Yoshida et al., (1999) Catalysis letters, **58,** 119-122.
7. Ray, D. and Shukla, A.D. (2018). Planet Space Sci **151**, 149-154, doi: 10.1016/j.pss.2017.11.005.
8. Thombre R.S., et al (2019). Astrobiology **19(6),** 785-796.http://doi.org/10.1089/ast.2018.1928.
9. Nath et al., (2013) Boreas, DOI 10.1111/j.1502-3885.2012.00304.x.

Microbial Resilience to Impact Triggers of Toba, Uncertainties of Jaramillo and Astronomy-Climate Interactions (MRITTUNJAI)

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The voyage of the Wilson Cycle transfers mass and energy in dual directions, both synthetic and degradative, through the same path, but in opposite directions of the redox continuum. In oligotrophic or organic-C depleted systems, hydrothermal signatures become distinct even in cryptic quantities with distinct chemolithotrophic proliferations. Astrobiologists have been hypothesizing the resilience of chemolithotrophic microbial communities during catastrophic geophysical or astrophysical events and the resilience of microbes is well established [1, 2, 3]. We discuss the response of microbes to multiple astronomical, climatic and impact induced events.

Multiple astrobiological sites were examined from the abyssal Central Indian Basin (CIB) siliceous oozes, sediments/ mats associated to alkaline hotsprings, paleolakes and ophiolitic biosignatures from Ladakh, India, and ilmenite placers, Ratnagiri, India. The data from **Mahadeva meteorite, India,** is being used as a reference data here to understand analogous impact related processes. The cosmogenic radionuclides activities were found consistent and matched with the production rate and solar cycle activity [4]. The CIB microbial systems exhibit interesting snapshots of Microbial responses to sunspot cycle, magnetic reversals, mass extinctions, catastrophic impacts and astronomical cycles, all inter-woven in a complex microbial matrix. The study of analogies between the hyperthermal successions in the seafloor sediment cores and meteorites thus seems feasible.

The CIB sediments clearly showed that chemolithotrophic proliferations related closely with Holocene anoxic event, two most recent mass extinctions, magnetic reversals and astronomical cycles including the sunspot cycle. The hotsprings in Ladakh spread over Panamik, Puga, Chumathang show different stages of microbial colonization post-propulsion of hotspring water-jets. Mutualistic succession between iron bacteria and diatoms had been observed in mesocosm experiments with ilmenite-rich placers minerals from Ratnagiri, Maharashtra, India. In diverse geothermal and hydrothermal systems, hyperthermia is succeeded by anoxia followed by productivity and finally oxygenic successions. The pivotal role of primitive microbes like methanogenic archaea and sulfur-oxidizers in regulating the 'sand-clock behaviour' of acidic/alkaline, oxic/anoxic and glacial/interglacial cycles is re-iterated once again. The interiors of meteors, the time of flight of meteors, the contact zone of meteorite impacts, the abrupt 'centripetal brakes' in crater lakes and paleolakes might be targeted as regular study objectives to understand bioreactor processes in meteorite associated samples, locations and events.

Reference:

1. Charles Cockell, (2015) Astronomy & Geophysics, **56**, 1
2. Charles Cockell, et al., (2014) Microbiology Today, **41**, 2, 95-96
3. Stevens A.H.et al (2019) Sci Rep **9**, 9706 https://doi.org/10.1038/s41598-019-46239-z
4. Panda D.K., etal (2020) Planet Space Science, **194**, https://doi.org/10.1016/j.pss.2020.105111