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Fractal chaotic analysis on Mars: signs of life?

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Abstract. An abstract should be given

1. Introduction

In Physics and Biology, the description of the world by the Physics of Chaos plays a fundamental role What Is Chaos? ”Chaos” implies the existence of unpredictable behavior. Chaos embodies important principles: complex dynamics where cause and effect are not proportional, extreme sensitivity to initial conditions due to nonlinearity, long-term prediction becomes impossible, only a statistical description of a dynamic system is possible. Physics of Chaos owns a geometry, it is the fractal geometry, created by Benoit B. Mandelbrot. In effect, trees and bronchial trees, tissues under microscope, as well neurons, can be easily described by fractal geometry. This geometry, where statistical laws, and principles like self-similarity permits to measure the biological entities with high deep meaning.

2. Searching for signs of life on Mrs by chaotic analysis

The first (and only) detected life detection experiments on Mars were performed by the Viking landers on 1976. One of which was the Labeled Release (LR) experiment by Levin and Straat with the injections of organic compounds in Martian soil samples. Immediatey after the injections of organic compounds in Martian samples, radioactive gas evolved approaching a plateau. These ≪active≫ experiments were run many times with similar results.Interestingly, the LR response in the 160 °C was very low, so satisfying the premission criteria for life (Levin & Straat 1977). However, a controversy towards a biologic interpretation of the LR data sudden arose, till today: Gas Chromatograph/Mass spectrometer (GCMS) didn’t find any organic compounds on Mars; no organic compounds = no life or GCMS was lacking of sensitivity? In an attempt to resolve this issue we have employed chaotic analysis of the Viking LR In an attempt to resolve this issue we have employed chaotic analysis of the Viking LR data and of terrestrial LR pilot studies using bacteria-laden active or inactive sterilized one as well others biological and abiological controls. Seven nonlinear chaotic indexes were used: Lempel-Ziv complexity, Hurst and Lyapunov exponents, Entropy (Kolmogorov), Time Correlation, BDS (Brock-Dechert-Scheinkman statistics), Correlation Dimension where used to perform a reanalysis of Viking LR experiments using 16,000 test points from #9 LR experiments carried out on Mars (active, sterilized, starved, Sun protected, tests).

The set of all the chaotic parameters distinguished the active LR experiments on Mars

Cluster 1 (controls/physical) of 2 Contains 8 Cases

Members		Statistics			
Case	Distance	Variable	Minimum	Mean	Maximum
VL2C4	0.464	LZ	0.294	0.790	1.379
Vl1C2	0.593	H	-0.984	-0.706	0.111
VL1C4	0.479	λ	0.000	0.724	2.404
VL2C5	0.966	K	-1.434	0.534	1.449
BIOL 6	0.311	BDS	-2.010	-0.721	0.190
DT VL2C3	0.790	τ	-0.645	-0.508	-0.156
VL1 Atmo. temp	0.413				
Pre-inj radioactivity	0.494				

Cluster 2 (actives/biological) of 2 Contains 7 Cases

Members		Statistics			
Case	Distance	Variable	Minimum	Mean	Maximum
BIOL5	0.534	LZ	-2.136	-0.902	-0.080
VL1C1	0.285	H	-0.218	0.806	2.190
VL1C3	0.409	λ	-1.202	-0.828	-0.219
VL2C1	0.544	K	-1.656	-0.610	0.673
VL2C3	0.622	BDS	0.664	0.824	1.291
VL2C2	0.587	τ	-0.174	0.581	3.304
Rat temp	1.354				

Table 1. Cluster analysis: active LR experiments and biological controls (cluster 2) vs. sterilized LR tests and abiological controls (cluster 1), $p = 0.001$ (Bianciardi et al. 2012)

and the biological ones on Earth from the abiotic control tests ($p = 0.001$), giving evidence to us that LR experiments detected extant life on Mars (Table 1, Bianciardi et al. 2012).

3. Searching for signs of life on MArs by fractal analysis of Martian outcrops

Are there fossil stromatolites/ microbialites on Mars? We investigated their presence by studying, by means of fractal analysis, the images taken by the Opportunity and Spirit Rovers which for more than 10 years have collected tens of thousands of photos of the Martian outcrops. Stromatolites and microbialites, are the oldest evidence of life on Earth. They live today but also in the anoxic Earth, anoxic like Mars today, dating back to 3.5 billion years ago. They are a primitive organization of cyanobacteria that secrete mineral substances, analogous to coral reefs. They grew in vast colonies. They can be identified with physical and chemical approaches but also through morphological analyzes in order to analyze their mineral structures produced by the specific growth patterns of their constituent bacteria. In effect, stromatolites/ microbialites are a frequently named target of life-detection missions on the Red Planet (see, for example,

	EARTH/ Mean (SD)	MARS/ Mean (SD)
Geometric Complexity, High scale	1.817 (0.023)	1.812 (0.018)
Geometric Complexity, Low scale	1.483 (0.070)	1.478 (0.071)
Information Entropy, High scale	1.876 (0.012)	1.874 (0.006)
Information Entropy, Low scale	1.421 (0.050)	1.436 (0.046)
Randomness (Lempel-Ziv index)	0.458 (0.045)	0.468 (0.042)
Tortuosity (Dmin)	0.777 (0.01)	0.775 (0.01)
Minimum diameter (mm)	0.077 (0.002)	0.078 (0.002)
Maximum diameter (mm)	0.2066 (0.003)	0.2068 (0.003)

Table 2. Fractal parameters and diameters of the Martian microscopic microstructures photographed by Opportunity Rover on Mars overlapped the ones of terrestrial biogenic microbialites. The probability of this occurring by chance is less than p = 0.004 (Bianciardi et al. 2014).

McKay & Stoker, 1989). To solve the problem, we have performed a fractal analysis of the microstructures present in the stromatolites and other microbialites on Earth, comparing them with the microstructures present in the outcrops photographed by Opportunity and Spirit rovers, Mars. The contours present in the terrestrial and Martian images were automatically extracted from the images and converted to single pixel outlines by a canny-edge filter. A fractal analysis was performed evaluating on the terrestrial or Martian images: Geometric complexities at low and high scales, Information dimensions (entropy) at low and high scales, Algorithmic complexity (Lempel-Ziv index or "randomness"), Fractal dimension of the minimum path (or "tortuosity"), Maximum diameter, Minimum diameter. The fractal analysis of the Athena images shot by Opportunity rover, analyzing 25,000 Martian microstructures, showed fractal parameters that were overlapping the ones of terrestrial biogenic microbialites (15,000 microstructures): the probability of this occurring by chance was less than 1/28, or p¡0.004 (while, abiogenic pseudostromatolites presented morphometric indexes statistically different from the ones of biogenic stromatolites) (Table 2, Bianciardi et al. 2014). Analogous results were obtained by us analyzing 20,000 microstructures shot by the Spirit rover on Mars (Bianciardi et. al. 2015), and, in the same year, Nofke, proposed evidences of stromatolites in the outcrops photographed by Curiosity (Nofke, 2015). Is it possible to collect evidence on Mars of more complex biological structures than prokaryotes such as microbialites? In the lacustrine environment explored by Curiosity rover at Gale crater, several lozenge-shaped microstructures arose from the Martian outcrops. Some Authors interpreted those structures as mineral crystals, as gypsum (Kah et al. 2018), others as biological structures (Rizzo 2020). In order to search to solve the problem, now we are using fractal analysis in order to compare those Martian microstructures with eukaryotic cells (Euglena mutabilis, an extremophile) and with Gypsum. Our preliminary analysis show that the Fractal Dimension, D0, and Entropy, D1, of the Martian "lozenge"(D0 = 1.580 + 0.04, n = 54; D1 = 1.55 + 0.1, n = 54) differ from the one of the negative control, gypsum (D0 = 1.61 + 0.03, n = 10;D1 = 1.59 + 0.08, n = 10), with high statistical significance (p = 0.01; p = 0.01). Vice versa, Fractal Dimension of the Martian "lozenge" overlaps the one of the unicellular alga Euglena mutabilis, positive control (D0 = 1.574 + 0.06, n = 32), so supporting the hypothesis by V.Rizzo (2020): the "lozenges" discovered by Curiosity could be fossils of complex unicellular life being, like Eukaria on Earth, and rejects the proposal by L.C. Kah et al (2018) as gypsum crystals.

4. Conclusions

The search for life on Mars, either in the present or in the past history of the "Red Planet", has been the main motivation behind research programs since the 1970s. In the present paper, we recall our data concerning a chaotic analysis of the dynamic of the gas released during the Viking LR experiments after addition of organic compounds to the Martian regolith giving us evidence that the released CO2 could be due to a biologic entity and summarize our fractal analysis of the Martian outcrops photographed by the Martian Rovers, Opportunity, Spirit and Curiosity, providing evidences of the possible presence of microbialites (produced by cyanobacteria on Earth) and fossils of unicellular cells on Mars, like unicellular eukaryotic cells on Earth.

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