

**TITAN : HABITABILITY AND GENERAL ASTROBIOLOGICAL ASPECTS** F. Raulin<sup>1</sup>, <sup>1</sup>LISA, CNRS & Universités Paris 7 & Paris12, 61 Avenue Général de Gaulle, F-94000 Créteil, France, [raulinf@lisa.univ-paris12.fr](mailto:raulinf@lisa.univ-paris12.fr)

**Titan:** largest satellite of Saturn and the only satellite in the solar system having a dense atmosphere, Titan is one of the key planetary bodies for astrobiological studies, due to:

- the already well observed presence of an active organic chemistry, involving several of the key compounds of prebiotic chemistry,
- the potential presence of a water ocean in its internal structure,
- its many analogies with planet Earth, in spite of much lower temperatures,

**Organic chemistry:** the recent data obtained from the Huygens instruments show that the organic matter in Titan low atmosphere (stratosphere and troposphere) is mainly concentrated in the aerosol particles. Because of the vertical temperature profile in this part of the atmosphere, most of the volatile organics are probably mainly condensed on the aerosol particles. The nucleus of these particles seems to be made of complex macromolecular organic matter, well mimicked in the laboratory by the "Titan's tholins". Now, laboratory tholins are known to release many organic compounds of biological interest, such as amino acids and purine and pyrimidine bases, when they are in contact with liquid water. Such hydrolysis may have occurred on the surface of Titan, in the bodies of liquid water which episodically may form on Titan's surface from meteoritic and cometary impacts. The formation of biologically interesting compounds may also occur in the deep water ocean, from the hydrolysis of complex organic material included in the chondritic matter accreted during the formation of Titan.

**Emergence and persistence of Life on Titan ?** All ingredients which seems necessary for the emergence of Life are present on Titan :

- liquid water : permanently as a deep sub-surface ocean, and even episodically on the surface,
- organic matter : in the internal structure, from chondritic materials, and in the atmosphere and on the surface, from the atmospheric organic chemistry
- and energy : in the atmosphere (solar UV photons, energetic electrons from Saturn magnetosphere and cosmic rays) and, probably, in the environment of the sub-

surface ocean (radioactive nuclei in the deep interior and tidal energy dissipation) as also supported by the likely presence of cryovolcanism on the surface

Thus, it cannot be excluded that life may have emerged on or in Titan. In spite of the extreme conditions in this environment life may have been able to adapt and to persist. For instance the temperature, pressure and pH conditions in the hypothetical subsurface Titan ocean are not incompatible with the presence of micro-organisms, similar to those known on Earth. Indeed, there are extremophile bacteria which develop on Earth at pressures close to 1 GaPascal, and at pH as high as 11-12, conditions presents in Titan's subsurface oceans. There are even (terrestrial) bacterias able to assimilate the organic laboratory tholins as efficient nutrients !! Calculation of the energy available for micro-organisms in Titan's ocean (Fortes, 2000) shows a possible biomass density of 1g /m<sup>2</sup>. It is only 1/1000 to 1/10000 the terrestrial value, but it is not negligible.

**Conclusions:** Even if these liquid water scenarios are false, the possibility of a pseudo biochemistry, evolving in the absence of a noticeable amount of O atoms cannot be ruled out, with alternatives of terrestrial biochemistry where, in particular the water solvent could be replaced by ammonia or other N-compounds (Raulin and Owen, 2002, Schulze-Makuch and Irwin 2004). Finally, even if life did not emerged on Titan, the organic processes which are occurring in this exotic environment, in the whole physical and chemical complexity of a planetary environment is of prime interest for astrobiology since it provides a fantastic ground truth environment to test our theories of terrestrial prebiotic chemistry on the primitive Earth, the environment of which is not available today.

**References:** Fortes, A.D. (2000), 'Exobiological implications of a possible ammonia-water ocean inside Titan', *Icarus* **146**, 444-452.

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