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Methane in outer space: The limit between organic and inorganic

I. Valentin Petrescu-Mag[1,2,3], Ioan G. Oroian[1], Benone Păsărin[2], and Ruxandra M. Petrescu-Mag[2,4]

[1]University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Romania; [2]Ion Ionescu de la Brad University of Agricultural Sciences and Veterinary Medicine, Iaşi (Postdoctoral Shool in Agriculture and Veterinary Medicine, European Social Fund; Sectoral Operational Programme Human Resources Development 2007-2013, project POSDRU/I.89/1.5/S62371); [3]Bioflux SRL, Cluj-Napoca, Romania; [4] Babes-Bolyai University, Cluj-Napoca, Romania. Corresponding author: I. V. Petrescu-Mag, zoobiomag2004@yahoo.com

Abstract. Methane is the principal component of natural gas, the simplest alkane, and among the most abundant organic compounds on our planet; it is also found in outer space in enormous amounts. The extremely abundant and natural occurrence of methane in outer space is a starting point in our understanding as regards the ability of matter to become “more organic”. Hydrogen and carbon were created to be together. We wonder… is organic soup of Earth's past only a vague assumption? It is enough to admire the variety and abundance of hydrocarbons in our solar system that we answer the question.
Key words: origins of life, organic compounds, inorganic, methane, outer space.

The Meaning of Being Organic Compound. The distinction between inorganic and organic compounds is somewhat arbitrary, but often useful in organizing the vast subject of chemistry (Seager & Slabaugh 2004). An organic compound is any member of a large class of solid, gaseous, or liquid chemical compounds whose molecules contain the element carbon (Seager & Slabaugh 2004). Few types of carbon-containing compounds such as carbonates, carbides, simple oxides of carbon, and cyanides, as well as the allotropes of carbon such as graphite or diamond, are considered inorganic. There are some simple chemical compounds that are considered truly organic: methane, ethane, propane, butane, pentane and so on.

Methane (CH_4) is the main component of natural gas, the simplest alkane, and among the most abundant organic compounds on our planet; it is also found in outer space in enormous amounts (McFadden et al 2007; Faure & Mensing 2007) (see also Table 1 and references therein). On Earth, methane originates in the same way as crude oil, by the anaerobic decomposition of microscopic sea animals under the pressure of layers of silt and mud over a period of millions of years. Other sources of methane in atmosphere are methanogenic bacteria from ruminants, termites etc. The formation of methane in outer space is resulted most probably from physical-chemical reactions (Mitchell 1977).

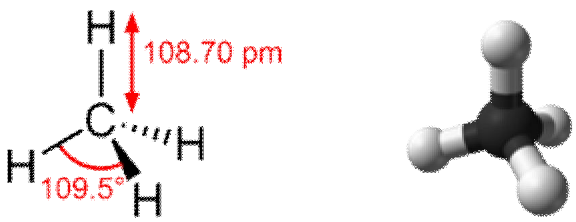

Figure 1. Stereo, skeletal formula of methane (tetrahydridocarbon) (left); Ball and stick model (right) (from wikipedia.org).

Table 1

Known sources of methane in universe (from the farthest to the closest)

Sources of methane	*Details: concentration/quantity, reference etc*
Interstellar clouds	It was shown by Mitchell (1977) that the abundance of methane in dense interstellar clouds is expected to be comparable to that of the most abundant observed polyatomic molecules; see also Lacy et al (1991).
Extrasolar planet HD 189733b	This is the first detection of an organic compound on a planet outside the Solar System. Its origin is not clear, since the planet's high temperature (about 700 °C) would normally favor the formation of other compound instead: carbon monoxide (Battersby 2008).
Comet Hyakutake	As a result of terrestrial observations, researchers found methane and ethane in the comet Hyakutake (Mumma et al 1996).
Comet Halley	Battrick et al (1986), but also Allen et al (1987) detected methane and ammonia in the coma of comet Halley.
Eris	Infrared light from the object revealed the presence of methane ice on Eris.
Charon	Methane is believed present on Charon, but it is not completely confirmed (Sicardy et al 2006).
Pluto	Spectroscopic analysis of Pluto's surface reveals it to contain traces of methane (Owen et al 1993).
Triton	Triton has a tenuous nitrogen atmosphere with small amounts of gaseous methane near the surface (Shemansky et al 1989; Miller & Hartmann 2005).
Neptune	The atmosphere of Neptune contains about 1.6% methane.
Umbriel	Umbriel has a solid coating of ice (it is not regular ice). Methane is a constituent of this surface ice (wikipedia.org).
Titania	As much as 20% of Titania's surface ice is composed of methane-related organic compounds (wikipedia.org).
Oberon	About 20% of Oberon's surface ice is composed of methane-related chemical compounds. These compounds are mainly based on carbon and nitrogen (wikipedia.org).
Miranda	The planet has a thick mantle composed of water ice containing amonnia and methane (Faure & Mensing 2007) (see also McFadden et al 2007).
Ariel	Methane is believed to be a constituent of Ariel's surface ice.
Uranus	The atmosphere of the planet contains about 2.3% methane.
Enceladus	The atmosphere of Enceladus contains 1.7% methane (Waite et al 2006).
Titan	The atmosphere of Titan contains 1.6% methane and thousands of methane lakes have been detected on the surface (Niemann et al 2005) (see also Figure 2). In the upper part of atmosphere the methane is converted into more complex organic molecules including acetylene, a process that also produces molecular hydrogen. There is evidence that acetylene and hydrogen are recycled into methane near the surface of the planet. This suggests the presence on Titan either of an exotic catalyst, or a peculiar form of methanogenic life (see details in Mckay 2010).
Saturn	The atmosphere has about 0.4% methane (wikipedia.org).
Jupiter	The situation seems to be rather similar; the content of methane in atmosphere is 0.3% (wikipedia.org).
Mars	Mars was seen by many as a host of life, at least in the past or future (Petrescu-Mag 2009). The atmosphere of Mars contains 10 nmol/mol methane. In January 2009, NASA scientists announced that they had discovered that the planet often vents methane into the atmosphere in specific areas, leading some to speculate this may be a sign of biological activity going on below the surface (Washington Post 2009).
Moon	Traces are outgassed from the surface (Stern 1999).
Earth	It is the result of methanogenic bacteria activity. Methane is a serious pollutant of atmosphere due to the fact it produces greenhouse effects.

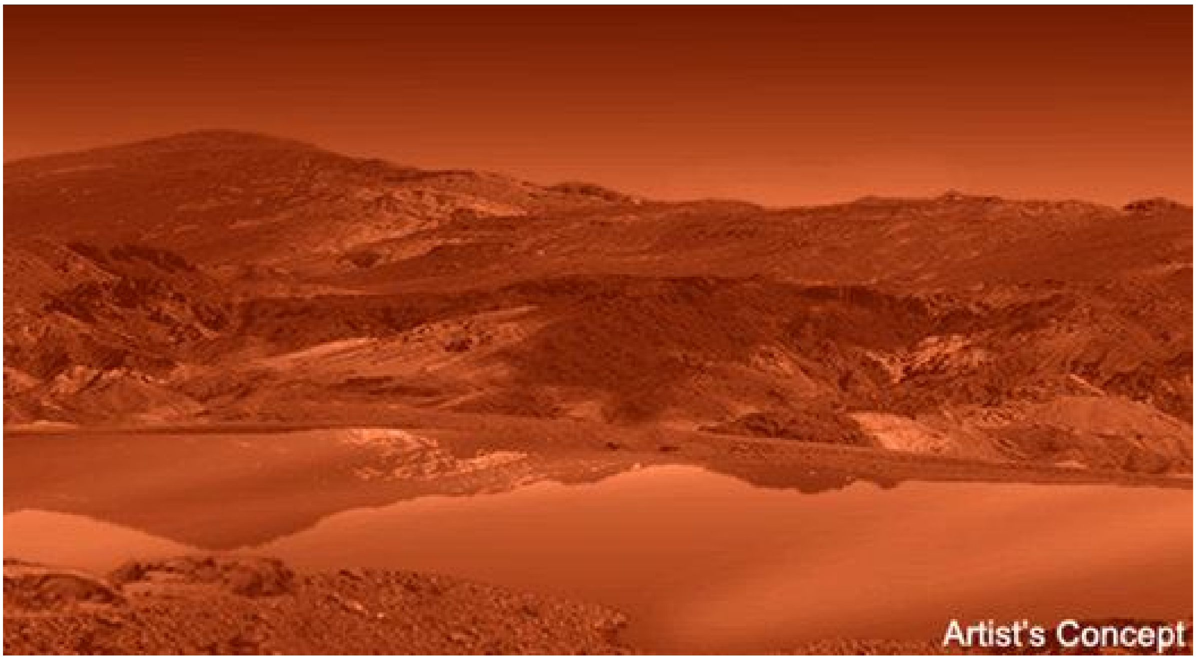

Figure 2. An artist's concept of a glassy hydrocarbon lake on Titan, which might harbor exotic forms of microbial life (source: NASA).

Final Remark. The extremely abundant and natural occurrence of methane in outer space is a starting point in our understanding as regards the ability of matter to became "more organic". Hydrogen and carbon were created to be together. We wonder… is organic soup of Earth's past only a vague assumption? It is enough to admire the variety and abundance of hydrocarbons in our solar system that we answer the question.

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Authors:
Ioan Valentin Petrescu-Mag, Faculty of Animal Sciences, Ion-Ionescu de la Brad University of Agricultural Sciences and Veterinary Medicine Iaşi (Postdoctoral School in Agriculture and Veterinary Medicine), 3 Aleea Mihail Sadoveanu Street, Iaşi, Romania, European Union, e-mail: zoobiomag2004@yahoo.com
Ioan Gheorghe Oroian, Faculty of Agriculture (Department of Environmental Sciences and Engineering), University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 3-5 Calea Mănăştur Street, Cluj-Napoca, Romania, European Union, e-mail: ioroian@usamvcluj.ro
Benone Păsărin, Faculty of Animal Sciences, Ion-Ionescu de la Brad University of Agricultural Sciences and Veterinary Medicine Iaşi, 3 Aleea Mihail Sadoveanu Street, Iaşi, Romania, European Union, e-mail: pbeno@uaiasi.ro
Ruxandra Mălina Petrescu-Mag, Babeș-Bolyai University, Faculty of Environmental Sciences and Engineering, 30 Fântânele Street, Cluj-Napoca 400294, e-mail: pmalina2000@yahoo.com
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