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Pluto's Surprises: Mountain Tectonics, Methane and Evidence of Biology

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Abstract

First results from the New Horizon Mission to Pluto shows evidence of a fluid interior with a presumed radioactive heat source driving mountain tectonics and surface restructuring. The presence of methane ice is intriguing, suggesting past or ongoing biological sources.

Keywords: Pluto; TNO objects; Radioactive heating; Mountain tectonics; Planetary bio-methane

Introduction

The early results from the New Horizon Mission have challenged assumptions in relation to the dwarf planet Pluto, confirming early ideas of radiogenic heating being dominant in icy bodies of the outer solar system [1,2]. Pluto is one of several 1000 km-sized bodies that are now seen as the largest amidst millions of trans-Neptunian objects (TNOs) occupying the frigid outer reaches of our planetary system[3]. They populate the misnamed Edgeworth-Kuiper Belt - misnamed because it is a toroidal distribution and very thick, extending beyond Pluto for several times its distance from the sun. The large outer moon of Neptune, Triton, is a "twin" of Pluto, and both are by no means dead bodies.

Pluto's surface shows clear evidence of restructuring, activity and mobility on timescales under millions of years as can be inferred from the surprising absence of meteorite impact craters (Figure 1). Its radius of ~1200 km and low density 1.9 g cm-3 imply a composition of water ice plus mineral and carbonaceous particles, much like comets.

Like Triton, Pluto has surface ices and a thin atmosphere with relatively small masses of methane and nitrogen. Surface temperatures of ~40 K in full sunlight ensure the ices sublimate to maintain a tenuous atmosphere, but also facilitate photolytic reactions that lead to loss of gases from the low surface gravity (escape velocity of 1.2 km/s).

The high mountains and deep chasms discovered by the New Horizon Mission evidencing tectonic activity point to interior energy sources, as predicted by Czechowski & Leliwa-Kopysty´nski [4]. Whilst a small amount of tidal heat is produced in the Pluto-Charon binary system [4], radioactive decays are a much more significant heat source. Depending on the admixture of radioactive elements, melting of ices is likely to occur due to heat they generate [1,5]. Two short-lived nuclides that have been considered in the context of comets are 26Al (half-life 0.74My) and 60Fe (half-life 1.5My). A limiting factor for heating by these short-lived nuclides is the time taken for the bodies to accrete following a supernova injecting radioactive nuclides into the solar nebula. If the process takes much longer than several million years, these radioactive heat sources would have become extinct.

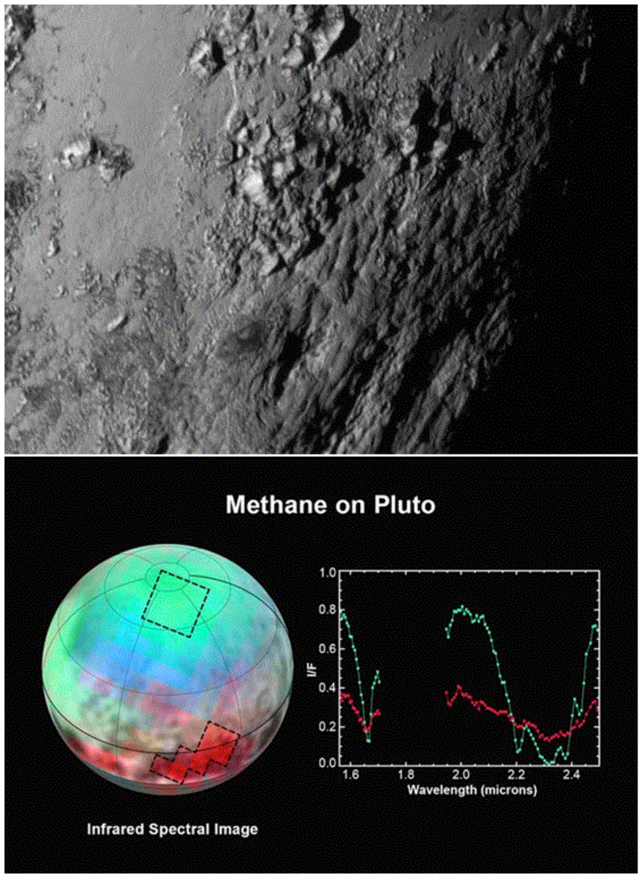

Figure 1: (Top) Rugged water-ice dominated terrain, flat plains and ice mountains up to 3500 m in height (New Horizon images: Courtesy NASA). (Bottom) Infrared spectral image showing planets wide deposits of methane ice. The methane-ice is partially obscured by deposits of semi-transparent nitrogen-ice away from the equatorial region (red, unobscured methane) which is deeper near the poles (Credit: NASA-JHUAPL-SwRI).

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Unlike comets, Pluto and its slightly larger twin Triton are big enough for longer-term radiogenic heating by 238U (half-life 4.5Gyr) and 232Th (half-life 14Gyr) serving to melt ices in their interiors. With (U+Th)/(C+N+O) ~10-8 by mass (solar system abundances) and given the total energy released from the fission of U + Th to be ~1014 J/kg we have an average heat release per unit mass of ~106 J/kg. When this is compared with ~3.34 x 105 J/kg appropriate for the heat of fusion of water ice, the implication is that a substantial mass fraction of the planet's water-ice content would be converted to liquid water/slush on energetic arguments alone[5].

To determine whether an interior liquid core can persist long enough in a body such as Pluto or Triton we need to consider the rate of heat transport through an outer frozen ice shell. For a body with a spherical liquid core of radius 1000 km and temperature 273 K surrounded by a concentric frozen shell of ice of outer radius 1200 km and surface temperature 40 K, it is readily shown that the characteristic timescale for heat loss and refreezing of the interior is of the order of 1010 yr [6]. Yabushita [2] and Bar-Nun and Owen [7] have performed more detailed numerical integrations to conclude that icy spheres larger than 100 km would have their slushy liquid interiors transformed, at least partially re-crystalizing their amorphous ice and mobilizing dissolved volatile gases. Any interior gases including CO and CH4 (sublimation temperatures ~25 K, 31 K respectively at normal pressure) diffuse outwards through pores. These gases would escape to the atmosphere and to space if not sealed in by surface layers of H_2O-ice or captured as H_2O-clathrates.

Long-term evolutionary models were also calculated for mainly H_2O-ice TNOs by Choi et al. [8]. Sarid and Prialnik [9] elaborated on this approach, adding pore-diffusion, but ignored the phenomenon of ice-convection which enhances heat transfer and loss, but also promotes the outward diffusion and escape of gases.

Convection of outer ice-shells (turnover time ~108 yr for a 200 km frozen outer layer) is responsible for the formation of the surface features on several icy satellites of Jupiter and Saturn. Czechowski and Leliwa-Kopystýnski [4] reviewed modeling of the tectonic activity driven by internal heating, by tidal stresses or radiogenic sources. The new images of Pluto with ice-mountains and planet-scale rifts verify that this is happening there too.

The major surprise is the presence of widespread methane ice on Pluto's surface, much covered by semi-transparent nitrogen-ice, which is especially thick at the poles (Figure 1: bottom). Methane is not expected to be abundant in the solar nebula material from which Pluto was formed (likewise not abundant in 'pristine' comets), and any small initial compliment of methane would have been largely lost through the diffusion and ice convection processes. We therefore infer an internal source of methane venting preferentially through equatorial "cracks". This applies likewise to Triton [10], with the difference that Triton has been subject to strong tidal stresses during its capture by Neptune – these enhanced the heating, causing rupture and turnover of its ice shell. Methane being weaker on Triton, but still surprisingly abundant, is possibly due to its faster loss.

On Mars, the methane source (that is now well attested) is explained as either biogenic –subsurface methanogens in the permafrost - or mineral serpentisation. Pluto lacks the rocks for a mineral source, so it may be argued that a biogenic source is indicated. On the panspermia hypothesis the material from which Pluto and Triton condensed would have included a small number of viable microbes. In its earliest history, when the interior ice first reached a temperature ~270 K due to radioactive heating, the initial number of microorganisms (including methanogens) would have increased exponentially on a short timescale with interstellar organics serving as nutrients. Some of this biogenic methane would have been trapped within the 100 km-scale ice shell and released more slowly than the 108 year ice-convection time for planet-scale cracks [11].

Alternatively the methane source in Pluto could be an indication of on-going microbiology - methanogens relatively close to the surface that are still active because the tectonic overturning brings them close to unused organic and mineral nutrients of the interstellar dust presumed incorporated in all TNOs. Organic material was discovered to be abundant in the dust from Halley's Comet (Giotto/Vega missions of 1986) and would provide the essential nutrients for microbial life in the absence of light. Similar organic material was found recently to dominate the very dark surface of the Rosetta comet 67P/C-G, and this may turn out to be so for Pluto as well. Far from writing off this region of our solar system as barren and lifeless its TNOs may turn out to be reservoirs of microbial life, just on our doorstep. The New Horizons mission over-fulfills expectations in initiating astrobiological exploration of the new worlds of dwarf planets.

References

1. Wallis MK (1980) Radiogenic melting of primordial comet interiors. Nature 284: 431-433.
2. Yabushita S (1993) Thermal Evolution of Cometary Nuclei by Radioactive Heating and Possible Formation of Organic Chemicals. Mon Not Roy Astr Soc 260: 819-825.
3. Merk R and Prialnik D (2003) Early Thermal and Structural Evolution of Small Bodies in the Trans-Neptunian Zone. Earth, Moon and Planets 92: 359-374.
4. Czechowski L, Kopystýnski J L (2005) Convection driven by tidal and radiogenic heating in medium size icy satellites. Planetary and Space Science 53: 695-780.
5. Wickramasinghe JT, Wickramasinghe NC, Wallis MK (2009) Liquid water and organics in Comets: implications for exobiology. International Journal of Astrobiology.
6. Hoyle F, Wickramasinghe NC (1985) Living Comets. (1stedn) Cardiff: Univ. College, Cardiff Press, UK.
7. Bar-Nun A, Owen T (1998) Trapping of Gases in Water Ice and Consequences to Comets and the Atmospheres of the Inner Planets. Astrophysics and Space Science Library 227: 353–366.
8. Choi YJ, Cohen M, Merk R, Prialnik D (2002). Long-term evolution of objects in the Kuiper belt zone - effects of insolation and radiogenic heating. Icarus 160: 300-312.
9. Sarid G, Prialnik D (2009) From KBOs to Centaurs: The thermal connection. Meteoritics & Planetary Science 44: 1905-1916.
10. Lellouch E, de Bergh C, Sicardy B, Käufl H U, Smette A (2011) The Tenuous Atmospheres of Pluto and Triton Explored by CRIRES on the VLT. ESA Messenger 145: 20-23.
11. Lellouch E, de Bergh C, Sicardy B, Ferron S, Käufl H U (2010) Detection of CO in Triton's atmosphere and the nature of surface-atmosphere interactions. Astronomy and Astrophysics 512 L8.