Mars and Titan: Assessing the plausibility of life on two worlds with similar features and exotic differences

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Mars has long been considered conducive to the possibility of life because of its proximity to Earth, evidence for geophysical processes similar to those on Earth, and episodic temperatures above the melting point of water. The abundance of organic molecules on Titan has stimulated speculation about the possibility of life there as well. Recent data from robotic missions to Mars and Titan have opened the door to a reassessment of the plausibility of life (POL) on both. The abundance of subsurface water now evident on Mars has enabled the reconstruction of a planetary history highly conducive to the origin and possible persistence of at least microbial life (Schulze-Makuch, *et al.*, 2005), strengthening the case for a POL of II on Mars (Irwin & Schulze-Makuch, 2001). Images from the Huygens probe to Titan reveal a heterogeneous surface with superficial similarities to Martian topography, indicative at least of chemical and energy cycles capable of reshaping what appears to be a young surface. Coupled with the abundance of organic matter, some of the requirements for living systems appear to be met. The nature of solvent availability remains a question. Subterranian water liquefied by internal heating or gravitational flexing could support water-based cellular life beneath the surface as known on Earth. The much colder temperature and consequent liquid state of organic compounds near the surface, if they are the prevalent solvents, would require a very different cellular boundary (membrane) composition and metabolic systems substantially divergent from anything known on Earth. Titan thus presents the possibility of harboring either relatively familiar or totally exotic forms of life. Ongoing analysis of data from Huygens should eventually support one possibility over the other, and suggest whether the original POL rating of III for Titan (Irwin & Schulze-Makuch, 2001) deserves to be elevated to II (Schulze-Makuch & Irwin, 2004).

References

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Mars and Earth: Results of recent Mars missions

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Current news releases to the contrary, many geological investigators have known for thirty years that Mars had an early history with aqueous activity on its surface. However, new mission results are revealing the extensive sedimentary and geochemical evidence for that history. The new results strongly corroborate the long-standing geological and geomorphological inferences that early Mars had extensive lakes and probably transient seas ("oceans") that were associated with a climate capable of generating the precipitation and runoff to sculpt its landscape and transport materials to sedimentary basins.

High-resolution images from the Mars Orbiter Camera (MOC) of the Mars Global Surveyor (MGS) Mission reveal a diverse suite of exceptionally young, globally distributed landforms of aqueous origin, including glacial, periglacial, fluvial, lacustrine, mass moverment, and phreatovolcanic features. These landforms are uncratered or exceedingly lightly cratered, implying an age of less than a few million years. If observed on Earth, most of these landforms would be ascribed to processes requiring a relatively dense atmosphere and extensive movement of water through precipitation from that atmosphere. Because such conditions do not currently prevail on Mars, these observations imply ongoing climate change on Mars

Results from the Mars Odyssey Mission are consistent with an early phase of plate tectonics, which could have produced the Martian highland crust by continental accretion. By concentrating volatiles in a local region of the Martian mantle the early plate-tectonic phase of Mars would have led to a superplume at Tharsis. The resulting concentration of volcanism at Tharsis would iinfluence climate change by initiating immense megafloods. The observed persistence of this volcanism through later Martian history provides the mechanism for the episodic, short-duration aqueous phases.

Earth's early history of megaglaciations has some broad similarities to the newly understood history of Mars. Earth's late Proterozoic glaciation is particularly interesting since there is considerable geological evidence that Earth may have temporarily switched to Mars-like icehouse conditions by freezing of the surface of the global ocean. Both Mars and Earth may be subject to major endogenetically driven shifts in climatic states.