Radiocarbon on Titan

RALPH D LORENZ[1], A. J. TIMOTHY JULL[2], TIMOTHY. D. SWINDLE[1], JONATHAN I. LUNINE[1]

[1]Lunar and Planetary Lab, University of Arizona, Tucson, AZ 85721 (rlorenz@lpl.arizona.edu, tswindle@lpl.arizona.edu, jlunine@lpl.arizona.edu)
[2]Department of Geosciences, University of Arizona, AZ 85721 (jull@email.arizona.edu)

Just as cosmic rays interact with nitrogen atoms in the atmosphere of Earth to generate radiocarbon (^{14}C), the same process should occur in the atmosphere of Saturn's giant satellite Titan. Titan's atmosphere, made predominantly of nitrogen with a few percent of methane, is thick enough (1.5 bar surface pressure) that cosmic ray flux, rather than nitrogen column depth, limits the production of ^{14}C. Absence of a strong magnetic field and the increased distance from the sun suggest production rates of ~9 atom/cm^2/s, approximately 4 times higher than Earth. On Earth the carbon is rapidly oxidised into CO_2. However, the fate and detectability of ^{14}C on Titan depends on the chemical species into which it is incorporated in Titan's reducing atmosphere : as methane it would be hopelessly diluted even in only the atmosphere (ignoring the other, much more massive carbon reservoirs likely to be present on Titan, like hydrocarbon lakes.) However, in the more likely case that the ^{14}C attaches to the haze that rains out onto the surface (as tholin, HCN or acetylene and their polymers - a much smaller carbon reservoir), haze in the atmosphere or recently deposited on the surface would therefore be quite intrinsically radioactive. Such activity may modify the haze electrical charging and hence its coagulation, and conceivably the radiocativity-induced near-surface enhancement of atmospheric electrical conductivity might be detectable by the ESA Huygens probe (part of the NASA-ESA Cassini mission) to arrive in 2005. Measurements with compact instrumentation on future in-situ missions could place useful constraints on the mass deposition rates of photochemical material on the surface and identify locations where surface deposits of such material are 'freshest'.

Extensive C- and S-rich black shale formations: abundant life around black smokers 2 Ga ago

LOUKOLA-RUSKEENIEMI, K.

Geological Survey of Finland, P.O. Box 96, 02151 Espoo, Finland (kirsti.l-r@gsf.fi)

Widespread black shale formations 2.1-1.96 Ga in age are encountered in Finland, with the following characteristics: thickness 20-400 m, average C concentration 6-9%, and S concentration 6-10%. The black shales can be followed for hundreds of kilometers by geophysical measurements and the thickness of the formations is 20-400 m. A map of the distribution of the black shales was completed in 2000 by Arkimaa and others. Geochemistry of the shales was studied with some 2000 drill core samples (Loukola-Ruskeeniemi 1999). In the NW Russia, well-known shallow-water formations of the same age contain in excess of shungitic C and practically no S.

Comparison with the distribution of black shales around the world reveals that thick black shale formations were deposited 2.2-2.0 Ga ago in different parts of the world. Condie and others (2000) suggest that this reflect the breakup of supercontinents. Several marine basins were restricted and ocean currents disrupted, and the amount of hydrothermal vents increased at ocean ridges, which could have led to widespread anoxia. However, there are no peaks in black shale abundance at 1.5-1.4 Ga when the Palaeoproterozoic supercontinent broke up.

A large portion of the present-day oceanic crust support hydrothermal activity and microbial life, but the black smoker-related unique life forms were probably more abundant 2.1-1.96 Ga ago. During the Palaeoproterozoic, the Earth was warmer than today and circulation under the Earth's crust was more intense. Concentration of oxygen was lower. Finnish rift-related black shales contain a lot of S and heavy metals in addition to C, and trace element contents evidence for the vicinity of black smokers. The Finnish black shale formations may thus represent evidence for ancient extensive black smoker chain teeming with life.

References

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