Depth Profile Of Radiolytic Fluence On Europa: Implications for Remote Sensing and In-Situ Analyses

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Europa's surface is bombarded by high fluxes of ionizing radiation (primarily high-energy electrons and protons) that destroy existing molecules and produce new species. The depth of direct radiolysis is ~ 1 mm, but the upper surface is being continuously overturned by micrometeoroid impact "gardening", burying exposed material and bringing material from depth to the surface. Continual exposure and redistribution produces a thick layer of radiolyzed matter whose composition is different than that of the unexposed, pristine material (Carlson et al., *Science* **283**, 2062, 1999; **286**, 97, 1999). Biomarker molecules that could indicate biotic processes on Europa would be degraded and become less diagnostic. The cumulative energy deposition (fluence) and its variation with depth indicates the extent of radiolytic decomposition and the sampling depth necessary to obtain unmodified samples.

The fluence profile was computed using fluxes compiled by Cooper et al. (*Icarus* **149**, 133, 2001), with the electron deposition concentrated on the trailing hemisphere (Paranicas et al., *Geophys. Res. Lett.* **28**, 672, 2001)) and uniform proton irradiation. Two gardening models were used (Cooper et al.and Phillips and Chyba, *LPSC* 2001) and both synchronous and asynchronous rotations were considered. A surface age of 10 My was assumed, with the crust composed of fresh, unexposed material 10 My ago. The time development of the fluence in the optical layer was also computed.

The depth of significant fluence is \~ 1 meter, and the exposure is sufficient to destroy even the most radiation resistant molecules many times over (Carlson et al., *Icarus* **157**, 456, 2002). The molecules within the upper meter will be in radiolytic equilibrium and different from the original parent mixture. The fluence levels are about 10^7 Mrad,; a level of \~ 10 Mrad is fatal to *Deinococcus radiodurans* Remote-sensing observations will sense altered material in radiolytic equilibrium except where very recent impacts have exposed material at meter depths, i.e. fresh craters with diameters \> about 10 m. The time required to attain a fluence of 1000 eV per 16-amu molecule in the optical layer (upper 500 μm) is about 700 years on Europa's trailing side. An in situ astrobiological mission should obtain samples from depths \> 1 m.

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