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The Influence of Europa's Radiation Environment on the Selection of Potential Landing Sites for Future Missions

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Abstract

The surface of Europa is weathered by photons, charged and neutral particles, and micrometeroids [1]. It has been proposed that these processes can have important astrobiological consequences [2,3] and both NASA and ESA have stated that the exploration of Europa's surface should be a high priority. However, Europa's radiation environment presents a significant challenge, chemically altering species of interest [4], and posing a significant hazard to any spacecraft investigating the satellite. Recent work has shown that radiolytic processes involving charged particles are not uniform with respect to location and depth across the surface of Europa [5]. Coupled with several other complicating factors, this has important implications when considering potential landing sites for future missions to the satellite (e.g., locations where relatively unaltered subsurface organic material may be found at or near the surface).

Particle interactions with the surface

Charged particles trapped by Jupiter's magnetic field continuously bombard Europa's surface. This processing primarily affects the top few cm of Europa's icy shell [e.g., 1, 7], although energetic electrons can penetrate deeper and their secondaries, bremsstrahlung photons, can easily reach one meter. Energetic ions can both sputter the ice, that is redistribute neutrals by adding energy to the uppermost layer, and also participate in forms of radiolysis, where new molecules are formed through interactions. Electrons likewise can lead to the production of hydrogen peroxide and other materials. Modeling suggests that electrons in the hundreds of keV to tens of MeV range, which dominate the radiation dose at Europa, preferentially get deposited into the satellite's trailing hemisphere and their bombarding fluxes systematically decrease across the remainder of the satellite as a function of longitude and latitude [5,7] (Fig. 1). This suggests that Europa's leading hemisphere is effectively shielded from a significant fraction of the radiation present at the body.

Other Complicating Factors

Impact gardening by micrometeorite bombardment results in vertical mixing of Europa's surface. Because the satellite is in nearly synchronous rotation about Jupiter, heliocentric impactors are expected to preferentially affect the leading hemisphere [9]. Given a mean surface age for Europa of ~10^7 yr [10], it has been suggested that the surface of the satellite could be affected by this process to depths of up to 1.3 m [1].

Modeling suggests that the decoupled outer shell of Europa should undergo nonsynchronous rotation due to torques imposed by tidal forces [11,12]. Comparisons of Voyager and Galileo images [13] suggest that this mechanism would lead to rotations of no less than 1° in longitude over timescales >10^3 yr. This rotation would serve to homogenize the effects of radiolytic processes and impact gardening across the surface of the satellite. However, this would also suggest that surfaces on the trailing hemisphere of the satellite that are <10^5 yr in age may be relatively unaffected by impact gardening processes.

Landing Site Characterization

Two primary factors to consider for future landed missions to Europa's surface are potential science return and mission lifetime. Given the likely presence of a subsurface ocean on Europa [14] and geologic evidence pointing toward its interaction with the surface [15], astrobiological potential will likely play a primary role in the choice of potential

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landing sites for future missions [16]. From the point of view of radiation, the equatorial latitudes on the leading hemisphere are certainly safer for a lander. Furthermore, we expect there to be at least marginally less sputtering on the leading hemisphere. From the point of view of gardening, the trailing hemisphere is preferred. These processes are ongoing and interact with each other to produce a complex and global cycle of chemical alteration and surface erosion. Understanding how this cycle works can provide essential information for assessing the science value and risk associated with potential landing sites. In this paper, we examine these processes in detail and discuss the merits of a number of proposed landing sites.

References

[1] Cooper et al. (2001), Icarus, 149, 133-159; [2] Chyba (2000), Nature 403, 381-382; [3] Irwin and Schulze-Makuch (2001), Astrobiology, 1(2), 143-160; [4] Delitsky and Lane (1997), J. Geophys. Res., 102, 16,385-16,390; [5] Paranicas et al. (2007), Geophys. Res. Lett., 34; [6] Chyba and Phillips (2001), P. Natl. Acad. Sci. USA 98(3), 801-804; [7] Paranicas et al. (2002), Geophys. Res. Lett., 29; [8] Johnson (1990), Springer-Verlag.; [9] Schenk et al. (2004), Cambridge University Press, Cambridge, 427-456; [10] Zahnle et al. (1998), Icarus, 136, 202-222; [11] Greenberg and Weidenshilling (1984) Icarus 58, 186-196; [12] Ojakangas and Stevenson (1989), Icarus 81, 220-241; [13] Hoppa et al. (1999), Icarus, 137, 341-347. [14] Kivelson et al. (1999), J. Geophys. Res., 104, 4609-4625; [15] Pappalardo et al. (1999), J. Geophys. Res., 104, 24,015-55; [16] Figueredo et al. (2003), Astrobiology, 3, 851-861.

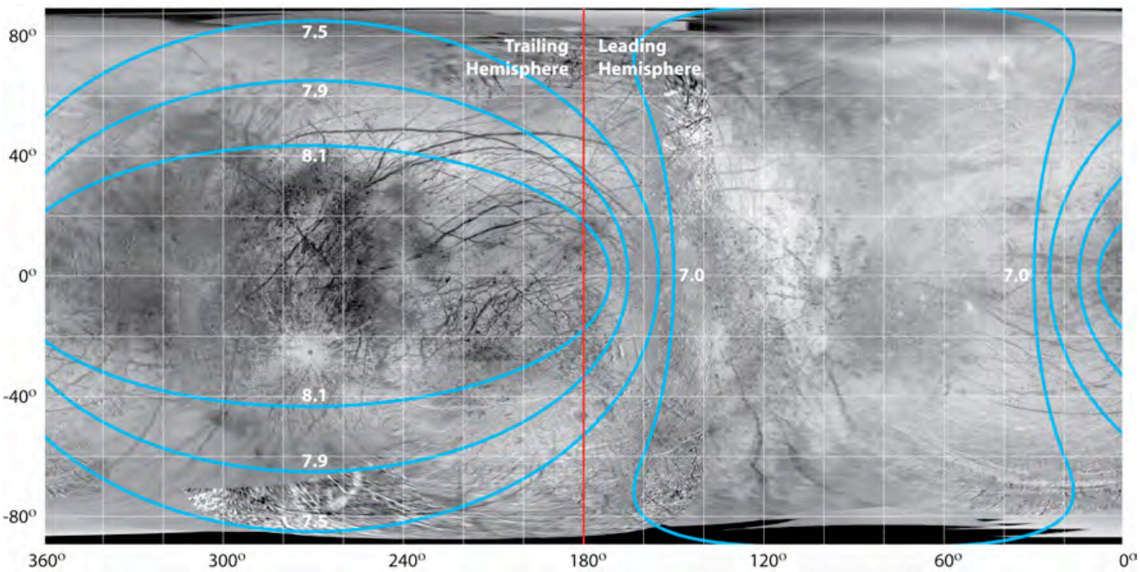

Fig. 1. Map illustrating preferential bombardment of Europa by energetic electrons in power per unit area from 10 KeV to ~25 MeV. Contours are labelled in units of log $MeVcm^{-2}s^{-1}$ show the order of magnitude difference in deposited energy between the leading and trailing hemispheres of the satellite.