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Comparative Magnetospheric Contributions to Polar Atmospheric Outflows at Enceladus and Ganymede

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Enceladus and Ganymede exist in magnetospheric regions of comparable radiation energy fluxes respectively within the Saturn and Jupiter systems. Both of these irradiated icy moons exhibit different forms of polar atmospheric outflows, from clearly active cryovolcanism at Enceladus to more diffuse ionospheric outflows presumably from surface and/or exospheric interactions at Ganymede. The latter's intrinsic dipole magnetic field funnels electrons and lower energy ions into the polar regions from the Jupiter magnetosphere, while Enceladus plume emissions are more likely driven by interior tidal heating but may also have kinetic and chemical contributions resulting less directly from polar surface irradiation processes. Global neutral atmospheres extending to the equatorial surface regions are less evident for both moons but are predicted from surface irradiation, more by energetic electrons at Enceladus and by energetic protons and heavy ions at Ganymede. Both have local magnetic field environments distorted by intrinsic energy sources, mass loading at Enceladus as compared to the internal magnetic field and the polar plasma source at Ganymede. Radiation shielding requirements for separate orbital spacecraft missions to these two moons, although differently challenging in other respects, would be comparably low compared to those for Europa. To some extent the polar nature of the respective mass outflows may also comparably drive the definition of science requirements for missions to these moons. E.g., if Enceladus has a component of polar cryovolcanic activity induced by magnetospheric interaction, as previously suggested, does an analogous unresolved polar component also exist at Ganymede? Both moons have visibly disrupted younger terrains potentially linked to present or past cryovolcanism. Alternatively, intrinsic magnetic shielding would enable higher sensitivity searches in near-equatorial regions for active cryovolcanism from Ganymede's deep subsurface ocean, due both to the minimal radiation background for instrumentation and to associated reduction in the surface irradiation energy source for any externally induced component of cryovolcanism. A hypothetical cryovolcanic and potential astrobiological scenario for Ganymede is that polar-produced radiolytic oxidants migrate deeply downward by rheological convection to an ocean that upwardly outgasses oxidation products more globally.