OBSERVATIONAL CONSTRAINTS ON THE DISTRIBUTION AND TEMPERATURE DEPENDENCE OF H_2O_2 ON THE SURFACE OF EUROPA

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Introduction: Hydrogen peroxide (H_2O_2) is part of an important radiolytic cycle on Europa. The bombardment of surface water ice by magnetospheric ions and electrons converts H_2O to H_2O_2, losing H_2 in the process and creating an oxidizing surface [1, 2, 4]. Understanding this cycle is not only important to our knowledge of the chemical composition of Europa's surface and to the study of surface-magnetosphere interactions throughout the solar system, but it is also critical for our understanding of the potential chemical energy sources to Europa's ocean [3, 6]. Water-rock interactions at the seafloor can be a source of reductants, but the energy available for redox chemistry will likely depend on the supply of oxidants, such as H_2O_2, from the radiolytically processed surface environment [3, 6].

Spectroscopic observations of potentially endogenous salts suggest that low-latitude chaos regions on the leading and anti-Jovian hemispheres may be important sites of exchange between the surface and subsurface environments [5]. However, laboratory experiments [7, 8] and disk-integrated spectroscopic observations of Europa's surface [9] suggest that the local H_2O_2 concentrations are controlled by the local temperature and availability of water ice, leading to the prediction that the highest H_2O_2 concentrations would lie at the cold, icy high-latitudes of the leading hemisphere, rather than the warm, salty equatorial regions. If these predictions are correct, such a spatial separation of H_2O_2 and the most likely locations of surface-subsurface exchange could limit the delivery of oxidants to the subsurface ocean. A definitive understanding of the distribution and controls of H_2O_2 across the surface of Europa is therefore crucial for understanding its potential habitability.

Observations and Results: We present L-band observations of Europa taken with the near-infrared spectrograph NIRSPEC and adaptive optics (AO) system (hereby combined to NIRSPAO) on the Keck II telescope, as well as with the near-infrared spectrograph SpeX of the NASA Infrared Telescope Facility (IRTF). Our NIRSPAO observations map the 3.5 µm H_2O_2 feature across the surface of Europa at a nominal spatial resolution of ~300 km, thereby testing the expectation that H_2O_2 is concentrated in the coldest, iciest regions. Contrary to expectations, our NIRSPAO data exhibit a depletion of H_2O_2 at the high latitudes and higher abundances near the warm equator. Intriguingly, as demonstrated in the mapped slit of Figure 1, these data also suggest a potential concentration of H_2O_2 within the salty chaos terrains, which may imply a compositional control on abundance.

Our SpeX data examine the strength of the 3.5 µm H_2O_2 feature in disk-integrated spectra taken before and after Europa's daily eclipse and are therefore sensitive to temperature controls that are independent of local geographic location. A simple thermal model of Europa's surface [10] predicts a temperature drop of 10–20 K during eclipse. Comparison of H_2O_2 band strengths before and after this temperature change will investigate the importance of temperature in the equilibrium concentrations of H_2O_2 on Europa.

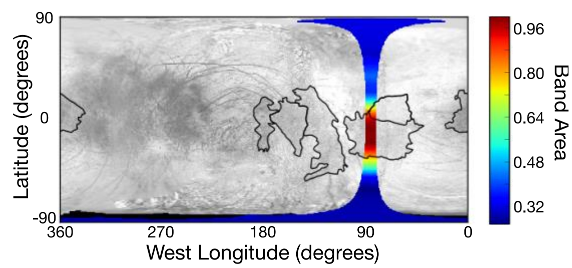

Figure 1: A NIRSPAO N/S slit across the leading hemisphere of Europa. The H_2O_2 abundance appears to be lowest at high latitudes and most concentrated in the salty chaos region, Tara Regio. This implies a potential compositional, rather than temperature, control on H_2O_2 abundance.

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