EPSC Abstracts
Vol. 13, EPSC-DPS2019-825-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

H_2O_2 within Chaos Terrain on Europa's Leading Hemisphere

S. K. Trumbo (1), M. E. Brown (1), and K. P. Hand (2)
(1) Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA, 91125, USA (strumbo@caltech.edu) (2) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 91109, USA

Abstract

We present spatially resolved observations of Europa's 3.5 µm hydrogen peroxide absorption, which we obtained using the near-infrared spectrometer NIRSPEC and the adaptive optics system at the Keck Observatory. We map the strength of the 3.5 µm band across the surface at a nominal spatial resolution of ~300 km. Though previous disk-integrated spectra seemed consistent with the laboratory expectation that Europa's hydrogen peroxide exists primarily in its coldest and iciest regions, we find nearly the exact opposite at this finer spatial scale. Instead, we observe the largest hydrogen peroxide absorptions at low latitudes on the leading and anti-Jovian hemispheres, correlated with chaos terrain, and relative depletions toward the cold, icy high latitudes. This distribution may reflect the effects of decreased hydrogen peroxide destruction due to efficient electron scavenging by CO_2 within chaos terrain.

1. Introduction

Hydrogen peroxide (H_2O_2) is part of an important radiolytic cycle on Europa. The bombardment of surface water ice by magnetospheric particles converts H_2O to H_2O_2, losing H_2 in the process and creating an oxidizing surface [1, 2]. 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]. Water-rock interactions at the seafloor can be a source of reductants, but the energy available for redox chemistry will likely depend on a supply of oxidants, such as H_2O_2, from the radiolytically processed surface [3].

The geographic distribution of Europa's H_2O_2 may constrain the processes governing its abundance as well as its potential relevance to the subsurface chemistry. However, spatially resolved maps of Europa's H_2O_2 have never been published. Laboratory experiments [2, 4] and disk-integrated observations of Europa's H_2O_2 [5] suggest that the local H_2O_2 concentrations are controlled by the surface 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. In order to address this hypothesis, we obtained spatially resolved L-band spectra of Europa's surface, with the goal of mapping the geographic distribution of its 3.5 µm H_2O_2 band.

2. Observations and Results

We present L-band spectra of Europa taken with the near-infrared spectrograph NIRSPEC and adaptive optics system on the Keck II telescope. Our observations map the 3.5 µm H_2O_2 feature across the surface of Europa at a spatial resolution of ~300 km, thereby testing the expectation that H_2O_2 is concentrated in the coldest, iciest regions. Figure 1 shows representative spectra from both the icy high latitudes and the warm, salty, low-latitude chaos terrain of the leading hemisphere. Puzzlingly, contrary to the hypothesis that Europa's H_2O_2 prefers cold, icy terrain, the low-latitude chaos spectrum (taken from Tara Regio) exhibits a much stronger H_2O_2 absorption than does the high-latitude spectrum. Tara Regio is likely salty in composition [6] and is located near the warm equator. Yet, its 3.5 µm H_2O_2 band strength reaches more than twice that of the icy region.

This pattern remains consistent across our entire dataset—within every NIRSPEC slit position, Europa's H_2O_2 prefers warm, low-latitude, ice-poor chaos terrain to the comparatively cold and ice-rich regions of the upper latitudes. Figure 2 maps several N/S slit positions, which together cover most of the large-scale leading-hemisphere chaos regions. All of the slit positions consistently show the largest 3.5 µm absorptions within the outlined chaos terrain. In all cases, especially those of Tara Regio (~85º W) and eastern Powys Regio (~125º W), this requires asymmetric displacement south of the equator. In fact, this map indicates that most of Europa's H_2O_2 falls between ~40º S and 20º N, in a latitudinal pattern that possesses similar N/S asymmetries to those of the overall pattern of leading/anti-Jovian chaos terrain. This observed distribution requires dominating influences on Europa's H_2O_2 other than temperature or water ice abundance.

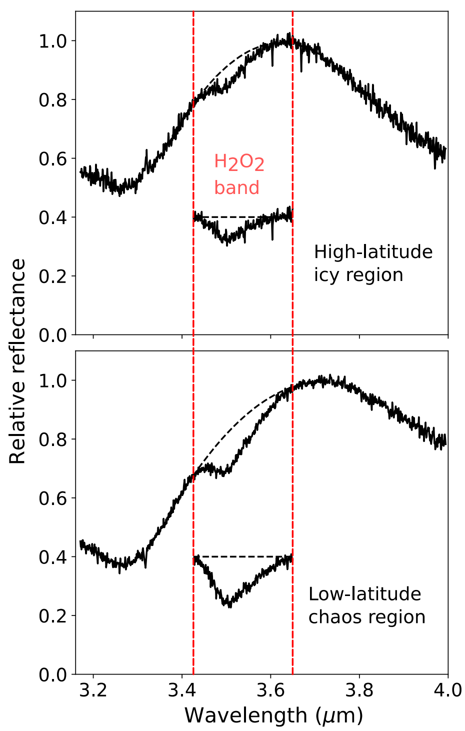

Figure 1: Representative spectra from both an icy high-latitude location and a low-latitude chaos region.

We explore multiple potential explanations and their caveats and find that a potential geographic association with CO_2 in chaos terrain provides the most compelling hypothesis. CO_2 has been shown to enhance H_2O_2 yields in the laboratory by scavenging destructive electrons created during continued irradiation of the ice [4]. Furthermore, very limited and unpublished *Galileo* Near Infrared Mapping Spectrometer (NIMS) spectra suggest concentration of CO_2 within leading-hemisphere chaos terrain [7]. If CO_2 is truly a dominant factor in controlling the H_2O_2 distribution we observe, then the widespread coverage of our data may hint at a broad association of Europa's CO_2 with its geologically young chaos regions, and therefore with an interior carbon source.

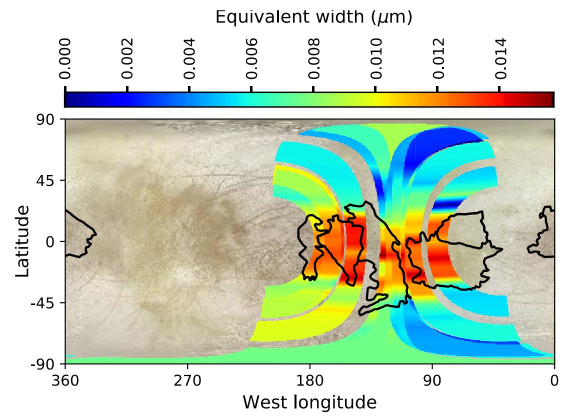

Figure 2: Map of Europa's 3.5 µm H_2O_2 band. The deepest absorptions map to low latitudes of the leading and anti-Jovian hemispheres and appear correlated with the geologically young and comparatively ice-poor chaos regions (outlined in black).

References

[1] Carlson, R. W., Anderson, M. S., Johnson, R. E., Smythe et al.: Hydrogen Peroxide on the Surface of Europa, Science, Vol. 283, pp. 2062-2064, 1999.

[2] Hand, K. P. and Carlson, R. W.: H_2O_2 production by high-energy electrons on icy satellites as a function of surface temperature and electron flux, Icarus, Vol. 215, pp. 226-233, 2011.

[3] Hand, K. P., Chyba, C. F., Priscu, J. C., Carlson, R. W., and Nealson, K. H.: Astrobiology and the Potential for Life on Europa, in Europa, University of Arizona Press, 2009.

[4] Moore, M. and Hudson, R.: IR Detection of H2O2 at 80 K in Ion-Irradiated Laboratory Ices Relevant to Europa, Icarus, Vol. 145, pp. 282-288, 2000.

[5] Hand, K. P. and Brown, M. E.: Keck II observations of hemispherical differences in H_2O_2 on Europa, ApJ Letters, Vol. 766, pp. L21, 2013.

[6] Trumbo, S. K., Brown, M. E., and Hand, K. P.: Sodium Chloride on the Surface of Europa, Science Advances, in press.

[7] Carlson, R. W.: Spatial distribution of carbon dioxide, hydrogen peroxide, and sulfuric acid on Europa, American Astronomical Society, DPS Meeting #33, New Orleans, USA, 2001.