

Abstract

The topic of this thesis is the surface composition of Jupiter's moon Ganymede. Goal of this work is to map the distribution of the surface components water ice, rocky material and volatile compounds, but also the size of the water ice particles and to study their relationships to the chemical and physical surface composition and the geology.

This work bases on data of the imaging spectrometer NIMS on board the spacecraft Galileo, that detects Ganymede's surface between 0.7 and 5.2 μm . Imaging data of the spacecrafts Galileo, Voyager 1 and 2 supply the geological context information. The central part of this work includes the processing of the spectral data, the quantitative analysis of the spectral signatures of the reflectance spectra of Ganymede, and the characterization of their spatial variations depending on geological surface features.

The results show, that variations of the reflectance properties of Ganymede's surface attribute to varying amounts of water ice, rocky material and the contents of gaseous CO_2 . Variations could be studied and mapped based on significant absorptions of water ice at 1.04, 1.25, 1.5, 2, 2.4 and 3 μm and of CO_2 at 4.25 μm . Additionally, the simultaneous analysis of the water ice absorptions made it possible to separate changes of the amount and the particle size of water ice.

Spectral variations were found to be partly related to the geology, that is the age and the geological evolution, but also to reflect the interaction between Ganymede and the interplanetary space. Thus, rocky material is concentrated in the geologically oldest regions of Ganymede, the *Regiones*. Youngest regions, represented by several impacts craters, are characterized by almost pure and fine crystalline water ice. NIMS data show no evidence for an endogen origin of the rocky material. It is assumed to be rather the result of the bombardement with carbonaceous (micro-) meteoritic material. On one hand, the rocky material becomes mixed with the surface ice during the impact process. On the other hand, sublimation processes contribute to the segregation of rocky material and water ice and thus the concentration of rocky material on the surface. One exception is the concentration of rocky material in the vicinity of the ejecta of several young impact craters. However, it is supposed to represent re-deposited surface material and no yielded material due the impact process.

The interaction between Ganymede's surface and the interplanetary space influences mainly variations of the particle size of water ice. Large particles ($> 500 \mu\text{m}$) were measured close to the equator ($\sim 30^\circ\text{N}$ to $\sim 30^\circ\text{S}$) and are assumed to be caused by sublimation processes, which dominate this region. In contrast, relative small water ice particles ($< 10 \mu\text{m}$) are concentrated in the polar regions of Ganymede ($> 30^\circ\text{N}$ and S). Ganymede's own magnetic field protects the equatorial region mostly from high energetic incoming radiation that causes chemical reactions and physical destruction and sputtering of water ice crystals. However this radiation easily reaches the polar regions and results in the a thin layer of fine crystalline water ice that masks the spectral properties of the underlying material.

Gaseous CO_2 in the surface material could be identified by the absorption at 4.25 μm . Because of the correlation of the band depth and the reflectance at 4.25 μm the relative content of CO_2 could only be estimated for regions which are characterized by a similar reflectance at 4.25 μm . Contrary to previous assumptions, the results of this work show no relationship between the existence of rocky material and the content of CO_2 . Additionally, it is shown that no CO_2 is in the polar deposits of water ice and so CO_2 is no result of the interaction with incoming radiation. But NIMS data indicate that CO_2 is mainly in the water ice of the equatorial regions. This work allowed for the first time the identification of higher concentrations of CO_2 in young morphologically fresh impact craters, which are enriched of fine crystalline water ice. This is strongly related to the impact process. However, NIMS data do not allow clearing up if CO_2 is excavated together with water ice, if CO_2 is a component of the former impactor or if it is a product of chemical reaction during the impact process. Nevertheless the NIMS data show that with increasing age of the impact craters not only an adjustment of the relative amount

of water ice and the size of the water ice particles between the impact crater and the surrounding region takes place but also that this alteration includes the content of CO₂. CO₂ remains within the surface material of Ganymede which is opposite to a delivery of CO₂ into an atmosphere as assumed in the case of the neighboring moon Callisto. CO₂ becomes delivered if water ice transforms from an amorphous into a crystalline phase due to thermal surface variations. This is assumed to be the case on Callisto. However, an equilibrium between the thermal crystallization and amorphization of water ice due to incoming (micro-) meteorites and radiation from Jupiter's magnetosphere is supposed on Ganymede.