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Landform Erosion and Volatile Redistribution on Ganymede and Callisto

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Background

We have been modeling landscape evolution on the Galilean satellites driven by volatile transport. Our work directly addresses some of the most fundamental issues pertinent to deciphering icy Galilean satellite geologic histories by employing techniques currently at the forefront of terrestrial, martian, and icy satellite landscape evolution studies [e.g., 1–6], including modeling of surface and subsurface energy and volatile exchanges, and computer simulation of long-term landform evolution by a variety of processes. A quantitative understanding of the expression and rates of landform erosion, and of volatile redistribution on landforms, is especially essential in interpreting endogenic landforms that have, in many cases, been significantly modified by erosion [e.g., 7–9].

Ice Segregation and Mass Wasting

The preferred site for bright frost deposits at low latitudes on all three icy Galilean satellites is on the upper flanks and summits of ridges, crater rims, and isolated knobs [e.g., 9–11]. On these satellites, summits or ridge crests are bright while dark material forms downslope streamers and pools in topographic lows. Sloughing off of lag deposits and re-frosting of the "bedrock" might explain the brightness of the high standing topography, but the great brightness of their summits is problematic, and the craggy, eroded, appearance of these landforms must also be accounted for. Semi-quantitative modeling [e.g., 11,12] suggests how these landscapes evolve by a process of volatile redistribution and lag formation and sloughing, but the evolution of realistic landscapes and their albedo patterns by this process is only now being rigorously modeled by us [13].

Callisto Knob Evolution

By far the most common positive relief landforms on Callisto are knobs, which appear to be remnants of crater rims, central peaks, palimpsests and ejecta deposits [11, 14, 15]. The loss of an icy volatile matrix or cement originally mixed with a dark, refractory, fine-grained material is implicated in the degradation of pristine landforms into knobs [e.g., 11,14–17]. The evolution of initially continuous deposits into discrete knobs can be inferred by comparing ejecta and/or impact melts associated with fresh impact features on Ganymede with similarly sized degraded impact features on Callisto. Whereas impact craters on Ganymede often show continuous proximal ejecta deposits that gradationally blend with the surroundings, a similar sized crater on Callisto is often surrounded by a field of knobs immediately beyond its rim.

In Moore *et al.* [11] sublimation degradation scenario of knob formation, bright knob summits owe their albedo to a coating of re-precipitated frost. It was hypothesized that the cold bright frost (perhaps only H_2O) suppresses sublimation of volatiles (both H_2O and CO_2 and/or NH_3) in the "dirty" ice directly covered by it. In this scheme, maximum sublimation takes place along slopes just below the edges of the bright-cold frost deposits where a dark lag of fine-grained refractories is thinnest. Recent heuristic modeling by us [4] lends strong support to this hypothesis, but that work did not employ actual sublimation or diffusion parameters. We are now developing models incorporating test parameters [13] and will report our progress at this meeting. We will also discuss tests of our hypothesis that could be made with imaging, radar, and spectroscopy data from JGO and JEO.

References

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