RHEOLOGIES OF PLANETARY ICES

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PROPOSAL SUMMARY

The remarkable diversity of observed icy surfaces and inferred internal structures of the icy planets and moons of the outer solar system implies differences in composition and structure, in the physical conditions and histories, and in how these factors have governed the physical responses of these cryominerals, including their responses to changes in the stress state. Insight into the mechanical responses of these materials comes not only from data and images of the solar-system objects themselves but also from laboratory study of these materials. As more data and higher resolution images from modern spacecraft appear and models of planetary deformation become more sophisticated, there are greater demands for more detailed knowledge of their mechanical behavior from laboratory study. The purpose of this experimental research is to acquire data on the deformation behavior and microphysics of the principal rock-forming cryominerals and the multiphase rocks composed of them. Using a suite of custom-designed-and-built deformation apparatus, unique techniques for making synthetic planetary ices, and new analytical tools to investigate deformed cryomaterials, we propose to extend the physical limits of materials and test conditions to acquire data on their flow properties. The proposal tasks include laboratory investigations of: (1) The rheologies of icy systems especially relevant to Titan, such as processes related to feeding CH_4 to Titan's atmosphere, cryovolcanism, and the compaction creep of granular ice saturated with liquid volatiles. (2) The strengths of several two-phase mixtures of ice with solid ammonia, hydrated Mg-sulfate hydrate, solid CO_2, and CO_2 clathrate hydrate in search of insights into the micro-physics of two-phase flow, including nonlinear mixing rules for their mechanical behavior, the effects of grain textures and phase distribution such as eutectic intergrowths, the effects of solid-solid reactions during deformation and the effects of changes in flow mechanisms with grain size during partial recrystallization. (3) The rheology of ice II in the grain-size-sensitive creep regime. To our knowledge, these systems have never been mechanically tested for strength at elevated pressures except by us.

These studies are relevant to deformation processes on terrestrial ice sheets, in the polar ice caps and regolith of Mars, the icy moons Europa, Ganymede, Callisto, Titan, and the smaller icy moons of Saturn and Uranus.