Laboratory Measurements of the Rheological Effects of Dust Upon Water Ice: Implications for Periglacial Processes on Mars

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PROPOSAL SUMMARY

We propose a laboratory study of the effect of dust on grain-size-sensitive (GSS) creep in water ice and of the creep of ice-poor soils, with application to surface features on Mars. Mars exhibits a wide variety of landforms indicative of periglacial processes, ranging from thin "snowpacks" associated with gullies to large lobate debris aprons similar in morphology to terrestrial rock glaciers. However, the time scales for such flow are not well constrained, due to the unknown rheological effects of dust upon water ice deforming via GSS creep, which is very plausibly an important mechanism under typical Martian conditions. The ice content of Martian soils is also poorly known, but estimates of minimum content required for terrain mobility would provide an important constraint on the overall water content of the Martian surface. We will carry out three tasks: (1) measure the effect of dust particle size and volume on the rate of GSS creep in ice; (2) measure the effect of dust content on grain growth in fine-grained ice, which will help us extrapolate the foregoing results to the extremely slow geologic deformation rates on Mars; and (3) measure creep rates in ice-poor mixtures of ice, rock, and dust to determine where the presence of ice first begins to affect deformation rates. We will synthesize our own samples of pure ice, fine-grained polycrystalline ice (necessary for activating GSS at the laboratory time scale), and ice plus dust and rock. The deformation experiments will be carried out in our specialized high-pressure cryogenic creep apparatus. Much use will be made of our cryogenic preparation and imaging stage for our scanning electron microscope to observe deformation structures, and to measure subtle amounts of deformation and grain growth. Both pieces of apparatus were purchased and constructed with earlier NASA support expressly for the purpose of studying icy planetary materials. Constraining models of the deformation of Martian permafrost, ice sheets, polar layered deposits, and debris flows is in keeping with the broad objectives of the Mars Fundamental Research program for the scientific exploration of Mars. Better knowledge of the behavior of water ice on Mars will enhance our understanding of the climatological role of water throughout Martian history.