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Enceladus: Correlation of Surface Particle Distribution and Geology

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The surface of Enceladus consists almost completely of water ice [1,2]. The band depths of water ice absorptions are sensitive to the size of particles [2,3,4] covering the surface. The Visual and Infrared Mapping Spectrometer [5] observed Enceladus with high spatial resolution during multiple Cassini fly-bys. Based on these data we measured the band depths of water ice absorptions over Enceladus' surface and mapped their distribution. The spatial resolution of VIMS is sufficient to distinguish three major geologic units: heavily cratered terrain, fractured and ridged terrain and complex tectonically deformed regions of troughs and ridges [6], which include the south pole region. Surface ages, as derived from the impact flux models of [7,8] indicate the cratered terrain being oldest while the Sulci the youngest unit [2,9]. From the distribution of particle sizes we can conclude that the largest particle diameters are those inside the tectonically deformed regions, with a decrease in size departing from the fractures. These occur not only at the south pole but also in older tectonic regions [2]. The basic correlation between particle diameter, geologic unit and age suggests the following relative stratigraphic sequence [2,10]: (1) Formation of a primary crust (heavily cratered terrain); (2) Mechanical weathering of the surface particles by microimpacts and sputtering during the last 4 billion years; (3) Tectonic disruption of the surface and deposition of new material with large particles. Although this newly deposited material has undergone mechanical weathering of the particles by microimpacts and sputtering, these particles are larger due to a shorter exposure time; (4) Recent deposition of larger particles in the south polar region. If the larger particles in the tectonically deformed regions have of the same cryovolcanic origin as at the south pole, the volcanic activity must have a temporal evolution. However, there are still different possibilities to explain this observation [2]: (1) The eruption zones may have moved from north to south. (2) Cryovolcanic eruptions might have occurred across the entire surface and later shrunk to a small zone at the south pole, which would be indicative of a probable decrease in internal heat transfer. (3) The intensity of cryovolcanic eruptions had a different temporal evolution at different locations with maximum activity in the south polar region.

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