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Global Thermal Segregation Explains Iapetus' Global Appearance

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We demonstrate that Iapetus' extreme leading/trailing albedo asymmetry is likely to result from thermal sublimation and runaway global migration of water ice, triggered by moderate exogenic darkening of the leading hemisphere. This idea was first proposed by D. Mendis and W. Axford in 1974 but has not previously been developed quantititively. Iapetus is uniquely susceptible to this global thermal segregation because of a combination of several factors. Its very slow rotation period of 79 days results in higher daytime surface temperatures and thus higher water sublimation rates for a given albedo and thermal inertia than for other Saturnian satellites (for example, mean sublimation rates for dark surfaces are nearly three orders of magnitude higher than on Phoebe, which has a 9-hour rotation period). Sublimation rates far exceed lunar-like near-surface impact gardening rates for dark ice on Iapetus. While the icy Galilean satellites have even warmer surface temperatures and higher ice sublimation rates, Iapetus' relatively small size and low gravity allow global migration of sublimed water molecules, unlike the much larger Jovian moons, where thermal segregation instead acts only on a local level.

Relatively simple numerical models of exogenic darkening and ice migration are able to reproduce the global distribution of dark and bright material on Iapetus. The model is also consistent with the abrupt bright/dark transitions, local segregation, and pole-facing bright slopes seen by Cassini's cameras, and with the surface temperatures measured by Cassini's CIRS instrument. Remaining concerns with the model include its prediction of higher ice albedos at low latitudes on the trailing side than are observed, and continued uncertainty about the source of the exogenic dark material that apparently triggers the global migration.