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Compositions of the Surfaces of Pluto and its Satellites

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The information we have on the chemical compositions of the surfaces of Pluto and Charon has been obtained from Earth-based near-infrared spectroscopy. These bodies are seen in diffusely scattered sunlight upon which absorption bands diagnostic of specific ices are superimposed. Identified so far on Pluto are molecular nitrogen (N_2), methane (CH_4), carbon monoxide (CO), and ethane (C_2H_6), all in the frozen state. Charon has the clear spectral signature of H_2O ice in the crystalline phase, plus an absorption band near 2.2 μm identified as a hydrated form of NH_3. No diagnostic spectra of Pluto's other satellites are currently available. A fraction of Pluto's CH_4 is dissolved in solid N_2, which is in the hexagonal beta-phase. When a small concentration of CH_4 exists in a N_2 crystalline matrix, its absorption bands are shifted in wavelength by a small but detectable amount. Indeed the shifting of the CH_4 bands is diagnostic of a host matrix. In the case of Pluto, the N_2 band (2.148 μm) itself is detected, but for other transneptunian objects where the N_2 band cannot be seen, the shifted CH_4 bands demonstrate the presence of N_2 or (less likely) some other spectrally neutral and transparent matrix material (e.g., Ar). The absence of detectable CO_2 and H_2O ices on Pluto, while they are clearly present on the otherwise very similar Triton, is noteworthy.

The ices of Pluto distributed non-uniformly across its surface, and the distribution shows long-term (decadal) changes. Both seasonal and secular changes may be occurring through transport across the surface as a result of changing temperature, and by seasonal changes in the vapor pressure equilibrium of the ice with the tenuous and variable atmosphere.

Models of the photochemistry of the surface ices and the atmosphere of Pluto predict the presence of several materials not yet detected; the most abundant photoproducts are expected to be C_2H_2, C_4H_2, HCN, C_2H_6; HCN has been detected on Triton.

Both Pluto and Charon have surface components in addition to the detected ices. These materials of presently unknown composition serve to reduce the albedos of both bodies below that expected for pure ices, and in the case of Pluto impart a yellow-brown coloration; the color of Charon is more nearly neutral. It is generally thought that the non-ice components are more refractory than the ices and that they may be complex carbonaceous materials derived from the ultraviolet and charged particle processing of the surface ices. Minerals are also plausible candidates for the non-ice fraction. The refractory colored components may constitute bedrock upon which variable amounts of the ices are alternately deposited and evaporated as the seasons change. Water ice is expected to be a component of the bedrock, although it has not yet been reliably identified.