

# On the Sputter Alteration of Regoliths of Outer Solar System Bodies

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This paper discusses several processes that are expected to occur when the porous regoliths on bodies without atmospheres in the outer solar system are subjected to energetic ion bombardment. The conclusions reached in many of the papers involving sputtering published in the planetary literature are qualitatively or quantitatively incorrect because effects of soil porosity have been neglected. It is shown theoretically and experimentally that porosity reduces the effective sputtering yield of a soil by more than an order of magnitude. Between 90 and 97% of the sputtered atoms are trapped within the regolith, where they are fractionated by differential desorption. Experiments indicate that more volatile species have higher desorption probabilities. This process is the most important way in which alteration of chemical and optical properties occurs when a regolith is sputtered. When a basic silicate soil is irradiated these effects lead to sputter-deposited films enriched in metallic iron, while O, Na and K are preferentially lost. The Na and K are present in the atmosphere above the sputtered silicate in quantities much greater than their abundances in the regolith. Icy regoliths of  $\text{SO}_2$  should be enriched in elemental S and/or  $\text{S}_2\text{O}$ . This prediction is supported by the probable identification of  $\text{S}_2\text{O}$  and polysulfur oxide bands in the IR spectra of H-sputtered  $\text{SO}_2$  reported by Moore (1984, Icarus 59, 114). When porous mixtures of water, ammonia and methane frosts are sputtered, the loss of H and surface reactions of C, N and O in the deposits should produce complex hydrocarbons and carbohydrates, some of which may be quite dark. Such reactions may have played a role in the formation of the matrix material of carbonaceous chondrites prior to agglomeration.