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The Mineralogy and Surface Properties of Mars

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The Thermal Emission Spectrometer (TES) spectra exhibit signatures of surface minerals, atmospheric dust, water-ice clouds, CO2, and water vapor in varying abundances. Spectra of dark regions, such as Cimmeria Terra are well fit by particulate samples of terrestrial basalts. Feldspar (45%; 53%) and Ca-rich pyroxene (26%; 19%) are positively identified above an estimated detection threshold of 10–15% for these minerals. Carbonates, quartz, and sulfates have not been identified in dark regions at detection limits of ~5, 5, AND 10%, respectively. The occurrence of unweathered feldspar and pyroxene, together with the inferred presence of pyroxene and unweathered basalts in other dark regions, provides evidence that extensive chemical weathering of materials currently exposed on Martian surface has not occurred. Among the mineral identifications to date is a localized zone of coarse-grained, crystalline hematite approximately 350 km in size in Sinus Meridiani. The TES results indicate that the hematite is $> 10\ \mu$m in size and is distinct from the fine-grained, red, crystalline hematite generally considered to be a minor spectral component in Martian bright regions. Sinus Meridiani hematite is closely associated with a smooth, layered, friable surface that is interpreted to be sedimentary in origin. We have considered give possible mechanisms for the formation of coarse-grained, crystalline hematite. These processes fall into two classes: (1) chemical precipitation that includes origin by (a) precipitation from oxygenated, Fe-rich water, (b) crystal growth from hydrothermal fluids, (c) low temperature dissolution and precipitation in water, and (d) surface coatings; and (2) high-temperature oxidation of magnetite-rich lavas. We favor precipitation from Fe-rich water based on the probable association with sedimentary materials, large geographic size, distance from a regional heat source, and lack of evidence for extensive groundwater processes elsewhere on Mars. The TES results thus provide probable mineralogic evidence for large-scale water interactions.