The Mineralogy of Mars: A View from Orbital Infrared Spectroscopy

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The last fifteen years of orbital infrared spectroscopy and in-situ exploration have led to a new understanding of the composition and history of Mars. Mars' primary composition is more homogenous than Earth's. Mars has a basaltic upper crust with regional variations in the relative abundances of plagioclase, pyroxene, and olivine minerals that indicate spatiotemporal changes in magma composition and generation. Several >1,000-km-diameter impact basins with circumferential rock units enriched in high-Mg olivine may indicate excavation of the upper mantle or high-temperature lavas emplaced following impacts early in Mars history. In contrast, many later Noachian (>3.7 Gyr) and Hesperian (3.7-3.1 Gyr) lavas on Mars are enriched in intermediate-Mg-number olivine. Alkali or evolved rocks are rare on Mars but are found locally, indicating local-scale igneous fractional crystallization of magmas, differences in their source compositions, or other differences in igneous processes.

A key discovery of the last decade has been the prevalence of rocks and sediments affected by secondary alteration and their preservation in stratigraphies. Clay minerals are widespread where there is exposure of Noachian crust, implying extensive global aqueous alteration at neutral to alkaline pH early in Mars history. Some portion of this alteration was hydrothermal and some was near-surface weathering. Groundwater played an important role in formation and diagenesis of clay minerals, and its upwelling produced large deposits of sulfates, hematite, and chlorides Paleolakes existed in late Noachian–early Hesperian Mars, roughly coincident with the timing of enhanced near-surface weathering inferred from aluminum clay formation. Some basins host sedimentary clay minerals and precipitated salts (sulfates, chlorides, carbonates). Salinity and pH differed regionally, as did the relative importance of detrital and precipitated sediments, as indicated by varied mineral assemblages. Many (but not all) hydrated mineral assemblages from the Hesperian have acid sulfate minerals such as iron and aluminum sulfates, implying more acidic conditions later in Mars history in some locations.Amazonian units do not generally have crystalline alteration minerals, implying substantially less water and aqueous alteration late in Mars history.