

Phosphates at the Surface of Mars: Primary Deposits and Alteration Products

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Phosphorus is an essential element in terrestrial organisms and thus characterizing the occurrences of phosphate phases at the martian surface is crucial in the assessment of habitability. The Alpha Particle X-Ray Spectrometers onboard Spirit, Opportunity and Curiosity discovered a variety of primary and secondary phosphate phases allowing direct comparisons across the three landing sites. The Spirit rover at Gusev Crater encountered the “Wishstone/Watchtower” class of P-rich (up to 5.2 wt% P₂O₅) rocks interpreted to be alkaline volcanic rocks with a physical admixture of ~10 to 20% merrillite [Usui et al 2008]. These rocks are characterized by elevated Ti and Y and anomalously low Cr and Ni, which could largely reflect the nature of the protoliths: Evolved magmatic rocks. Many of these chemical signatures are also found in pyroclastic deposits at nearby “Home Plate” and in phosphate precipitates derived from fluid interactions with these rocks (“Paso Robles” soils). The Opportunity rover at Meridiani Planum recently analyzed a ~4 cm clast in a fine-grained matrix, one of numerous rocks of similar appearance at the rim of Endeavour Crater. This clast, “Sarcobatus,” has minor enrichments in Ca and P relative to the matrix, and like the P-rich rocks at Gusev, Sarcobatus also shows elevated Al and Ti. On the same segment of the Endeavour rim, subsurface samples were found with exceptional levels of Mn (~3.5 wt% MnO). These secondary and likely aqueous deposits contain strong evidence for associated Mg-sulfate and Ca-phosphate phases. Finally, the Curiosity traverse at Gale crater encountered P-rich rocks compositionally comparable to Wishstone at Gusev, including elevated Y. Phosphorous-rich rocks with similar chemical characteristics are prevalent on Mars, and the trace and minor element signatures provide constraints on whether these are primary deposits, secondary products of physical weathering, or secondary products of chemical weathering.