Crystallography on Mars with the CheMin XRD Instrument

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The CheMin instrument is an X-ray diffractometer on Mars Science Laboratory *Curiosity* rover, and the only XRD instrument ever flown on a space mission. The instrument consists of a Co X-ray source, a rotating sample wheel, and an energy-dispersive CCD camera. The rotating wheel allows for the reuse of sample cells. Individual sample cells are vibrated causing samples to convect, thus ensuring representative powder diffraction patterns without preferred orientation.

CheMin's short X-ray path, necessitated by the miniaturization required for space flight, results in a low 2θ resolution compared to typical terrestrial XRD. Variable sample offsets, below the engineering tolerance level, cause peak shifts in the processed diffraction pattern. A novel technique, based on the covariance of mineral structural parameters of plagioclase, allows an independent remote calibration of sample position, correcting for these shifts.

CheMin XRD patterns are interpreted via Rietveld refinment to identify crystalline phases and estimate their proportions. To constrain mineral chemistry, crystallographic unit-cell parameters of major phases are refined; the correlation between unit-cell parameters and crystal chemistry allows quantitation of mineral composition. Variations in crystal chemistry between samples are used to infer their parental sources and alteration histories. XRD has been used to demonstrate mineral chemical changes not represented by bulk analysis. For example, a transition from tri- to mixed di-tri-octahedral clays and a magnetite to hematite transition indicating a temporal evolution to more oxidizing saline lake conditions. Work to characterize the amorphous component (up to 60%) by their XRD contributions is ongoing, and should yield new insights into diagenesis of Gale sediments.

Recently, CheMin has been used to investigate preferential mineral sorting between barchan and linear dunes in the Bagnold dune field. Orbital infrared observations suggest barchan dunes have more olivine relative to high-Ca pyroxene, whereas CheMin results show that barchan dunes have more high density minerals (e.g. olivine + pyroxene) than the linear dunes, which are more enriched in plagioclase.