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On the occurrence of jahnsite/whiteite phases on Mars: A thermodynamic study

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Abstract

Jahnsites/whiteites are a large family of phosphate hydrate minerals of relevance to terrestrial and martian mineralogy. It was recently hypothesized as being present in Gale Crater sediments from XRD analyses performed by the CheMin analyzer aboard the Curiosity rover. However, the conditions of formation and thermodynamic properties of these compounds are essentially unknown. In this work, we have optimized the ThermAP predictive thermodynamic approach to the analysis of these phases, allowing us to estimate for the first time the standard formation enthalpy (ΔH_f°), Gibbs free energy (ΔG_f°), and entropy (S°) of 15 jahnsite/whiteite end-member compositions, as well as of related phases such as segelerite and alluaudites. These estimations were then used to feed speciation/phase diagram calculation tools to evaluate the relative ease of formation and stability of these hydrated minerals, including considering present martian conditions. Selected laboratory experiments confirmed calculation outcomes. All of our data suggest that the formation of jahnsites is an unlikely process, and point instead to the formation of other simpler phosphate compounds. The stability domain, as calculated here, also raises serious questions about the possible presence of jahnsites on Mars as in Gale Crater, which appears rather improbable.

Keywords: Jahnsite, whiteite, thermochemistry, phase diagram, ThermAP, PHREEQC, stability, Curiosity rover, CheMin, precipitation, dehydration