

Chemical models for formation of clay-rich layered rocks in the Mawrth Vallis region, Mars

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Clay minerals have been detected in ancient martian terrains with the near-infrared orbital spectroscopy [1,2]. In the Mawrth Vallis region, a prospective landing site for the MSL rover in 2012, minerals are observed within the following stratified sequence of layered rocks (from the top): silica and kaolinite, montmorillonite-like Al-rich clays, a Fe²⁺ phyllosilicate, Mg/Fe smectites, and sulfates [2-6]. We use three numerical models to explore a formation of these rocks through alteration of a fragmented basaltic material by a downward percolation of H₂SO₄-rich fluids. One model assumes a decrease in the solution to rock ratio with depth. In another model, the downward fluid migration is considered. In both models, fluids reach chemical equilibrium with rocks. In the third model, kinetics of mineral dissolution is considered along with fluid percolation. The modeling is performed for 0 °C and pressure from 0.006 to 1 bar. The system was either open or closed with respect to CO₂ and O₂.

The modeling reproduces the observed silica-kaolinite-montmorillonite-smectite sequence of dominated minerals. In the models, the sequence reflects neutralization of fluids with depth. Open system models also lead to formation of goethite and/or hematite, and carbonates form in association with smectites (saponite). In closed systems, zeolites and Fe²⁺-chlorites occur with smectites, and Fe²⁺-chlorite rich rocks form between layers rich in montmorillonite and smectites. The latter result is consistent with observations, though the upper part of the martian profile also agrees with an open-system acid alteration. Modeled Ca sulfates coexist with clay minerals, and more soluble sulfates could form through evaporation of neutralized fluids accumulated in the lower part of the stratigraphic sequence.

[1] Poulet *et al.* (2005) *Nature* **438**, 623-627. [2] Mustard *et al.* (2008) *Nature* **454**, 305-309. [3] Wray *et al.* (2008) *Geophys. Res. Lett.* **35**, L12202. [4] Bishop *et al.* (2008) *Science* **321**, 830-833. [5] McKeown *et al.* (2009) *J. Geophys. Res.* **114**, E00D10. [6] Wray *et al.* (2010) *Icarus* **209**, 416-421.

Study on the phase equilibrium of the quaternary system Cd²⁺, K⁺, Na⁺//SO₄²⁻-H₂O at 298 K

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Solid- Liquid Equilibrium of quaternary system Cd²⁺, K⁺, Na⁺// SO₄²⁻-H₂O at 298 K were studied by an isothermal solution saturation method. Experimental results indicate that there are five univariant curves E₁F₁, E₁F₄, E₁E₂, E₂F₂ and E₂F₃, two invariant points E₁, E₂ and four crystallization fields in the quaternary system. The system belongs to a quaternary system, and there is a double salt (Na₂SO₄·3K₂SO₄) existing. The crystallization zones of equilibrium solid phases are K₂SO₄ (E₁F₁MF₄ field), Na₂SO₄·3K₂SO₄ (E₁E₂F₃F₄ field), Na₂SO₄·10H₂O (E₂F₂AF₃ field), and CdSO₄·H₂O (E₂F₁BF₂ field), respectively. The composition of the invariant point E₁ is K₂SO₄, Na₂SO₄·3K₂SO₄ and CdSO₄·H₂O, respectively. The composition of the invariant point E₂ is Na₂SO₄·3K₂SO₄, Na₂SO₄·10H₂O and CdSO₄·H₂O, respectively. The physico-chemical properties of solution in the quaternary system show regular changes along with the increased cadmium concentration. CdSO₄ possessed the highest solubility among those three salts, which means a strong transfer of Cd ion and a high pollution risk of soil environment.

