CLAY-BEARING PARAGENETIC ASSOCIATIONS IN RIOTINTO (SW SPAIN): DISENTANGLING MULTIPLE PATHWAYS OF ACIDIC BEDROCK ALTERATIONS ON MARS

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Abstract

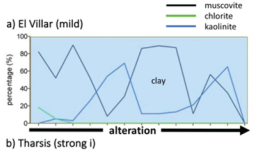
Numerous studies at the Riotinto mining district have focused on astrobiology, sulfates and extremophilic microbial communities in the highly acidic aqueous environments [1-3]. In contrast, this project investigates past acidic alteration of nearby volcanic rocks. The present study covers a variety of alteration pathways that may influence volcanic protoliths, with the specific types of clay minerals present acting as the key to decode the degree of acidity. Different acidity-dependent alteration pathways are explored that lead to the formation of a variety of secondary clay minerals and sulfates. Examining the alteration pathways at this site is expected to further our understanding of potential alteration on Mars. Characterization of the spectral properties and XRD patterns of these materials will contribute toward interpreting similar data of Mars.

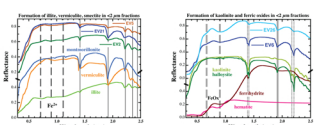
Materials and Methods

Rock samples collected from three alteration sequences were sampled at the Riotinto mining district. Geologically, an Upper Palaeozoic (Late Famennian-Tournaisian) complex including siliciclastic sediments and mafic and felsic volcanics underwent hydrothermal alteration. The latter enriched the bedrock with quartz, chlorite and illite (2M1 muscovite). Oxidation of an extensive pyrite-rich orebody occurred due to fluctuation of the water table (Miocene). As a consequence, moderate to extreme acidic fluxes leached the surrounding rocks for over 20 million years. Powder separates for the clay fraction (<2 μm) were analysed using a PanAlytical X'PERT-PRO X-ray diffractometer (45 kV and 40 mA, 2-40 °2Θ range). Oriented aggregates were prepared on glass slides and measured in both air-dried and ethylene-glycol-solvated conditions [5]. The XRD patterns were then modeled using ClaySim (from MDI) for the quantitative investigation of clay mineralogy as described in [6]. The spectral properties of these samples were measured for comparison with the lab XRD data and spectra of Martian outcrops. VNIR and mid-IR reflectance spectra were acquired at RELAB (Brown University).

Types of alteration

Mild

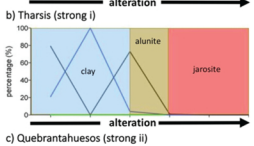


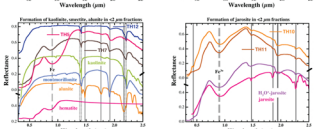


- chlorite alters into vermiculite through chlorite-vermiculite mixed-layering, revealing mildly acidic conditions;

- kaolinite forms as a function of progressive alteration of chlorite and sericitic illite; no sulphates detected.

Strong i)



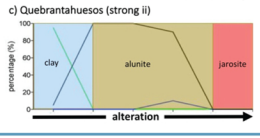


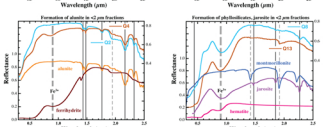
- hydrothermal kaolinite and illite alter into kaolinite-smectite mixed-layers;

- alunite paragenesis with kaolinite-smectite and illite; jarosite does not coexist with any phyllosilicate;

- strongly acidic conditions (no clays remain).

Strong ii)





- patchy alteration of primary chlorite and illite occurs very fast upon further drop of pH, beudantite and jarosite form;

- alunite coexists with kaolinite and illite; jarosite and beudantite are incompatible with phyllosilicates;

- greatest acidic alteration.

Conclusions and implications for Mars

Clay mineralogy served as a valuable tool to disentangle alteration processes at the Riotinto study sites. Utilizing the observed parageneses allowed us to distinguish at least three acidic alteration pathways that could be identified on Mars through determination of phyllosilicate and sulfate components. Future work on this project will involve investigating the whole rock compositions of these outcrops at Riotinto. Another component of this study includes identifying martian outcrops exhibiting similar trends in phyllosilicate and sulfate mineralogy.

Literature

[1] Sobron P. et al. (2014) American Mineralogist, 99, 1199-1205. [2] Amils R. et al. (2002) Rev. Environ. Science Biotech., 1, 299-309. [3] Amils R. et al. (2007) PSS, 55, 370-381. [4] Essalhi M. et al. (2011) Mineralium Deposita, 46, 981–999. [5] Moore D.M. et al. D.C. (1997). [6] Mavris C. et al., in preparation.