

Direct observation of water-rock interactions by image processing, spectro-colorimetry, visible, infrared, Raman microspectroscopies – some examples of transformation of iron hydroxides and hydrous silica

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In the surface geochemical environment, common water-rock interactions are dissolution, precipitation, transformation of minerals and reactions at the mineral surfaces. The speciation of solid and aqueous components and its change in time and space are the bases to understand the mechanisms of these interactions, which often play significant roles in accumulation of natural resources and environmental pollution. Direct characterization methods for some iron and silica phases in real rock systems and in-situ measurement cells for microspectroscopies have been developed here.

Direct characterization of weathering/alteration fronts on rock/soil surfaces by image processing and spectro-colorimetry

The image-processing and spectro-colorimetry for weathering/alteration fronts of rock/soil surfaces give us direct semi-quantitative information on the speciation and distribution in space of different coloured alteration products such as iron hydroxides by means of visible spectra and colour parameters such as Red-Green-Blue or $L^*(white-black)-a^*(red-green)-b^*(yellow-blue)$. Some examples of weathering fronts with various crystallization degree of goethite-like yellow-brownish minerals and hydrothermal alteration fronts with hematite with some

presence of FeOOH will be presented. The line profile analyses both by spectro-colorimetry and by digital image processing are the powerful tools for characterizing the hydrothermal alteration, weathering and diagenesis.

Direct characterization of hydrous silica and iron on rock thin sections by IR and visible microspectroscopies

Visible and infrared microspectroscopies can be used for rock thin sections to quantitatively characterize species and their distribution of hydrous silica and iron phases. Some examples will be presented on quartz veins, agate and weathered granites. Dehydration-crystallization of silica is observed in an agate thin section. Distribution of different hydrous silica in relation with gold, clay and iron minerals are characterized for some quartz veins. Formation of iron hydroxides around biotite in granite is traced.

In-situ measurement of coloured alteration product formation by spectro-colorimetry

The above methods can also be applied to the in-situ characterization of coloured alteration products in aqueous solution experiments. Some examples will

be given on the precipitation-crystallization of iron hydroxides and iron sulphates. These data can be used for determining kinetics parameters such as rate constants and activation energies for the process.

Development of hydrothermal reaction cells for *in situ* measurement by visible, infrared and Raman microspectroscopies

We are currently developing hydrothermal reaction cells for the direct measurement of solid and aqueous species such as iron, silica, organics by visible, infrared and Raman microspectroscopies. Some preliminary results will be presented.

Combined field/laboratory *in situ* characterization

All these methods can be combined to characterize water-rock interactions both in the field and in the laboratory. The speciation of reaction products and its spatial distribution in natural samples provide us the working hypotheses and constraints on geochemical reaction pathways of their formation. In the laboratory simulation experiments, the direct measurement by the above methods without any extraction procedures are essential for determining the real speciation of phases, and realistic kinetic/thermodynamic parameters.