Geophysical Research Abstracts,
Vol. 11, EGU2009-4966, 2009
EGU General Assembly 2009

Experimental constrain of hydrogen production during early serpentinization stages

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Hydrothermal alteration of mantellic peridotites and ultramafic rocks along axial valleys of low spread oceanic ridges plays a key role in different fundamental domains like, 1) energetic gaz production (H2 and hydrocarbons) representing a potential source of energy for future generations, 2) formation of organic pre-biotic molecules in potential relation with the origin of life. Moreover, such complex volcanic-related alteration processes play fundamental role in economic geology, being widely associated to important polymetallic sulphides ore deposits.
Recent researches proposed an initial hydrogen production due to the integration of ferric iron in Fe,Mg-serpentine. To better understand the early stages of hydrogen production, a series of natural peridotite rocks have been experimentally exposed to hydrothermal conditions, up to 300°C, 300 bars during different time scales. Experiments have been performed in using autoclaves with a sampling gas system. A systematic mineralogical characterization of the new products was carried out using classical spectroscopic tools. In particular, we focused on the iron behaviour using a redox and structural micro-XANES investigation. Redox information has been accurately derived from the pre-peak features previously calibrated from model compounds, while structural information about short and medium range order around iron has been extracted from the XANES region of the spectra, based both on experimental standards and ab-initio theoretical calculations.
Two processes of oxidation emerged. Before two month experiment duration, serpentine displays a not negligible oxidation of ferrous iron in his structure (up to 60%), while after two months, iron oxides and hydroxides appear in the system. These results seem to correspond to natural observations. The iron coordination decreases linearly with time. It means that iron also integrates the serpentine tetrahedral sites. Moreover, high resolution μ-XAS maps on experimental samples were collected on the iron K-edge (7712 eV). These maps give valuable information concerning both kinetic of mineral phases transformation and spatial speciation of iron through the altered part of the samples. Finally, these results allow us to define a non linear model of “Fe3+ in serpentine vs hydrogen production” as a function of time.