European Mineralogical Conference
Vol. 1, EMC2012-377-2, 2012
European Mineralogical Conference 2012

Geochemical characterization and modelling of water-rock interaction in the metabasalt-serpentinite aquifer of Lago (CS, Italy)

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The study focus on the rock-to-water release and fate of major elements in the shallow aquifer of Lago (CS, Italy). The study area is characterized by the presence of meta-ophiolitic rocks, chiefly including meta-basalts and serpentinites.

A detailed field and laboratory work on both local shallow groundwaters and primary minerals of the two main lithotypes was carried out to acquire the data needed to simulate relevant rock dissolution processes by means of the software package EQ3/6, version 8.0.

The mineral assemblage of meta-basalts is dominated by chlorite, epidote, actinolitic amphibole, and albite, with small quantities of white mica and calcite. The paragenesis of serpentinites comprises prevailing antigorite, with subordinate magnetite, and low quantities of chlorite, lizardite, and diopside. All these minerals were taken into account as solid reactants to model separately the dissolution of average meta-basalt and mean serpentinite, apart from chlorite in the last case.

Most groundwaters have Ca–HCO_3 chemical composition, which is assumed to be controlled by dissolution of Ca-rich phases of meta-basalts. There are, however, some Mg–HCO_3 groundwaters, probably resulting from the interaction of meteoric water with serpentinites.

Results of reaction path modeling indicate that the dissolution of meta-basalts is mainly governed by destruction of calcite, whose dissolved mass is larger than those of other primary minerals, that are amphibole, epidote, albite, chlorite, and white mica, in order of decreasing importance.

During the dissolution of serpentinites, magnetite and antigorite are destroyed in nearly similar amounts, whereas the quantities of dissolved diopside and lizardite are 1.5 and 2.5 orders of magnitude lower than those of prevailing solids.

The main secondary minerals forming during dissolution of meta-basalts are α-cristobalite, trigonal carbonate, smectites, Fe (III) rich oxy-hydroxides, saponites, kaolinite and haussmannite, whereas those precipitating upon serpentinite dissolution are α-cristobalite, Fe (III) rich oxy-hydroxides, kaolinite, smectites and orthorhombic carbonates.

The theoretical paths of meta-basalts dissolution indicate that concentration of aqueous Ca increases owing to calcite dissolution as long as the aqueous solution is undersatured with calcite. In contrast, the concentration of dissolved Mg remains constant during the first calcite-dominated stage of meta-basalts dissolution since Mg supplied by amphibole, chlorite, and white mica destruction is completely insignificant.

The computed trend of serpentinites dissolution is characterized by nearly constant Ca concentration due to the virtually negligible amount of Ca supplied by destruction of diopside, the only Ca-bearing mineral of these rocks. In contrast, the concentration of dissolved Mg experiences a gradual increase, mainly due to antigorite destruction.

Analytical data for all the Ca-HCO_3 groundwaters are explained by the theoretical paths of meta-basalts dissolution, whereas Mg–HCO_3 springs are consistent with the computed trend of serpentinite dissolution.

Reaction path modeling provides a quantitative description of rock-to-water release and fate of major elements in the considered system, in agreement with qualitative expectation.