Thermodynamic simulation of peridotite - sea water interaction in serpentinite hosted hydrothermal system in the Slow-Spreading Ridges

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Serpentine hosted hydrothermal systems are common for Slow- and Ultra Slow – Spreading Ridges: MAR, Gakkel, SWIR. Ultramafic outcrops are widespread along MAR axis and sometimes occupies a floor space of hundreds square kilometers: e.g. at 15°04'N MAR – Bougault and Dmitriev Mountains (ODP, Leg 209, Initial Report, 2003). Main goal of this work is thermodynamic simulation of processes related with hydrothermal alteration of ultramafic rocks during hydration of Slow-Spreading Ridge lithosphere. The modeling is aimed at solving a following tasks: 1) Estimation of time of effective serpentinization of the Slow-Spreading Ridge ultramafic substratum at various P-T conditions; 2) Reconstruction of formation succession of secondary phases in Oceanic Peridotites during their interaction with Sea Water derived Fluid according to conditions of Hydrothermal System; 3) Reconstruction of compositional evolution of Sea Water derived Fluid and Host Peridotites with space (setting in sequence) and time.

We used a developed version of GEOCHEQ complex [Mironenko et al., 2000]. A thermodynamic database on gas and aqueous species and one-component solids up to 650 c and 5 kbar is based on SUPCRT92 database [Johnson et al., 1992; Shock et al., 1997] mainly. Additional information on non ideal gas and solid solutions, as well as kinetic data for calculating rates of mineral dissolution at various conditions were added. The calculating code was further developed for thermodynamic-kinetic modeling of irreversible chemical water-rock interactions. It takes to note that estimations of time of chemical transformations are relative because of uncertainty of several input parameters like degree of exposition of mineral grain surface to water, etc.

The CHEMEQ code was enhanced to consider non-ideality of gases, formation of solid solutions, and reaction progress with use of kinetic data.

As evident from modeling data serpentinization degree (SD = Serpentine/Rock%) in peridotites by their exposition on sea floor surface is left extremely low (0.11) even during first 10000yr interaction with Sea Water at low temperature. Serpentinization becomes effective beginning at temperatures are of 130° - 150°C and reaches SD more than 70 approximately after 4800 yr for hydrothermal interaction. Data obtained by Modeling allow to suppose that the most part of serpentinites of Slow-Spreading Ridge (typically SD ≥ 60) were formed at temperature no less that 130^{o}C and on the sequence depth is of 3.5-4.5km. Succession of secondary phases formation in peridotites related with serpentinite hosted hydrothermal systems is strongly depend on values of W/R, pH and temperature. Changes in secondary phase assemblages of peridotite corresponding three main types fluid regime established earlier for serpentinite hosted hydrothermal systems: sharp oxidizing (near-surface), moderate oxidizing (fluid-dominating), and reducing (rock-dominating) [Silantyev et al., 2003]. As it has been shown by modeling generation of CH4 becomes effective beginning at temperatures are of 130^o and Sequence Depth is of 3 km and continues until 460^o C and Depth about 11 km. Same behaviour is characteristic of H2 and H2S. The change in bulk chemistry of Host Peridotite (Ca-Input and Mg-Loss) is most pronounced in near bottom surface conditions and corresponding to low temperature.Modeling Data can be applied to reconstruction of geodynamic conditions favourable for serpentinite hosted Hydrothermal system formation.

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