Phase transformations and matter balance in serpentinite hosted hydrothermal systems of slow-spreading ridges

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Kinetic and thermodynamic simulation of the interaction of seawater and its metamorphosed derivatives with peridotites and gabbro in the Slow-Spreading Ridges (SSR) have been used for reconstruction of phase transformations and matter balance in Serpentinite Hosted Hydrothermal Systems (SHHS). The thermodynamic modulus of the model is based on the GEOCHEQ complex, which makes it possible to simulate equilibrium in systems of aqueous solutions–minerals–gases [Mironenko et al., 2000]. The calculating code was modified and adjusted for the thermodynamic–kinetic simulation of the passage of irreversible solution–rock reactions with time. In detail simulation techniques discussed in [Silantyev et al., 2009].

Simulations were carried out for a simplified vertical crustal section of a slow-spreading ridge of the Hess type that consists only of mantle peridotites (spinel harzburgites). Main results of modeling allow propose the geodynamic model for formation of the SHHS that includes:(1) The serpentinization of mantle rocks in the SSR takes place at crustal depths of 3.5–4.5 km; (2) The major heat source for launch of the SHHS is gabbroic intrusions; (3) The serpentinites are exhumed to the seafloor surface, and this is associated with the development of large detachment faults; (4) A combination of all of the aforementioned factors is a necessary condition to trigger the action of hydrothermal circulation systems in peridotites at the SSR. Data of modeling demonstrate that serpentinization degree of peridotite under the effect of low-temperature seawater when the rocks are exposed at the seafloor remains very low even after 10000 years of interaction. Serpentinization becomes efficient only at temperatures of 130–150°C at crustal depths of 3.5–4.5 km.

The simulated mineralogical facie's of hydrothermally modified SSR peridotites are in good agreement with the stability fields of secondary minerals in the MSH system. Data of our model simulations suggest that differences in the compositional parameters of hydrothermal vents at the different SHHS are predetermined by the different depths of the corresponding hydrothermal circulation systems. An estimation of geochemical and mineralogical effects related to the transport of hydrothermal fluid to the seafloor surface in the upwelling limb of a SHHS has been attempted also. The three variants of the location of the root zone of the circulation cell considered in this research were as follows: (1) shallow-depth, with T= 107°C, P= 1.14 kbar; (2) moderate low depths, with T= 151°C, P= 1.4 kbar; and (3) deep, with T= 500°C, P= 4 kbar. The modeling results demonstrate that ore material is accumulated in the discharge zones of the SHHS only at a high temperature of the fluid in the discharge zone of the upwelling limb of the circulation cell. The root zones at hydrothermal fields that meet this condition should be situated at a significant depth in the crustal section.

It was also established that a significant volume of ore material involved in hydrothermal material exchange between the peridotites and fluid is precipitated in the down welling limb of the hydrothermal system and gives rise to disseminated ore mineralization. The activity of moderately low-temperature and low-temperature hydrothermal systems in peridotites does not concentrate ore

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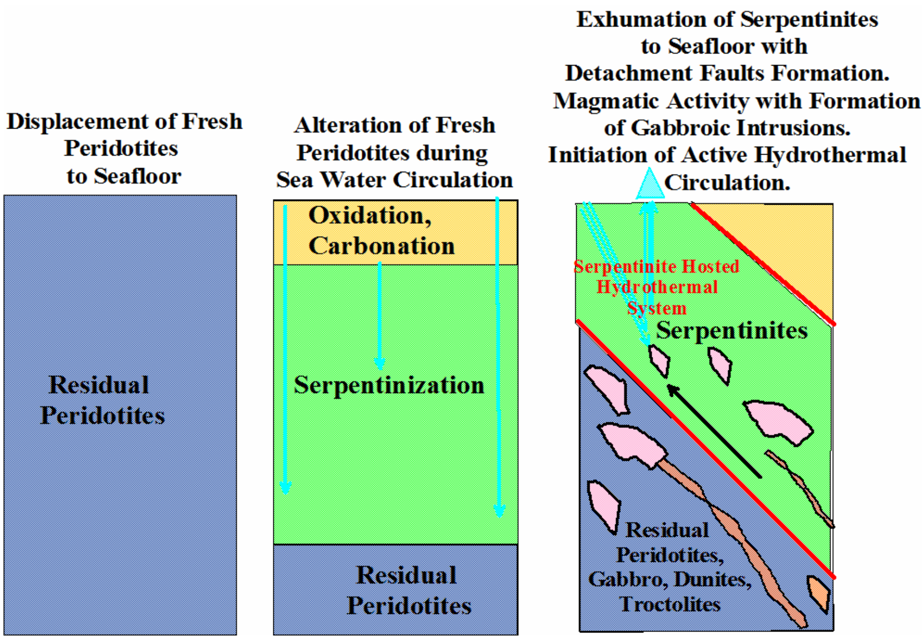

Fig. 1. Geodynamic scheme of the SHHS formation

material in the discharge zone, and no hydrothermal edifices can grow at such systems. Final stage of modeling carried out was estimation of role of gabbro in the ore mobilization during hydrothermal transformation of oceanic (gabbro–peridotite) crust at the SSR. The same modeling was used to reconstruct the geochemical and mineralogical trends of evolution of gabbroids during their hydrothermal interaction with marine fluid. The results of simulation offered a new insight into some problems of material balance and ore formation during hydrothermal process in the SSR. It was shown that the root zones of all known MAR SHHS are made up of ultramafic rocks and located within peridotite protolith near hot and yet no cooled gabbroic bodies. It was also demonstrated that the observed mineral and geochemical diversity of metagabbro of the SSR was provided by the interaction of hydrothermal fluid percolating through the Hess type oceanic crust with gabbroic bodies. It was established that almost cooled gabbroic bodies, being involved in hydrothermal circulation in the shallow root zones, may play an important role in the redistribution of the ore matter within the Hess type oceanic crust.

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