Bidirectional replacement zoning developed in metasomatic reaction of olivine and its implication for development of mesh zoning of serpentinites

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Serpentnization reaction, which occur though a coupled process of mass transfer, surface reaction, and volumetric expansion, affects both chemical and physical properties of oceanic lithosphere. Mesh texture characterizes most serpentinized peridotite. Mesh rims are considered to be formed via precipitation from a fluid bringing Mg, Fe, and Si into the rock from external resources (e.g., Andreani, 2004, 2007), or replacement reaction after/before mesh core formation (e.g., Beard et al., 2009; Schwarzenbach et al., 2016); However, it is difficult to interpret the processes of mesh texture development and related volumetric changes and mass transfer from texture.
In this study, we conducted hydrothermal experiments using mineral powder of plagioclase and olivine, and found Al-rich serpentine (Al-serpentine) which has a characteristic chemical zoning was formed around contacts between olivine and plagioclase via metasomatic reaction of Si and Al, while lizardite + brucite + magnetite was formed at far from the boundary. Al content in Al-serpentine once decreases from core to rim, and increases. At the center of chemical zoning which has relative low Al content, and a clear outline is observed in its texture. It could be interpreted that the outline preserves an outline of pre-existed olivine, therefore it suggests reaction front propagated both inside and outside direction of olivine. The chemical zoning was formed due to changes of Si and Al concentration in reacting fluid which may occur via metasomatic reaction front propagation. Hydration reaction proceeds toward inside direction requires removal Mg, Fe, and Si to fluid on serpentinization. The removed components from olivine and Si and Al from plagioclase were transported to pore and precipitated at outside.
This experiment used mineral powder (25-53μm) and initial porosity is ~40%; therefore, our experimental results represent an analogue of serpentinization in natural hydrothermal systems with a high porosity such as serpentinization of highly fractured peridotite. It is usually considered that mesh core and rim were formed in another stage. Our result showed a large mass transfer were required on iso-volumetric serpentinization which proceeds toward inside, and reaction towards inside proceeds to make mesh core and reaction towards outside proceeds to make mesh rim, simultaneously; therefore, mesh rim and core could be formed in same stage. On that, the thickness of mesh core represents the thickness of olivine that has been replaced while mesh rim was enlarged with volumetric expansion.

Keywords: serpentinization, mass transfer, mineral replacement, metasomatism, hydrothermal experiment

