

Interplay of irreversible reactions and deformation: a case of hydrofracturing in the system rodingite - serpentinite

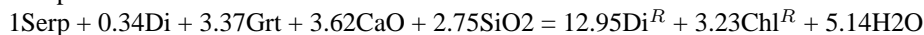
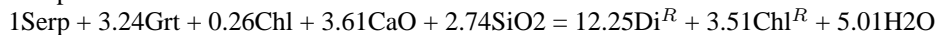
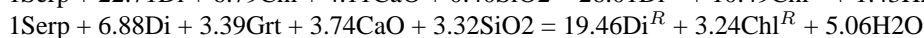
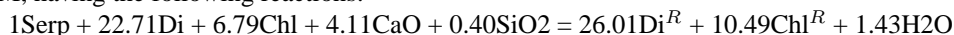
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This paper examines hydrofracturing caused by reactions between rodingite and serpentinite during a regional metamorphism. Hydrofracturing is driven by rapid increment of fluid pressure, and therefore will be likely to occur in the contact metamorphic aureole due to rapid and irreversible reactions (Nishiyama, 1989). This paper aims to show the same type of hydrofracturing can occur even in the regional metamorphic terrane.

Rodingites occurs ubiquitously in serpentinite from the Nomo metamorphic rocks, western Kyushu, which is a Cretaceous accretionary complex of greenschist to epidote - amphibolite facies condition (Miyazaki and Nishiyama, 1989). Fukuyama et al. (2014) made geochemical and geochronological studies on these rodingites, and gave U-Pb age of zircons from the rodingites as 108 - 105 Ma. This study classified the rodingites into two types depending on the occurrence and the rock texture: vein type and dyke type. Mineralogy of both types of rodingites are almost the same, consisting of diopside, garnet (grandite), chlorite, vesuvianite and titanite with rare occurrence of epidote and pumpellyite. Both vein-type and dyke-type rodingites are associated with reaction zones between serpentinite. Tremolite veins commonly develop from the reaction zone into serpentinite, representing hydrofracturing associated with the formation of the reaction zone. A conspicuous feature is that perovskite occurs in some reaction zones consisting mainly of diopside and chlorite, whereas titanite is common in rodingites. The reaction perovskite + SiO₂ = titanite indicates the condition poorer in SiO₂ in the reaction zone. We investigated the reaction relation between rodingites and serpentinites using the singular value decomposition (SVD) technique (Fisher, 1989). Constant solid volume is assumed during the formation of the reaction zone because of lack of ductile deformation in the reaction zone. The condition of constant solid volume is incorporated into the SVD analysis as was firstly done by Yuguchi et al. (2015).

The seven component system CaO - SiO₂ - Al₂O₃ - Fe₂O₃ - FeO - MgO - H₂O is considered. Antigorite (serpentinite), diopside, garnet and chlorite (rodingite), and diopside^R and chlorite^R (reaction zone) are considered. The superscript R denotes minerals from the reaction zone, because they also occur in the rodingite but have different compositions. We took the following strategy to find the reaction relation. First we tried to find reaction relations which hold the conservation of pseudoquaternary components CaO - SiO₂ - AF (Al₂O₃ + Fe₂O₃) - FM (FeO + MgO) among the mineral assemblage, but we got no reaction relation. Next we omitted CaO as an inert component from the system, and consider reaction relations that hold conservation of pseudoternary SiO₂ - AF - FM components, then we got three reactions consuming CaO and evolving H₂O. This strongly suggests increment of fluid pressure associated with the progress of the reactions. We have further examined the system AF - FM, having the following reactions:



All of these reactions consumes SiO₂ and CaO, and evolves H₂O. This relation holds if we take any linear combination of above reactions. When we consider the perovskite formation from titanite in the reaction zone, reactions in the system AF-FM are preferable, because SiO₂ liberated by the titanite breakdown will be consumed by the above reactions in the system AF - FM.

Keywords: rodingite, serpentinite, hydrofracturing, irreversible reactions, singular value decomposition