Forward analyses of hydration reactions in mafic rocks during retrograde metamorphism

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Fluids play an important role during progressive regional metamorphism. Although prograde dehydration reactions proceed whether fluid exists or not, the occurrence of retrograde hydration reactions require enough external H2O fluid. Otherwise, only solid-solid (fluid-absence) reactions would occur during retrograde metamorphism (Ohmori and Masago 2004). Recent detailed studies have suggested that hydration reactions proceed heterogeneously during retrograde metamorphism, and the extent of reactions is variable within a metamorphic belt (Ohta et al. 2004; Okamoto and Toriumi 2005). It is widely accepted that the existence of fluid strongly affects retrograde metamorphism as well as temperature and pressure (Maruyama et al. 2004).

In this study, we perform the thermodynamic forward simulation (Spear 1993) for mafic rocks during retrograde metamorphism. The assumed mineral assemblage is Amphibole + Epidote + Chlorite + Plagioclase + Quartz (+ Water), and the system is NCFFMASH. Perfect equilibrium is assumed. Two cases are considered in this study: One is open-system behavior (free access), and the other is closed-system behavior for Water.

Case 1 (Open-system behavior for Water): As pressure and temperature decrease, molar amounts of Epidote and Chlorite increase at the expense of Amphibole (hydration proceeds). Amphibole composition changes from barroisitic hornblende to actinolite, and Plagioclase becomes albite. This case is the exact reverse of prograde dehydration reactions.

Case 2 (Closed-system behavior for Water): As pressure and temperature decrease, molar amounts of minerals change a little. Amphibole composition changes from barroisitic hornblende to tschermakitic hornblende, and Plagioclase becomes anorthite-rich.