

Thermodynamic equilibrium for fluid-dominant metamorphic systems

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Classical metamorphic petrology has generally considered chemical equilibrium only among solid phases, but not among solid phases and aqueous species in the intergranular fluid (aqueous solution). It has been implicitly assumed that the chemistry of fluid is entirely buffered by the coexisting minerals. On the other hand, hydrothermal chemistry has modeled that the generation and extinction of the minerals are mostly controlled by the aqueous chemistry in the coexisting water. In most cases, however, the formulation in hydrothermal systems has treated minerals only as pure components but not as solid solutions (e.g. Reed 1983; Henley 1984). In this study, we develop the unified thermodynamic model that seamlessly integrates both the classical concept of metamorphic petrology and the concept of hydrothermal chemistry. The incorporation of the amount of water and chemistry of the aqueous species into the theory of the metamorphic equilibria enables us to investigate the water-rock interaction in metamorphism and metasomatism. In the numerical modeling, the rock shows a wide variety of mineral assemblages according to the amount of water, or the water/rock ratio, even in the same pressure, temperature and bulk-composition conditions. With the increase of water, the number of phase decreases and eventually the system becomes bimineralic or monomineralic. The present model will be the basis for the future study of the various reaction textures such as the formation of the metamorphic banding and the pseudomorphic replacement.