Dolomite, dolomitization, and dolomite problem: A new song with old tune

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Most hydrocarbon reservoirs in the US are related to sedimentary dolomite. Sedimentary dolomite is abundant in the geologic record, yet scarce in Holocene and modern marine sediments. Many dolomitization models only address the role of hydrologic circulation (or mass transfer) in supplying the necessary Mg^{2+}. Formation mechanism for sedimentary dolomite is still under debate. Although ankeritic dolomite were reported in cultured media of sulfate-reducing bacteria and methanogenic groundwater, dolomite and protodolomite could not been synthesized inorganically at room temperature. The key to dolomite problem needs to address the following two aspects: (i) high energy barrier of dehydration of aqueous Mg^{2+} (inhibiting dolomite and disordered dolomite nucleation / crystallization); and (ii) Ca-Mg ordering in protodolomite and dolomite. The results from our room temperature synthesis experiments indicate that protodolomite and disordered dolomite can nucleate and grow in aqueous media that contain small amount of dissolved hydrogen sulfide or organics with low dielectric constants. The dissolved molecules with low dielectric constants can increase randomness of local water and OH dipoles. This weakens the bonds between the water dipoles and Mg^{2+}, and therefore lower kinetic energy barrier of dehydration of the hydrated Mg^{2+}. Fast crystallization at low temperature will result in disordered dolomite and protodolomite. Slow crystallization or re-crystallization of early formed proto-dolomite (especially at high temperature) will result in ordered ideal dolomite. Average composition of disordered dolomite contains ~ 46 mole % of magnesite component. Ca-Mg ordering of the disordered dolomite results in protodolomite structure with locally ordered domains. Because dissolved sulfide and low dielectric organics serve as catalysts for lowering kinetic energy barrier of dehydration and dolomite crystallization, sedimentary dolomites and sandstones with dolomite cementation may be directly related to hydrocarbon source rocks or rocks influenced by hydrocarbon-bearing fluids. The proposed dolomitization mechanism may also shed new light into practical problems of hydrocarbon source rocks and reservoirs, and long-term performance evaluation of sites for carbon sequestration. Author acknowledges supports from NASA, NSF, and US Department of Energy.

Occurrence of ß-cristobalite precipitates in omphacite of UHP eclogite and its petrological implication

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The mineralogy of micro-phases / nano-phases and their textural relationship in host minerals from ultra-high pressure (UHP) metamorphic rocks can provide information about the history of subduction and exhumation of their host rocks. Using high-resolution transmission electron microscopy (HRTEM) and associated analytical techniques, we have examined omphacite crystals in a UHP eclogite from Qinglongshan area of the Sulu terrane, eastern China. Selected-area electron diffraction patterns confirm that the needle-like precipitates in the central part of the omphacite are ß-cristobalite (instead of quartz) and amphibole micro-crystals. The precipitates keep crystallographic orientation relationship with their host omphacite. It has been reported that ß-cristobalite can occur even at 800 °C during dehydration of amphibole by heating amphibole minerals, although ß-cristobalite is thermodynamically stable at low pressure and very high temperature according to phase diagram for silica. We propose that the ß-cristobalite precipitates indicate the transformation from amphibole (precursor of the omphacite) to omphacite happened in low temperature. Pyroxene with amphibole-like composition (or Si-rich pyroxene) was preserved in omphacite due to the reaction kinetics. The omphacite will have extra Si and vacancies with respect to normal stoichiometric pyroxene (Xu *et al*. 1996, American Mineralogist). Such kind of phenomenon may indicate fast subduction and low geothermal gradient history of the rock during subduction. The formation of the silica-rich precipitate inside the omphacite can be visualized as exsolution of extra Si and vacancies from host omphacite. This process produces a locally low pressure environment, although the host omphaceite was under high pressure. Strictly crystallographic orientation relationship between the ß-cristobalite and the host omphacite indicate that silica chain in pyroxene also serves as substrate for heterogeneous nucleation of the ß-cristobalite. The omphacite is composed of anti-phase domain boundaries and mixture of C- and P-lattice domains with several tens of nano-meters in size. This project is supported by National Science Foundation.