



Where can we find anhydrite in the marine environment?

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When seawater is heated when it percolates through the oceanic crust in hydrothermal systems, anhydrite can precipitate due to its retrograde solubility. This may lead to a reduction of porosity and permeability of the oceanic crust and of the sediment cover. Anhydrite precipitation may alter the fluid flow rate and the thermal characteristics of the high-temperature hydrothermal circulation, therefore modifying the geometry of fluid circulation (Lowell et al., 2003; Lowell & Yao, 2002). Bishoff and Seyfried (1978) have shown that anhydrite formation occurs at 150°C when seawater is heated under a 500 bars pressure. These conditions of anhydrite formation from seawater have been widely accepted since then.

Recently, Monnin (1999) developed a new thermodynamic model of calcium sulfate solubility in multi-component electrolyte solutions to investigate the solubility of anhydrite in seawater or in marine sediment pore-waters at high temperature and pressure. The model predicts that, upon heating at 500 bars, standard seawater becomes saturated with respect to anhydrite at $147 \pm 5^\circ\text{C}$, which compares well with value of laboratory experiments of 150°C (Bischoff and Seyfried, 1978). However, at 20 bars, the calculated saturation temperature is $117 \pm 3^\circ\text{C}$. This points to a non-negligible pressure effect even at moderate pressures. In a normal thermal gradient, a difference of 30°C corresponds to a shift of 1 km in the depth of anhydrite precipitation.

On the other hand, it is possible to trace the occurrence of anhydrite in pelagic sediments using their geochemical composition and their Sr isotope signature, while the direct mineralogical and petrographic observation remains difficult for a mineral of low abundance. At the Rainbow hydrothermal vent along the Mid-Atlantic Ridge

(36°14'N), Chavagnac et al. (2005) showed that the hydrothermal component of the sediment can be attributed to the presence of anhydrite. This can be detected using rare earth elements and $^{87}\text{Sr}/^{86}\text{Sr}$ isotope signatures. In this case, anhydrite is present several kilometres away from the source of high temperature hydrothermal vents where pressure and temperature conditions are outside its stability field. This mineral represents between 0.5 and 1.2% of a bulk sediment composed at 80% of coccolithe ooze.

It is paradoxical to observe the occurrence of anhydrite at pressure and temperature conditions outside the generally accepted boundaries of its stability field. It is, therefore, extremely important to better constrain its stability conditions in order to assess more accurately the effect of its precipitation on the geometry of hydrothermal circulation in the oceanic crust.

References: Bischoff J.L., Seyfried W.E., 1978. *Am. J. Sci.*, 278: 838-860; Chavagnac V., German C.R., Milton J.A., Palmer M.R., 2005. *Chemical Geology*, 216 : 329-352; Lowell R.P., Yao Y., 2002. *J. Geophys. Res.*, 107: 1029/2001JB001289; Lowell R.P., Yao Y., Germanovitch L.N., 2003. *J. Geophys. Res.*, 108: 1029/2002JB002371; Monnin C., 1999. *Chemical Geology*, 153: 187-209; Monnin C., Balleur S., Goffe B., 2003. *Geochim. Cosmochim. Acta*, 67: 2965-2976.