Effects of seawater Ca/SO_4 and Mg on Sr isotope exchange in MOR hydrothermal systems

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Modern mid-ocean ridge (MOR) hydrothermal systems have been extensively studied for decades. The evolution of seawater-derived fluids as they flow through heated MOR rocks is well understood when the fluids start out with modern seawater chemical composition [1]. However, for much of the past 500 million years, seawater has had higher Ca/SO_4 and lower Mg [2]. These differences can have a substantial effect on chemical and isotopic exchange in MOR's, especially as it relates to Ca, Sr, and Sr isotopes in high-T fluids. We use a charge-balance model calibrated to modern MOR systems and checked with reaction-path modeling to calculate how ancient MOR systems would change due to differences in paleoseawater composition. In modern seawater Ca, Sr, and Ca/SO_4 are low (10 and 0.09 mmol, 0.35) and Mg is high (53 mmol). In mid-Cretaceous seawater, for example, Ca, Sr, and Ca/SO_4 were high (30 and 0.3 mmol, 3.2) and Mg was lower (30 mmol). These differences imply that Cretaceous vent fluids were higher in Ca, Sr, and $^{87}Sr/^{86}Sr$. Lower Mg in seawater may also have slowed down chemical exchange processes. This model can explain the high $^{87}Sr/^{86}Sr$ in Cretaceous ophiolite epidosites and epidote-quartz veins [3-6], and is consistent with low $^{87}Sr/^{86}Sr$ in Jurassic ophiolite epidosites [7]. The model implies that the efficiency of Sr isotope exchange at MOR varies as a function of seawater Ca/SO_4 and Mg. Consequently, modeling the effect of seafloor exchange versus continental weathering in fitting the seawater $^{87}Sr/^{86}Sr$ history [6] has additional complexity and may imply that continental weathering fluxes varied more than previously thought [7]. The model also has implications for MOR exchange in low-SO_4 Precambrian oceans.

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