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Calcium and strontium isotope ($\delta^{44/40}\text{Ca}$, $\delta^{88/86}\text{Sr}$) fractionation in high temperature hydrothermal systems: First insights from 4°48'S, MAR

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Ca isotope fractionation in hydrothermal systems has been recently demonstrated as a result of fluid flow and mineral precipitation (Amini et al., 2008). In this study, we investigate the Ca and Sr isotopic systematic of three hydrothermal vent sites in order to further constrain potential isotopic effects along hydrothermal pathways in particular during phase separation at temperatures $>400^\circ\text{C}$. Therefore, the Ca ($\delta^{44/40}\text{Ca}$) and Sr ($\delta^{88/86}\text{Sr}$) isotopic compositions of high-temperature vent fluids of the hydrothermal vent sites Turtle Pits (TP), Comfortless Cove (CC) and Red Lion (RL) at the 4°48' S Mid-Atlantic Ridge were determined and compared. Both, Ca and Sr isotope ratios were measured by thermal ionization mass spectrometry using double spike technique ($^{48}\text{Ca}/^{43}\text{Ca}$ - and $^{87}\text{Sr}/^{84}\text{Sr}$ -double spike, respectively) and reported in δ notation relative to seawater.

At the non-boiling system RL, the Ca concentration of pristine seawater ($[\text{Ca}]_{\text{SW}}$) changes from about 10.2 mM to about 16 mM (RL) in the hydrothermal end-member ($[\text{Ca}]_{\text{HydEnd}}$) adopting thereby a $\delta^{44/40}\text{Ca}_{\text{HydEnd}}$ of $-0.91 \pm 0.09\text{‰}$ (RL) relative to seawater. This value is in good agreement with previously reported data for non-phase separated fluids from the Logatchev hydrothermal field (LHF; 15°N) (Amini et al., 2008). In contrast, the Ca concentration of hydrothermal fluids from the two boiling vent sites Comfortless Cove and Turtle Pits ($[\text{Ca}]_{\text{HydEnd}} = 10.5$ mM) rather resemble that of seawater, and with a $\delta^{44/40}\text{Ca}_{\text{HydEnd}}$ of $-1.14 \pm 0.08\text{‰}$ relative to seawater they are isotopically significantly lighter than fluids from the non-boiling systems, RL and LHF. This suggests that Ca isotope fractionation along hydrothermal pathways is influenced by the thermal conditions prevailing in a hydrothermal system. Amini et al. (2008) indicate a negative correlation between Ca isotope fractionation during the precipitation of anhydrite and the mineral formation temperature. We, therefore suggest hydrothermal anhydrite precipitation being a controlling factor for Ca isotope fractionation in hydrothermal systems.

Likewise, the Sr concentrations and isotopic compositions of the fluids differ between seawater, the non-boiling hydrothermal vent site RL and the boiling systems CC and TP. While the strontium concentration of seawater ($[\text{Sr}]_{\text{SW}}$) change during the transformation to a hydrothermal fluid from about 90 μM to ~ 70 μM at RF and adopt a $\delta^{88/86}\text{Sr}_{\text{HydEnd}}$ of $-0.17 \pm 0.01\text{‰}$ relative to seawater, $[\text{Sr}]_{\text{HydEnd}}$ of fluids from CC and TP is ~ 50 μM lower with $\delta^{88/86}\text{Sr}_{\text{HydEnd}} = -0.14 \pm 0.01\text{‰}$. Changes in the Sr composition in hydrothermal systems are due to water/rock interaction and fluid-mineral reactions during ocean crust alteration.. The mechanism underlying these processes to fractionate Sr isotopes and their meaning for the global Sr cycling is not known yet and has to be further constrained.

References:

Amini, M., Eisenhauer, A., Böhm, F., Fietzke, J., Bach, W., Garbe-Schönberg, D., Rosner, M., Bock, B., Lackschewitz, K. S., and Hauff, F., 2008. Calcium isotope ($\delta^{44/40}\text{Ca}$) fractionation along hydrothermal pathways, Logatchev field (Mid-Atlantic Ridge, 14°45'N). *Geochimica et Cosmochimica Acta* 72, pp. 4107–4122.