

CHEMISTRY OF HYDROTHERMAL SOLUTIONS FROM PELE'S VENTS,  
LOIHI SEAMOUNT, HAWAII

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## ABSTRACT

Hydrothermal fluids were sampled from Pele's Vents on the summit of Loihi Seamount, an intraplate, hotspot volcano, on four occasions from February 1987 to September 1990. The warm ( $\leq 31^\circ\text{C}$ ) vent solutions are enriched in dissolved Si,  $\text{CO}_2$ ,  $\text{H}_2\text{S}$ , alkalinity,  $\text{K}^+$ ,  $\text{Li}^+$ ,  $\text{Rb}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{NH}_4^+$  and possibly  $\text{Ni}^{2+}$ , and depleted in  $\text{SO}_4^{2-}$ ,  $\text{O}_2$ ,  $\text{Mg}^{2+}$ ,  $^{87}\text{Sr}/^{86}\text{Sr}$ ,  $\text{NO}_3^-$ , and sometimes  $\text{Cl}^-$  and  $\text{Na}^+$ , relative to ambient seawater. Silica correlates with sample temperature, indicating that solutions sampled from numerous vents in the  $\sim 20$  m diameter field have a common source and that Si can be used as a tracer for mixing of the vent fluids with ambient seawater. There are general similarities of the vent waters with mid-ocean ridge warm springs on the Galapagos Rift and Axial Seamount, but also striking differences: very high total dissolved  $\text{CO}_2$  ( $> 200$  mmol/kg), high alkalinity ( $> 8$  meq/kg) and dissolved  $\text{Fe}^{2+}$  (up to 1 mmol/kg), and relatively low pH ( $\sim 4.5$ - $4.7$  *in situ*) and dissolved  $\text{H}_2\text{S}$  (several  $\mu\text{mol/kg}$ ). The  $\text{Mg}^{2+}$  and  $\text{SO}_4^{2-}$  data are inconsistent with the "Galapagos model" proposed for the warm springs at  $86^\circ\text{W}$ , Galapagos Rift, whereby the warm fluids result from sub-seafloor mixing of a high-temperature ( $\sim 350^\circ\text{C}$ ) hydrothermal endmember with essentially unaltered seawater. The variable  $\text{Cl}^-$  depletions in the vent fluids, however, do suggest a high-temperature component in the warm vent waters. The fluid history can be qualitatively described by a modified "Galapagos model" which includes the overprint of reactions resulting from the addition of juvenile  $\text{CO}_2$  and  $\text{SO}_2$  to the circulating fluids; the  $\text{CO}_2$  attacks the basalt releasing metal cations and bicarbonate into solution, and the  $\text{SO}_2$  is hydrolyzed to  $\text{SO}_4^{2-}$ . These juvenile inputs likely reflect the shallow, hotspot setting of this system. One possible fluid-history scenario is considered and shown to be consistent with mass-balance constraints and thermodynamic calculations. Temporal changes in the vent fluid chemistry

between expeditions are consistent with variable phase segregation of the proposed high-temperature endmember for  $\text{Cl}^-$ ,  $\text{AT}$ ,  $\text{CO}_2$ ,  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Fe}^{2+}$ , and perhaps  $\text{NH}_4^+$ , whereas the causes of temporal changes in  $\text{Mg}^{2+}$ ,  $^{87}\text{Sr}/^{86}\text{Sr}$  and  $\text{Mn}^{2+}$  are not apparent. The vent field hydrothermal deposits are consistent with the vent water compositions; native sulfur on the vent throats likely forms from  $\text{SO}_2$  hydrolysis or  $\text{H}_2\text{S}$  oxidation, whereas the abundant Fe-oxyhydroxides form during mixing of the  $\text{Fe}^{2+}$ -rich, anoxic vent fluids with oxic, ambient seawater. The global chemical fluxes estimated for off-axis (hotspot and island-arc) hydrothermal venting, if analogous to Pele's Vents, are negligible compared to estimates of mid-ocean ridge-axis hydrothermal fluxes except for  $\text{CO}_2$  and alkalinity; for these species the off-axis hydrothermal fluxes may be of the same magnitude as the ridge-axis fluxes.