

He, CO₂, and δ¹³C variations during a mid-ocean ridge eruptive event

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We report ³He/⁴He, He and CO₂ concentrations for the dissolved (glass) and vapor (vesicle) phase of basalts, plus δ¹³C of vesicles, for a suite of 23 lavas from the 2005-2006 eruption on the East Pacific Rise. This sample suite provides a rare opportunity to study magma recharge along the mid-ocean ridge system and to quantify degassing prior to and during a single eruptive event. Our study covers the spatial and temporal extent of the months-long eruption (ages from ²¹⁰Po-²¹⁰Pb dating). ³He/⁴He is in isotopic equilibrium between vesicles and glass (mean = 8.51±0.04(1σ) R_A). Vesicle He and CO₂ concentrations vary by factors of 17 and 230, respectively. Nearly all samples lie in a narrow range of 280-370 ppm for total CO₂ (vesicles+glass), suggesting volatile saturation at ~1.5 km depth in the crust, similar to depths of the seismically imaged magma lenses. Vapor phase CO₂/He co-varies positively with the fraction of CO₂ contained in vesicles (r²=0.94) due to kinetic fractionation between He and CO₂ during vesiculation. There is no evidence for kinetic fractionation of ¹³C from ¹²C. Vesicle δ¹³C varies negatively with fraction of CO₂ in vesicles (r²=0.83), ranging from -2.6 to -5.0 ‰, and straddles the isotope composition of EPR vent fluids. The ¹³C-enrichment during CO₂ exsolution from the basaltic melt is similar to experimentally determined fractionation factors. Collectively the observations are explained by quasi-closed-system degassing, where melt ascent from the magma lens was sufficiently rapid that minimal bubble loss occurred during the eruption and flow of lava onto the seafloor.