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Carbon Isotope Composition of Basalts from Kama'ehuakanaloa (Loihi Seamount) : Primordial vs. Recycled Carbon in the Hawaiian Mantle Plume

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We analyzed the C isotope composition of vesicle CO_2, plus He isotopes and He and CO_2 concentrations in the vesicle and glass phase of 37 submarine basalts from the summit, north and south rifts, and east flank of Loihi Seamount. Tholeiites and transitional basalts lie in a narrow range of vesicle $\delta^{13}C$ = -0.9 to -4.6‰, while alkali basalts range from -2.1 to -7.2‰ (Fig. 1). Calculated total (vesicle+glass) $\delta^{13}C$ in tholeiites and transitional basalts range from -2.5 to -6.0‰ for $\Delta = \delta_{vapor} - \delta_{melt}$ = +2 to +4‰. Although the vapor-melt isotope fractionation factor (Δ) for Loihi basalts is uncertain, there is a broad trend of vesicle $\delta^{13}C$ with the proportion of total CO_2 trapped in vesicles. This trend suggests that Δ may be $\leq$ +2 ‰ for Loihi magma, and implies total $\delta^{13}C$ = -3 to -5‰ for most lavas. This range resembles mantle source values deduced from gas-rich MORBs and Iceland basalts, and for Kilauea deduced from its fumarole gas. However, this similarity is a conundrum because all Loihi basalts extensively degassed their initial CO_2. CO_2/Ba systematics and crystal fractionation modeling reveal that Loihi primary magmas (MgO=18 wt.%) lost >97% of their initial CO_2 (0.6 to 1.8 wt.%). Total $\delta^{13}C$ vs. total CO_2 in most Loihi tholeiitic and transitional basalts approximates a closed-system degassing trajectory. Extrapolating this trend to initial (pre-degassing) CO_2 concentrations implies $\delta^{13}C$ = -0.5 to -3.0‰ in Loihi primary magmas having the highest $^3He/^4He$ ratios (>30 R_A). This primary magma estimate is based on Δ=+2 during closed-system degassing; larger values of Δ, as measured experimentally, and/or open-system degassing, lead to even higher estimates of $\delta^{13}C$ for primary magmas. The Hawaiian plume source therefore seems to be characterized by $\delta^{13}C$ that is markedly higher than the values of -4 to -6‰ commonly found throughout Earth's mantle. This higher value of $\delta^{13}C$ could imply some tectonic recycling of inorganic C (limestone) to the Loihi mantle source. However, a mantle source $\delta^{13}C$ of -0.5 to -3.0‰ is also within the possible range of Earth's primordial carbon given the large range of $\delta^{13}C$ in chondritic meteorites.