Carbon fluxes beneath cratons: Insights from West Greenland kimberlites and carbonatites

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Kimberlite and carbonatite magmas intruding cratonic lithosphere are considered the deepest probes into Earth's mantle. In this setting their co-existence is commonly interpreted to represent a primary melting sequence of carbonated peridotite at >150 km depths, possibly as deep as the transition zone. The carbon involved in this magmatism is thought to be either of primordial origin or derived from recycled subduced oceanic crust [1].

To better understand carbon fluxes beneath cratons and their role in the deep carbon cycle, we have studied kimberlite dyke swarms and associated carbonatite intrusions of the North Atlantic craton in West Greenland [2, 3]. Our new Nd-Hf-Pb isotope data suggest that both magma types were derived from a common convective upper mantle source. Moreover, the absence of hallmark recycled oceanic crust signatures such as highly radiogenic Pb and decoupled Nd-Hf isotope systematics are indicative of a primordial mantle origin of the carbon involved in Greenland kimberlite and carbonatite magmatism. Based on phase relationships and geochemistry, including carbon isotopes, we identify Greenland kimberlites as near-primary melts (-6 to -4‰ $\delta^{13}C$). The intrusive carbonatites (-4 to -2‰ $\delta^{13}C$), however, represent mixtures of cumulus crystals and liquid. The kimberlites and carbonatites appear to be linked by a two-stage fractionation process that commenced at uppermost mantle depths. First, liquidus olivine+phlogopite were removed from kimberlitic carbonate-silicate melts at high-T, leading to residual carbonate-rich melt fractions. Second, upon continued ascent into the cratonic crust and cooling, these carbonate-rich melts precipitated calcite+dolomite along with minor olivine+magnetite [2].

Rayleigh carbon isotope fractionation modelling suggests that 70-to-90 vol% of mantle-derived carbonate involved in this deep magmatism is now captured in the intrusive carbonatite bodies. Thus, it appears that CO_2 outgassing associated with kimberlite and carbonatite magmatic activity is volumetrically insignificant compared to global basaltic magmatism, and that carbonatite intrusions represent a major cache of primordial mantle carbon.

[1] Deines (2002) *Earth-Science Reviews* **58**, 247-278. [2] Tappe et al. (2009) *Lithos* **112**, 385-399. [3] Tappe et al. (2011) *EPSL* **305**, 235-248.

$^3He/^4He$ in volcanic and hydrothermal fluids of the Mexican subduction zone

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New and published data on $^3He/^4He$ in volcanic and hydrothermal fluids of Mexico are discussed in terms of the structure and geodynamics of the Mexican subduction zone that extends from the Gulf of California at ~ 22°N to Tacana volcano on the border with Guatemala and includes at least three apparently independent volcanic areas: a ~700 km-long Trans Mexican Volcanic Belt (TMVB), a short, ~150 km-long Chiapanecan Volcanic chain (CVC), and Tacana volcano that belongs to the Central America Volcanic Arc (CAVA). The TMVB is a volcanic front that originates from the subduction of two oceanic plates beneath the continent: a mini Rivera plate at north and the Cocos plate further to south. The subduction of the Cocos plate is also responsible for the CVC and Tacana volcanism. In spite of a complicated geometry of the TMVB, high-temperature hydrothermal fluids from deep wells and natural manifestations of four drilled geothermal fields along the TMVB (La Primavera, Los Azufres, Los Humeros and Acaculco) are characterized by high and uniform $^3He/^4He$ maximum values of 7.2Ra to 7.5Ra (Ra = $1.39x10^{-6}$, air $^3He/^4He$ ratio). Numerous thermal groundwater systems along TMVB discharge gases with a wide spectrum of $^3He/^4He$ ratios from 2 to 6Ra with higher values in the western part, close to the triple point of intersection of three rift-like structures: Chapala, Colima and Tepic-Zacoalco. El Chichon, the only active volcano of CVC is characterized by MORB-like $^3He/^4He$ values of 7.7Ra to 8.1Ra in the crater fumaroles, while in fumaroles and hot springs of the Tacana volcanic complex much lower values of <6.2Ra were measured. A high-temperature (850°C) fumarole of Colima volcano discharged gas with $^3He/^4He$ of 6.6Ra.
Distribution of He isotopes adequately responses on the complex tectonic structure of the western part of TMVB together with the fore-arc area that includes Jalisco Block, a newly forming terrain originated from the present day complex tectonic mobility and bordered by Colima and Tepic-Zacoalco rifts and the Rivera plate subduction trench. He-isotopes clearly mark deep fault systems surrounding the Jalisco Block and shed light on the geometry of the Cocos-Rivera plate boundary close to the trench. $^3He/^4He$ anomalies in coastal thermal springs near Colima graben may be interpreted as being provided by a difference in the initial dip angle of the subduction and thus indicating a gap between plates and permeability for mantle He.