

Biogeochemical controls on trace elements in maple syrup

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Fifty maple syrup samples from 16 producers (2000 – 2005) in N. Nova Scotia were analyzed by ICP-MS for 40 elements. Exploratory statistics shows that composition correlates with producer/woodlot of origin, color (darkness) and production methods (boiling or reverse osmosis plus boiling). Many elements including high-field-strength Ga, Cr, Hf, and U, rare Earth elements La, Pr and Nd, chalcophile Cu; and alkaline Earth Ba and Ca correlate with producer/woodlot of origin, but the alkali metals (Na, K, Rb and Cs) are most distinctive. On average, element concentrations are 1.6 times higher in dark, late-season syrup than in light-colored, early-season syrup. Apparently, late-season sap contains lower sugar but similar element concentrations. It requires more boiling to concentrate sugars resulting in caramelization (dark syrup) and higher trace element concentrations. Boiled and osmosis syrups have similar average concentrations for large radius, low-charge cations, but small, high-charge cations (3+, 4+) are ~1.6 times higher in boiled samples. It appears that small, high-charge cations pass through the osmosis filter and are lost. It also indicates that metals are not attached to large organic molecules (e.g. sucrose). The latter idea is also supported by high element concentrations in dark syrup produced from low-sugar sap. Relative element concentrations in boiled syrup reflect solubility in ground water. Highly-soluble elements (e.g. alkali metals), have the highest crust-normalized concentrations (0.1 * average continental crust). Insoluble, high-charge cations (e.g. Hf, Th, La) exhibit the lowest normalized concentrations (0.0001 times). Although ~ 35 liters of sap are required to make 1 liter of syrup, element concentrations are only ~ 10 times higher than in Nova Scotia white wine. Evapotranspiration apparently concentrates elements in grapes. Several elements including Sn, Cu, and Zn show producer-related concentration anomalies that probably reflect equipment (tanks, pumps, solder in evaporators) used during production.

Coupled Oxygen and Hydrogen isotope exchange in Archean Igneous rocks: Constraints on the seawater and the hydrosphere

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We examine $^{18}\text{O}/^{16}\text{O}$ and D/H ratios of hydrothermally exchanged Archean and Proterozoic epizonal igneous rocks in order to constrain the isotopic composition of the Precambrian hydrosphere. Differing rates of ^{18}O exchange and concentration differences for hydrogen between water and silicates enable the calculation of starting surface water compositions at the time the rocks cooled through the solidus [1, 2]. The isotopic composition of seawater, the standard, anchors the δ values of waters that plot on the global meteoric water line. The slope of the line is approximately equal to the ratio (~8) of the liquid-vapor fractionation between D and ^{18}O . This ratio is robust against surface temperature change; the position of the meteoric water line (MWL) is affected by the D-excess, the y-intercept of the MWL and a function of the average vapor over the oceans. As a result, mean global precipitation (-4, -22) is ^{18}O and D depleted with respect to the initial ocean (0,0)[3]. Processes hypothesized on the basis of low ^{18}O metasediments (e.g. cherts and carbonates [4]) or inferred H-loss should move the MWL away from its Phanerozoic position because the D-excess will reach values approaching +100. For the inferred extremely low ^{18}O oceans with no change in δD -values, the altered igneous rocks should plot above the modern meteoric water line. For cases where the oceans are both ^{18}O and D-depleted, exchange trajectories should mimic those seen in Cordilleran batholiths at high latitudes [1]. Results for the Archean Pilbara block, Western Australia, and the Proterozoic Darb Zubaydah ophiolite, Saudi Arabia, exhibit isotope systematics similar to modern Phanerozoic hydrothermally-altered igneous rocks suggesting that the MWL and hence seawater had already obtained modern values by 3.5 Gyr ago.

- [1] Criss & Taylor (1986) *Rev. Mineral.* **16**, 373-424.
[2] Gregory *et al.* (1989) *Chem. Geol.* **75**, 1-42. [3] Rosanski *et al.* (1993) *Am Geophys U. Monogr* **78**, 1-36. [4] Kasting *et al.* (2006) *Earth Planet. Sci. Lett.* **252**, 82-93.