

Salts and Water: Stable Isotope Evidence for the Direction of Solute Flow in Deserts

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Abstract

Soil is the epidermis of a planet, bearing chemical and physical properties that reflect the processes driven by its surroundings. Due to heat, gas, and water/solute transport between soil and the atmosphere, its properties are highly depth dependent. Soil forms with or without biology, and while life imparts unique characteristics to soils, its absence does not impinge on many geophysical processes that constitute soil formation. In that vein, soils found in the lifeless or nearly lifeless places on Earth are highly illuminating as analogs for the now dry and abiotic soils of Mars.

One of the key revelations of isotope research in arid and hyper-arid soils on Earth is that *stable isotopes in soils are rarely conservative tracers of elemental source*, and instead reflect complex post-depositional processes caused by aqueous or gaseous transport. Research in the past decade in both the warm and cold hyperarid regions of the world show distinctive depth trends in both the mass and the isotope composition of calcium and sulfates (Ewing et al., 2008), as well as chlorides (Amundson et al., in review). These profiles, resulting from aqueous transport, can be mimicked by physical models that describe the processes, and the direction of solute flow.

Based on our understanding from these dry environments, the exploration of the chemistry and isotope composition of salts on the Mars surface must rely on careful observation strategies to minimize ambiguities in interpretation. Chemical profiles of Mars soils record a history of aqueous processes that can be revealed through our better understanding of similar processes that occur here on Earth (Amundson et al., 2008).

[1] Ewing, S.A. et al. (2008) *Geochimica et Cosmochimica Acta* **72**, 1096-1110.

[2] Amundson, R. et al. (2008) *Geochimica et Cosmochimica Acta* **72**, 3845-3864.

Calibration of the B isotope paleo-pH proxy in the deep sea coral *Desmophyllum dianthus*; fine scale sampling and 2-D mapping

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The boron isotope ratio ($\delta^{11}\text{B}$) of marine carbonate has been proposed to record seawater pH [1], and thus has the potential to provide information about the evolution of the ocean carbonate system and atmospheric pCO_2 [2]. Here we discuss calibrations based on distinct skeletal sampling strategies of this pH proxy in the deep sea coral *Desmophyllum dianthus* (*D. dianthus*). Ten modern corals from a depth range of 274-1470m in the Atlantic, Pacific, and Southern Oceans were analyzed using multi-collector ICP-MS (Neptune), and the measured $\delta^{11}\text{B}$ was regressed against ambient pH taken from hydrographic data sets (range pH 7.6 to 8.1) [3]. The array of $\delta^{11}\text{B}$ values for these corals plots above the seawater borate $\delta^{11}\text{B}$ vs. pH curve [4] by an apparently constant value of 11‰, well above the range of values seen in foraminifera and surface corals. This offset is attributed to physiological manipulation of the calcifying fluid to pH 8.7-9.0. The uncertainty in estimation of seawater pH from $\delta^{11}\text{B}$ currently limits the precision of absolute pH reconstructions to ± 0.05 - 0.10 pH units. To reduce potential uncertainty resulting from spatial heterogeneities among skeletal sub-structures, we compare $\delta^{11}\text{B}$ made on bulk septal skeleton to $\delta^{11}\text{B}$ of fibrous aragonite regions. Fibrous aragonite boron isotope data plot somewhat below those of bulk analyses and suggest a stronger dependence on ambient seawater pH. Finally, we discuss our findings with reference to 2-D maps of $\delta^{11}\text{B}$ across distinct skeletal features.

[1] Sanyal et al. (2001) *Paleoceanography* **16**, 515-519. [2] Hönisch et al. (2005) *EPSL* **236**, 305-314. [3] Anagnostou et al. (in review) *EPSL*. [4] Klochko et al. (2006) *EPSL* **248**, 276-285.