

Drying behavior of a rock and its implication to weathering

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Rocks near the ground surface undergo cyclic wetting and drying. Dynamic movement of pore water and significant change of chemical composition are induced by drying. Knowledge on these processes is important for considering weathering of rocks. We studied the way pore water moves and solute concentration changes during drying. A core of porous rhyolite from Kozushima, Japan [1], main pore diameter ranging from 0.1 μm to 260 μm , was used in the experiment. The core was saturated with deionized water, dried at 20°C and weight loss was monitored. Figure 1 shows the change in water-saturation (water volume per total pore volume) with elapsed time of drying. Drying rate was relatively constant for the initial 5 hours (constant-rate stage [2]) and then decreased (falling-rate stage [2]). In order to evaluate the size and chemical composition of pore water under different degrees of drying, we employed centrifugation. It is known that water is progressively extracted from water-bearing rock in order of large to small pores as centrifugal speed increases [3]. Therefore, by extracting pore water with increasing centrifugal speed in incremental steps, we can know the changes in the size of pore water and the solute concentration with progress of drying. The result of the stepwise centrifugation (Figure 2) demonstrates that as drying advances, first larger pores and subsequently smaller pores lose water. Also, solute concentration significantly changed with the progress of drying. Based on the results, we discuss how drying affects dissolution of primary minerals and precipitation of secondary products.

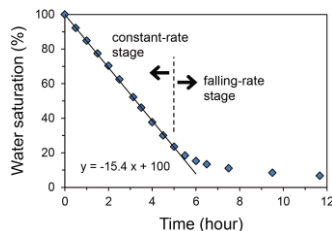


Figure 1: Change in water-saturation with elapsed time of drying

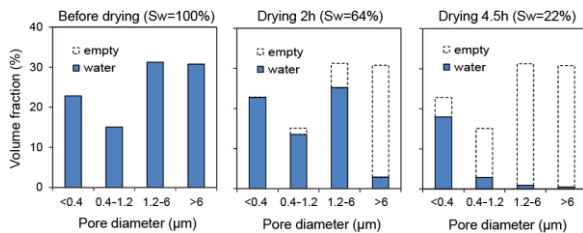


Figure 2: Change in size distribution of pore water with progress of drying (Sw: water saturation)

[1] Yokoyama & Banfield (2002) *GCA* **66**, 2665-2681. [2] Jury & Horton (2004) *Soil Physics* 370 pp. [3] Yokoyama *et al.* (2011) *Appl. Geochem.* **26**, 1524-1534.

Sr isotope anomalies in chondritic acid leachates

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A variety of nucleosynthetic isotope anomalies for heavy elements are documented in bulk chondrites and their components. Such data point to the existence of isotope heterogeneity in the protosolar nebula [1-2], although the mechanism that preserved nebular spatial heterogeneity at the time of planetary formation is not totally understood. In this study, we investigated stable Sr isotopic anomalies in carbonaceous chondrites. Strontium has four isotopes produced by the stellar nucleosynthesis of s-process (⁸⁶Sr, ⁸⁷Sr and ⁸⁸Sr), r-process (⁸⁷Sr and ⁸⁸Sr), and p-process (⁸⁴Sr). Radioactive decay of ⁸⁷Rb ($T_{1/2} = 48.8$ Gyr) also contributes to ⁸⁷Sr. Recently, high precision TIMS analysis revealed both mineral and planetary scale Sr isotope anomalies in various meteorites [3]. Large ⁸⁴Sr excesses (>100 ppm) were also found in CAIs [3,4].

To better understand the isotopically anomalous carriers for Sr in chondrites, we examined the sequential acid leaching for bulk rocks of two chondrites, Allende (CV3) and Tagish Lake (C2-ung), and analyzed Sr isotopes by TIMS. We followed the leaching procedure of [5], in which powdered chondrites were successively leached from weak to harsh acids in six steps; AcOH (20°C) – HNO₃ (20°C) – HCl (75°C) – HF+HCl (75°C) – HF+HCl (150°C) – HNO₃+HF (120°C). The ⁸⁴Sr/⁸⁶Sr ratios are reported in $\mu^{84}\text{Sr}$ units, which represent 10⁶ relative deviations from NIST987 Sr. Most of the Allende leachates have positive $\mu^{84}\text{Sr}$ that are close to the bulk Allende (+75 ppm). For Tagish Lake, the $\mu^{84}\text{Sr}$ gradually decrease from leachate #1 (+40 ppm) to #5 (-16 ppm), and an extremely large negative anomaly (-326 ppm) is observed in leachate #6. Bulk Tagish Lake has a marginally positive $\mu^{84}\text{Sr}$ (+16 ppm) that is apparently lower than that of bulk Allende.

The positive $\mu^{84}\text{Sr}$ represents the existence of materials enriched in Sr synthesized by the p- and/or r-process, while the enrichment of s-process Sr makes a negative $\mu^{84}\text{Sr}$. Most of the presolar phases in Allende has been destroyed via thermal metamorphism on the parent body. Thus, the anomalies in Allende leachates are presumed to be dominated by CAI components. We found no FUN-like CAI signature which has a drastically low $\mu^{84}\text{Sr}$ (-4200 ppm, [6]). The $\mu^{84}\text{Sr}$ in Tagish Lake leachates suggest that leachates 1 and 2 contain presolar grains rich in p- and/or r-process Sr, while leachate 6 contains presolar grains rich in s-process Sr. This means that Tagish Lake has at least two different presolar phases produced in different stellar environment. The easily leachable presolar phase(s) in leachates #1 and #2 is not yet identified, but presumably consists of minerals produced by supernovae. The acid resistant phase in leachate #6 is most likely presolar SiC synthesized in AGB stars.

[1] Trinquier, A. *et al.* (2009) *Science* **324**, 374–376. [2] Burkhardt, C. *et al.* (2011) *EPSL* **312**, 390–400. [3] Moynier, F. *et al.* (2011) *LPSC XLII*, 1239. [4] Hans, U. *et al.* (2011) *LPSC XLII*, 2672. [5] Reisberg, L. *et al.* (2009) *EPSL* **277**, 334–344. [6] Papanastassiou, D. A. and Wasserburg, G. J. (1978) *GRL* **5**, 595-598.