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Using Strontium Isotopes to Quantify Calcium Fluxes from Atmospheric Dust in Carbonates of Southwestern Idaho Soils

Kellie Wight
Boise State University

Jen Pierce
Boise State University

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Abstract

Inorganic carbon, or $CaCO_3$, makes up approximately 40% of global carbon in soils in arid and semi-arid regions (Stanbury et al., 2017). As many soil studies often focus on organic carbon, the role of soil inorganic carbon (SIC) and its formation is not well understood. In addition, the source of the calcium in $CaCO_3$ is not well known. Potential sources of calcium in southwest Idaho soils include weathered bedrock and/or aeolian dust, whose provenance is also poorly quantified.

This study uses strontium ($^{87}Sr/^{86}Sr$) as a calcium proxy to 1) describe the contribution of atmospheric dust to pedogenic carbonates and 2) infer the source of dust in southwestern Idaho.

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BOISE STATE UNIVERSITY

Kellie Wight and Dr. Jen Pierce

Boise State University Department of Geosciences

Reynolds Creek Critical Zone Observatory

USDA

INTRODUCTION

Inorganic carbon, or $CaCO_3$, makes up approximately 40% of global carbon in soils in arid and semi-arid regions (Stanbury et al., 2017). As many soil studies often focus on organic carbon, the role of soil inorganic carbon (SIC) and its formation is not well understood. In addition, the source of the calcium in $CaCO_3$ is not well known. Potential sources of calcium in southwest Idaho soils include weathered bedrock and/or aeolian dust, whose provenance is also poorly quantified.

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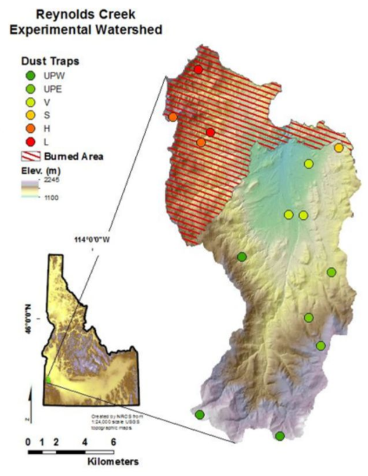

Figure 1. Dust trap locations in RCEW. *From Roehner, 2018.*

STUDY AREA

The Reynolds Creek Critical Zone Observatory (RC CZO) was established as part of the 239 km^2 Reynolds Creek Experimental Watershed (RCEW), Idaho, USA, to focus on the quantification of soil carbon and critical zone processes.

The northern section endured part of the large Soda Fire of 2015, affecting pedogenic and aeolian processes in the following years (Roehner, 2018).

Variable elevation (1100-2245m) results in temperature, precipitation, soil and vegetation trends that follow elevation gradients (Roehner, 2018, Seyfried et al., 2018, Stanbery et al., 2017).

METHODS

Figure 2. Field photo of dust trap set up at Reynolds Creek. *From Roehner, 2018.*

FIELD METHODS

Passive dust traps are made from inverted bundt pans that hold marbles, providing a rough surface on which dust collects.

Traps are placed 2m above ground to ensure no contamination from saltation or other potential ground inputs.

They are distributed throughout RCEW based on observations of topography, elevation and vegetation.

Traps are removed from the field and processed in a lab seasonally.

LAB METHODS

Dust was extracted from traps using a DI water rinse process, then dried and picked free of impurities.

To generate sufficient material for analysis, sites with multiple traps and/or similar field characteristics were consolidated down to eight samples.

Samples will be prepared with a lithium tetraborate flux for mass spectrometry analysis.

Figure 3. Image of extracted RCEW dust sample in a collection tray.

WHY STRONTIUM?

Strontium (Sr) is a radiogenic isotope that can substitute for calcium (Ca) in minerals due to a similar ionic radius. Sr is an ideal geochemical tracer as its relative high mass limits isotopic fractionation during geologic and biologic processes. Thus, measuring $^{87}Sr/^{86}Sr$ ratios can yield provenance information for a sample without significant interference from local climatic or biological variations (Capo et al., 1998).

By comparing Sr measurements in RCEW dust samples to local soil and bedrock samples, as well as published regional playa aerosol compositions, it is possible to trace dust sources and quantify calcium fluxes in a complex soil-vegetation-atmosphere system.

NEXT STEPS

Eight RCEW dust samples will be analyzed in the mass spectrometry lab, at Boise State University, for $^{87}Sr/^{86}Sr$ ratios the summer of 2021. Dust and soil samples from previous RCEW studies will also be analyzed to compare and infer potential dust sources.

Once the appropriate measurements are obtained, a steady state model will be used to estimate Sr (and therefore calcium) fluxes in RCEW soils from atmospheric dust.

$$\delta_{mix} = \frac{M_1^{Sr}\delta_1 + M_2^{Sr}\delta_2 + \cdots + M_n^{Sr}\delta_n}{M_1^{Sr} + M_2^{Sr} + \cdots + M_n^{Sr}} \quad \text{(Eq. 1)}$$

Eq. 1. Steady-state mixing model where δ_{mix} is a mixture of n components. M_n^{Sr} represents the mass of Sr in component n.

References

Capo, R., Stewart, B., Chadwick, O., 1998, Strontium isotopes as tracers of ecosystem processes: theory and methods, *Geoderma*, v. 82, p. 197-225.

Roehner, C., 2018, Post-fire variation in aeolian deposition in the Northern Great Basin, Master's thesis, Boise State University.

Seyfried, M., Lohse, K., Marks, D., Flerchinger, G., Pierson, F., Holbrook S., 2018, Reynolds Creek Experimental Watershed and Critical Zone Observatory.

Stanbery, C., Pierce, J., Benner, S., Lohse, K., 2017, On the Rocks: Quantifying storage of inorganic soil carbon on gravels and determining pedon-scale variability, *Catena*, v. 157, p. 436-442.

Stewart, B., Capo, R., Chadwick., O, 1997, Quantitative strontium isotope models for weathering, pedogenesis and biogeochemical cycling, *Geoderma*, v. 82, p. 173-195.

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