Pilot Study on Tracing Fugitive Dust from the Parleys Canyon Kilgor Quarry, Utah.

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Introduction:

Strontium (Sr) isotope ratios (i.e., 87Sr/86Sr) have emerged as a valuable tracer in dust studies, offering insights into the origin and transport of dust particles. The natural variation in Sr isotopic ratios across different geological rocks and regions makes it a powerful tool for source identification and tracking dust movement. Particularly if a local dust source (e.g., Rock Quarry) is contributing a unique ratio when compared with the region's baseline dust. This allows for unique geochemical fingerprints of Sr isotopes and provides a means to investigate dust sources and their impacts on various environments.

Several studies have highlighted the effectiveness of Sr isotopes in dust analysis. For example, Neff *et al.*, (2008) demonstrated the utility of Sr isotopes in identifying dust sources and transport pathways in the Western United States. Qu *et al.*, (2023) used strontium isotope ratios to analyze kidney stones from people living in Beijing, China. The study found that the strontium isotope ratios in kidney stones were consistent with the strontium isotope ratios of local dust, suggesting that dust was a major source of strontium for the people in Beijing. These studies showcase the ability of 87Sr/86Sr ratios to distinguish between different dust sources based on their distinct isotopic signatures.

Moreover, the stability of Sr isotopes during transport and deposition processes ensures that the isotopic signature of dust sources is preserved. This characteristic enables identifying dust origins even after long-distance transport reliably (Goodman *et al.*, 2019; Carling *et al.*, 2020). The combination of Sr isotopes with other tracers, such as lead isotopes or rare earth elements, can further enhance the accuracy and precision of dust source identification (Grousset and Biscaye, 2005).

Overall, the use of Sr isotopes as tracers in dust studies provide valuable, accurate, and quantitative information on dust sources, transport patterns, and their environmental impacts. By analyzing Sr isotopic ratios in dust samples, we gain insights into the geographic origins of dust particles and their contribution to the local environment.

This report presents the findings of a pilot study conducted by the City of Millcreek, Utah, USA, to evaluate the use of Sr87/Sr86 isotope ratios as indicators of the proportion of dust coming from the Kilgore Quarry, located in Parley's Canyon, Utah. The study aimed to determine if the dust samples collected from 3336 E Larchmont Dr in the City of Millcreek, UT, within the Canyon Rim - Neighborhood situated near the mouth of parleys canyon contained a significant contribution of fugitive dust from the rock quarry. The dust was collected by the city's staff from a utility shed’s exterior wall (Figure 1). The shed is located on private property and has appeared to have been naturally collecting presumed canyon wind-delivered dust for several years. The University of Utah Geology and Geophysics Department's ICPMS laboratory conducted the isotope analysis on both bedrock and dust samples. Bedrock samples were collected along I-80 road cuts adjacent to the quarry. The resulting data are attached to this report and can be accessed at Hydroshare.org.

Results:

Baseline Sr isotope data for dust samples in the Salt Lake City area during 2017-2018 were available from a previous study (Carling et al., 2020). These data included seven samples collected over a two-year period, with Sr isotope ratios ranging from 0.7121 to 0.7111 (mean=0.7116, sd=0.00054). The dust sample collected at Canyon Rim had a Sr isotope ratio of 0.70906. Bedrock samples of the TwinCreek Limestone (n=2, with 2 triplicates each) had an average Sr isotope ratio of 0.70739.

$$\left(\frac{87Sr}{86Sr}\right)_{\mathrm{CR\_Dust}} = \mathrm{x}\left(\frac{87Sr}{86Sr}\right)_{\mathrm{TW\_Rx}} + (1-\mathrm{x})\left(\frac{87Sr}{86Sr}\right)_{\mathrm{SLC\_Dust}}$$

The above equation represents a mass fractionation estimate (x) of the dust sourced from the Kilgore Quarry. It assumes no significant external dust sources and that the dust from Salt Lake City (SLC) represents the end member component, which is likely to be present in the Canyon Rim dust sample. Using the mean of the SLC dust samples, the proportion of Kilgore dust in the Canyon Rim sample is estimated to be 60.35%, with the remaining portion likely attributed to the baseline valley dust of SLC (Figure 2).

Wind Transport:

Fundamental atmospheric dynamics play a critical role in the transportation of dust particles from the up-canyon quarry to the down-canyon valley site. Canyon winds are a significant factor in the transport and dispersion of dust particles in areas like Parleys Canyon. These winds occur due to the pressure and temperature differences between the air inside the canyon and the air outside of it, resulting in winds that flow along the canyon's axis. Canyon winds can be daily occurrences, as they are typically driven by diurnal heating and cooling patterns. These winds are common at particular times of the day, such as during the morning and evening transition periods, and can also exhibit seasonal variations (Whiteman, 2000; Minder, Mote and Lundquist, 2010). The topography of Parleys Canyon, with its steep slopes and converging ridges, likely create strong winds that accelerate dust dispersion from the quarry site into the Salt Lake Valley.

The wind data collected by UDOT since 2008 at the quarry site provides significant insights (Figure 3). The prevailing winds, dominated in the WNW-ESE direction, align with the axis of Parleys Canyon and its watershed. This alignment facilitates the movement of dust particles along the canyon and toward the valley. Notably, the data reveal significant wind speeds, with an average annual occurrence of wind exceeding 25 mph 25% of the time. Moreover, wind speeds above 15 mph were recorded for the majority of the time, occurring 80% annually. These robust wind conditions create an efficient natural conduit for dust transport from the quarry. This process, combined with the topographical funneling effect of the canyon, likely contributes significantly to the deposition of dust at the downcanyon site and Canyon Rim neighborhood.

Conclusion:

This pilot study confirms the utility of Sr isotope ratios for tracing quarry-originated dust deposited at a single sample site located in the City of Millcreek, Utah. Data indicates that approximately 60.35% of the dust sample collected from the Canyon Rim neighborhood is attributable to the Kilgore Quarry. This underlines the importance of effective dust management strategies at the quarry to mitigate potential impacts. Future investigations could further refine our understanding of dust sources and transport pathways, contributing to the protection of environmental quality and public health.

Study Expansion:

To enhance the reliability of the initial results, it is recommended to expand the study by increasing the sample size and extending the sampling locations to encompass and delineate the plump of dust originating from the quarry. This can be achieved by setting up permanent dust collection boxes at various optimal sites. This approach would provide data on a larger spatial scale and allow for the collection of samples over time. Additionally, the amount of dust can be estimated using the collection boxes in conjunction with isotope ratios. Constructing and installing these collection boxes are cost-effective measures.

Disclaimer:

This study was funded by the City of Millcreek. If the results of this study are to be utilized in legal proceedings, it is advised that an environmental consulting firm with the appropriate state licensing evaluates, reproduces, and or validates the raw data presented here.

References:

Carling, G.T. *et al.* (2020) 'Using strontium isotopes to trace dust from a drying Great Salt Lake to adjacent urban areas and mountain snowpack', *Environmental Research Letters*, 15(11), p. 114035.

Goodman, M.M. *et al.* (2019) 'Trace element chemistry of atmospheric deposition along the Wasatch Front (Utah, USA) reflects regional playa dust and local urban aerosols', *Chemical Geology*, 530, p. 119317.

Grousset, F.E. and Biscaye, P.E. (2005) 'Tracing dust sources and transport patterns using Sr, Nd and Pb isotopes', *Chemical Geology*, 222(3–4), pp. 149–167.

Minder, J.R., Mote, P.W. and Lundquist, J.D. (2010) 'Surface temperature lapse rates over complex terrain: Lessons from the Cascade Mountains', *Journal of Geophysical Research: Atmospheres*, 115(D14).

Neff, J.C. *et al.* (2008) 'Increasing eolian dust deposition in the western United States linked to human activity', *Nature Geoscience*, 1(3), pp. 189–195.

Qu, R. *et al.* (2023) 'Strontium isotope ratios in kidney stones reveal the environmental implications for humans in Beijing, China', *Environmental Geochemistry and Health*, pp. 1–10.

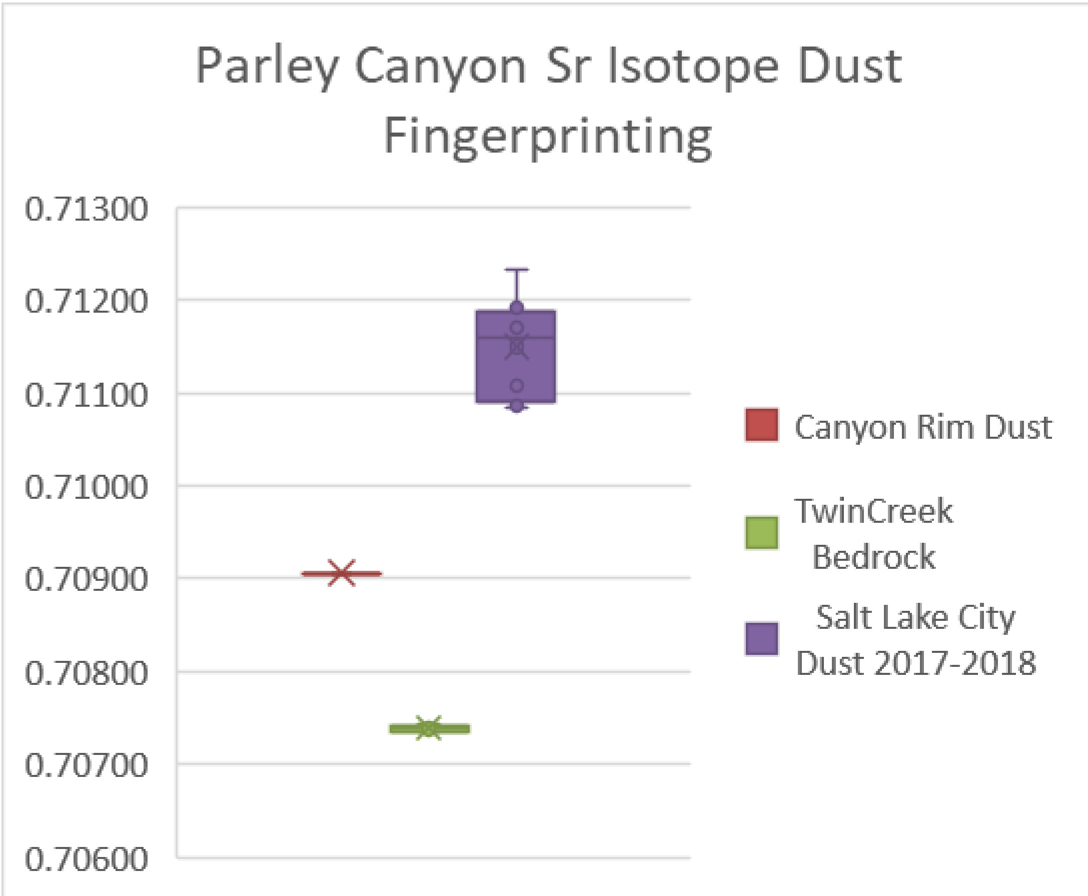
Whiteman, C.D. (2000) *Mountain meteorology: fundamentals and applications*. Oxford University Press.

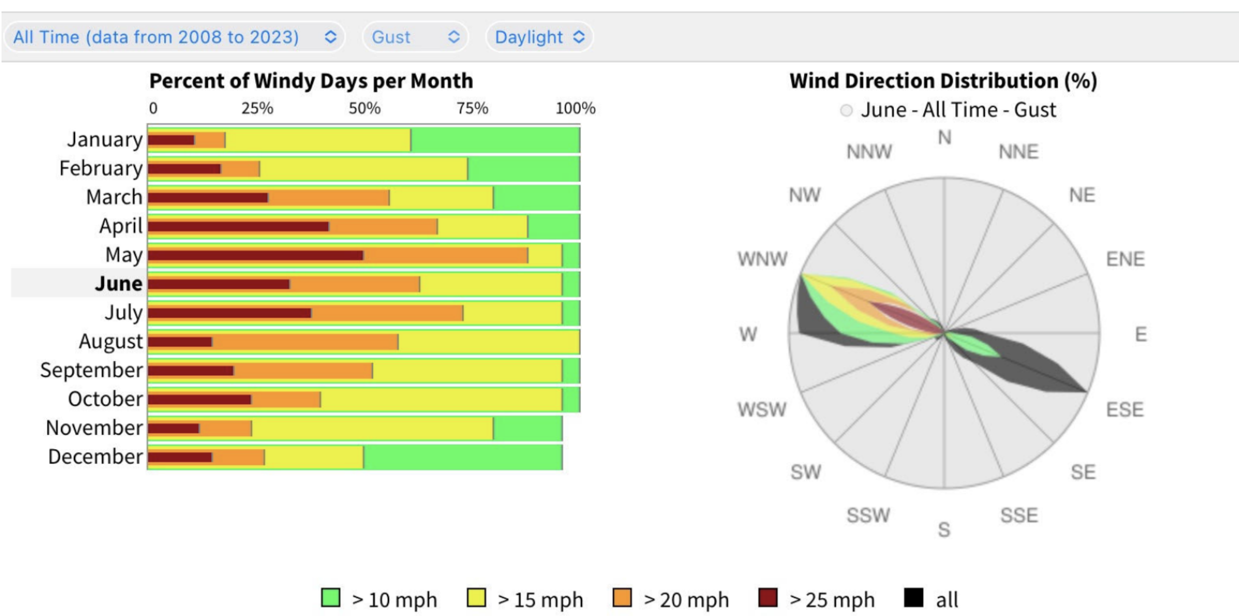
Figures:

Figure 1. Image of the utility shed where the sample was collected at 3336 E Larchmont Dr in the City of Millcreek, UT. The image shows the visible gray dust collecting on the wall of the shed.

Figure 2. Strontium isotope ratio (87Sr/86Sr) plot of baseline valley and canyon rim site samples compared to the bedrock samples collected from the twin creek limestone of parleys canyon.

Figure 3. Charts of wind statistics collected from 2008 to 2023 at the Quarry UT DOT site. The left panel shows the percent of windy days per month colored using wind speed categories from 0 to greater than 25 MPH. The right panel show recorded wind direction and speeds in the WNW-ESE directions, with dominance in the WNW direction towards the mouth of the canyon and valley. Data can be requested from windalert.com.


Parley Canyon Sr Isotope Dust Fingerprinting
0.71300
0.71200
0.71100
0.71000
0.70900
0.70800
0.70700
0.70600
Canyon Rim Dust
TwinCreek Bedrock
Salt Lake City Dust 2017-2018


All Time (data from 2008 to 2023)
Gust
Daylight
Percent of Windy Days per Month
0
25%
50%
75%
100%
January
February
March
April
May
June
July
August
September
October
November
December
Wind Direction Distribution (%)
June - All Time - Gust
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
> 10 mph
> 15 mph
> 20 mph
> 25 mph
all