Decoupling carbon and uranium isotope anomalies in Neoproterozoic carbonates

University of Maryland 1856 — DEPARTMENT OF GEOLOGY

Matt Pedersen

Advisors: Dr. Alan Jay Kaufman, Dr. Geoffrey J. Gilleaudeau, Tian Gan

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Introduction

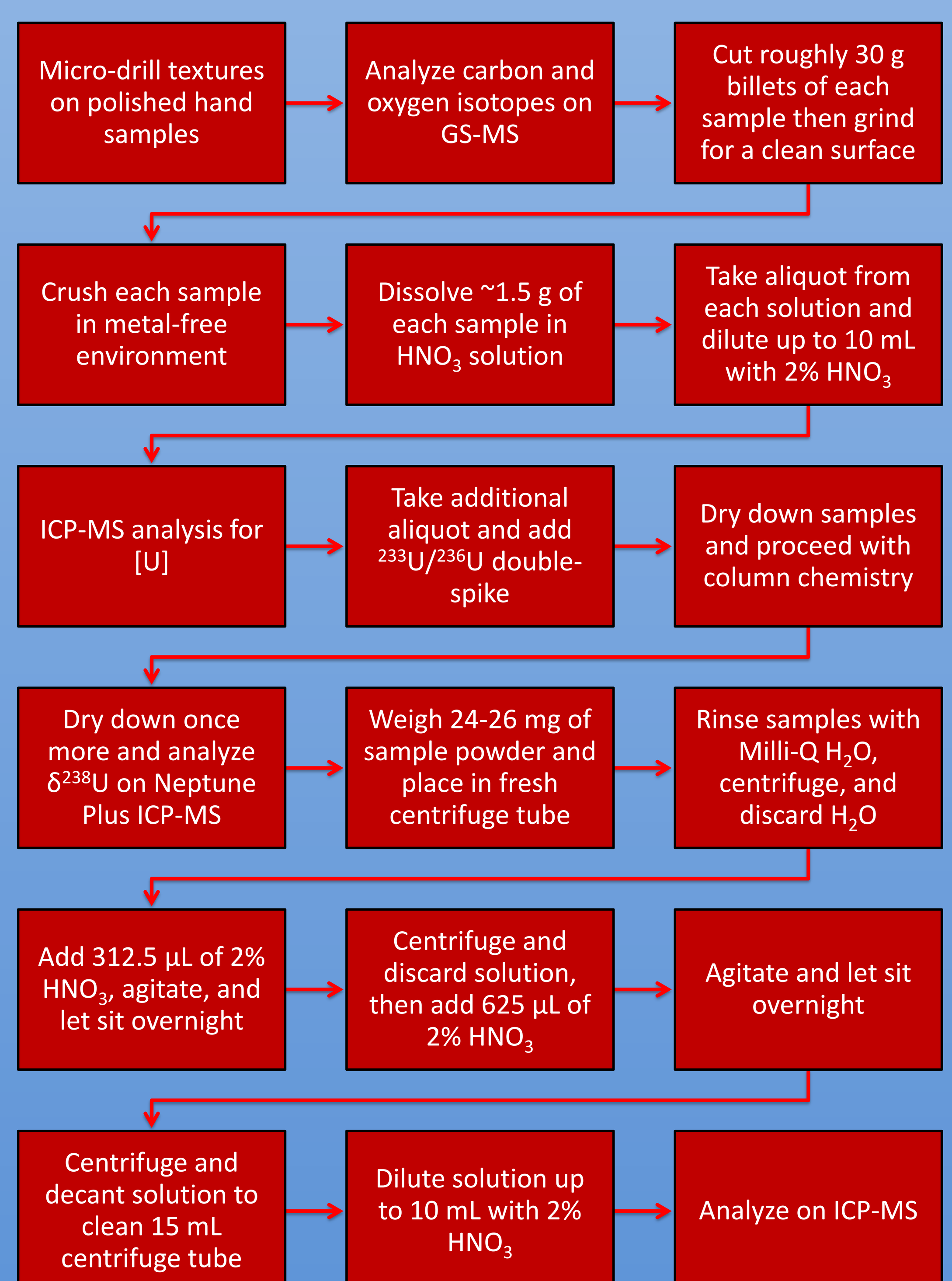
Insofar as animals need oxygen to breathe, geobiologists have sought for geochemical benchmarks that provide measures of the oxidation state of seawater during the rise of multicellular organisms on Earth. In this study I have used carbon and uranium isotope abundances as well as REE abundances to evaluate oceanic oxygen levels in the late Neoproterozoic. New paleontological evidence suggests that sponge-grade animals evolved at this time and they may have had an impact on elemental cycling and oxygenation of surface environments.

Hypothesis

Based on the assumption that anoxia promotes C burial, driving the $\delta^{13}C$ composition of carbonates, I hypothesize periods of $+\delta^{13}C$ would be coupled with more $-\delta^{238}U$, and vice versa.

Methods

Figure 1: Flowchart of methods employed throughout the project



Results

Figure 2: Chencha Formation chemostratigraphy

Composite illustrating the chemostratigraphic composition of the reef complex (Left). Outcrop photos from the bioclast layer (Right). These bioclasts have been interpreted as sponge-grade animals and hence may have had an impact on oceanic redox and element cycling.

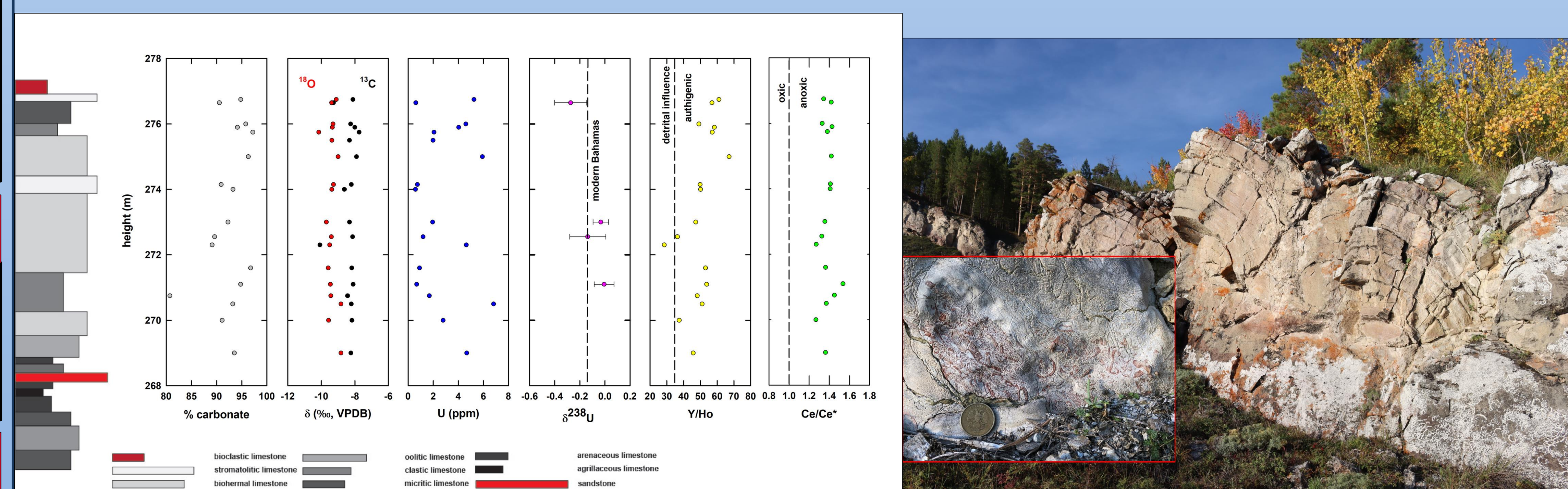


Figure 3: Chernaya Rechka Formation chemostratigraphy

Chemostratigraphic composite from the Chernaya Rechka Formation (Left). Outcrop photos illustrating the extent of deformation within the formation (Right).

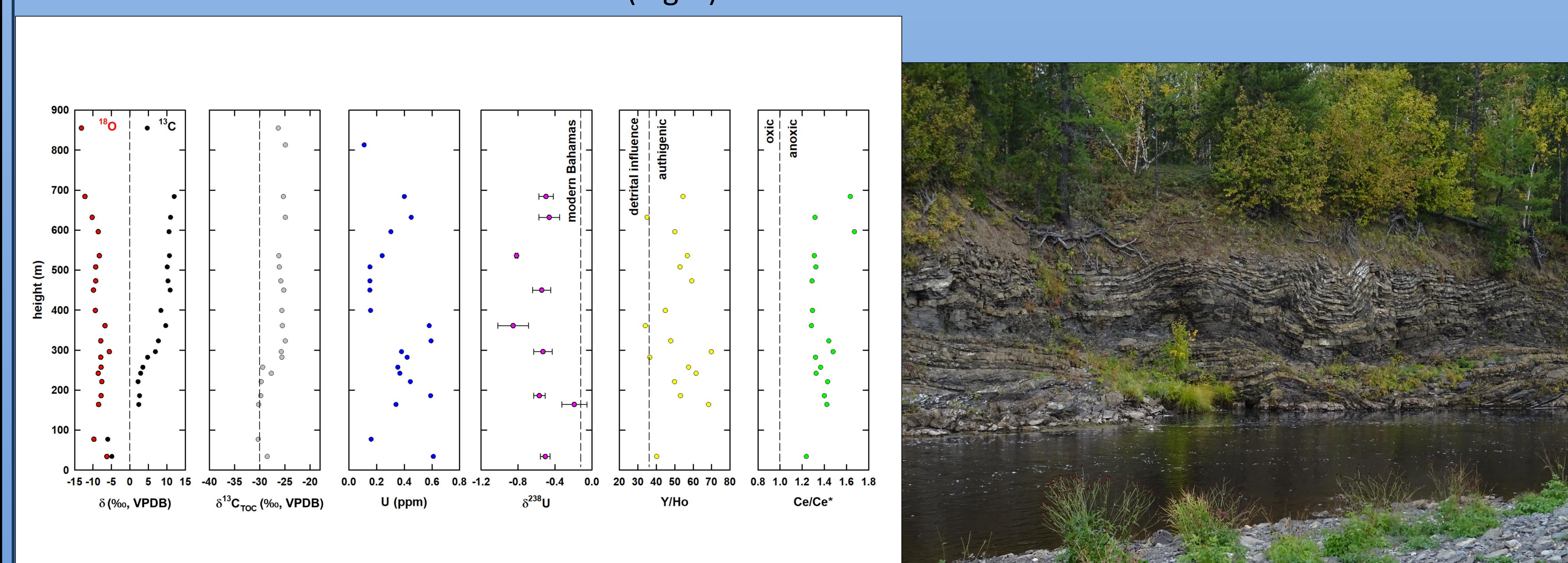
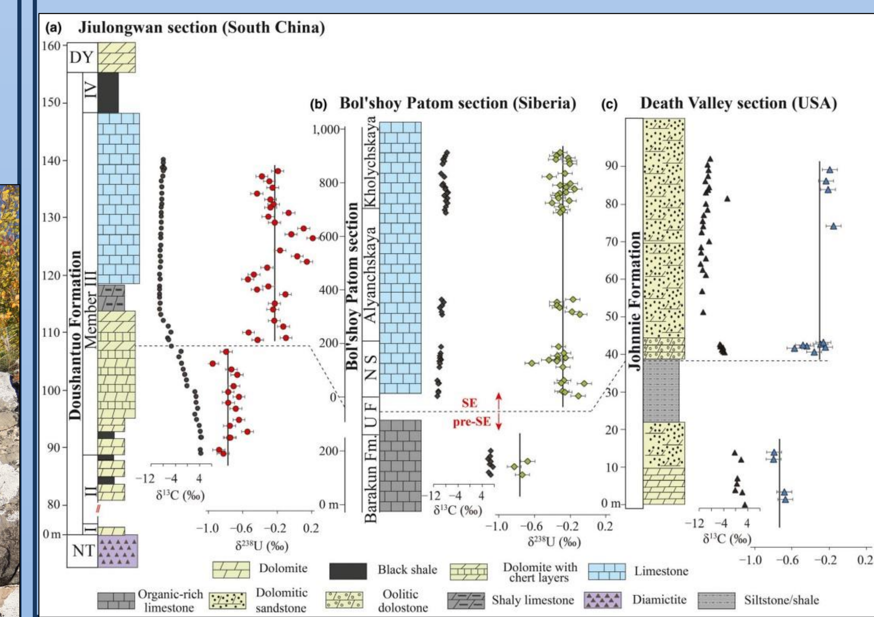


Figure 4: Table of average measurements and associated uncertainties

	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	[U] (ppm)	$\delta^{238}U$ (‰)	$\delta^{13}C$ (‰)	$\delta^{13}C_{OC}$ (‰)	$\delta^{18}O$ (‰)	[U] (ppm)	$\delta^{238}U$ (‰)
Average	-8.4	-9.3	2.6	-0.09	6.1	-25.0	-8.5	0.35	-0.55
Uncertainty	±0.04 (JTB1) ±0.06 (MCC)	±0.09 (JTB1) ±0.07 (MCC)	±2.4% (RSD)	±0.09 (2σ)	±0.1 (2σ)	±0.1 (2σ)	±0.2 (2σ)	±2.4% (RSD)	±0.09 (2σ)

Figure 5: from Zhang et al. (2019)

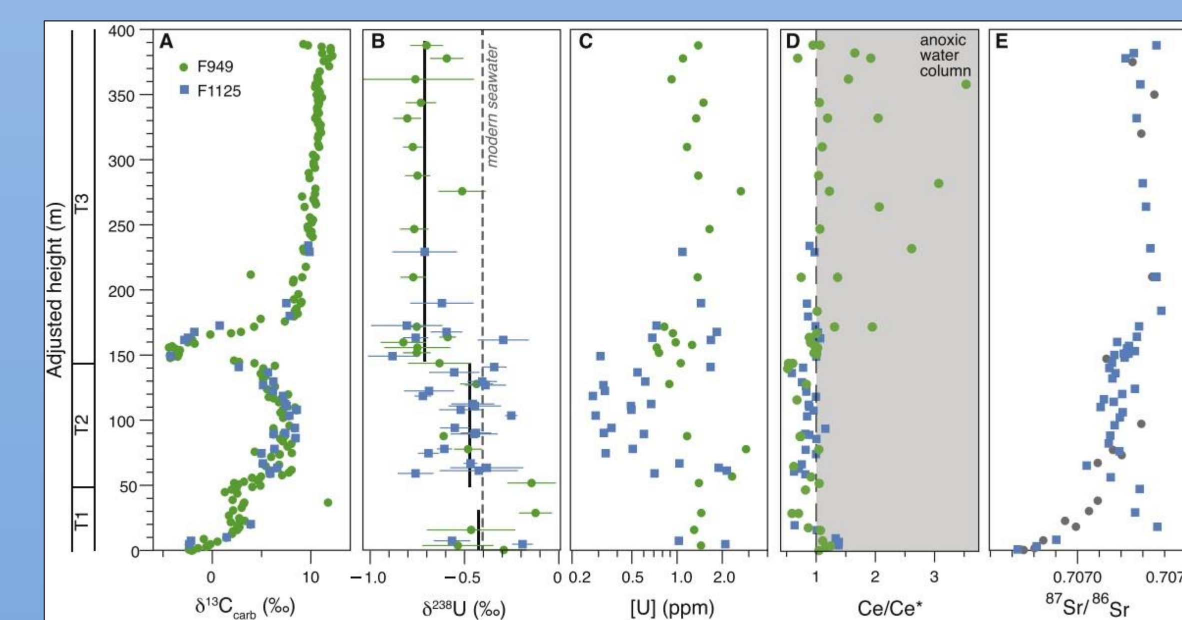
Three equivalent Shuram Excursion successions across the globe.



- All three show progressive declines in $\delta^{13}C$ and a step-wise increase in $\delta^{238}U$.
- The Bol'shoy Patom section is from the same region as our study.

Figure 6: from Lau et al. (2017)

Data from the Cryogenian Taishir Formation (Mongolia), that preserves a $+\delta^{13}C$ anomaly; a possible Chernaya Rechka equivalent.



Conclusions

- The Chernaya Rechka $+\delta^{13}C$ event corresponds to more $-\delta^{238}U$ values, similar to the Cryogenian Taishir Formation, signifying an enhanced flux of organic carbon burial and expanded euxinia at this time.
- In contrast, the Ediacaran Chencha $-\delta^{13}C$ anomaly, which has several equivalents worldwide, is associated with more $+\delta^{238}U$ values, implying greater degrees of oceanic ventilation during the Shuram Excursion.
- Both preserved positive Ce/Ce*, suggesting anoxic water column conditions.
- While this was predicted for the Chernaya Rechka carbonates, it was not for the Chencha reef, which contains fossil remains interpreted as sponge-grade animals. Insofar as these animals are known to concentrate oxygen and metals, like Mn, from seawater, and Ce complexes with Mn oxides, the positive Chencha Ce anomaly may alternatively indicate active Mn cycling by these simple animals under an oxidizing water column.

References and Acknowledgements

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