

# Can terrestrial Mn-rich samples help distinguish Mn-enrichments in Gale crater, Mars?

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## Terrestrial Sedimentary Manganese Enrichments

Manganese in solution mainly precipitates as Mn-oxides or Mn-carbonates.

**Mn-oxides** Mn(III), Mn(IV), Mn(III/IV)- oxides

- Requires strong oxidant to oxidize (high pH and eH)
- Highly negative surface and large surface area
  - ↳ Strongly adsorbs trace elements
- Precipitation dominated by catalyzation of microorganisms

**Mn-carbonates** Mn(II) - carbonates

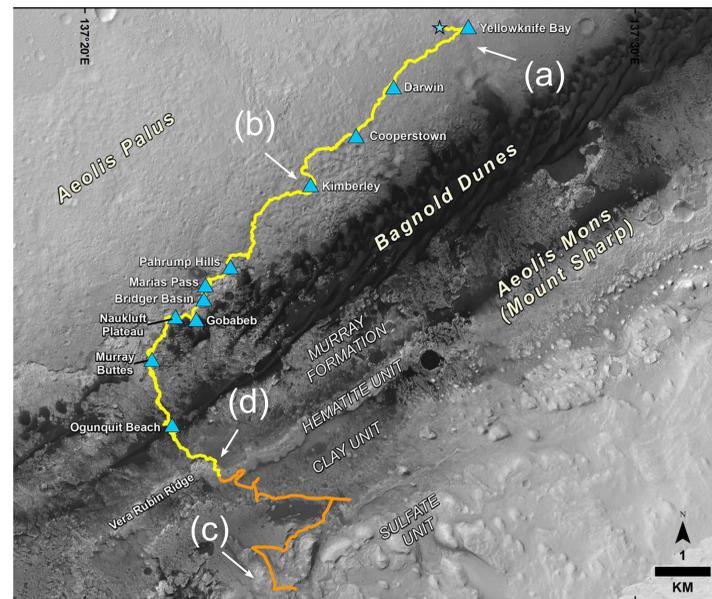
- Believed to form by secondary process from reduction of Mn-oxides
  - ↳ Largely due to microorganisms
- Recent studies point to possible primary precipitation in water column of redox-stratified lakes



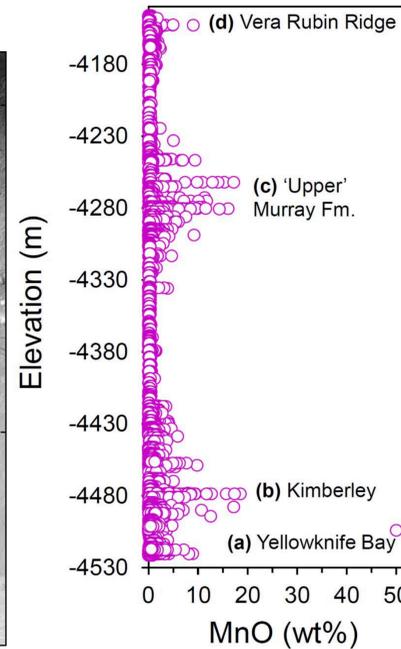
Knowing the state Mn is in can help to better constrain environmental deposition of Gale crater.

## Manganese Enrichments in Gale crater, Mars

Manganese(Mn)-enrichments have been detected on Mars by **LIBS**, an instrument on the Curiosity Rover which is currently investigating Gale crater.



The Curiosity Rover's traverse through Mars. Spots labeled (a)-(d) are areas where Manganese-enrichments have been detected.



Manganese abundance across Curiosity's traverse. Wt% determined through LIBS data. Average Mn abundance in Gale crater is 0.6 wt% MnO.

### What is LIBS?

- Analysis technique called **Laser-Induced Breakdown Spectroscopy**.
- Laser that can hit a sample up to 7m away.
  - Outputs spectral data between 240 and 850nm.
  - Elements determined based on its characteristic peak(s) in the spectra.
  - Can only give elemental data and not mineralogical data.

To discriminate if the Mn-enrichments observed in Gale crater represent Mn-oxide or Mn-carbonates, terrestrial sediments containing Mn-oxide and Mn-carbonate minerals were analyzed by LIBS under Mars conditions.

Can eventually compare with LIBS data from Curiosity.

## Distinguishing Mn-oxides and Mn-carbonates

### Method:

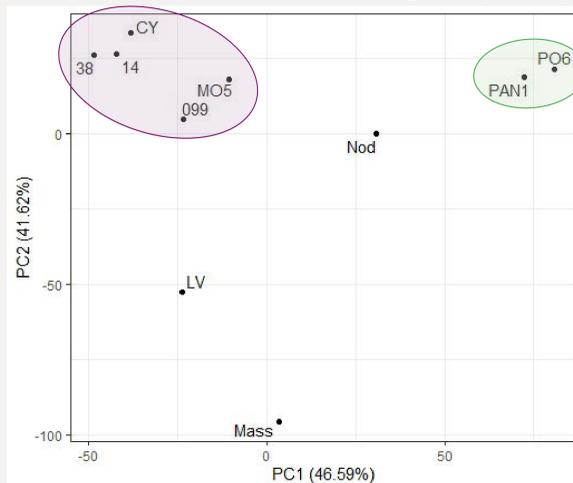
10 terrestrial samples from aqueous environments were collected and analyzed by X-Ray Fluorescence and LIBS.

### Principal Component Analysis:

PCA was produced from LIBS data by normalizing all wavelength emissions from LIBS spectra produced by the 10 samples.

- Pink Circle: Manganese- carbonates
- Green Circle: Brownie Lake sediments

### Principal Component Analysis (PCA)



### Sample List

- Environment favored for Mn-carbonates
- Environment favored for Mn-oxides

Sample	Origin	Sample	Origin
<span style="color: pink;">14</span>	Calumet MGS-8 core; Biwabik Fe-Formation, Animike Basin, MN	<span style="color: pink;">38</span>	Calumet MGS-8 core; Biwabik Fe-Formation, Animike Basin, MN
<span style="color: pink;">CY</span>	18290 core; Fe-Formation, Animike Basin, MN	<span style="color: pink;">MO5</span>	Lake Malawi, South-west Africa
<span style="color: blue;">Nod</span>	Lake Wentworth, NH	<span style="color: blue;">Mass</span>	Lake Wentworth, NH
<span style="color: blue;">LV</span>	Lake Vermillion, MN	<span style="color: blue;">099</span>	Otter Lake, MI
<span style="color: blue;">POX6</span>	Brownie Lake, MN	<span style="color: pink;">PAN1</span> *	Brownie Lake, MN

\* PAN1 are from an environment that favor formation of Mn-carbonates but sample was not handled anoxically so may also have some Mn-oxide formation.

## Outlook

- Using the PCA, the project successfully distinguished terrestrial Mn-carbonate samples from Mn-oxides using LIBS spectral data.

### Ongoing Research

- 1) Determining what is causing the dissimilarity in the PCA between Mn-carbonates and Mn-oxides.
  - Hypothesized that Mn-oxides have much higher trace element associations compared to Mn-carbonates.
- 2) Determining if this method can work to distinguish Mn-enrichments with LIBS data from Curiosity Rover.