A photograph of a cave interior. The walls and floor are covered in a white, mineral-rich deposit, likely ferromanganese. The cave is dimly lit, with the light source highlighting the texture of the deposit. The background shows the dark, rocky walls of the cave.

**In the Land of Black and White,
Microbial Deposition of Ferromanganese
on the Walls of Snowy River,
Ft Stanton Cave , NM**

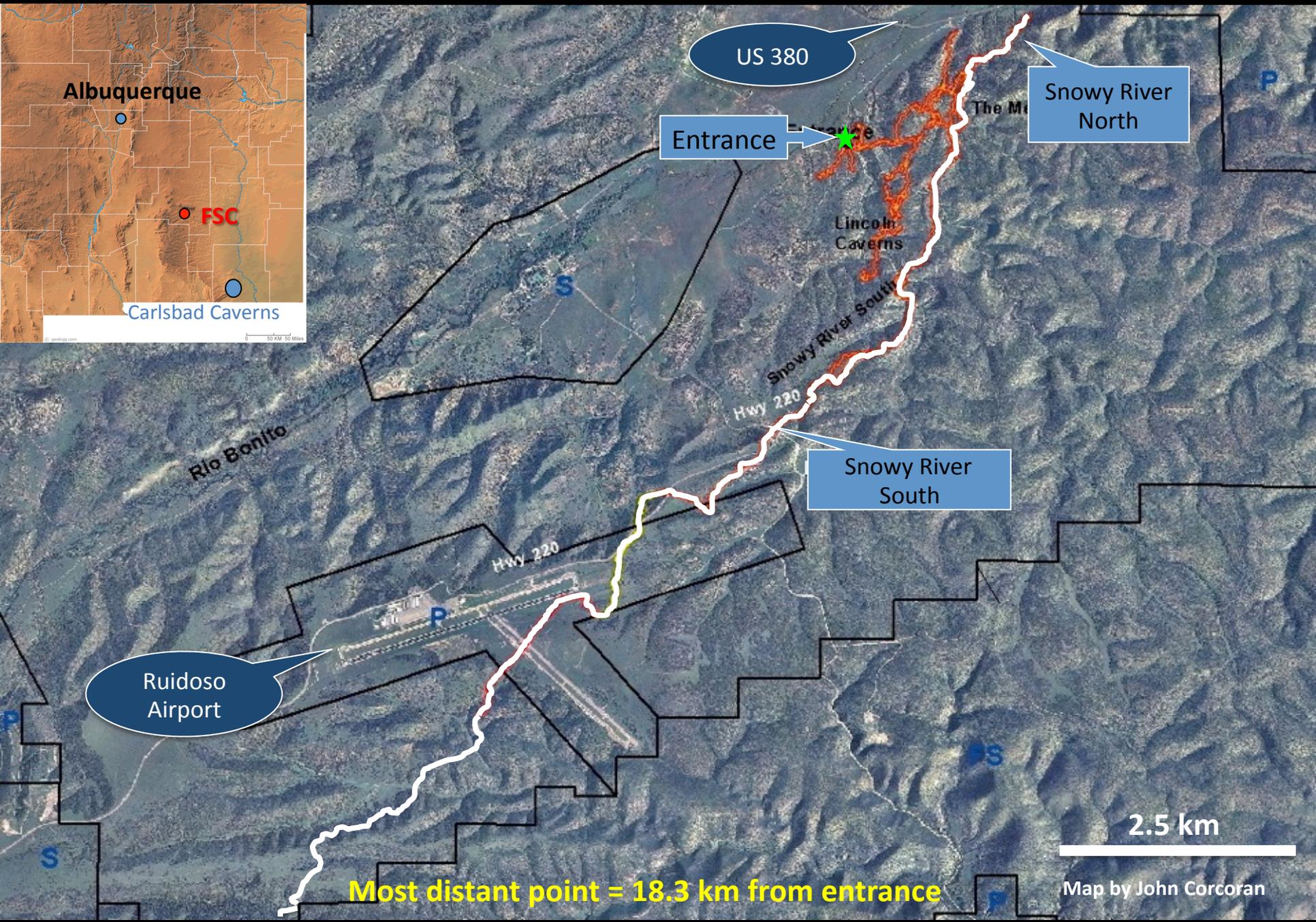
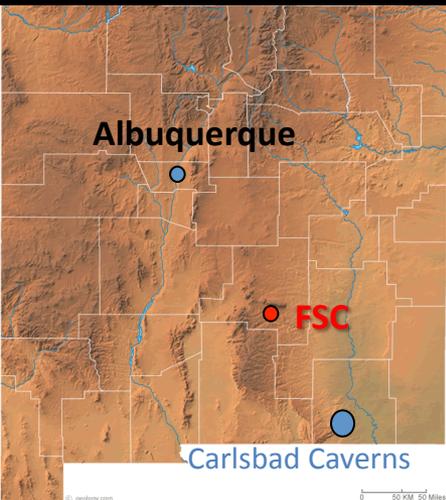
Michael Spilde, Jason Kimble, Diana Northup

University of New Mexico

Penelope Boston

New Mexico Institute of Mining & Technology
and NASA Ames Research Center

Fort Stanton Cave

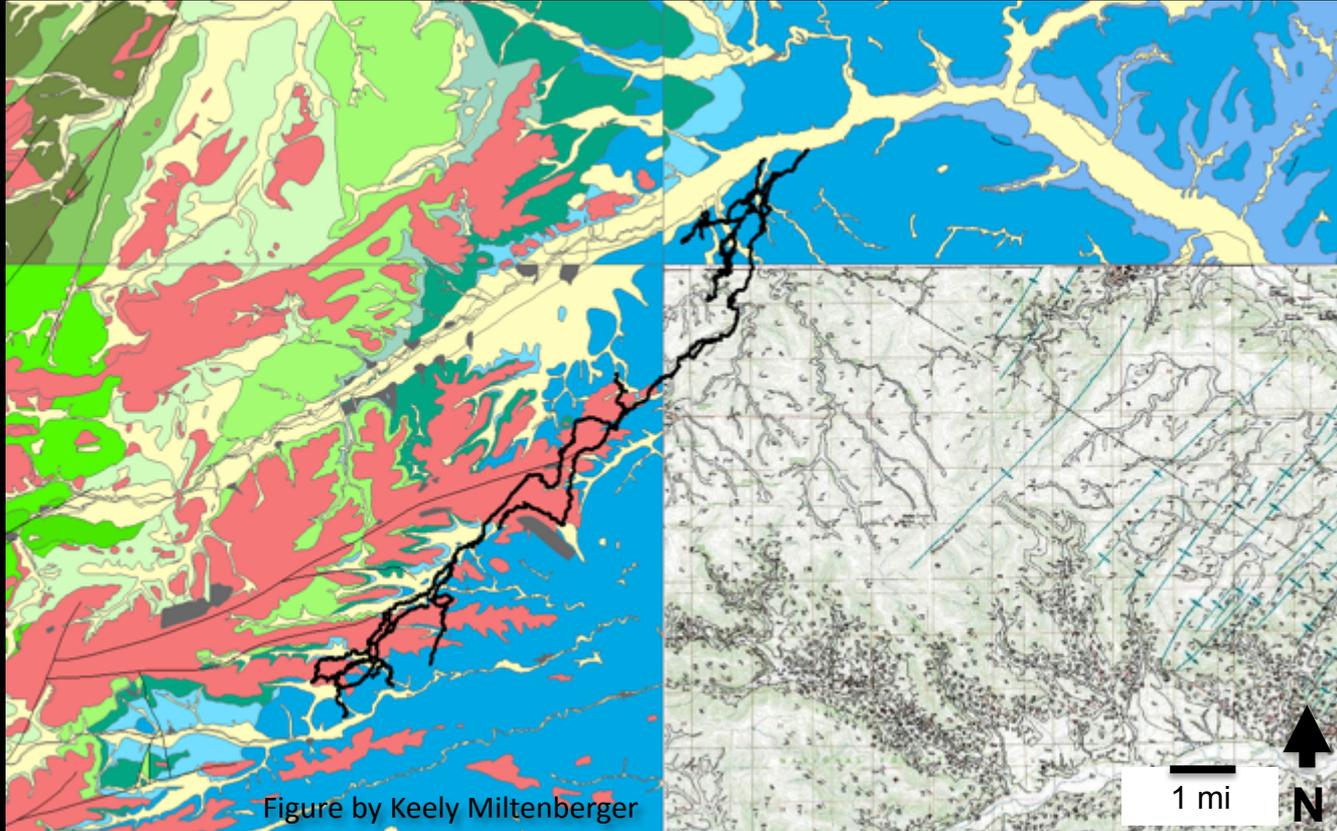


The Snowy River Passage

A photograph of a person in a red suit and helmet standing in a cave passage next to a river. The person is holding a camera or light. The cave walls are rocky and illuminated by a bright light source, possibly a flashlight or a lamp, creating a strong contrast between the lit areas and the deep shadows of the cave. The river is visible in the foreground, flowing through the passage.

Ft Stanton Cave: 50+ km of surveyed passage (14th longest in US)
Snowy River: 19.1 km long and still going!

Geology of Ft Stanton Cave



- Cave is hosted in Permian San Andres Limestone
 - Soils above the cave developed in mainly limestone and Tertiary gravels (stay tuned for the next talk!)
 - Likely source of water in Snowy River is 6 km to SW

Natural History of Snow River Passage

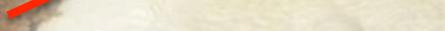
- Large passage forms
- Silt & clay deposited on walls/floor



- Sand & pebbles deposited



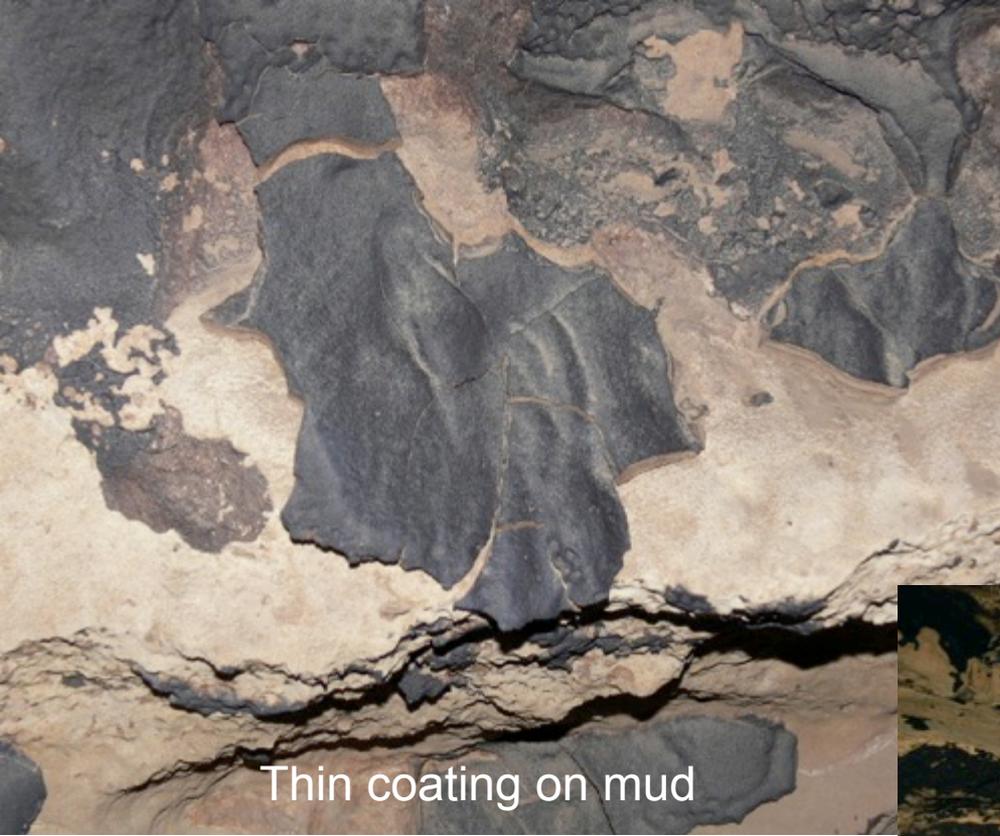
- Mn-oxide on walls



- Snowy River calcite



Ferromanganese



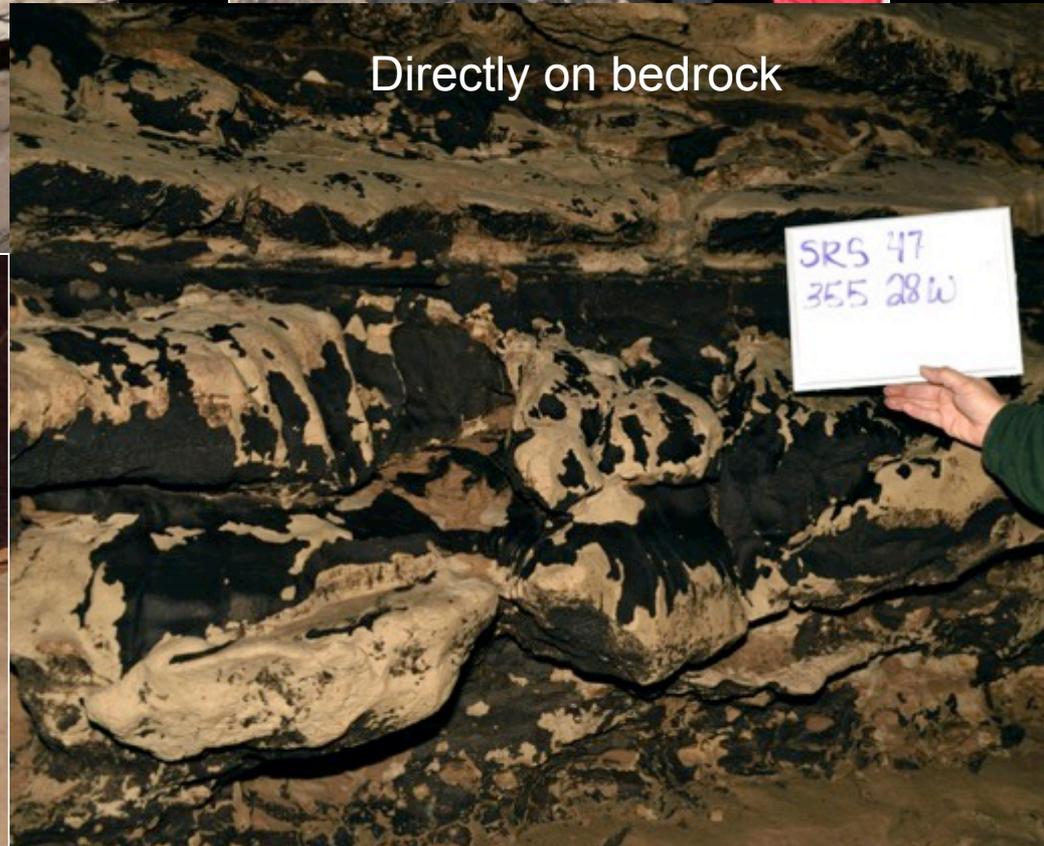
Thin coating on mud



Directly on bedrock



Evidence of multiple episodes of growth



Ferromanganese Coatings

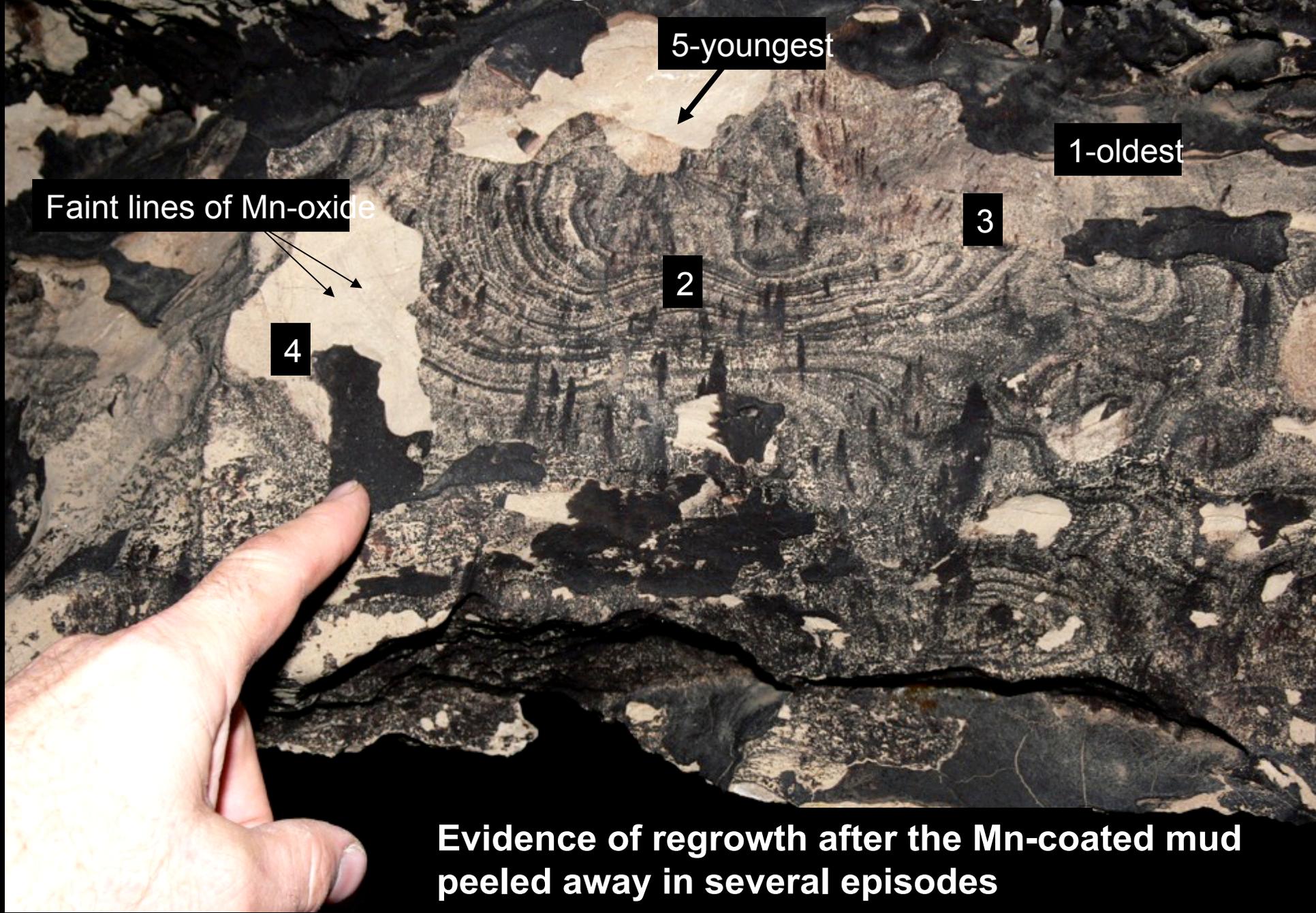


May be patchy and discontinuous



Or cover nearly every surface

Ferromanganese Coatings



5-youngest

1-oldest

Faint lines of Mn-oxide

3

2

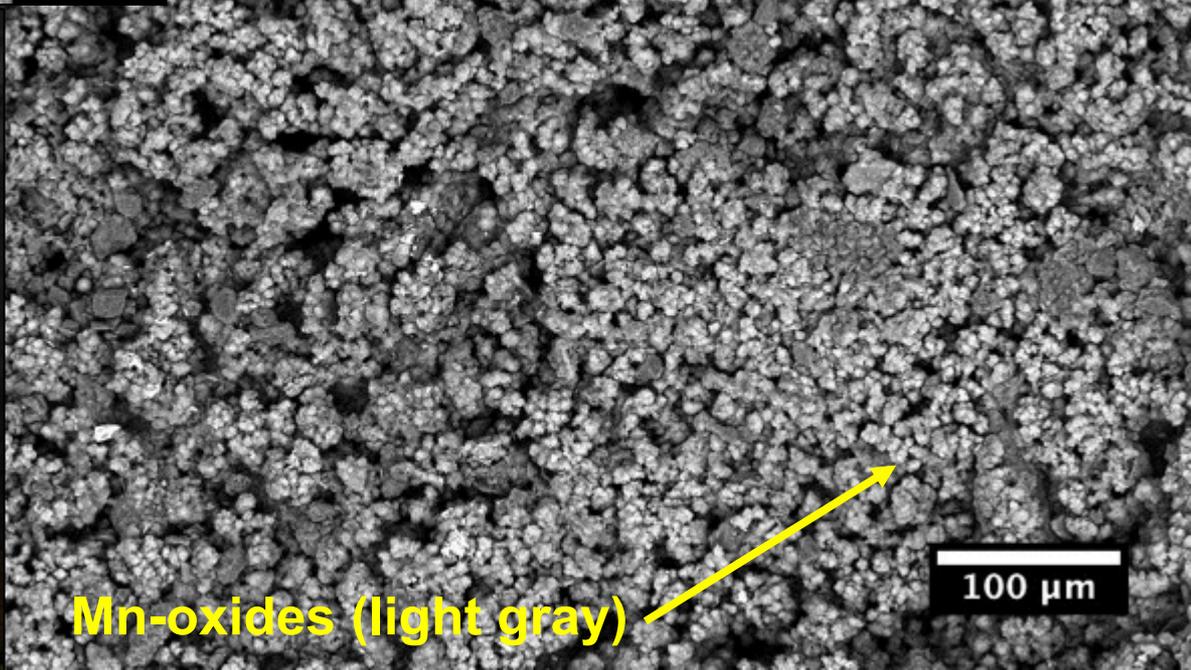
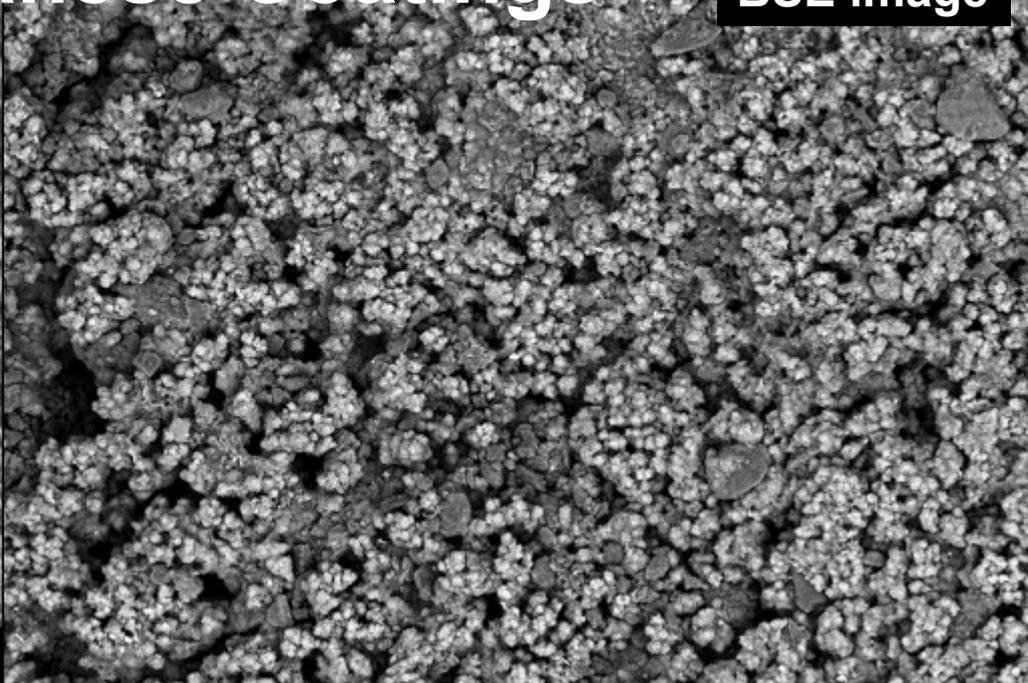
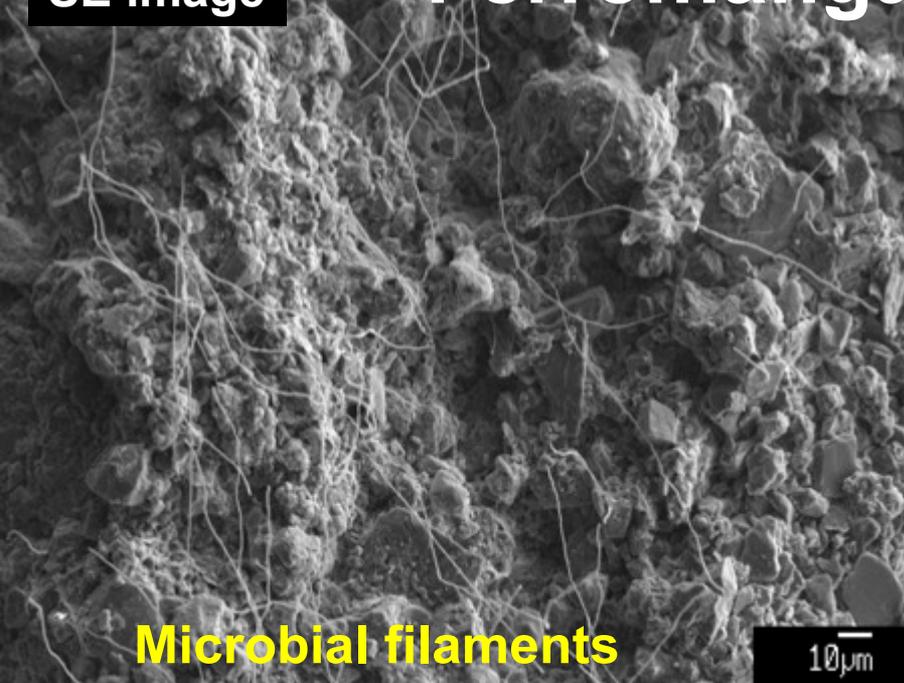
4

Evidence of regrowth after the Mn-coated mud peeled away in several episodes

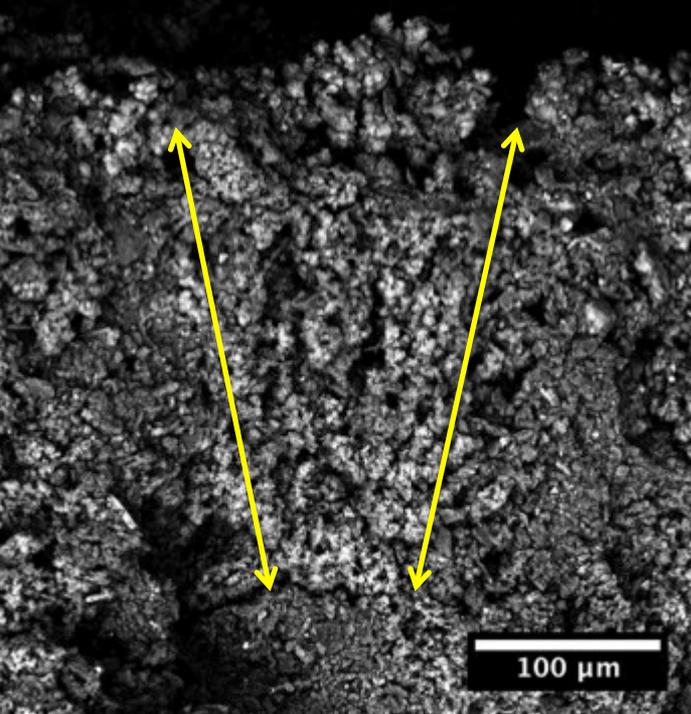
Ferromanganese Coatings

SE image

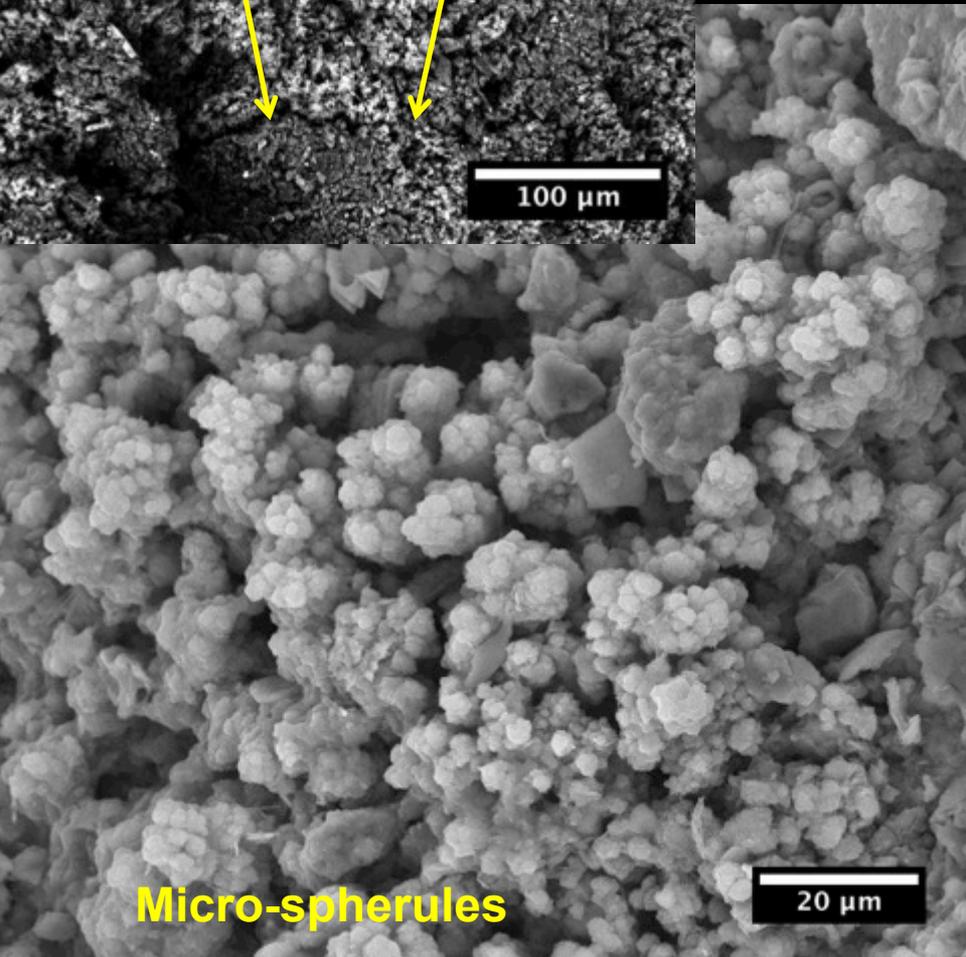
BSE image



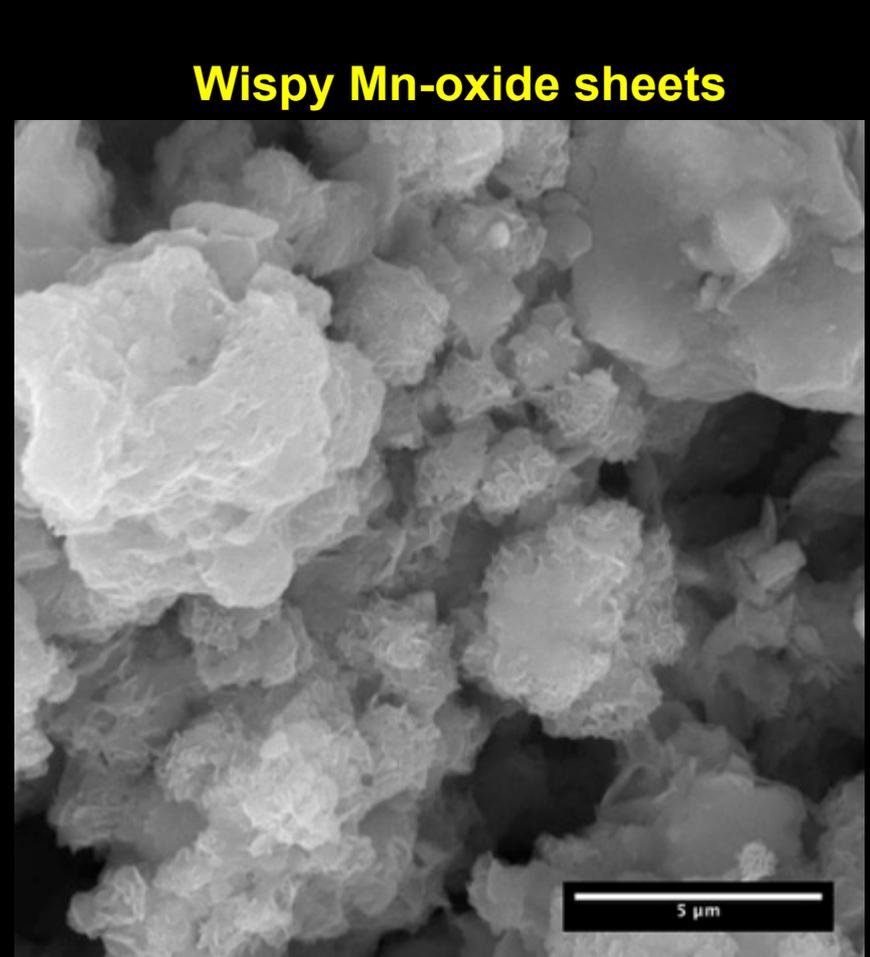
FMD Coatings in the SEM



Root-like structures



Micro-spherules



Wispy Mn-oxide sheets

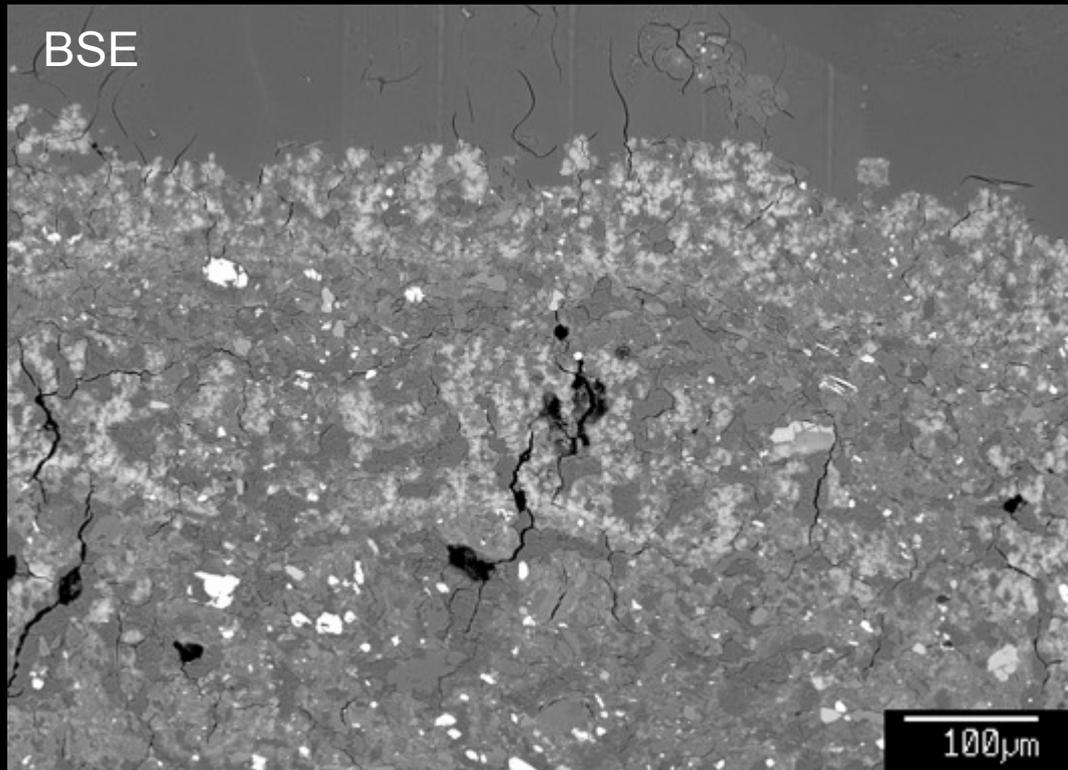
EPMA Analysis of FMD

- Polished section prepared without carbon-based epoxy
 - Section of Mn-oxide crust on mud collected from cave
 - Sample vacuum impregnated with Na-silicate solution
 - Evaporated copper used for conductive coating instead of carbon for electron probe analysis

	CO ₂	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	K ₂ O	CaO	MnO ₂	Fe ₂ O ₃
Mn-oxide	5.00	7.91	2.06	5.13	20.48	0.59	1.70	42.06	4.67
Mn-oxide	3.54	8.52	1.52	6.25	15.54	0.50	1.86	48.18	4.17
Clay	0.61	2.74	1.10	14.24	66.40	1.96	0.90	2.57	5.24

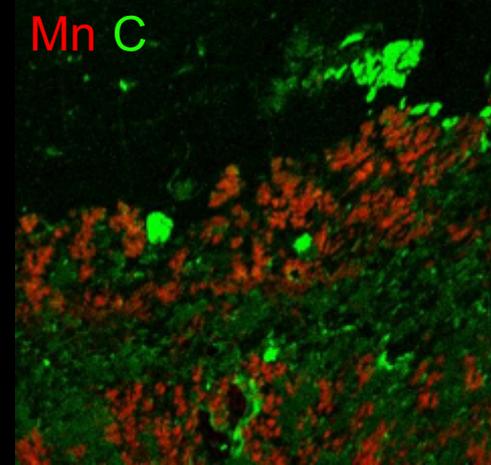
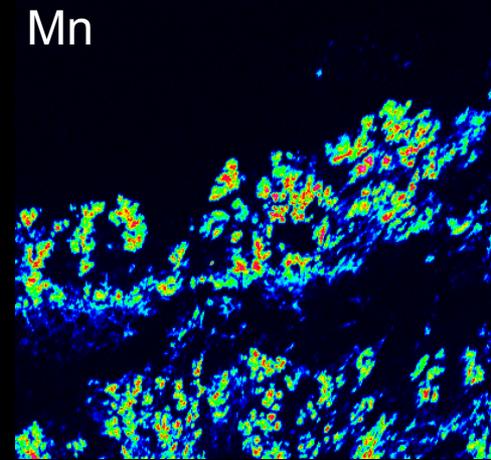
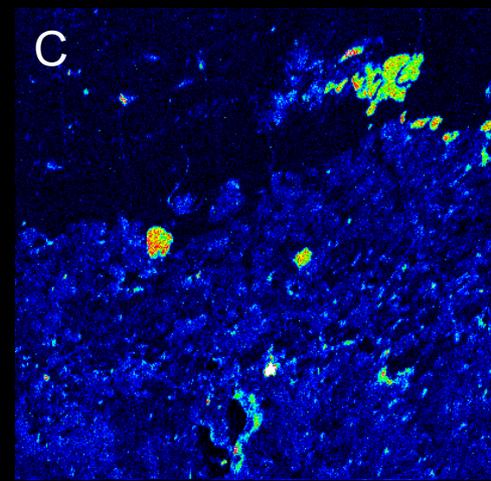
EPMA Mapping of FMD

- X-ray maps on polished section
 - Higher carbon associated with FMD
 - Maps show 2 layers of FMD crust
 - Crust inundated with mud then regrowth

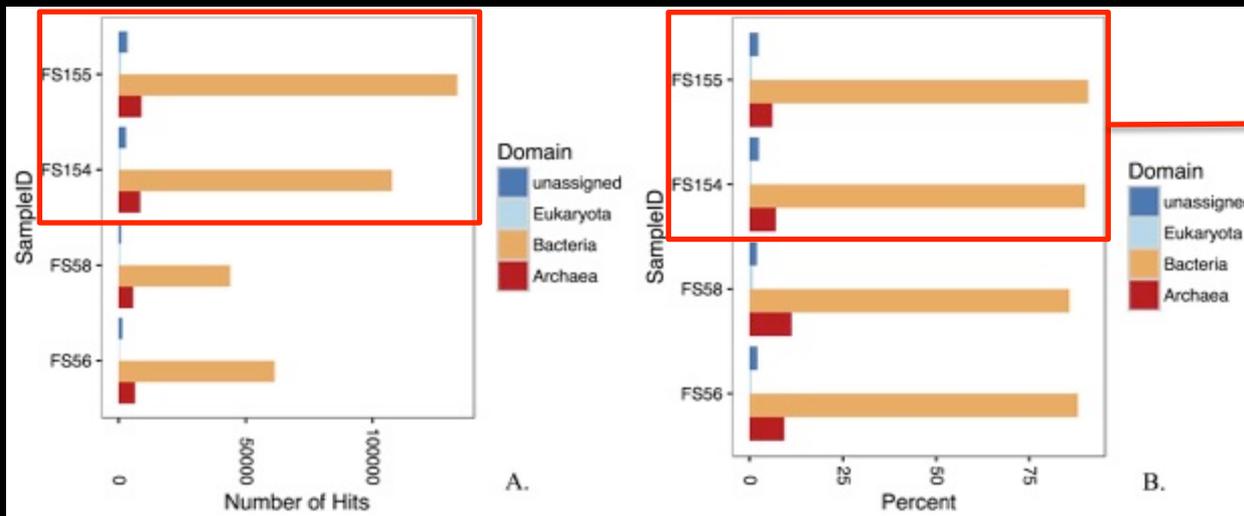


} Surface layer

} Buried layer



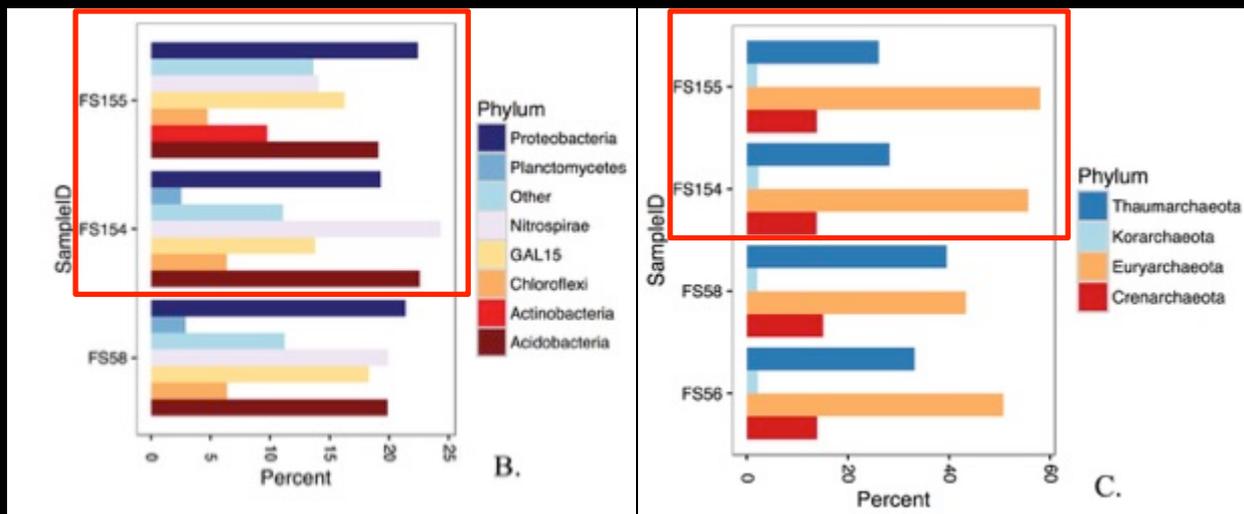
Metagenomic Dataset from FMD



Black coating

Number of hits for each domain

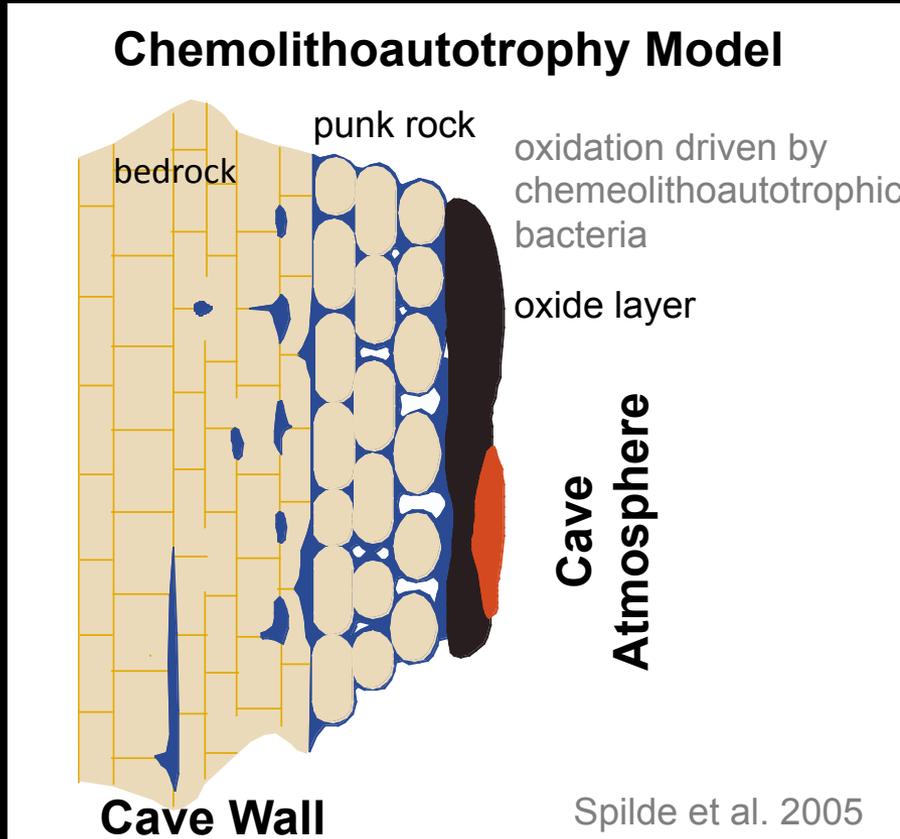
By percent of each domain



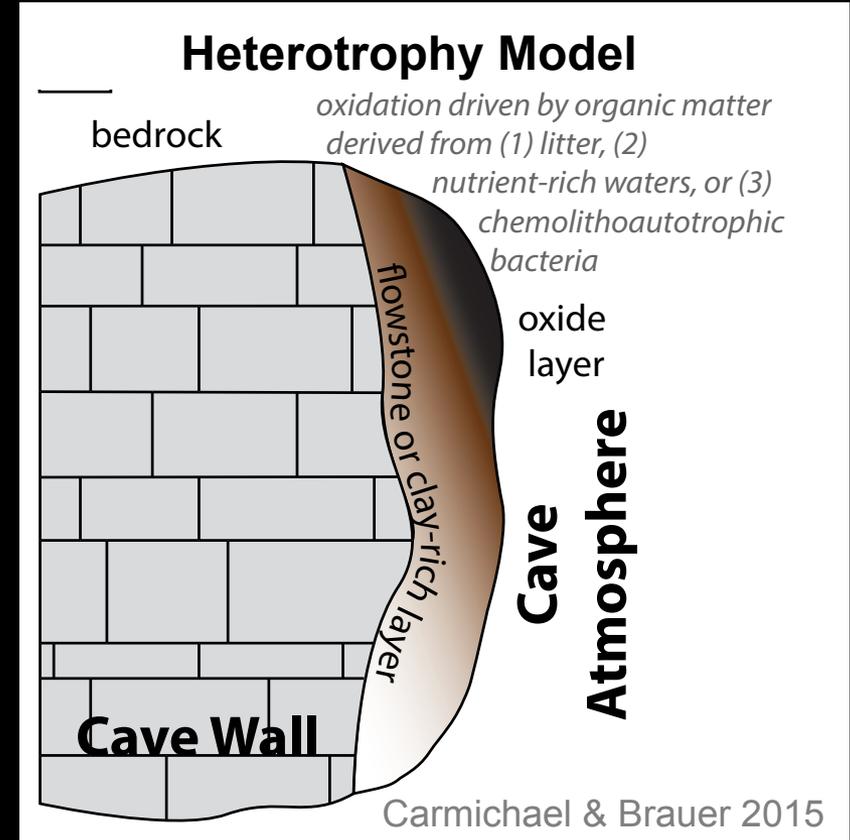
Top six bacterial phyla

Top archaeal phyla

Mn Oxidation in Oligotrophic Cave Systems



Mn oxidation driven by chemolithoautotrophic bacterial breakdown of bedrock (hypogene caves)



Mn oxidation driven by nutrient input from exogenous carbon in water, clay, etc. (epigene caves)

Conclusions

- Careful preparation of samples allows EPMA analysis of carbon
- FMD is associated with higher carbon, likely the result of microbial activity
- Microbial community in FMD is dominated by heterotrophic bacteria, chemolithoautotrophs rare
- Nutrients/metals supplied by water & detrital material
- FMD deposition has continued over time and is still active in the cave

Acknowledgements

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