# Searching for framework builders after the regional extinction of archaeocyathan reefs in the Cambrian Mule Spring Limestone near Split Mountain, Nevada, USA


David R. Cordie[1], Stephen Q. Dornbos[1], Pedro J. Marenco[2]

[1]University of Wisconsin-Milwaukee, Milwaukee, WI; [2]Bryn Mawr College, Bryn Mawr, PA


## Introduction

Terreneuvian and Series 2 reef ecosystems were built by microbial-metazoan consortiums. Archaeocyathan sponges in particular were instrumental in providing varied substrate for encrusting microbial organisms[1]. When archaeocyaths underwent a dramatic reduction in diversity, new metazoan framework builders replaced archaeocyaths in some reefs (i.e., Australia[2] and China[3]) prior to the Ordovician, while others underwent a prolonged "metazoan reef gap"[4]. Here we investigate the Mule Spring Limestone for cryptic metazoans in a post-extinction carbonate environment.

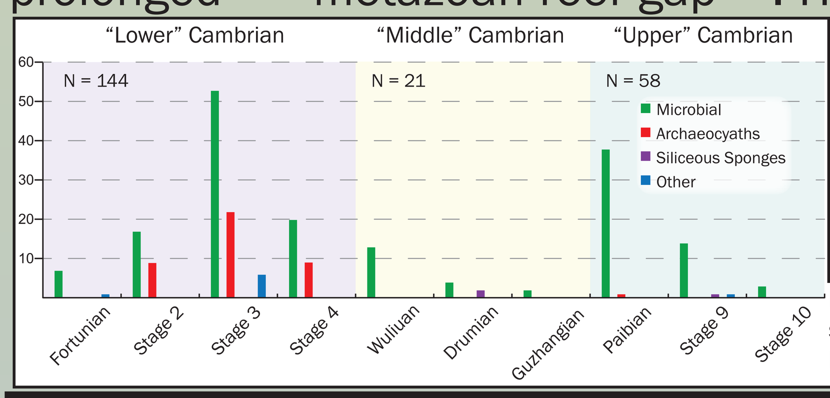
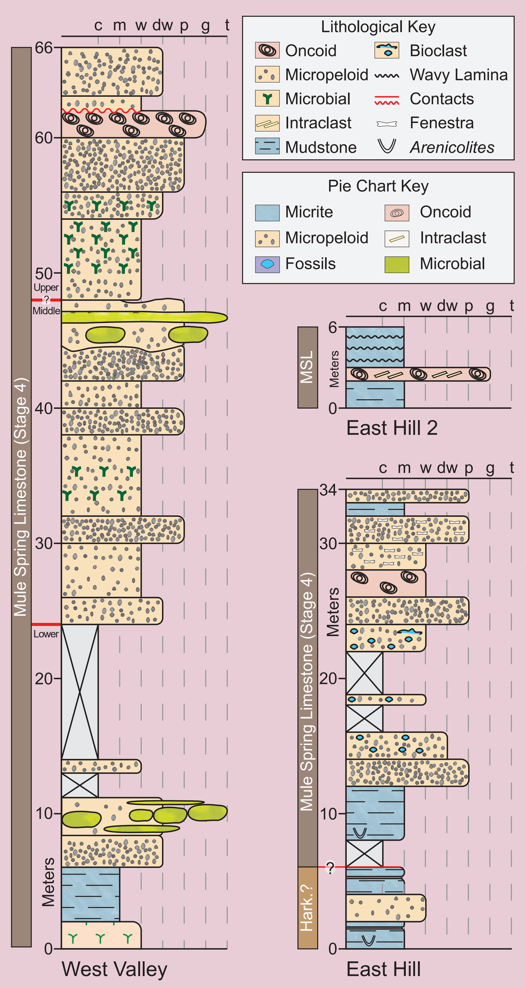



Figure 1 - Reef occurrences during the Cambrian separated by primary framework-building organism. Data from PaleoReefs Database.

## Geologic Setting and Raw Data



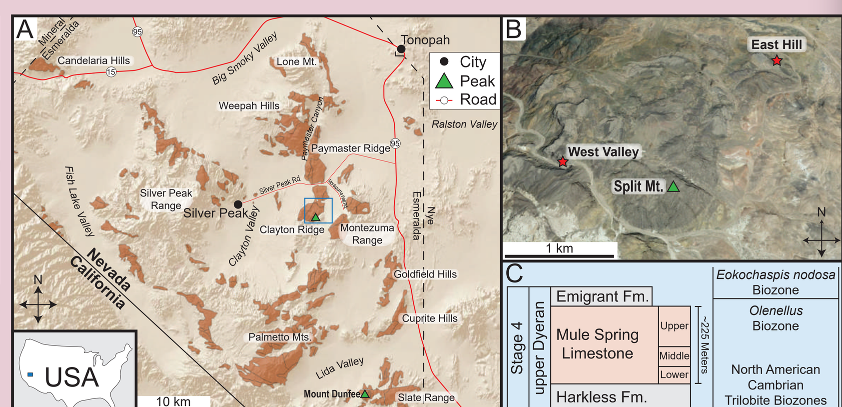




Figure 2 (above) - Early Cambrian deposits in Esmeralda County, Nevada (A) with detailed field map (B) and stratigraphic context of the Mule Spring Limestone (C).

Figure 3 (left) - Stratigraphic columns of Mule Spring Limestone.

Table 1 - Percent contribution of carbonate grains.

| Section | Micrite | Peloids | Fossils | Oncoids | Intraclast | Microbial |
|---|---|---|---|---|---|---|
| East Hill 2 | 78.3 | 14.5 | 0.2 | 4.3 | 2.8 | 0.0 |
| East Hill | 71.9 | 22.0 | 1.4 | 4.7 | 0.0 | 0.0 |
| East Hill | 73.3 | 23.3 | 3.4 | 0.0 | 0.0 | 0.0 |
| East Hill | 94.7 | 5.0 | 0.2 | 0.0 | 0.0 | 0.0 |
| Upper West Valley | 66.8 | 29.1 | 1.3 | 1.9 | 0.0 | 0.8 |
| Mid/Upper West Valley | 60.2 | 6.8 | 0.1 | 0.0 | 0.0 | 32.8 |
| Middle West Valley | 76.7 | 20.5 | 1.1 | 0.0 | 0.0 | 1.7 |
| Lower West Valley | 50.9 | 0.0 | 0.0 | 0.0 | 0.0 | 49.1 |
| Lower West Valley | 72.5 | 13.7 | 0.7 | 0.3 | 0.0 | 12.8 |
| Average | 64.9 | 15.0 | 0.8 | 1.2 | 0.2 | 5.8 |

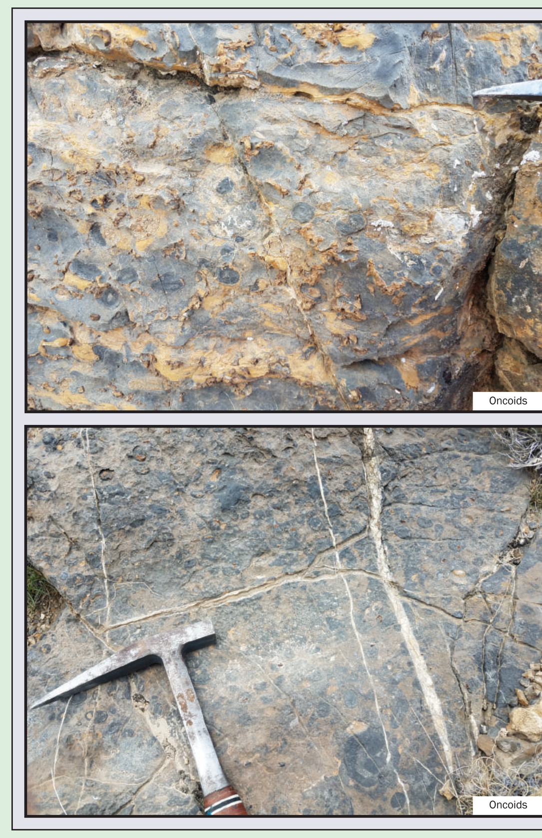
## Methodology

Petrographic thin sections (N=49) were prepared from samples collected every 2 meters at three outcrops of the Mule Spring Limestone near Split Mountain in Nevada. The proportion and relative changes of micritic, peloidal, metazoan, oncoid, intraclast, and microbial grains were quantified from 300 point counts.


### Funding & Acknowledgments

Additional thanks to C. Tubic, M. Harris and M. Webster.

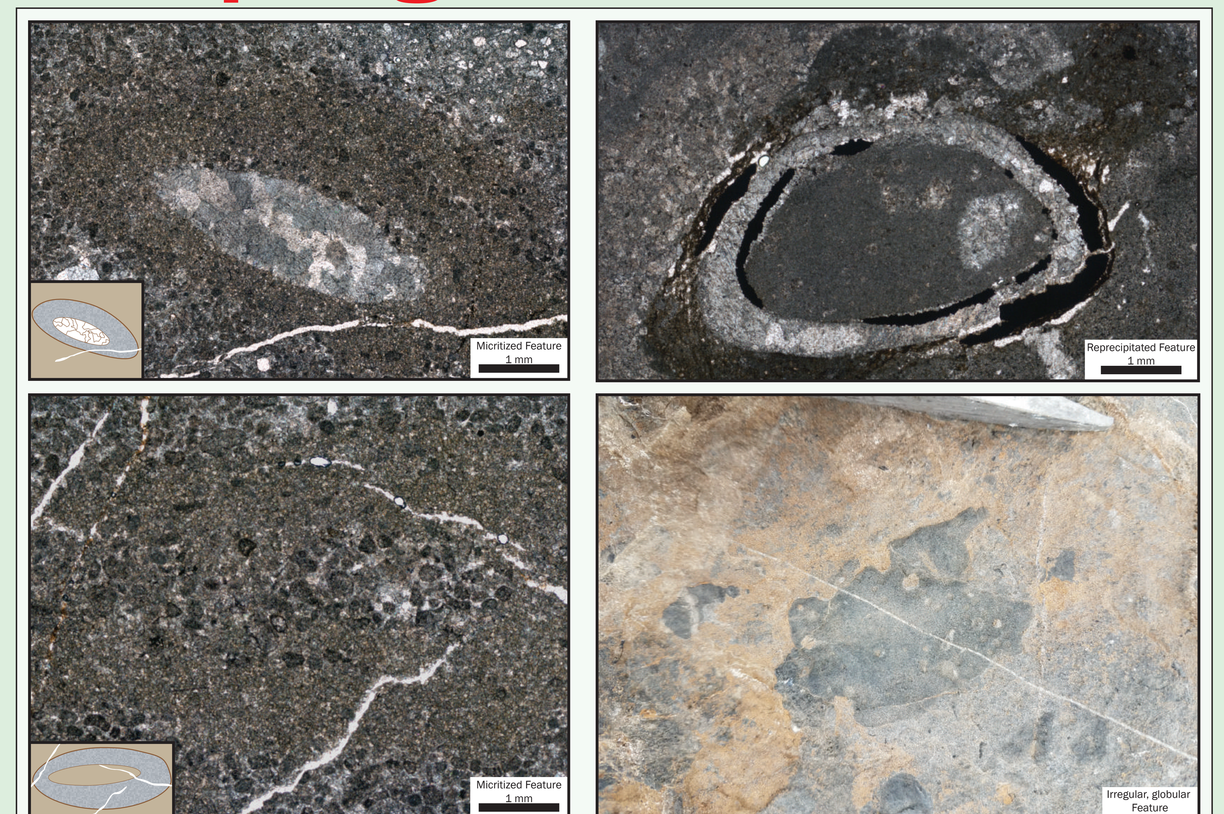

## What is in the Mule Spring Limestone?





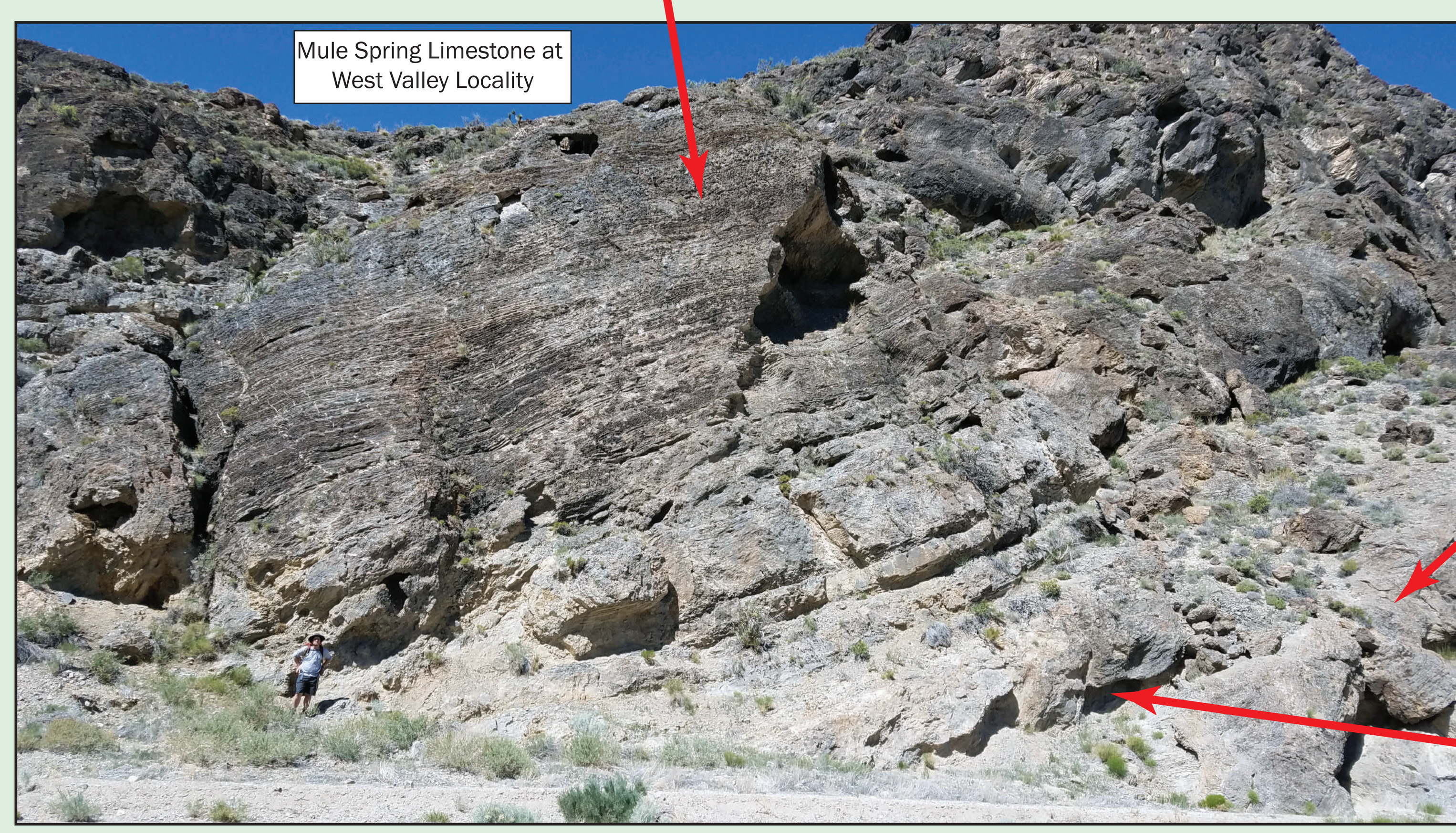
### Oncoids

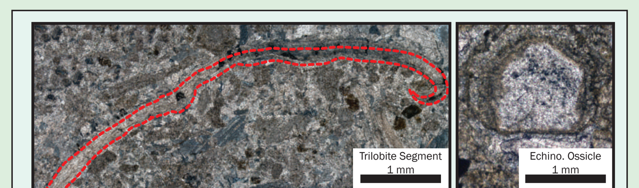
Roughly spherical, type R, oncoids with faint asymmetrical laminations. No obvious nuclei are present. Contains crudely clotted texture with occasional pockets of sparry cement and a dark outer crust. Occur more frequently in upper member of Mule Spring Limestone.




### Rigid Metazoans?

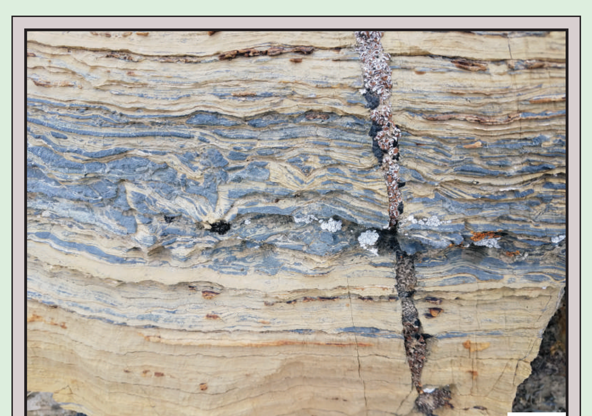
Irregular, globular features observed in outcrop with vacant openings along surface. Additional, micritized or reprecipitated cylindrical features seen in thin section, again with vacant space internally.




### Metazoa

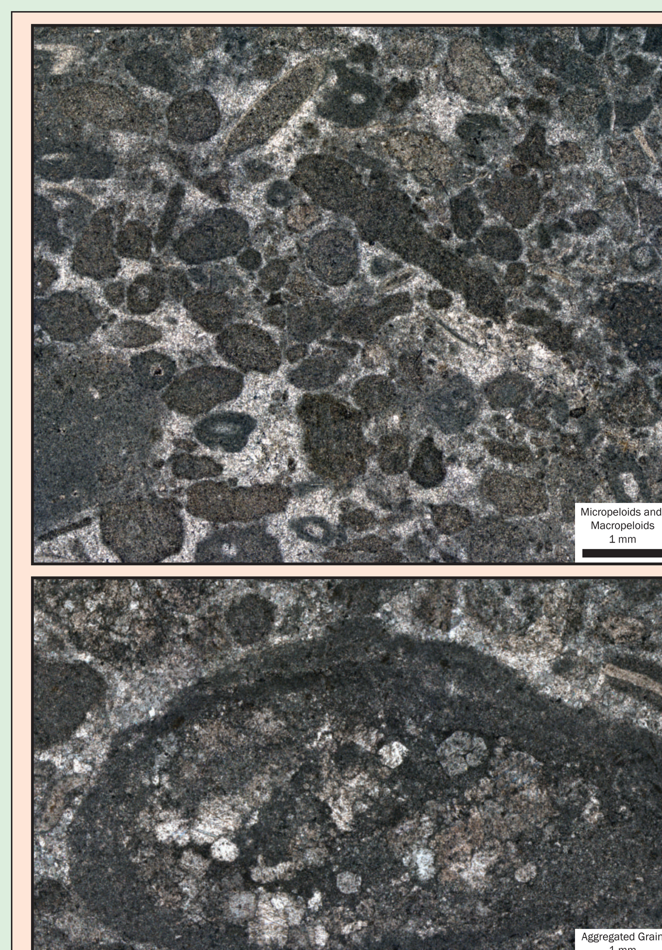
Sparse remnants of mobile, sessile, and infaunal organisms. Trilobites and calcitic-shelled brachiopods are most common. *Arenicolites* also common.

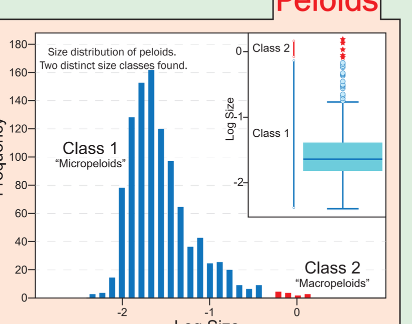


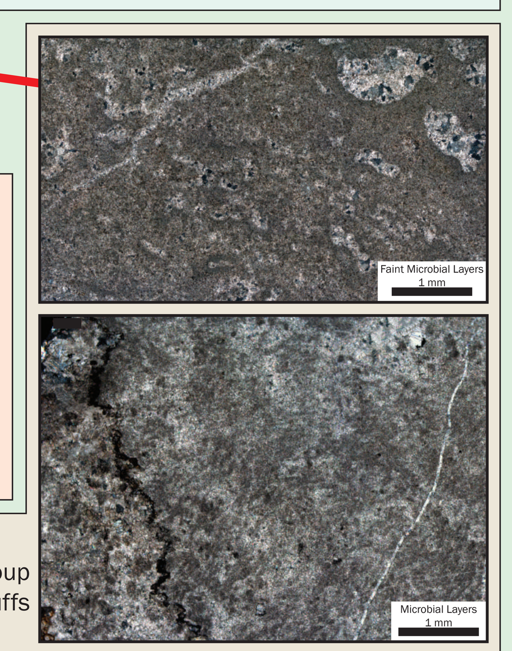
### Bindstone

Laminated bindstone with minor amounts of accretion. Sand, silt, and intraclasts common.

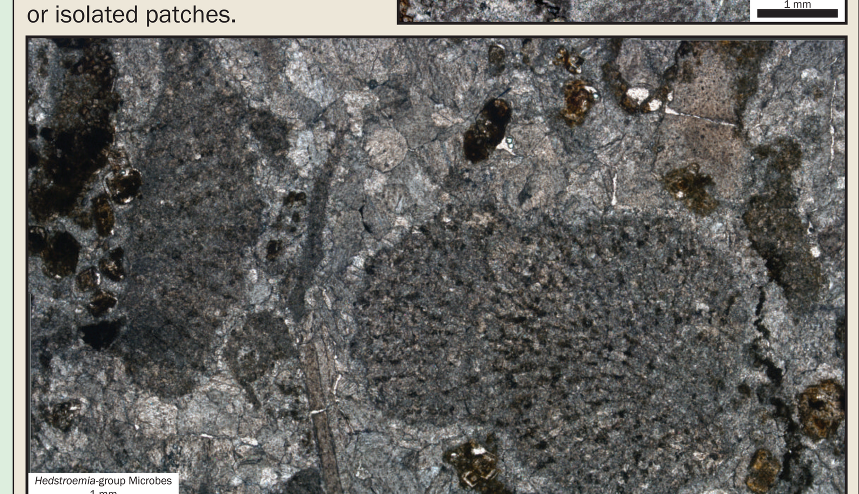

### Peloids




### Calcifying Microbes

*Hedstroemia*- and *Renalcis*- group microbes in layered (riged?) tuffs or isolated patches.



## Preliminary Conclusions

The Mule Spring Limestone represents an intertidal to moderately deep, potentially restricted, marine environment. Several microbial environments (tidal flats, mud flats, shallow low energy) are present with encrusting microbes. Iterative encrustation by microbes is a common initial condition for future reef environments, however, there is no strong evidence of prolific metazoan or microbial reef building. It appears that in this locality there was not an immediate turnover to novel reef-building organisms after the extinction of archaeocyaths. Additional study of the geochemical conditions is ongoing to determine potential environmental causes for this delayed onset of biodiversification.

## Encrusting Microbial Activity

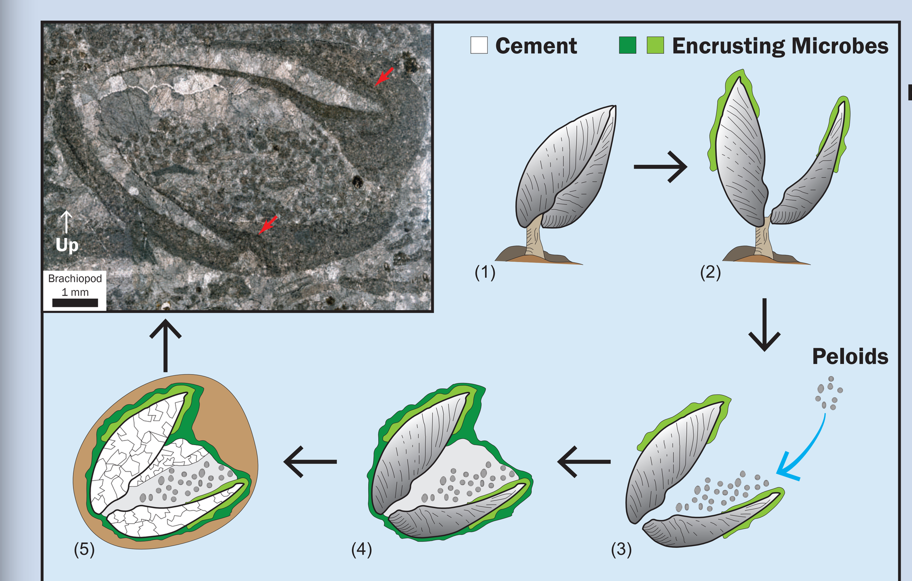
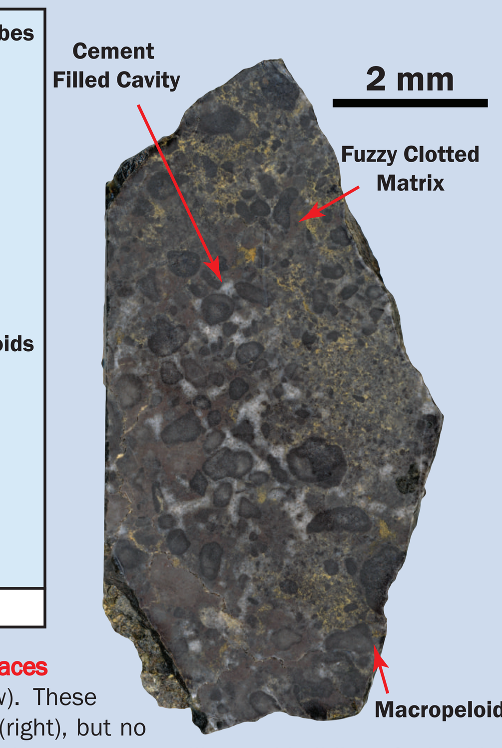



Figure 4 - Encrustation of microbial organisms on hard surfaces.




Microbial organisms are commonly found with iterative growth on hard surfaces such as brachiopods (above) or in microbial mats (reconstruction below). These encrusting microbes created small amounts of accretion and cavity space (right), but no significant topographic relief as in reefs. Numerous occurrences of oncoids also suggest enrolling and building of microbial elements on top of one another. Poorly preserved thrombolite texture seen in two intervals. Additionally, bushy microbial organisms also occur, suggesting a general lack of herbivory in these ecosystems.

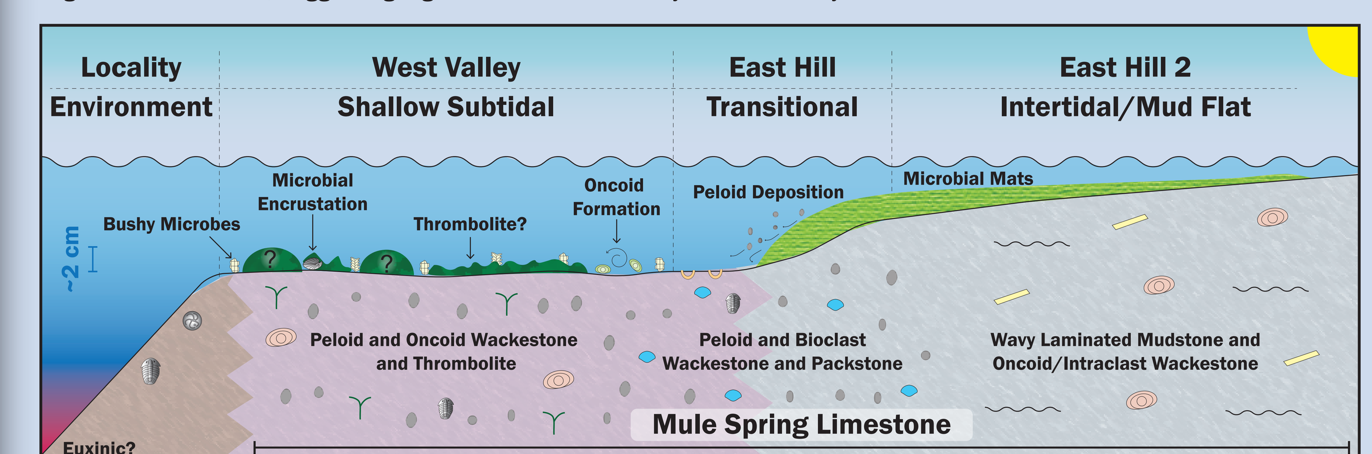



Figure 5 - Reconstruction of Mule Spring Limestone based on thin section analysis in this study.

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**References:** 1 - Adachi *et al.*, 2014. *Facies* 60: 703-717. 2 - Kruse and Reitner, 2014. *AAP Memoir* 45: 31-53. 3 - Zhang *et al.*, 2017. *Geosci. J.* 21: 655-666. 4 - Rowland and Shapiro, 2002. *Phanerozoic Reef Patterns* SEPM Special Publication 72: 95-128.