

MODERN AND ANCIENT MICROBIAL CARBONATES IN UTAH, U.S.A.

EXAMPLES FROM GREAT SALT LAKE AND THE UINTA BASIN'S TERTIARY (EOCENE) GREEN RIVER FORMATION

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GREAT SALT LAKE, UTAH: A MODERN ANALOGUE

Satellite Image of Great Salt Lake

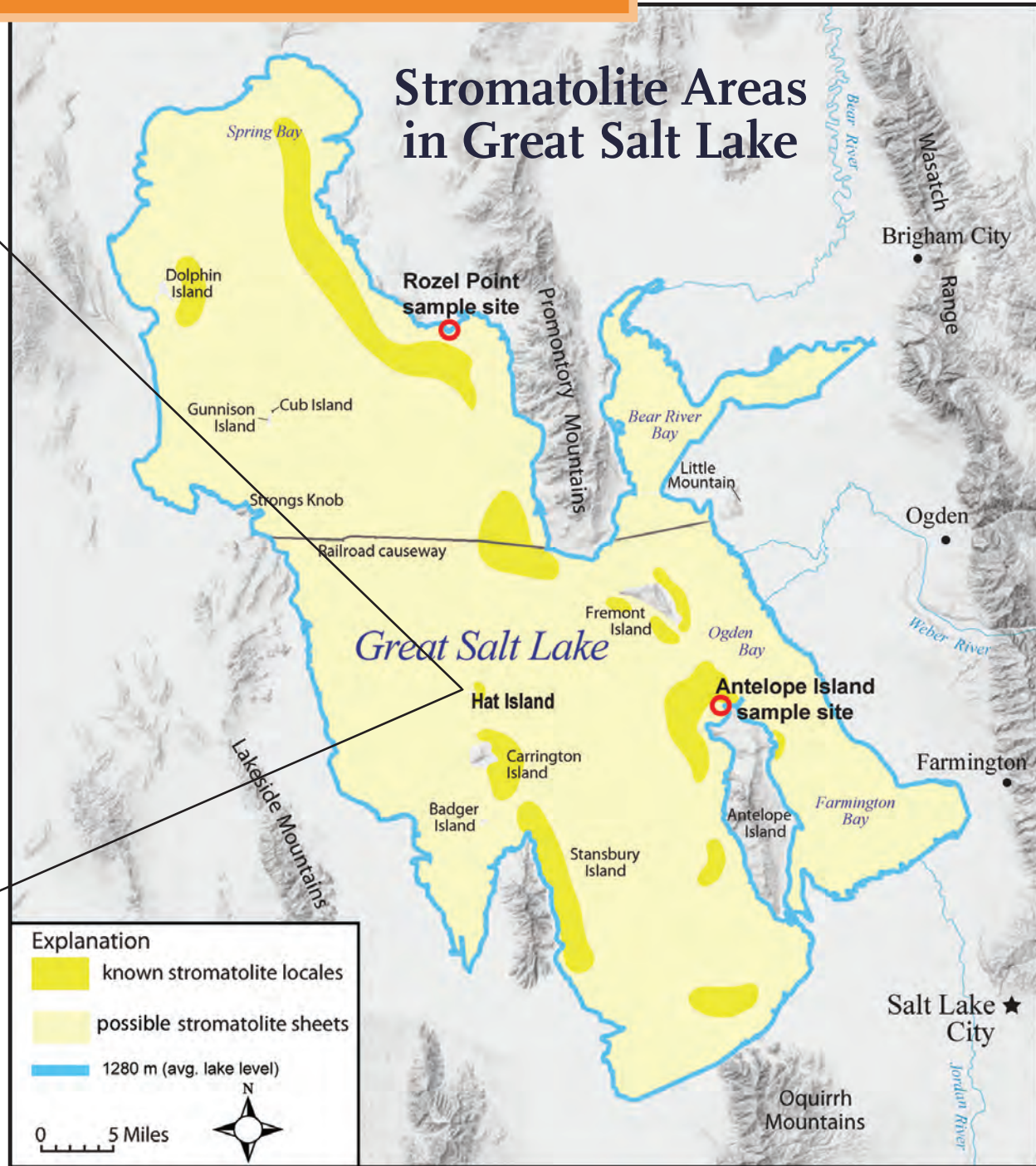


NASA #STS047-097-021; date: September 1992

Stromatolites near Hat Island, Great Salt Lake



In September 2007, the lake level was nearly 1.5 m (5 ft) below the average of 1280 m (4200 ft).
Photo by Jim Van Leeuwen; courtesy of the Utah Division of Wildlife Resources, Great Salt Lake Ecosystem Program.



Modified from Eardley, 1938; Gwynn and Murphy, 1980; Davis, 2012.

MICROBIALITES



Close-up view of exposed remains of stromatolite heads, Rozel Point.



Close up of stromatolite displaying laminations and porous microstructures, Rozel Point.



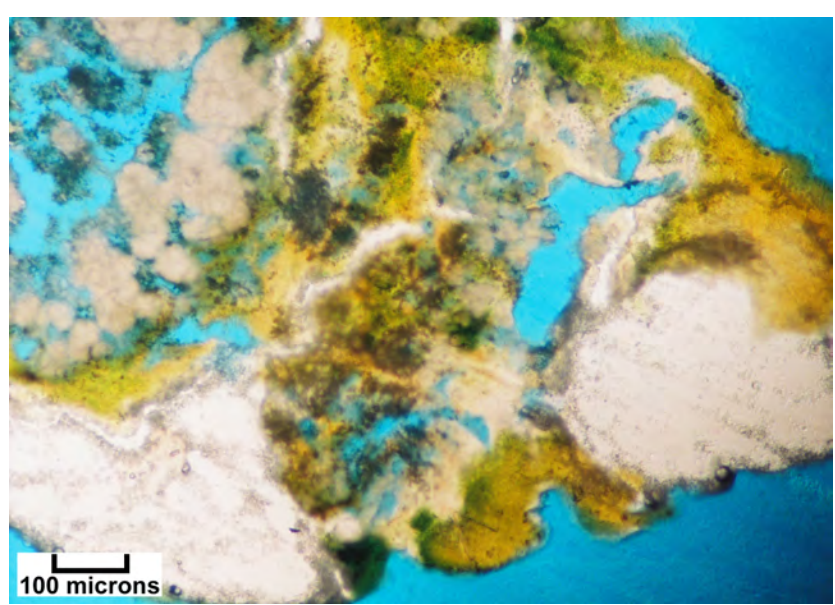
Northwest beach of Antelope Island composed of complex microbial and associated oolitic deposits.



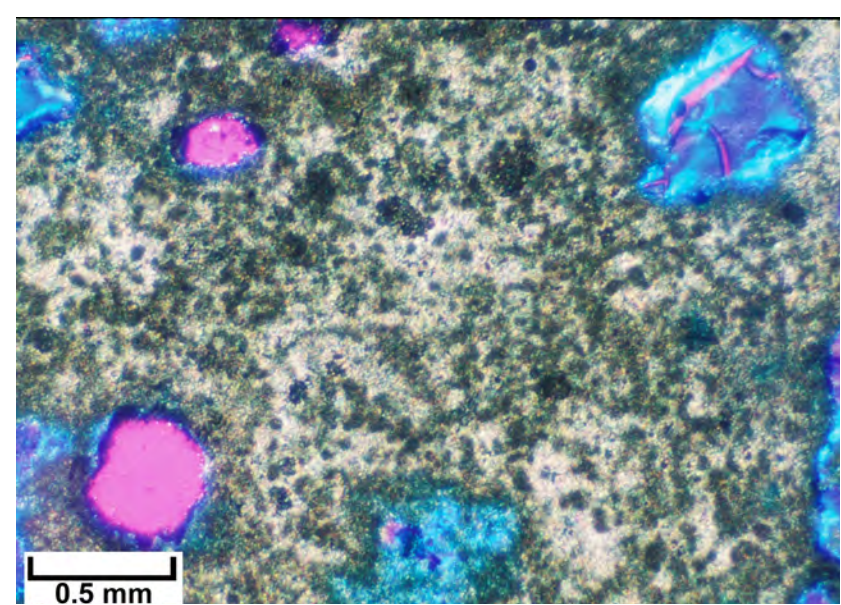
Close up of pustular microbial deposits, Antelope Island.

MICROBIALITE EXAMPLES: Antelope Island

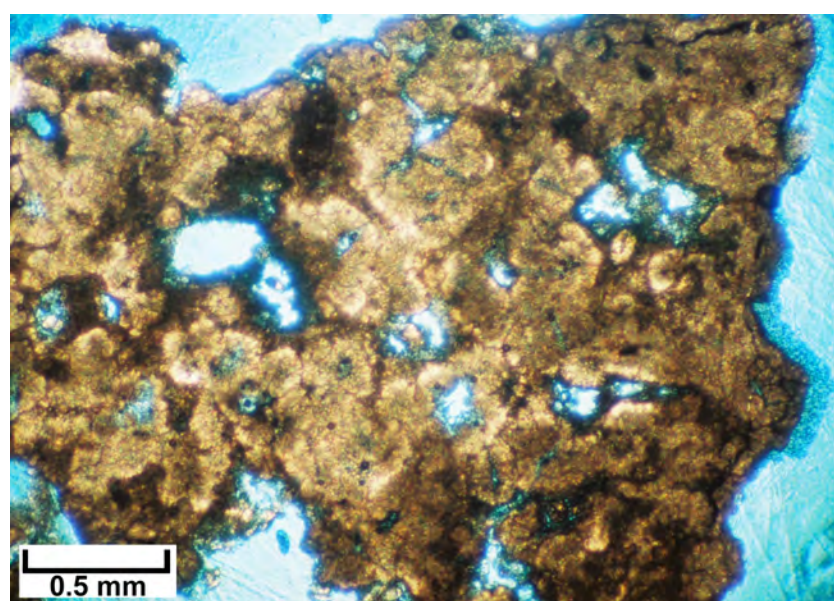
Pustular microbialites - large number of discrete pustular microbial structures composed of very lightly lithified, clotted thrombotic fabrics with moderate amounts of filamentous cells. The margins of some pustules display a honey-brown, highly organic crust. Detrital silicate and carbonate grains are incorporated into some pustules.



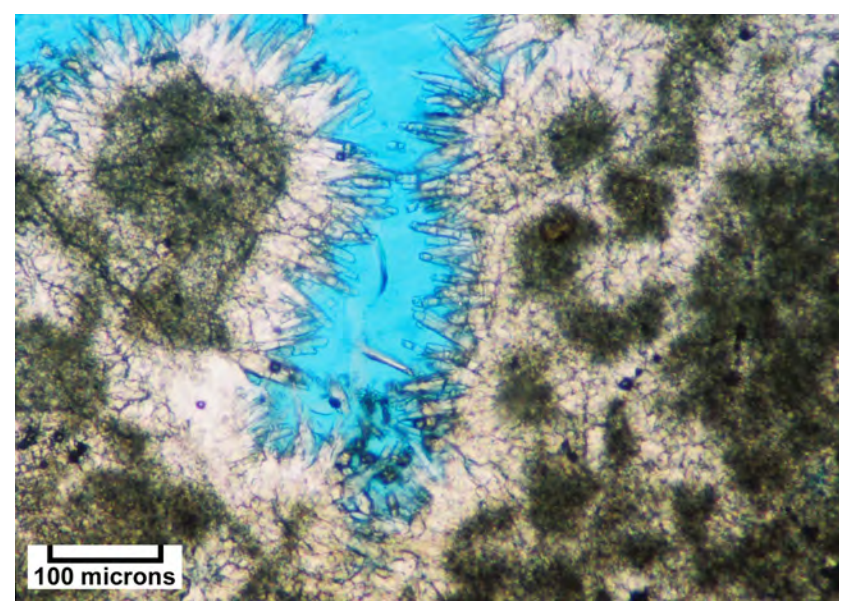
Small microbial pustule incorporating two silicate silt grains into honey-brown organic crust. (Plane light w/ white card)



Close-up view of clotted microbialite head interior including primary constructional pores. (Crossed-nichols w/ accessory)



View of the internal lumpy texture of a well-lithified microbialite fragment. Note the internal primary constructional pores. (Plane light)

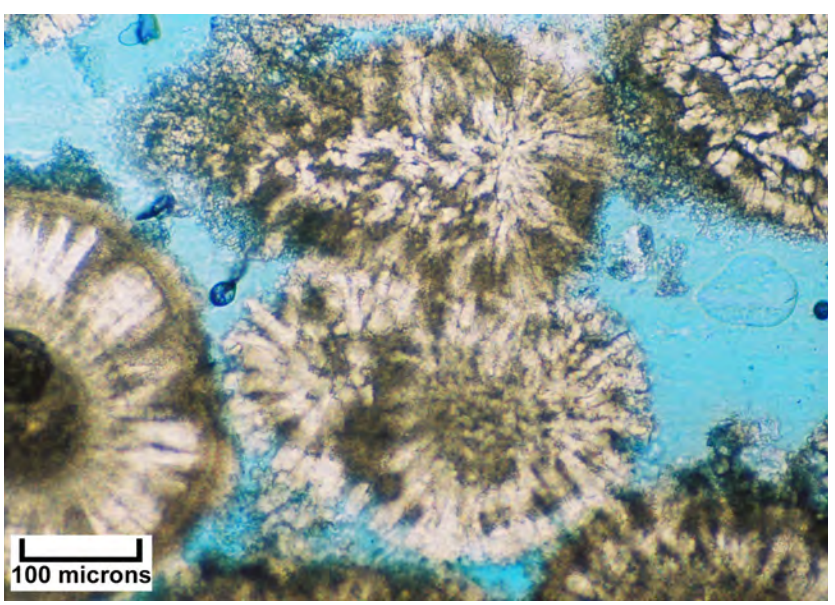


Close-up view of constructional pores within a microbialite head; pores are lined with acicular radial cements. (Plane light)

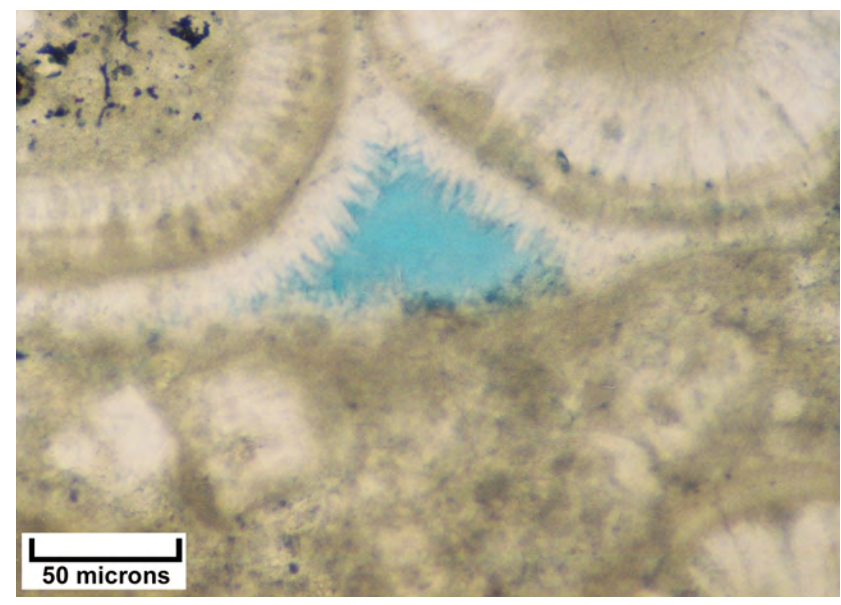
CARBONATE GRAINS ASSOCIATED WITH MICROBIALITES

EXAMPLES OF GRAINS AND CEMENTS: Antelope Island

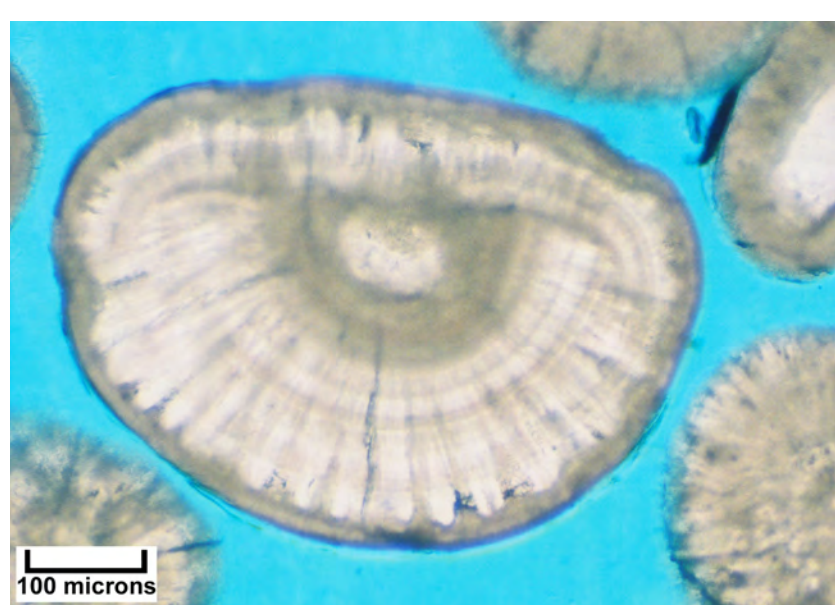
Hypersaline ooids which display extensive radial recrystallization and cerebroid margins. Many ooids are broken across their cortex layers, and then are re-coated (regenerated ooids). Nuclei include quartz grains, well-rounded peloids (some with micro-pyrite), broken ooid fragments, chert grains, igneous (volcanic?) rock fragments, and microbialite fragments.



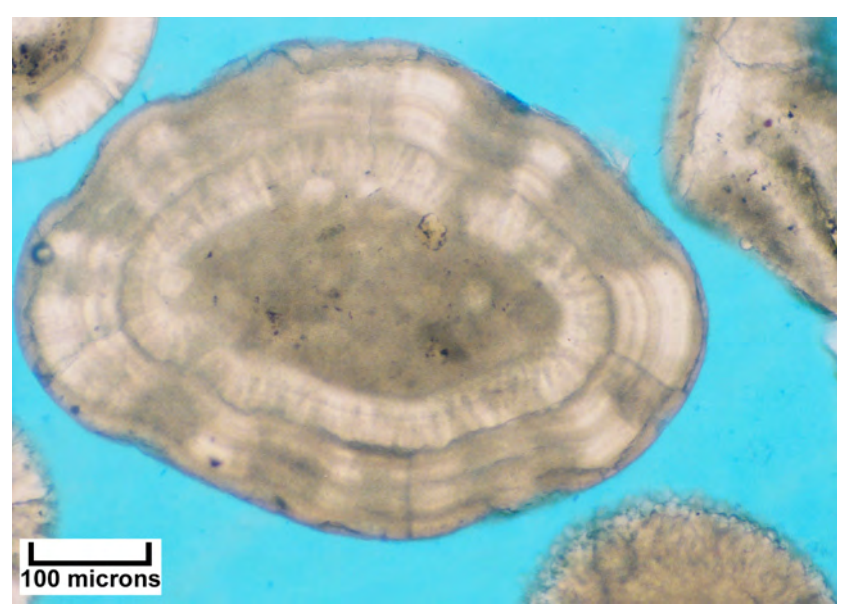
View of radially recrystallized ooids with rough grain margins and micritic cements. (Plane light)



Ooid contacts with extensive acicular radial axial cements as well as micritic cements. (Plane light w/ white card)



Single, regenerated ooid with broken ooid nucleus. (Plane light)



Single, large cerebroid ooid. (Plane light w/ white card)

REFERENCES

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Eardley, A.J., 1938, Sediments of the Great Salt Lake: American Association of Petroleum Geologists Bulletin, v. 22, p. 1305-1411.

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Hintze, L.E., and Kowallis, B.J., 2009, Geologic history of Utah: Brigham Young University Geology Studies Special Publication 9, 225 p.

Sprinkel, D.A., 2009, Interim geologic map of the Seep Ridge 30' x 60' quadrangle, Uintah, Duchesne, and Carbon Counties, Utah, and Rio Blanco and Garfield Counties, Colorado: Utah Geological Survey Open-File Report 549, compact disc, GIS data, 3 plates, scale 1:100,000.

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ACKNOWLEDGMENTS

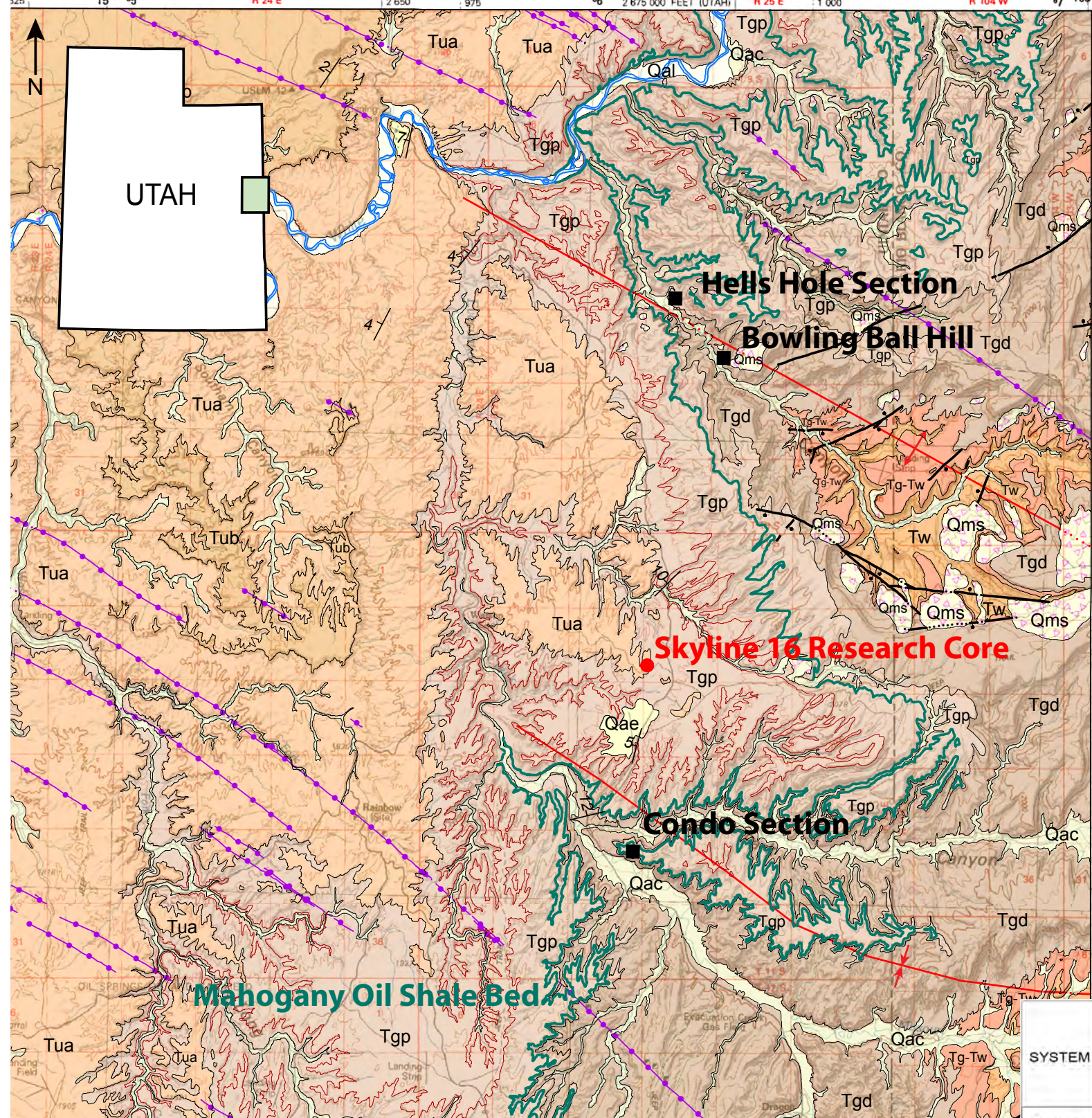
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GREEN RIVER FORMATION: OUTCROP EXAMPLES

Geologic Map of the Eastern Uinta Basin

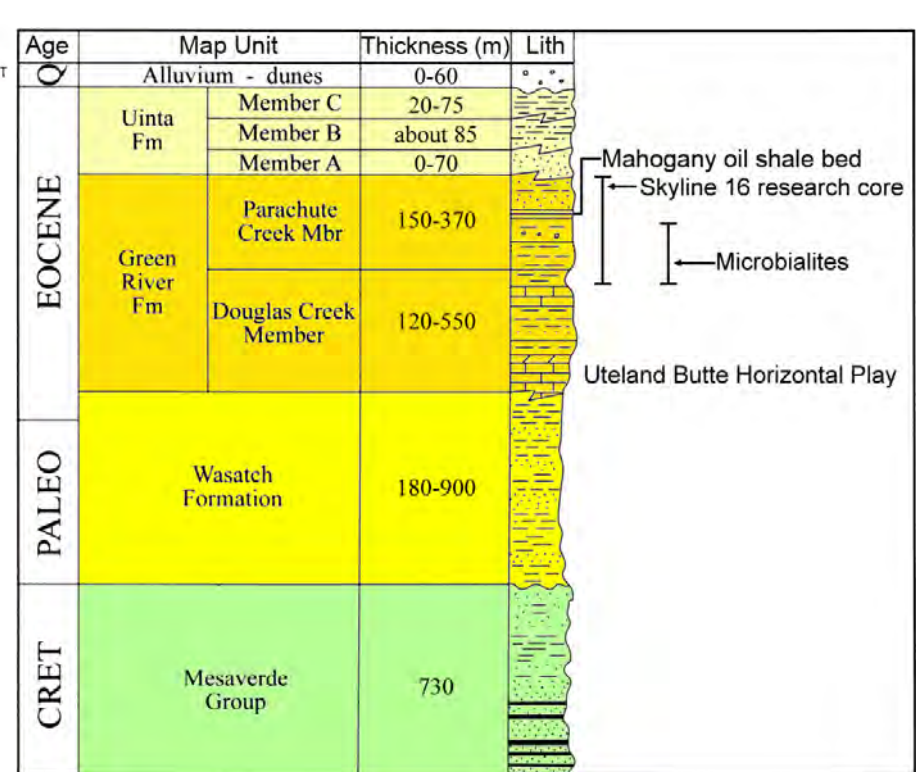


Locations of the outcrop sections accessed for this study as well as the Skyline 16 Research core.

Geologic map modified from Sprinkel, 2009.

Three spectacular outcrops were studied in the eastern Uinta Basin (south of Vernal, Utah) for the distribution and lateral continuity of microbialites and related carbonate facies.

Regional Stratigraphic Column, Eastern Uinta Basin



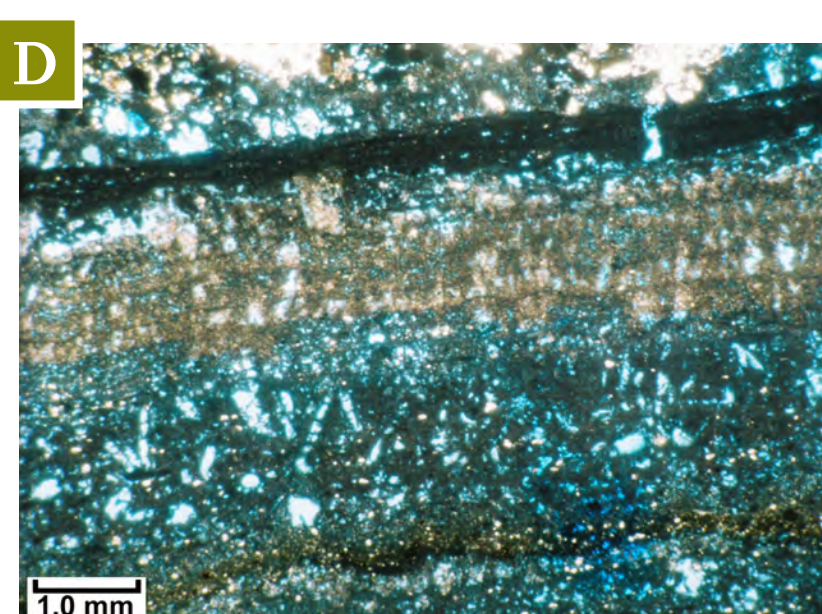
Note the stratigraphic position of the interval in which microbialites and associated carbonate facies occur (right bar). In addition, the location of the famous Mahogany oil shale bed is also shown.

Modified from Hintze and Kowallis, 2009.

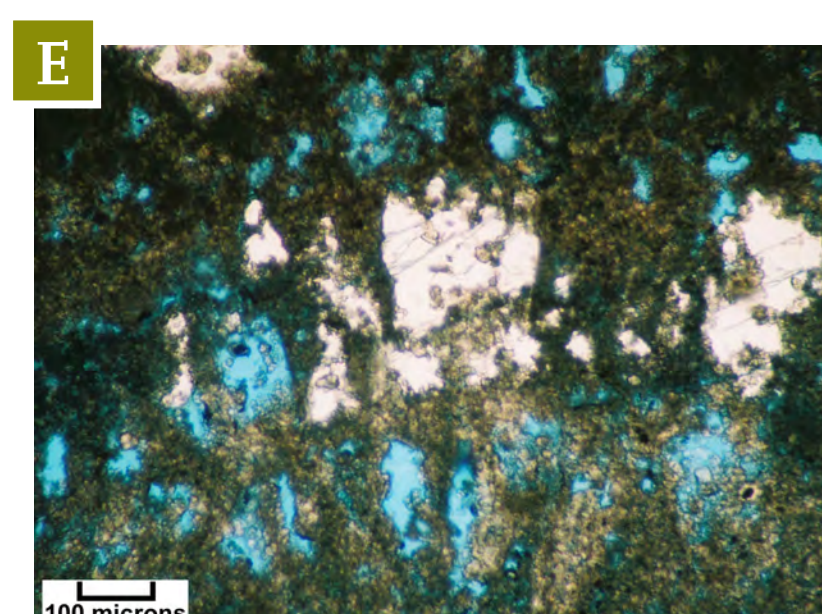
Map Stratigraphic Column

SYSTEM	STAGE	FORMATIONS	Thickness (meters)	LITHOLOGY	NOTES
Quaternary	Qp1	Unconsolidated deposits	0-10	Sand, silt, clay	
Tertiary	Tu6	Member 6 of Uinta Formation	10-225	Sandstone	
	Tu5	Member 5 of Uinta Formation	20-225	Sandstone	
	Tu4	Member 4 of Uinta Formation	20-225	Sandstone	
	Tu3	Member 3 of Uinta Formation	20-225	Sandstone	
	Tu2	Member 2 of Uinta Formation	20-225	Sandstone	
	Tu1	Member 1 of Uinta Formation	20-225	Sandstone	
	Tu0	Member 0 of Uinta Formation	20-225	Sandstone	
	Tu-1	Member -1 of Uinta Formation	20-225	Sandstone	
	Tu-2	Member -2 of Uinta Formation	20-225	Sandstone	
	Tu-3	Member -3 of Uinta Formation	20-225	Sandstone	
	Tu-4	Member -4 of Uinta Formation	20-225	Sandstone	
	Tu-5	Member -5 of Uinta Formation	20-225	Sandstone	
	Tu-6	Member -6 of Uinta Formation	20-225	Sandstone	
	Tu-7	Member -7 of Uinta Formation	20-225	Sandstone	
	Tu-8	Member -8 of Uinta Formation	20-225	Sandstone	
	Tu-9	Member -9 of Uinta Formation	20-225	Sandstone	
	Tu-10	Member -10 of Uinta Formation	20-225	Sandstone	
	Tu-11	Member -11 of Uinta Formation	20-225	Sandstone	
	Tu-12	Member -12 of Uinta Formation	20-225	Sandstone	
	Tu-13	Member -13 of Uinta Formation	20-225	Sandstone	
	Tu-14	Member -14 of Uinta Formation	20-225	Sandstone	
	Tu-15	Member -15 of Uinta Formation	20-225	Sandstone	
	Tu-16	Member -16 of Uinta Formation	20-225	Sandstone	
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	Tu-21	Member -21 of Uinta Formation	20-225	Sandstone	
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	Tu-80	Member -80 of Uinta Formation	20-225	Sandstone	
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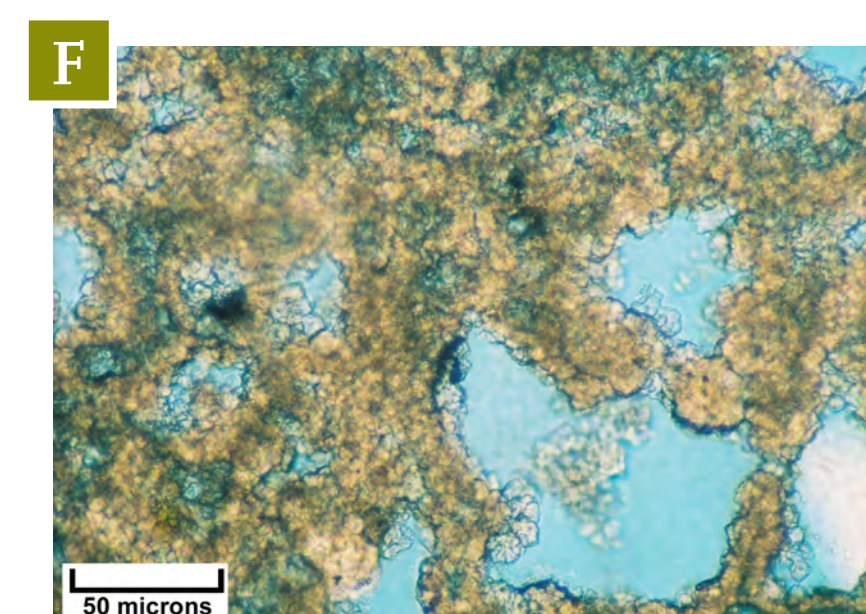
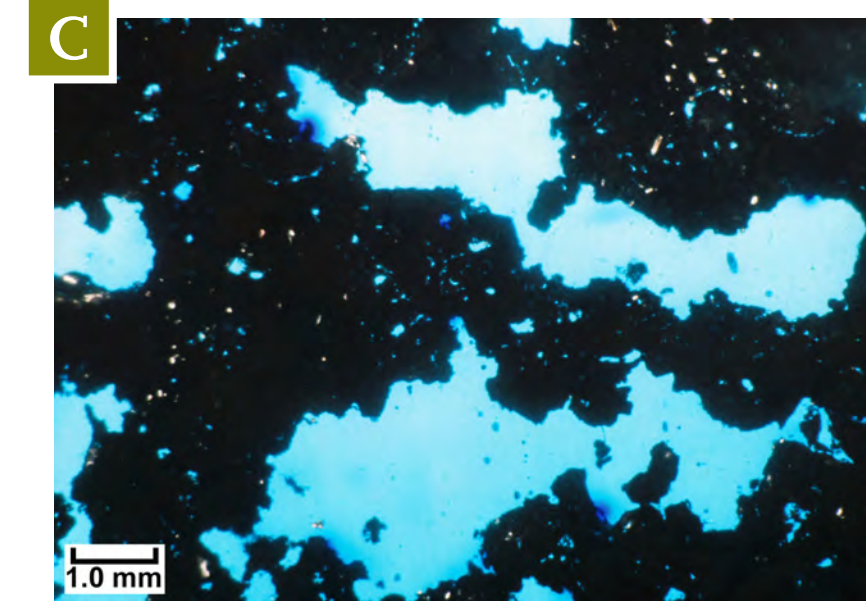
Microbialite Examples in Condo Section



A - Continuous beds of stromatolites. (Lower R-6 oil shale zone)
B - A meter-scale thrombolite head (right side of photo). Note the steep margin of this domal structure. (R-5 oil shale zone)

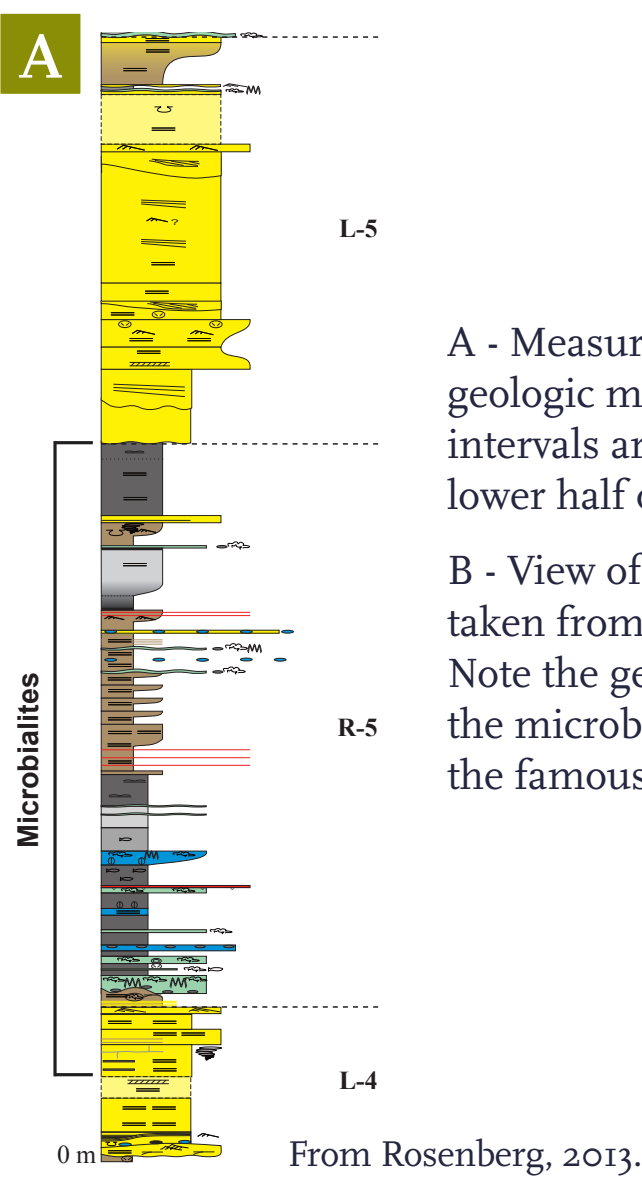


D - Closer view of stromatolitic laminae with well-developed porosity (in blue) between constructional microbial filaments. (Plane light)
E - Highly magnified microbial filaments within stromatolitic laminae protect primary pores (in blue). Calcified evaporate crystals (probably after gypsum) are present in the white patches. (Plane light)



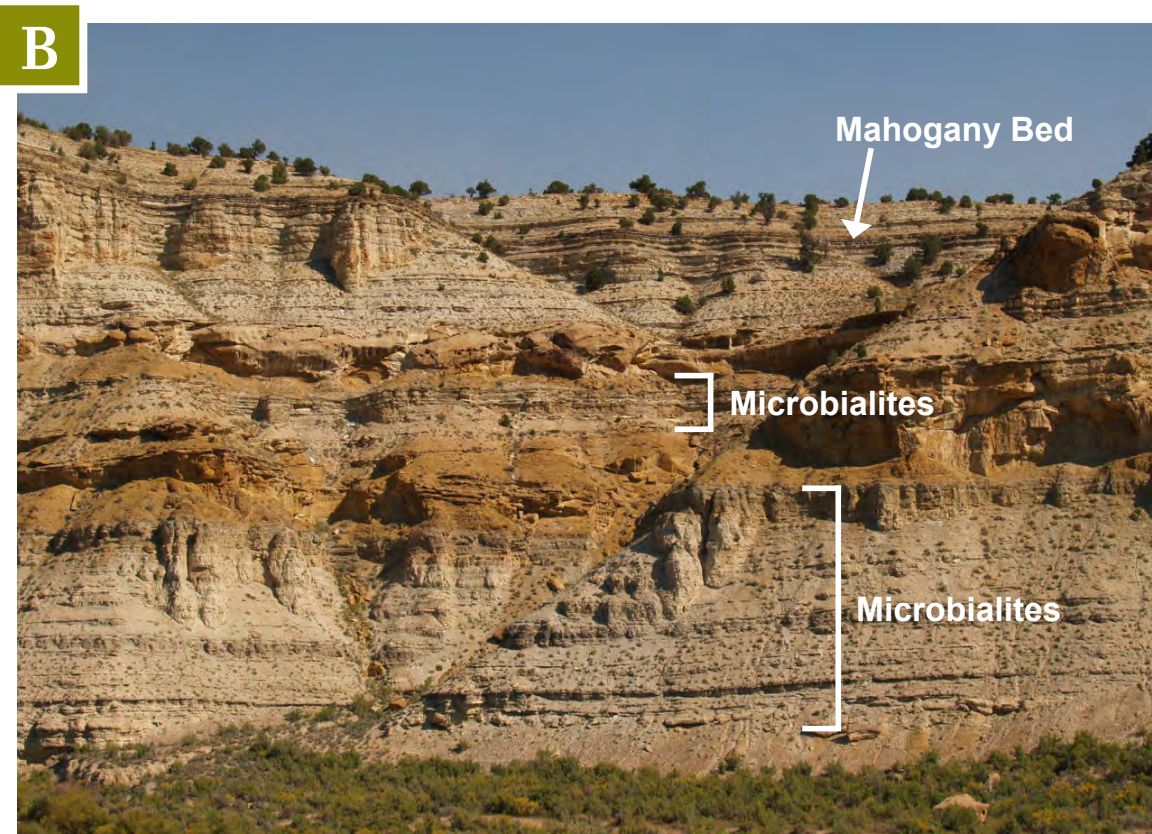
F - Interlocking microbial filaments are preserved by the precipitation of small dolomite crystals. Note the open pores (in blue) encased by the dolomitized filaments. (Plane light)

CONDO SECTION



A - Measured Condo section (see geologic map above right). Microbialite intervals are concentrated mostly in the lower half of this 135 m section.

B - View of the entire Condo section taken from the base of the outcrop. Note the general vertical distribution of the microbialite-rich interval as well as the famous Mahogany bed (oil shale).



BOWLING BALL HILL



View of Bowling Ball hill. Note the location of the dolomitized "Bowling Ball" stromatolite zone in the lower foreground as well as the Mahogany bed in the middle right.

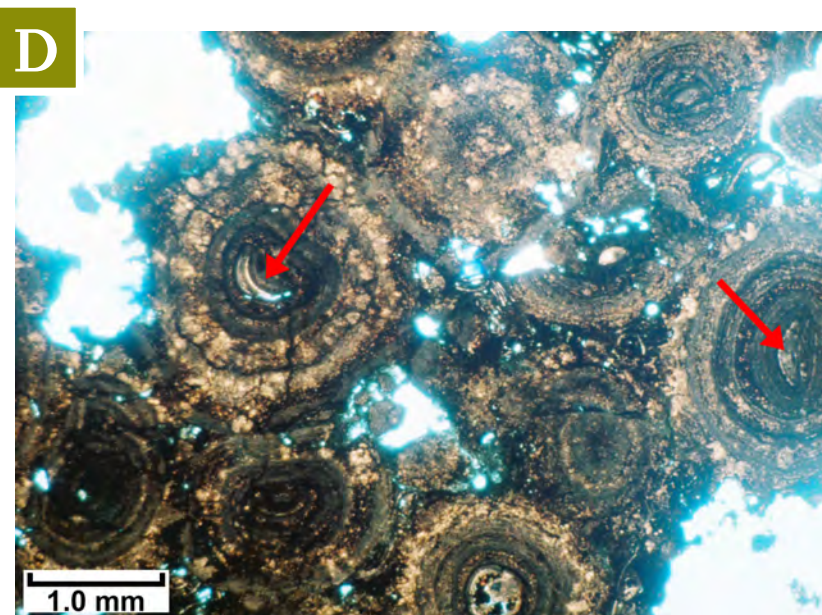
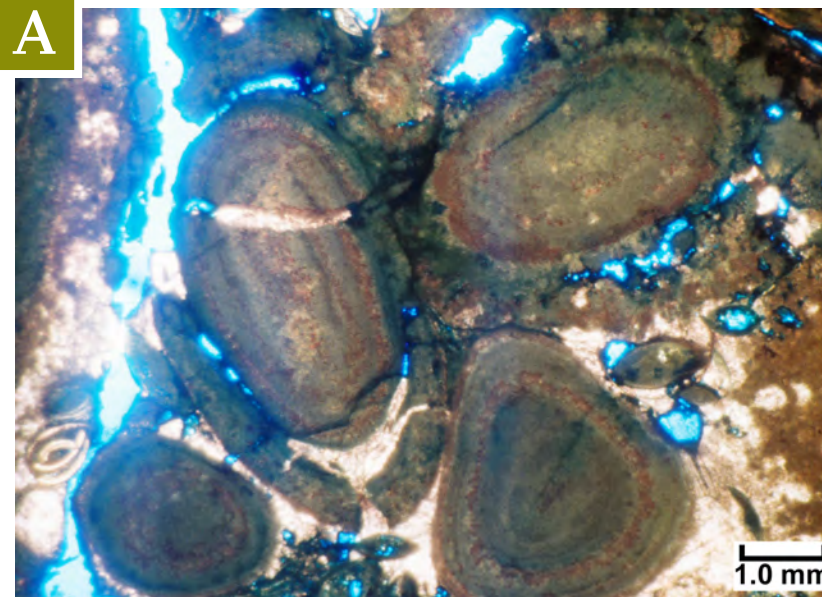


Ground view of the large rubble blocks from the "Bowling Ball" zone composed of multiple meter-scale coalesced stromatolite heads.

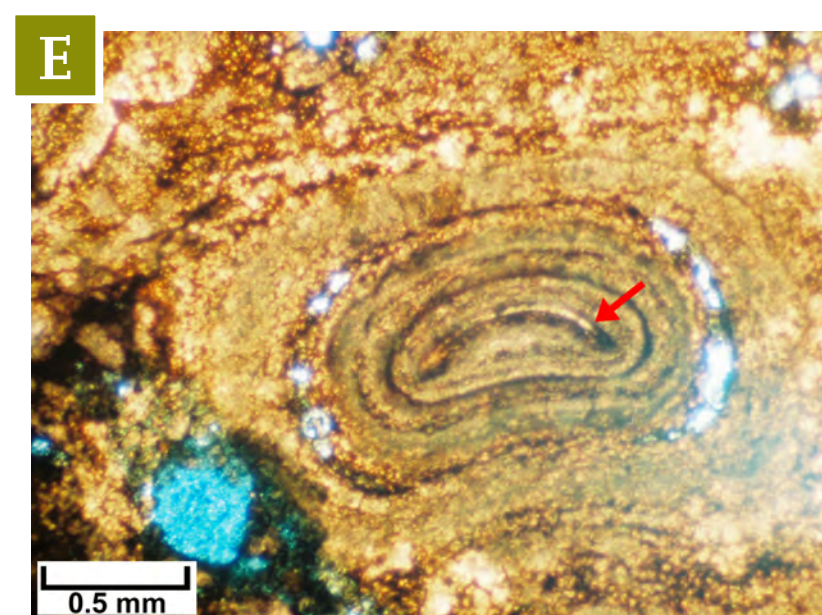
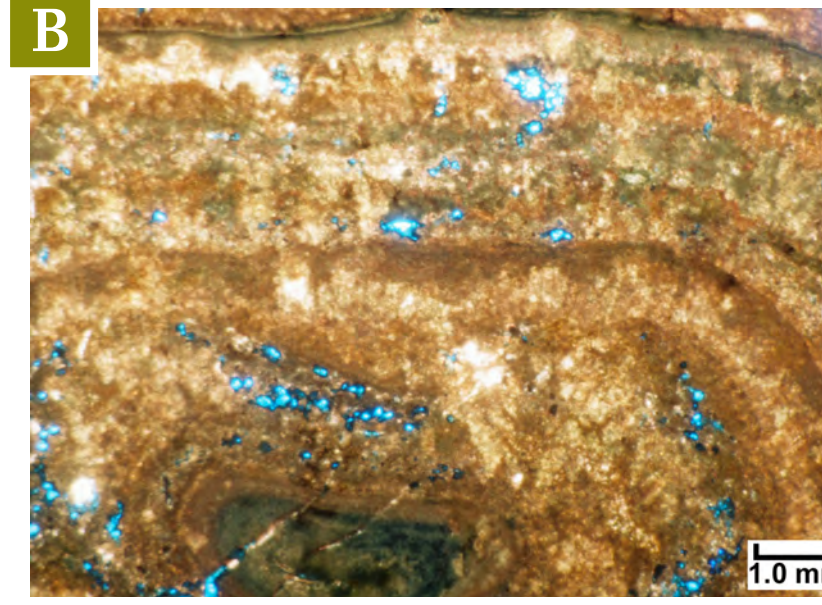


Inclined bedding plane surfaces of partially silicified oolite/pisolite beds that are associated with microbialite facies on Bowling Ball hill.

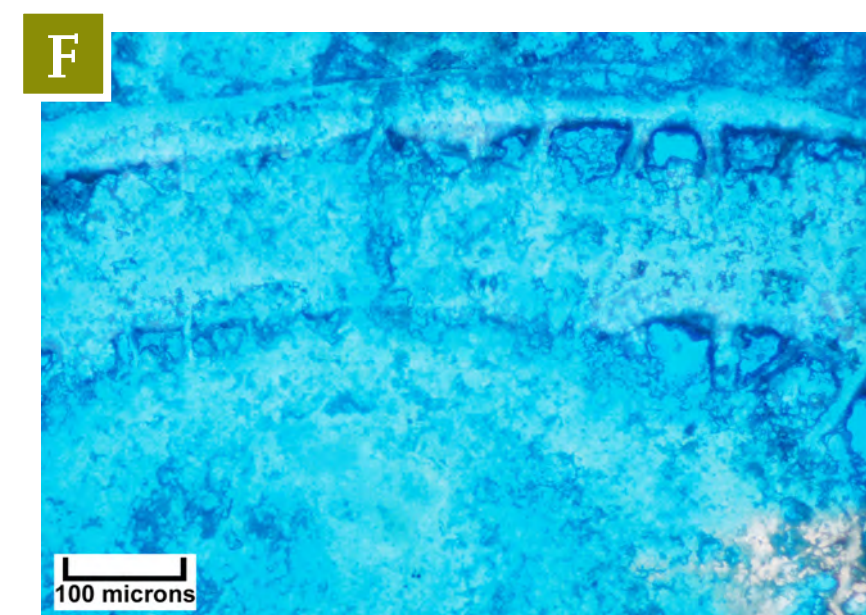
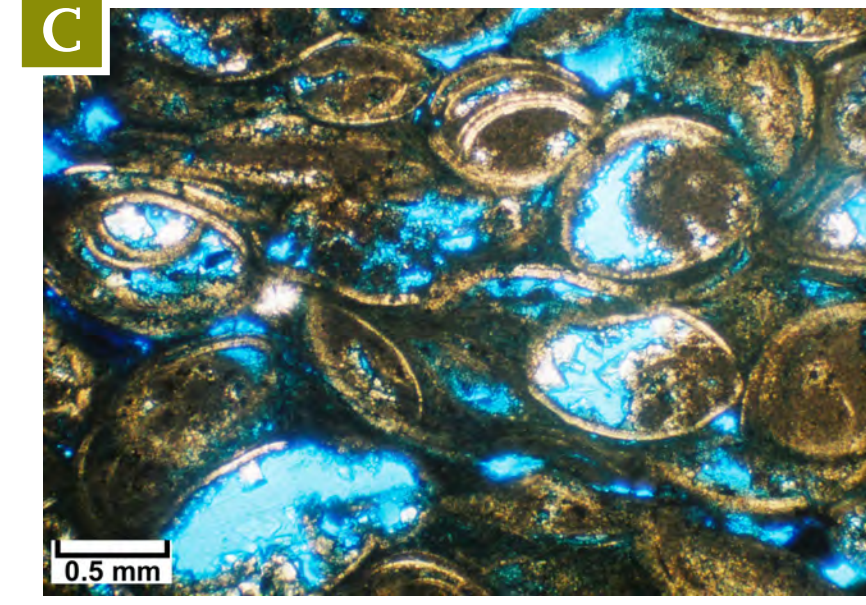
Microbialite Examples from Bowling Ball Hill



A - Grouping of several small oncoids in a thin section from a microbial near Bowling Ball hill. Note the rounded margins but irregular shape of individual oncoids. Ostracods and clotted microbial fabrics surround these oncoids, especially along the right margins of this micrograph. (Plane light)
B - Cross section through a representative oncoid from a microbial bed near Bowling Ball hill. Note the patches of good porosity (in blue) preserved within some of the cortex bands in this oncoid. Remnants of some of the filamentous microfabrics can also be seen. (Plane light)



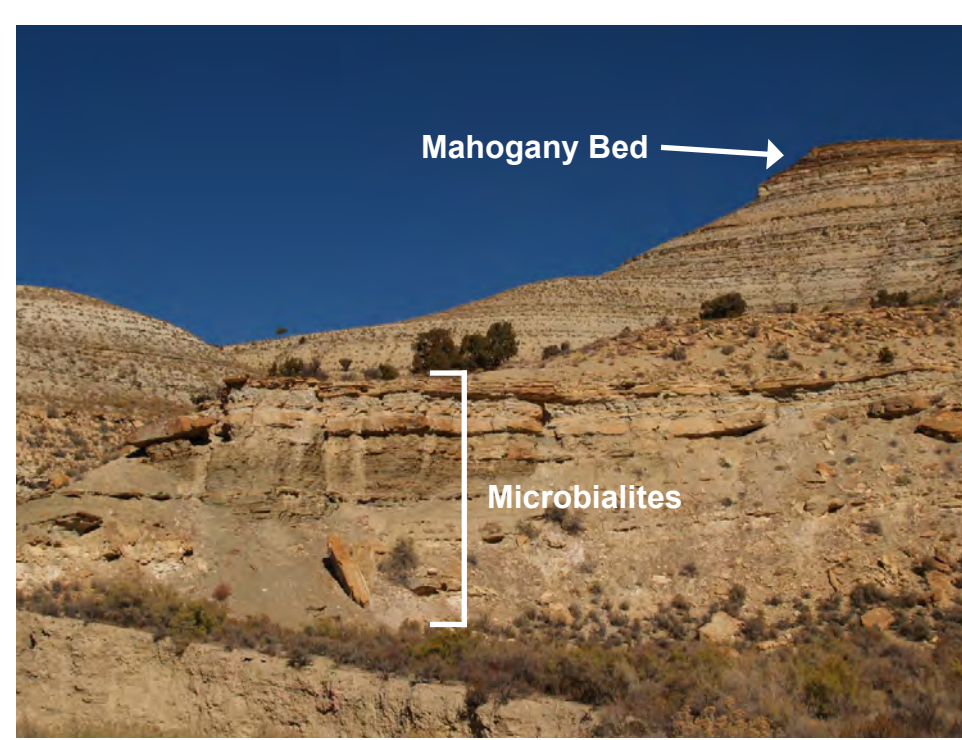
C - Articulated ostracods and carbonate mud shown in this micrograph provide the sediment fill between many of the microbial heads and oncoids from Bowling Ball hill. Note the geopetal fills containing peloids within some of the cavities formed by paired ostracod shells. (Plane light)



D - Small pisoids in thin section from carbonate facies associated with microbialite beds near Bowling Ball hill. Many of the nuclei (see red arrows) of these pisoids are broken ooids (which are also present in Great Salt Lake shoreline sediments). (Plane light)
E - Cross section of a typical pisoid associated with microbialite beds. Note that this particular large grain contains a single ostracod valve (see red arrow) as the nucleus. (Plane light)

F - Highly magnified view of the microbial microstructure of a representative oncoid from a microbial interval near Bowling Ball hill. Note the tubular and filamentous elements of this microfabric, as well as the very high microporosity (in blue). (Plane light w/ white card)

HELLS HOLE SECTION



View of the entire Hells Hole section, taken from the base of the outcrop. Microbialite-rich intervals are common within the carbonate facies in the lower part of this section. The famous Mahogany bed is present near the top of the section.

