APPENDIX J:
THIN SECTION CATHODOLUMINESCENCE AND DESCRIPTIONS, BUG AND CHEROKEE FIELDS, SAN JUAN COUNTY, UTAH

UTAH DNR GEOLOGICAL SURVEY

MAY-BUG 2 WELL,
BUG FIELD

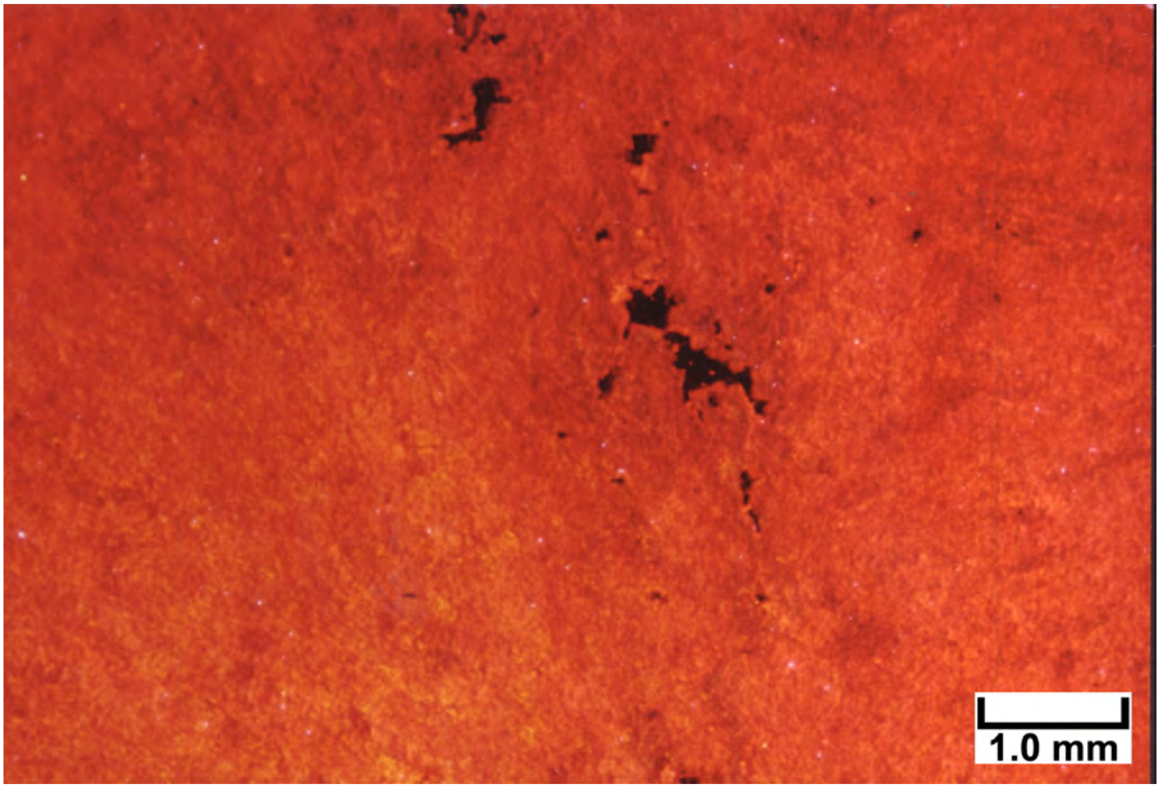
<u>6306 feet</u>

Top Photomicrograph

Cathodoluminescence imaging of a large botryoidal fan of dolomitized cements (originally aragonite) shows reasonably uniform orange and red luminescence. Note the blunt-shaped or square-ended crystal bundles evident in the area just to the right of center. Hints of radiating fibrous cements can be seen from bottom of the photograph to the top in this view. The black (non-luminescent) patches represent secondary pores within these early marine botryoidal cements.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. This micrograph shows ghosts of the radiating fibrous crystal habit of these completely dolomitized, early marine botryoidal cements. Without the CL view (see above), it would be difficult to see either the blunt crystal fan terminations or the dissolution pores.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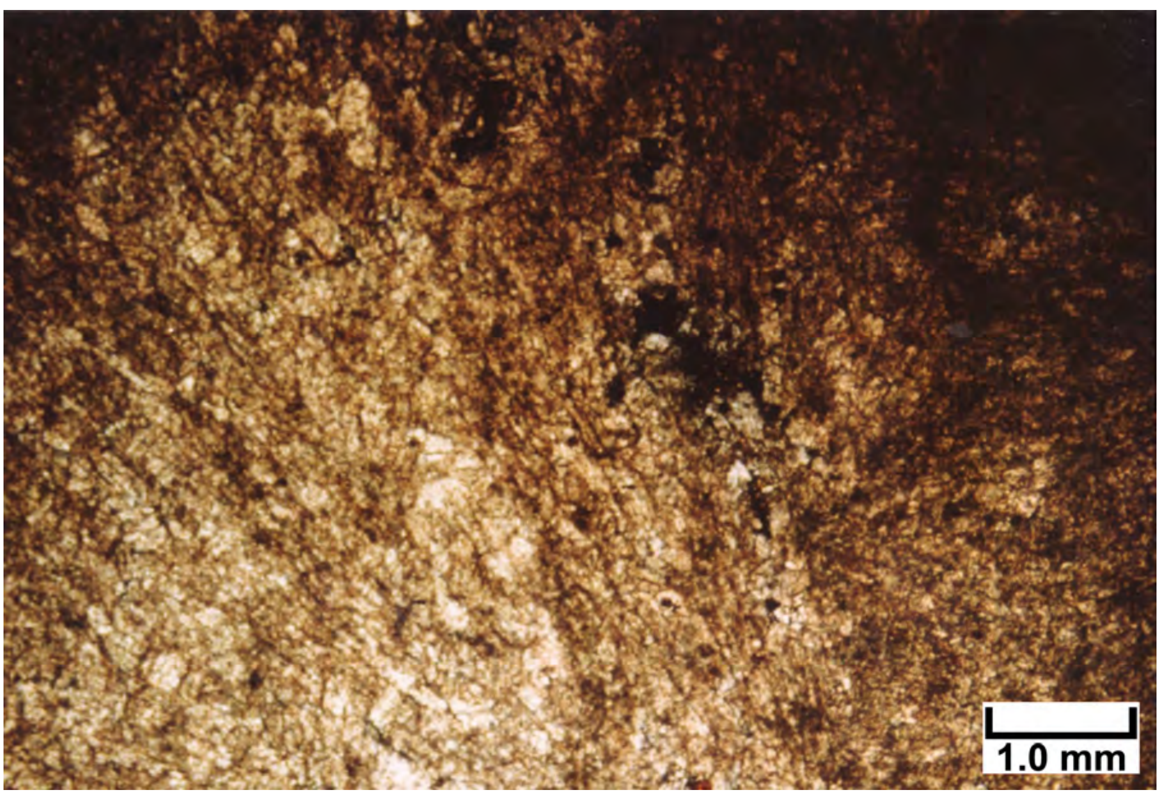
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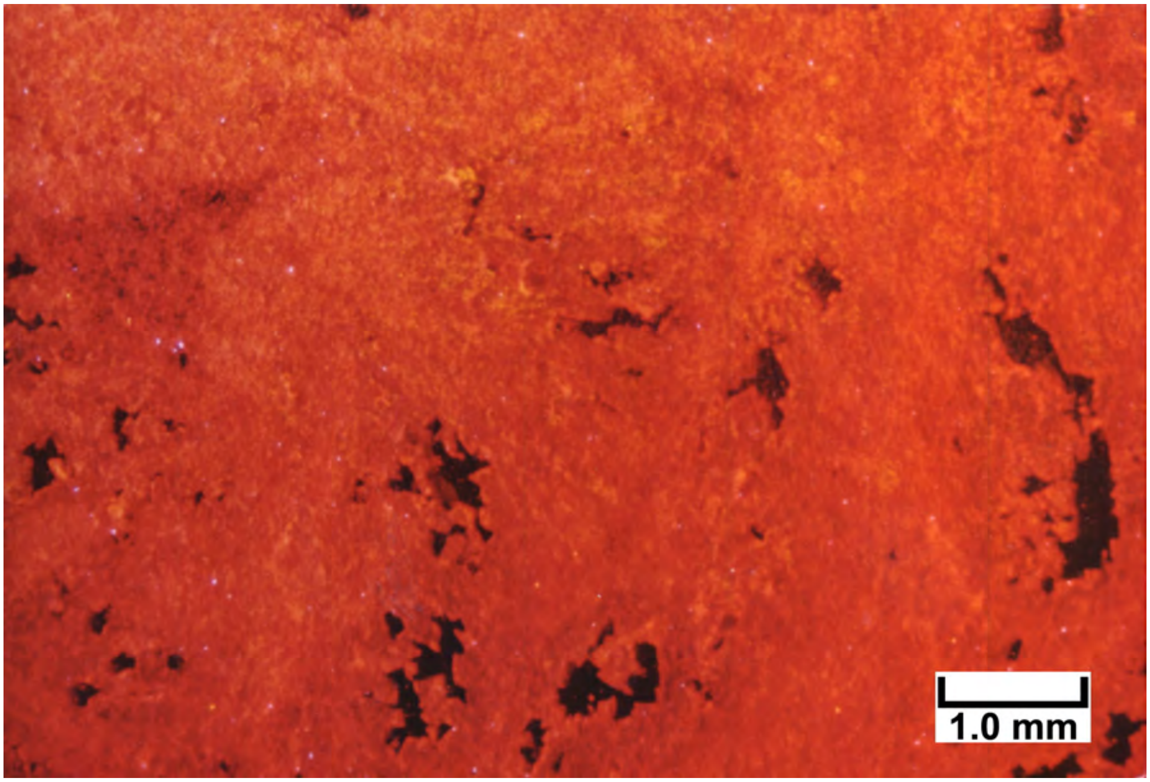
6306 feet

Top Photomicrograph

This CL view cuts across fibrous calcite (originally aragonite) crystal fans that are part of botryoidal cement precipitated between brecciated phylloid-algal mounds. Despite the fairly uniform dull luminescence of these cements, it is possible to see hints of the radiating fibrous crystal bundles (in general, radiating from left to right). The black (non-luminescent) patches were originally dissolution pores within these botryoidal cements.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Except for ghosts of fibrous crystal bundles at various orientations, it is difficult to see much detail within these botryoidal cements without viewing under CL. Note that the root beer-colored crystals in this view are calcite spars and pore-filling epoxy that have been discolored by the electron beam during viewing under CL.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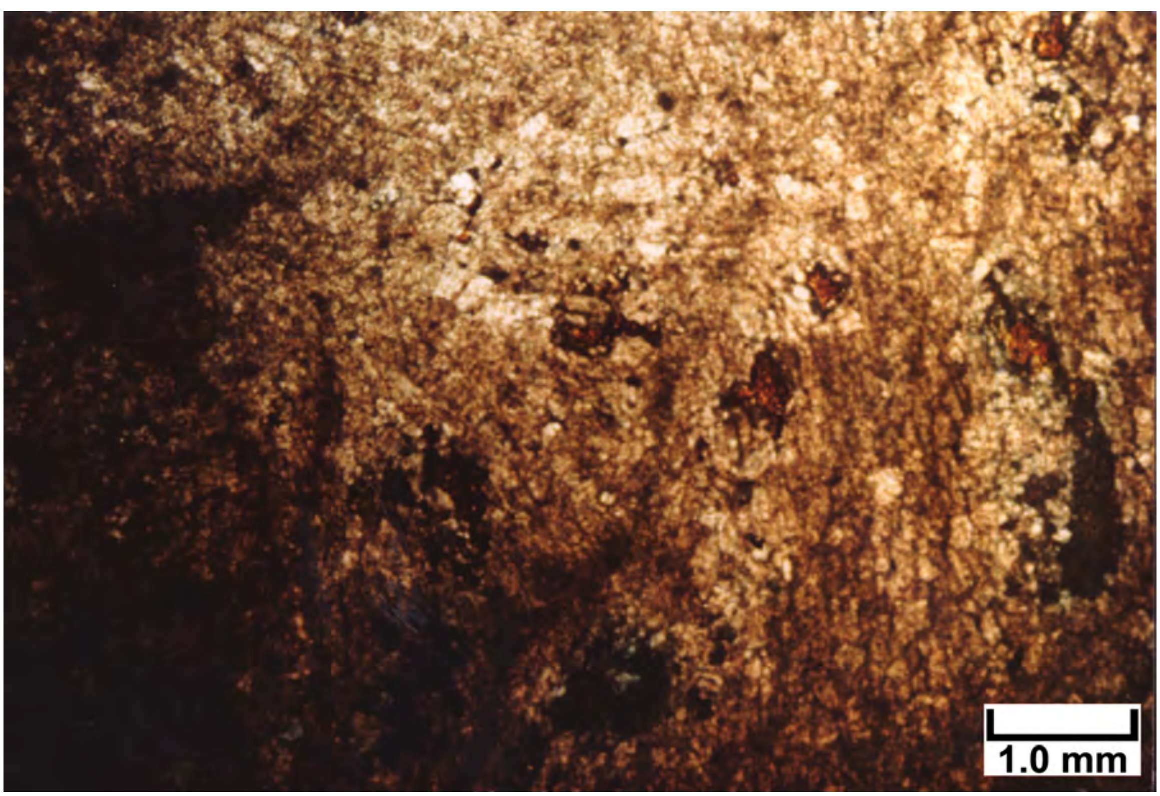
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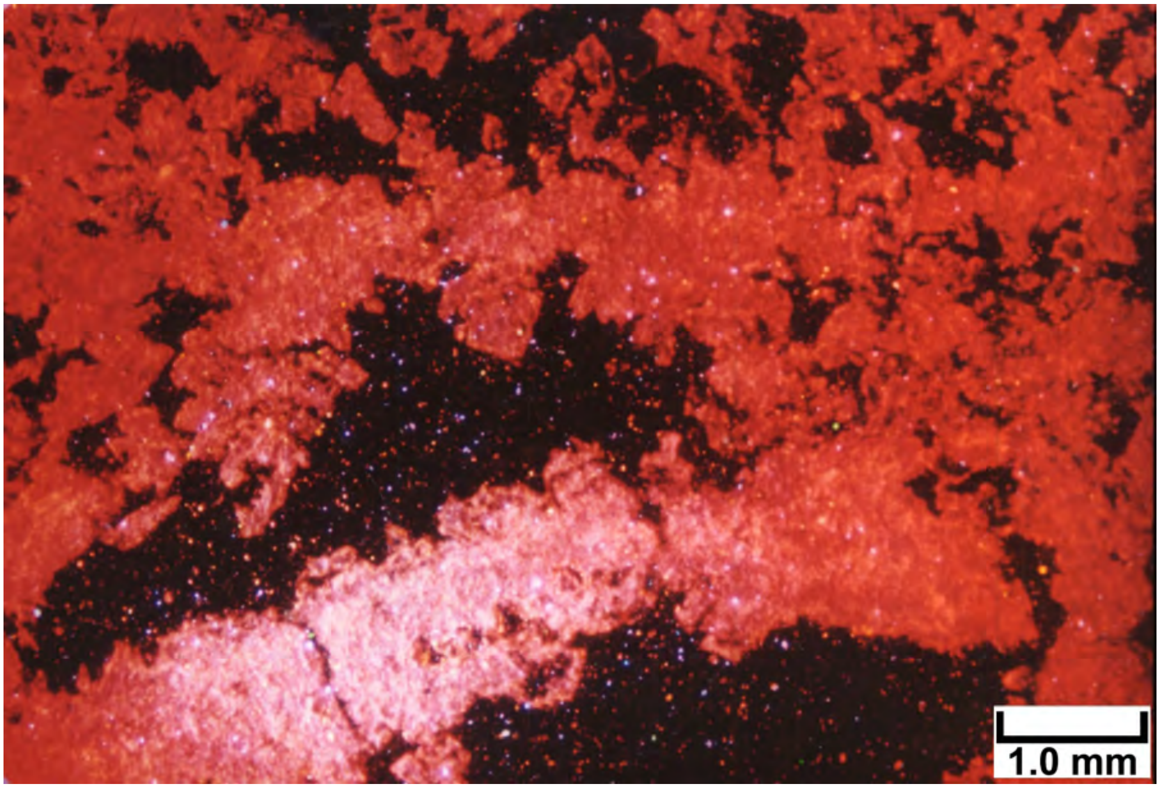
6312 feet

Top Photomicrograph

This CL view nicely shows micro-rhombic dolomites that have completely replaced a brecciated phylloid-algal mound fabric. Despite the dull red luminescence of these dolomites, growth zones and different crystal sizes can readily be seen within the replacement fabric. For instance, note the dolomite crystals (in the upper center portion of this micrograph) with dead (black) cores and bright luminescent (red) rims. This zonation is probably related to two distinct growth stages of this replacement dolomite. The resulting dolomitization of this mound fabric creates small sucrosic or rhombic crystals that produce an effective intercrystalline pore system. The large black patches in the lower half of this micrograph consist of open pores within this brecciated phylloid-algal mound fabric.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Note that there is very little detail within this replacement dolomite that is visible under plane-transmitted light. For instance, it is impossible to see any of the zoned dolomite rhombs or the precursor fabrics before dolomite replacement without the use of CL.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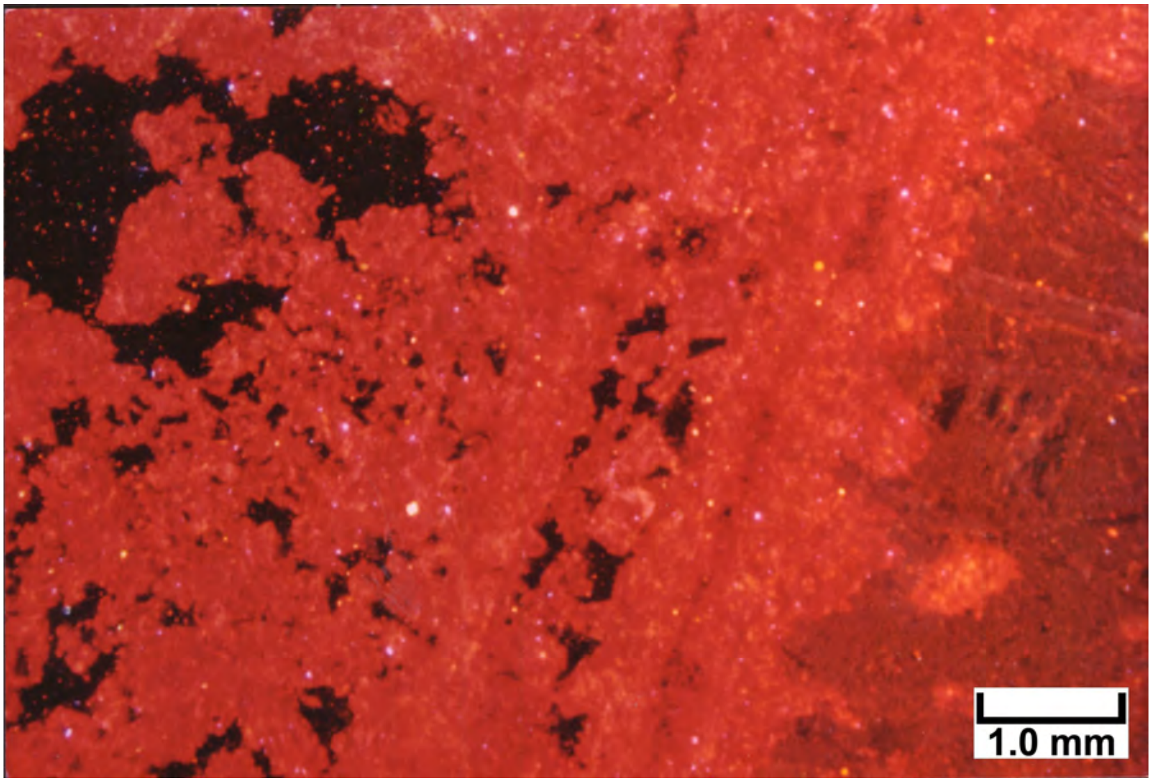
6312 feet

Top Photomicrograph

Cathodoluminescence imaging of this completely dolomitized phylloid-algal mound fabric shows a number of interesting features. Note the ghost of a large phylloid-algal plate (from bottom center to right center) which was partially dissolved out and is now filled with micro-zoned dolomite crystals. These zoned crystals can be observed by the alternating dull and bright red bands within the dolomite rhombs. Some rhombs appear to have as many as four growth zones. The left half of this micrograph shows carbonate skeletal grains and internal sediments that have been replaced by micro-rhombic dolomites. The large black patch in the upper left consists mostly of an open dissolution pore. Finally, the dull brownish luminescence along the right hand margin of this micrograph nicely shows bladed replacement anhydrite following dolomitization of this carbonate sediment. Islands of original dolomite can be seen (as the bright red patches) “floating” in the bladed anhydrite.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Note that there are only faint hints of the dolomite-filled solution mold after the phylloid-algal plate from bottom center to right center. In addition, the plane-transmitted lighting does not show any internal growth zonation of the replacement dolomite in the left half of this view. However, the bladed lathes of replacement anhydrite are visible along the right hand margin of this photomicrograph.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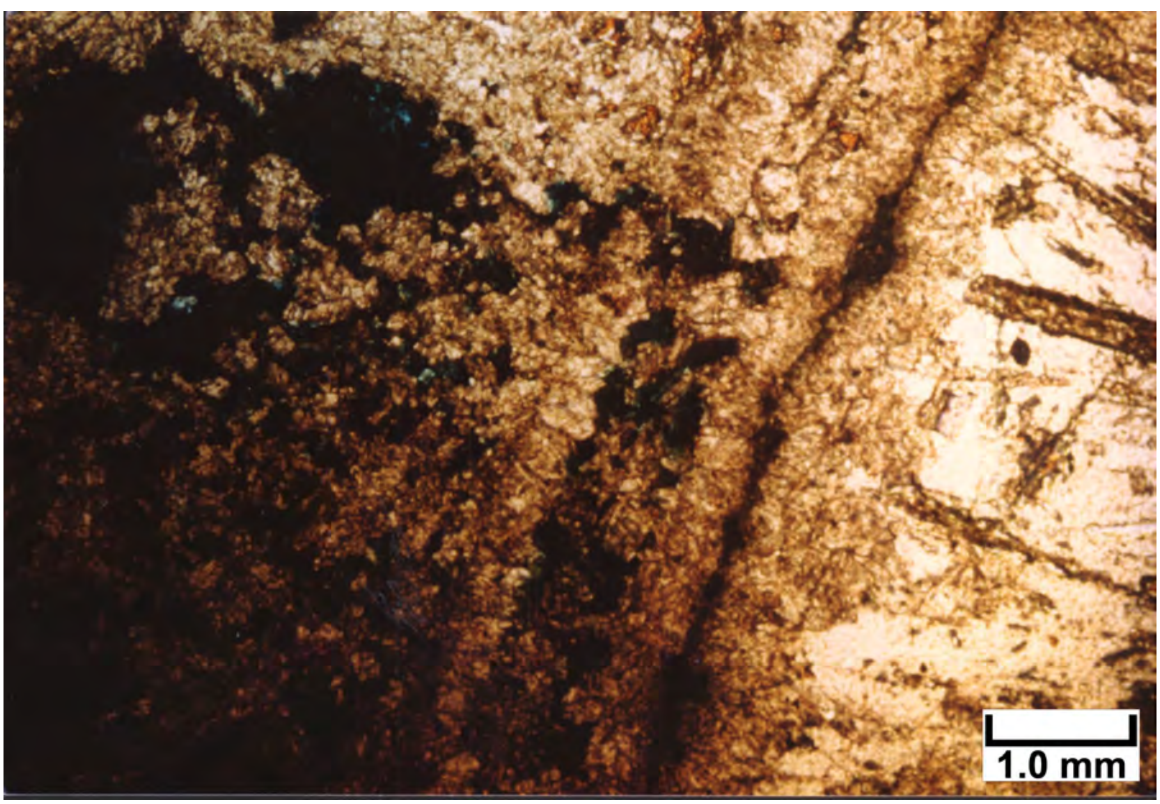
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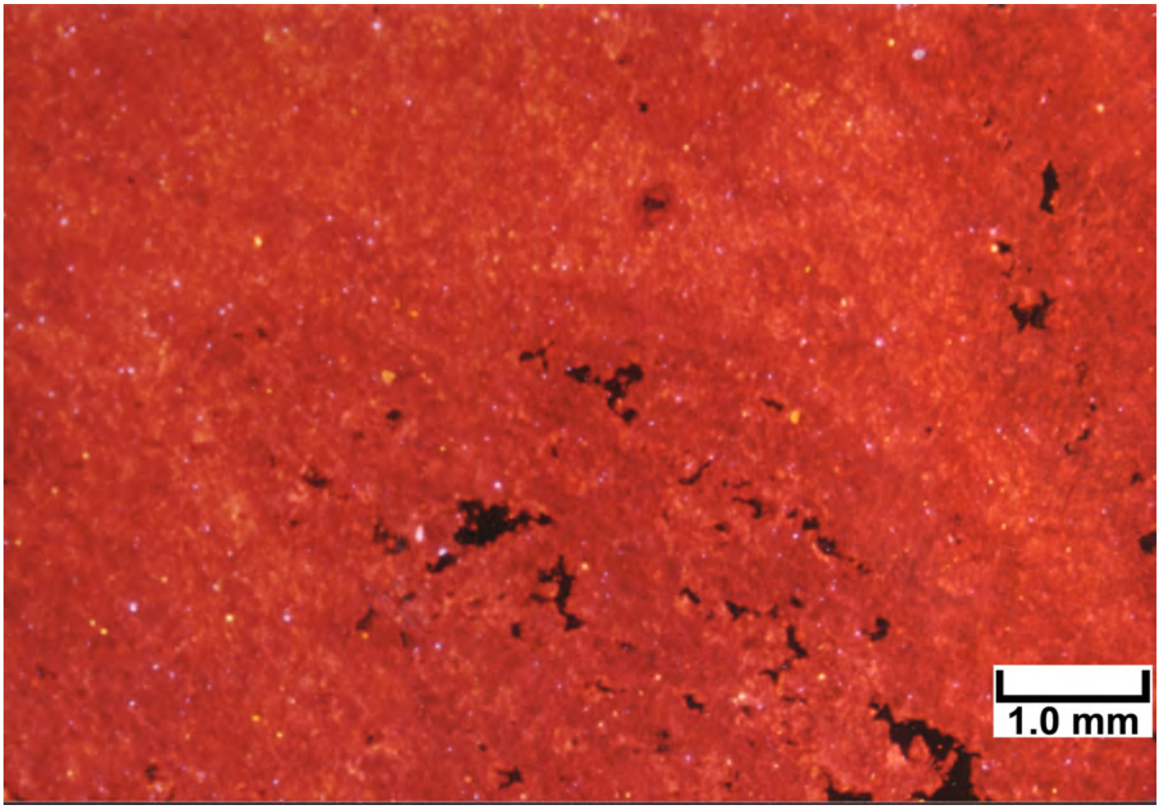
<u>6312 feet</u>

Top Photomicrograph

This CL overview shows a completely dolomitized carbonate sediment that was well-cemented prior to dolomitization. Note that the darker red patterns show ghosts or remnants of the original carbonate sediment grains (mostly peloids and fragmented skeletal debris). The brighter, orangish red areas show the original areas of carbonate cement. The black patches represent open pores, which are a combination of remnant primary (uncemented) pores and possibly small solution cavities. The yellow, white, and blue specks disseminated throughout this dolomite are mostly silt-sized detrital siliciclastic grains (mostly quartz and feldspar) that were probably delivered to this sediment by eolian processes.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Except for the very dark blue open pores, it is very difficult to distinguish carbonate grains from cement in this microcrystalline dolomite without the use of CL.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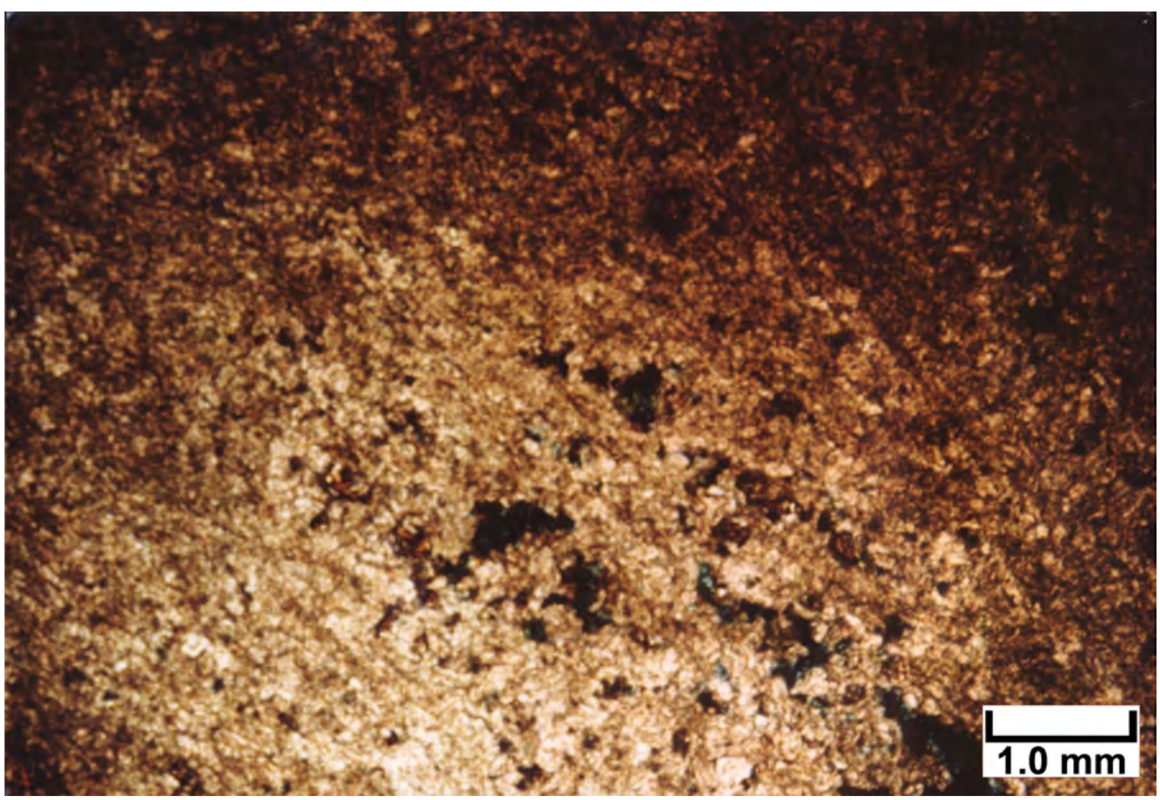
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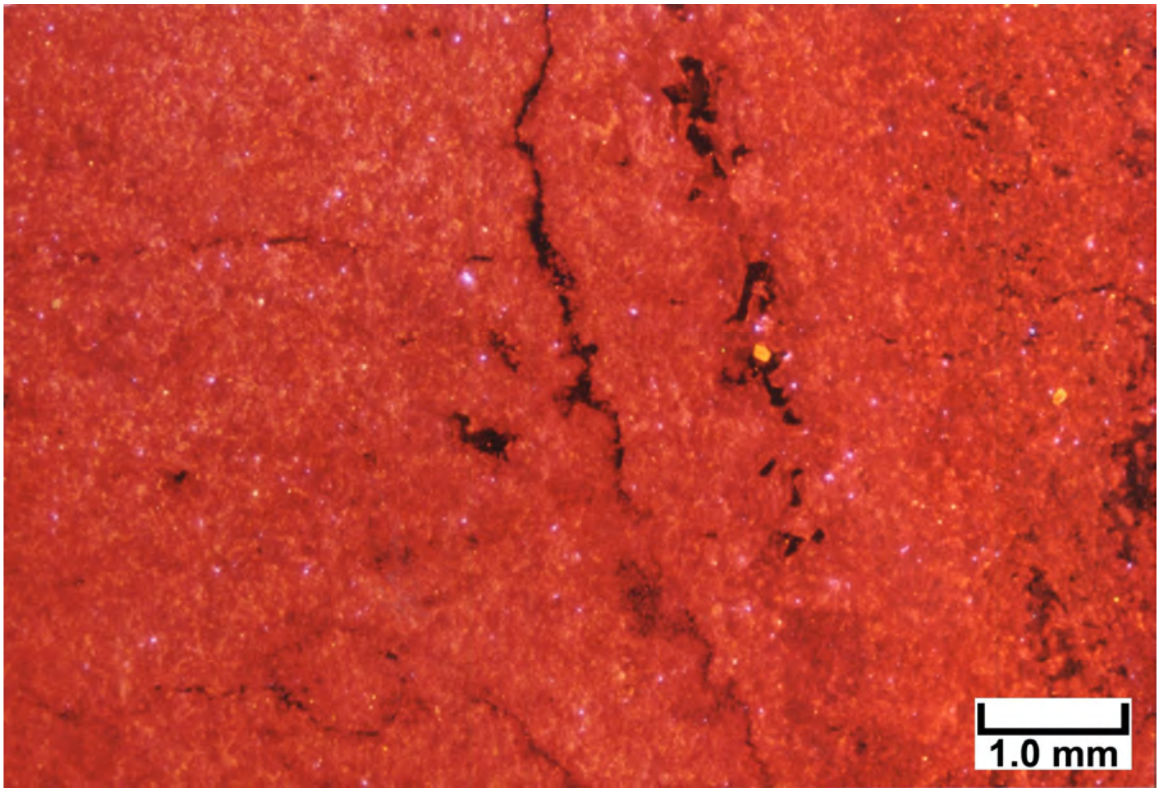
6312 feet

Top Photomicrograph

Cathodoluminescence imaging of a completely dolomitized phylloid-algal bafflestone nicely shows the distinction between original carbonate grains (in dull red) versus early cements (in bright orangish red). Note the two orientations of microfracture swarms which trend from top to bottom and from left to right in this view. Many of these microfractures can be seen as the dark gray to black curvilinear lines. It is possible that some of these open microfractures may have originated from dissolution along microstylolites.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Note that it is difficult to determine original carbonate grains from early carbonate cements in this transmitted plane-light view. Open pores can be seen as the blue epoxy-filled areas. Although it is possible to see some intercepting microfractures here, the CL view above nicely shows additional microfractures.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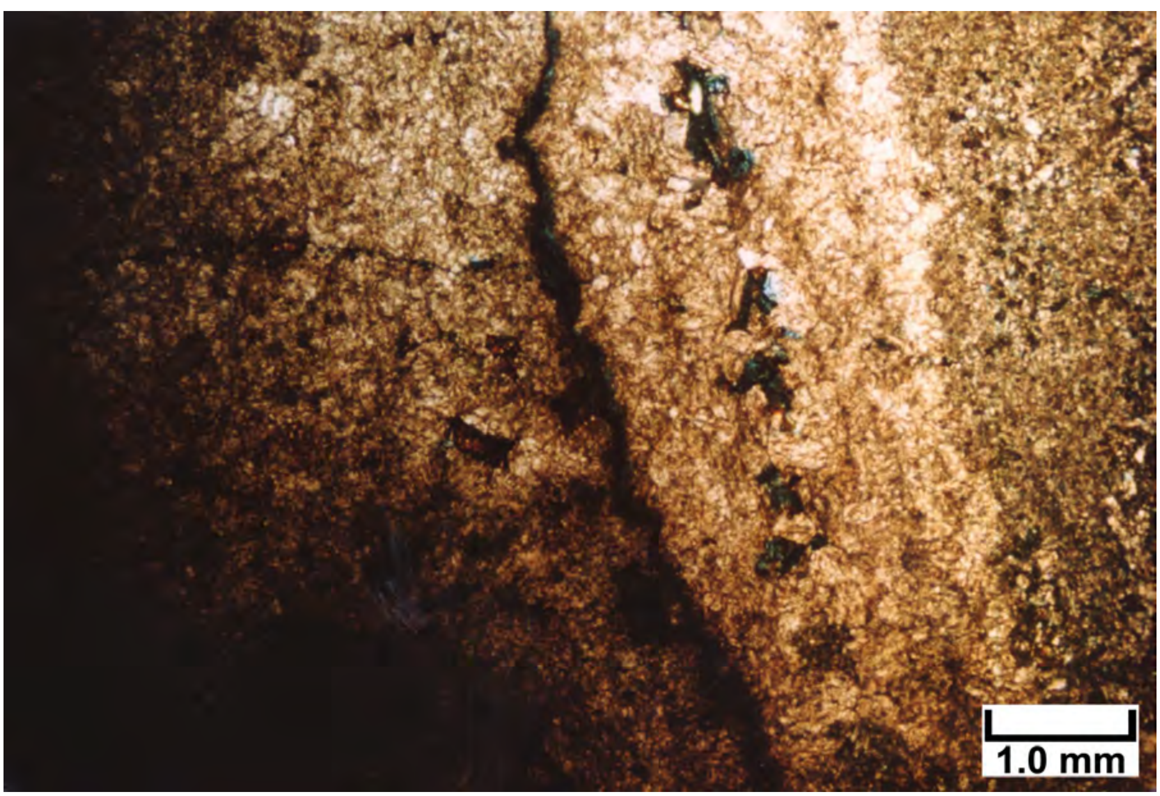
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BUG 10 WELL,
BUG FIELD

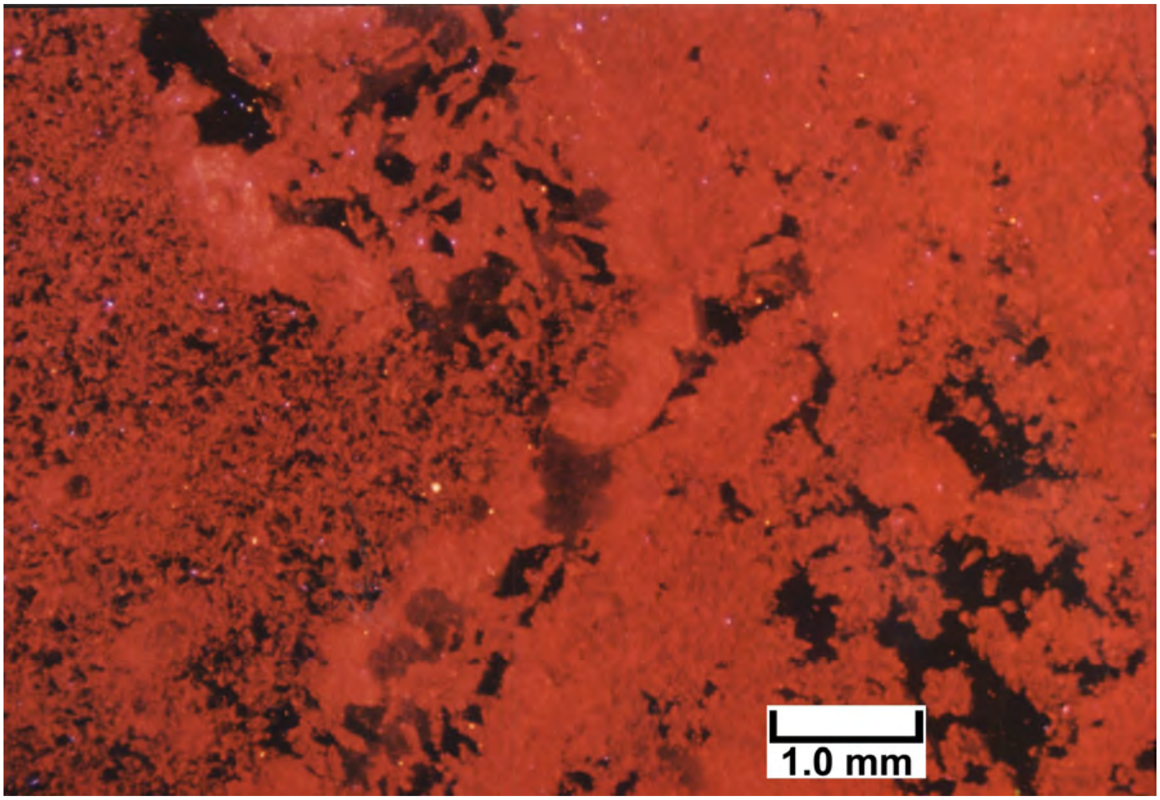
6327.5 feet

Top Photomicrograph

Cathodoluminescence imaging clearly shows some of the distinctive fabric elements within a completely dolomitized, phylloid-algal/skeletal, grain-rich sediment. Note the elongate blades of poorly preserved phylloid-algal plates from bottom center to upper right in this micrograph. Within these blades are preserved remnants of skeletal materials in bright red, and cements in dull reddish gray. For the most part, dolomitized skeletal grains, or their remnants, appear as bright red luminescent areas with clear skeletal shapes. Some of the grains easily visible in this field of view are rounded crinoids with their distinctive circular cores and single crystal, red luminescent rims. Early cements (prior to dolomitization) are very dull red. Porous microdolomites dominate the left quarter of this micrograph. Note also the remnants of dolomitized bladed cements and micro-box-work dolomite fabrics visible in the upper left center of this view. The black areas throughout this field of view are open pores.

Bottom Photomicrograph

The same field of view is shown here under combined Pl and CL (that is, a double exposed image) at the same magnification. In this view, remnants of bright red luminescence show through the coarse and fine dolomite crystal patterns. The blue and black areas of this slide consist of open pores.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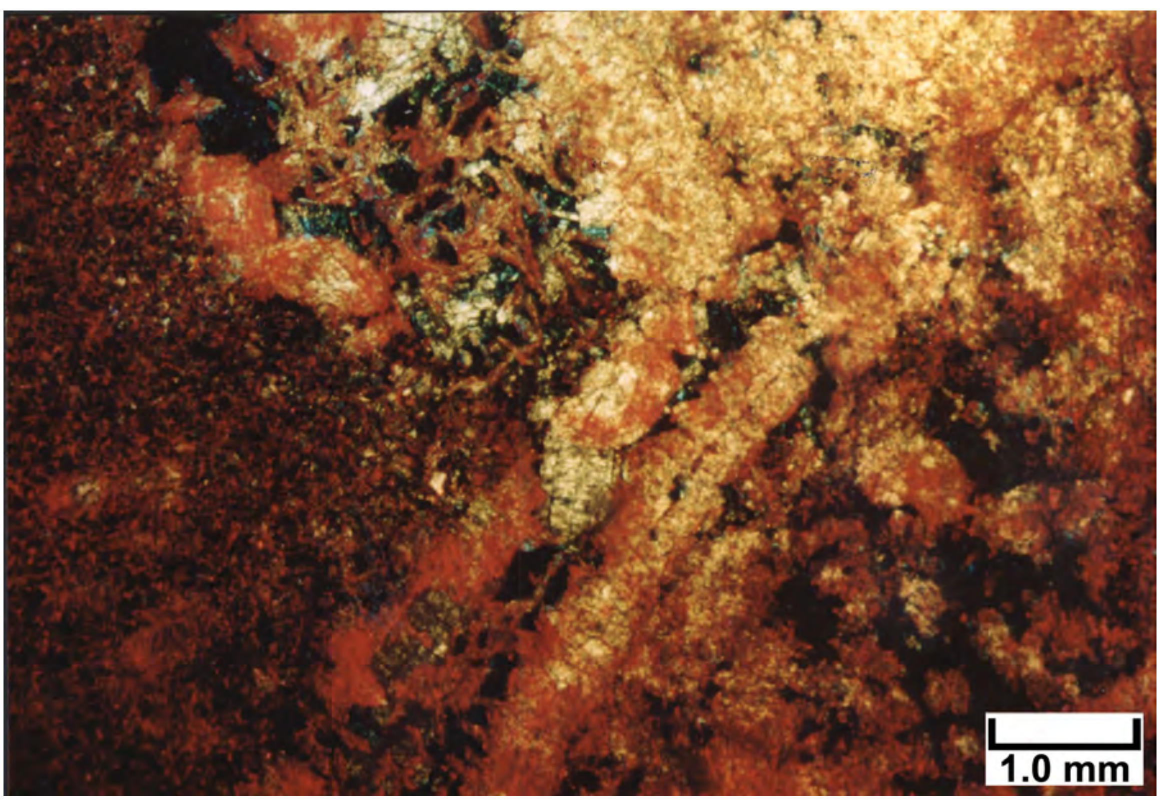
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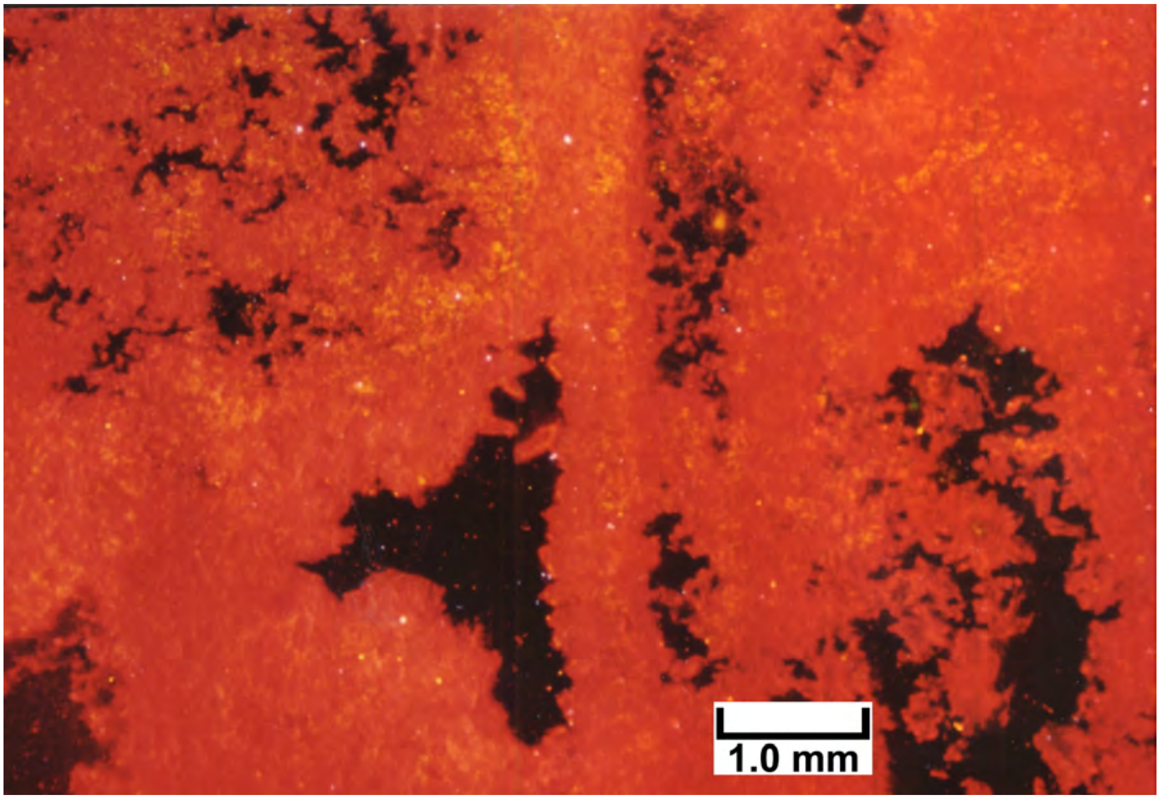
6327.5 feet

Top Photomicrograph

Cathodoluminescence imaging nicely shows remnants of phylloid-algal plates (from upper to lower center) that are lined with bladed cements exhibiting bright and dull bands. Other features within this completely dolomitized mound fabric can be seen within both the dolomitized sediments in the upper left corner and the zoned dolomite cements within the megascopic and microscopic porosity patches (in black) throughout this micrograph. Cathodoluminescence in this image is very effective in distinguishing the pore boundaries from the dolomite matrix crystal boundaries.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Note that there is relatively little detail preserved within this dolomite other than vague patches of dark brown and clear crystals. Details of different zoned and replacement dolomite crystals can be seen more clearly in the CL view above. The blue areas within this view are open pores impregnated with blue epoxy.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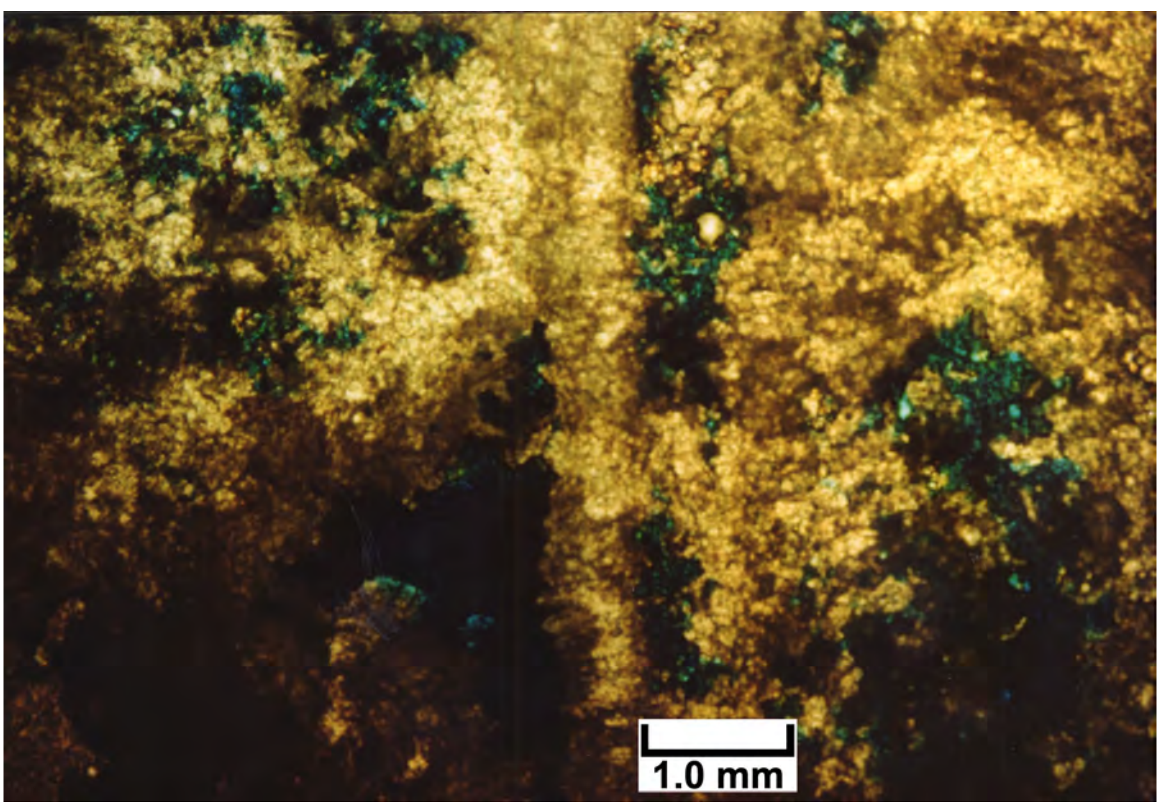
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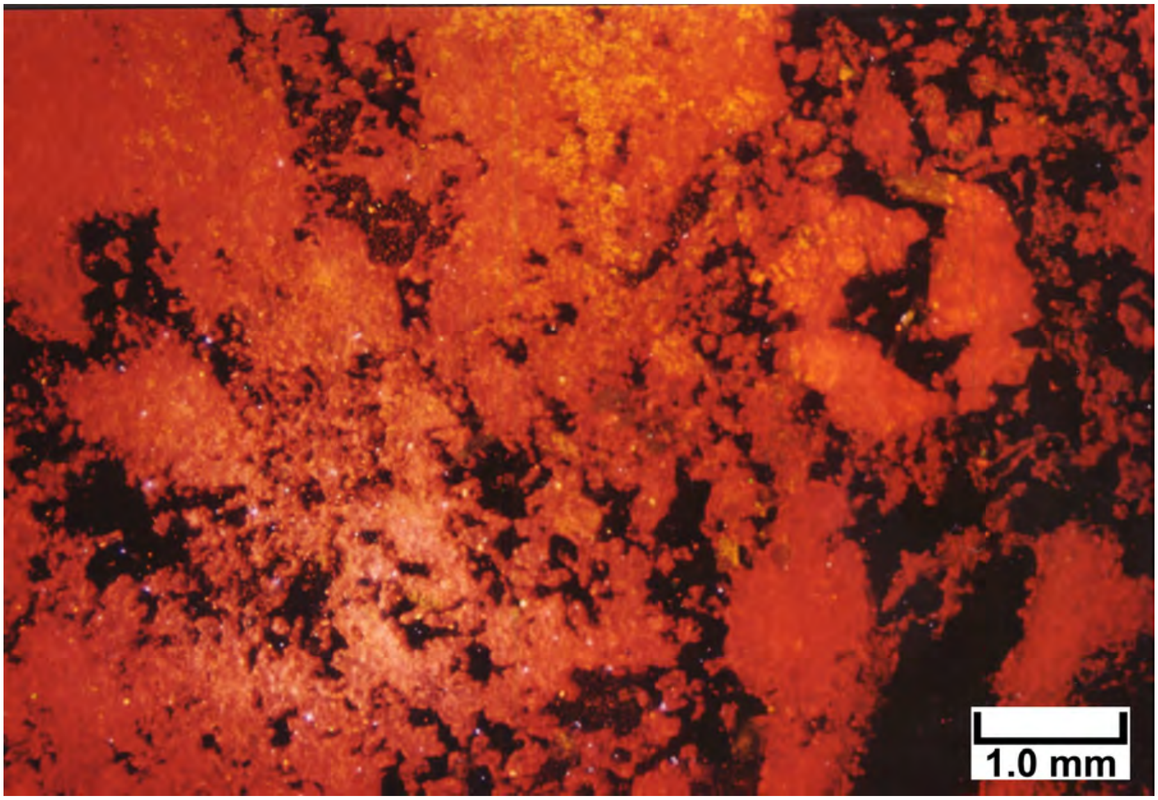
6327.5 feet

Top Photomicrograph

This CL overview very nicely shows the distribution of completely dolomitized sediment in various shades of red versus open pores in the black areas. It is easy to see the well-connected macro- and micro-pore links. Within this view, it is difficult to distinguish individual carbonate grains from cements. But in general, the dull, intense reds conform to dolomitized carbonate grains and the brighter, orangish red areas are remnants of dolomitized early cements. Note that this sample displays a highly brecciated character, followed by some dissolution and corrosion of grains and cements.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Despite the areas of blue and black within this view, the ability to clearly identify pores versus dolomitized matrix is difficult. Black bitumen linings of most pores make this identification difficult. However, better resolution of dolomite matrix versus open pores can be seen in the CL view above.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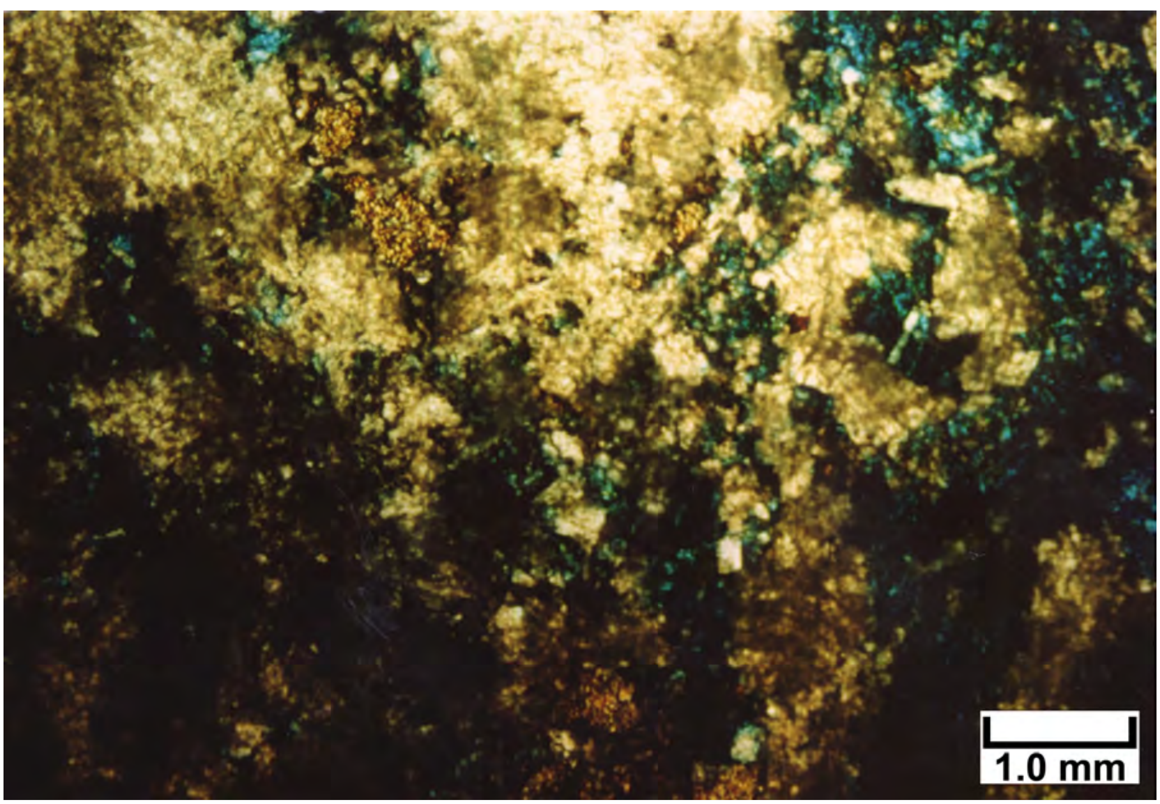
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BUG 13 WELL,
BUG FIELD

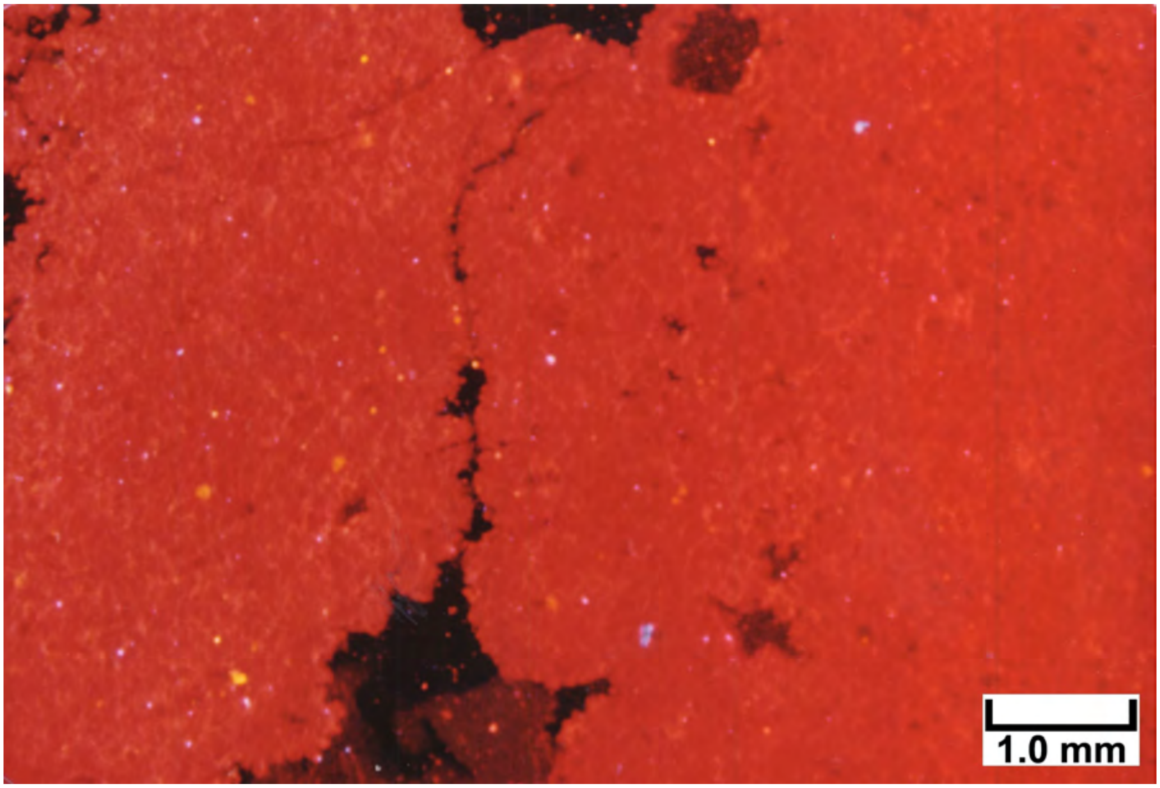
5930.6 feet

Top Photomicrograph

This CL view is from a sample of pisolites and coated-grain aggregates. Note that it is possible to see the carbonate-grain outlines (in uniformly dull red) versus early carbonate cements (in orangish red). Late-stage, dolomitized, spar crystals can be seen in the dull-gray patches in the lowermost and uppermost center of this view. The black (non-luminescent) areas clearly image the open pores and microfractures.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. In this view, it is possible to see the large coated grain aggregates (pisolites and possible grapestones). However, Pl viewing does not show the individual carbonate grains that compose the larger grain aggregates as well as the CL imaging.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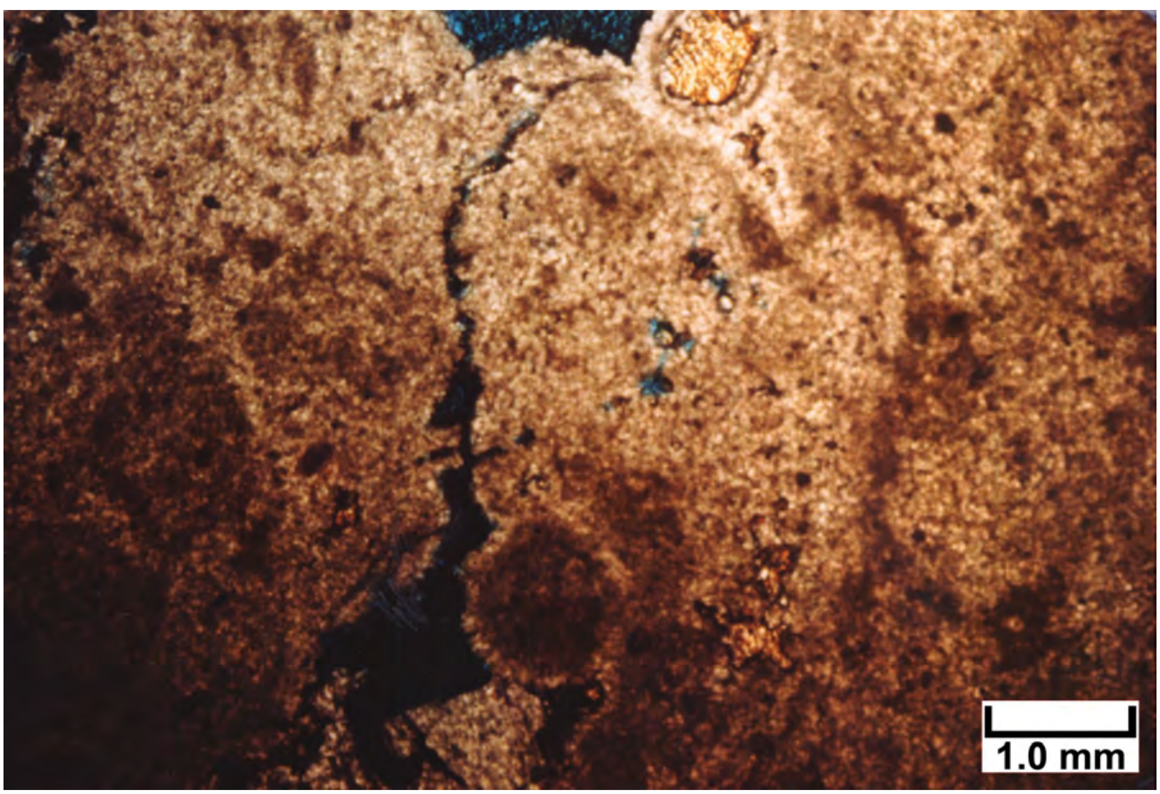
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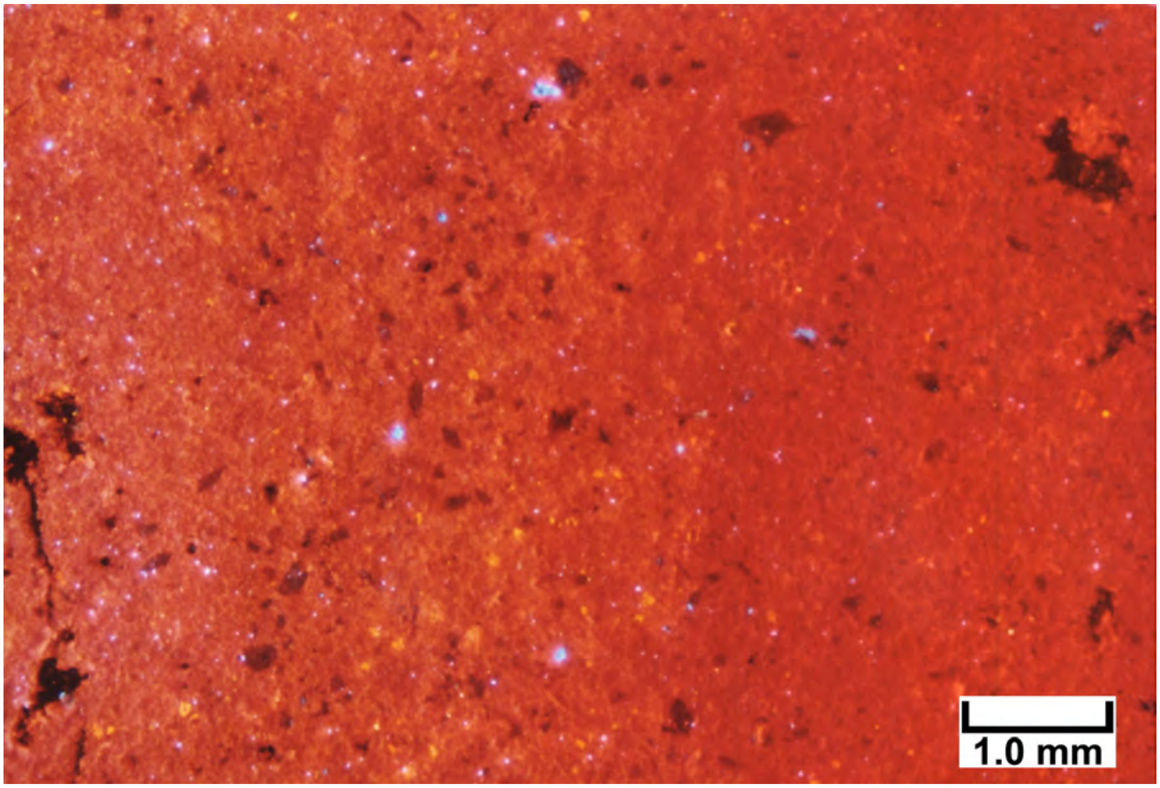
5930.6 feet

Top Photomicrograph

Cathodoluminescence imaging of internal muddy sediment between coated-grain aggregates and brecciated phylloid-algal fabrics is shown here. The bright blue specks consist of quartz silt grains that were probably delivered to this internal sediment by eolian processes. Individual dolomitized carbonate grains can be resolved by the shapes associated with bright-red and dull-red color patterns. Note that there is a distinct pelleted appearance to the dense mud portions of this view (especially in the right half of this micrograph). Most of the orangish red areas consist of pre-dolomitization cements. The black patches are associated with open pores and microfractures.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Only vague outlines of possible carbonate grains and dense, dark colored carbonate muds can be seen here. Dolomitization of this internal sediment has destroyed most of the original fabric definition. Without CL, the detrital quartz silt grains and many of the sand-sized carbonate grains would not be identifiable.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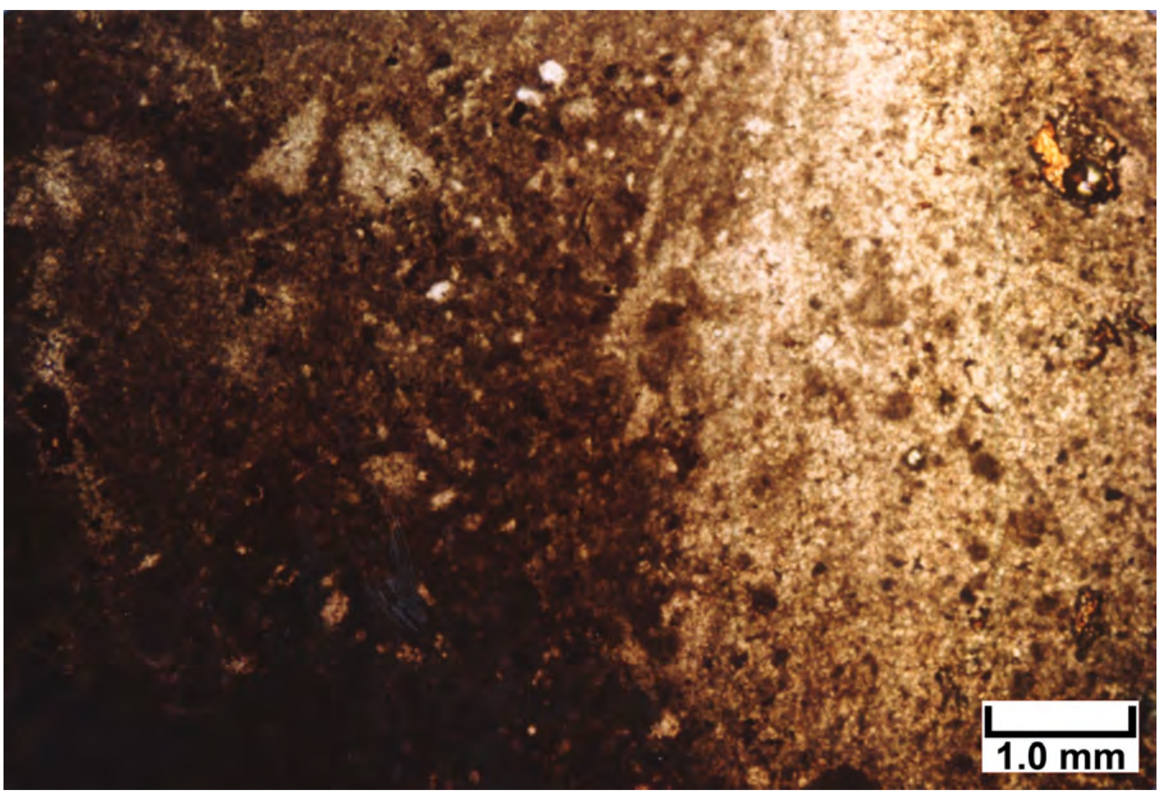
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BUG 16 WELL,
BUG FIELD

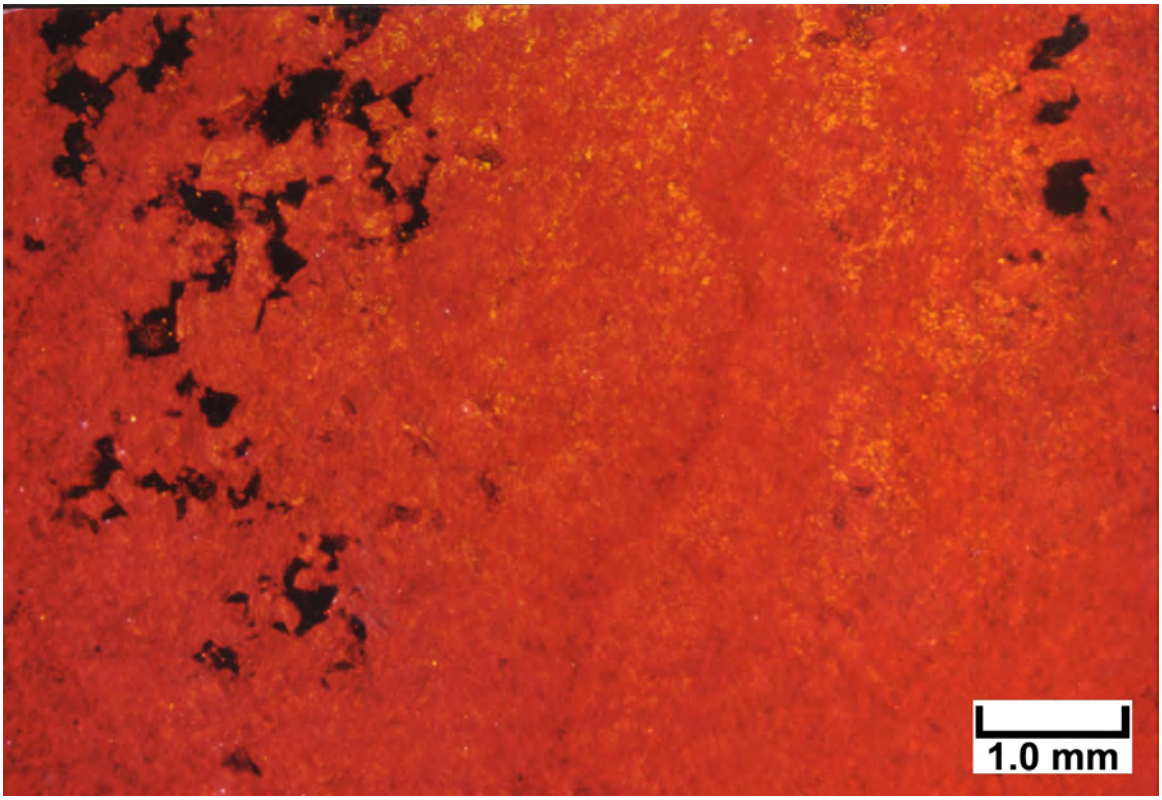
6300.5 feet

Top Photomicrograph

Cathodoluminescence of an area displaying micro-box-work dolomite and early fibrous marine cements is imaged here. Note the patterns of dull red, bright red, and orangish red throughout this dense, tight dolomite. Most of the original carbonate fabric associated with carbonate sediment and early marine cements can be seen in the dull and bright red patterns. The orangish red areas represent later dolomite cement growth bands. In some areas of this view (especially in the left third of the image), there are dolomite crystals that have developed a clear rhombic shape. The black areas clearly define open pores associated with dissolution as well as the development of intercrystalline porosity.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Only the outlines of larger dolomite crystals are visible here. Cathodoluminescence imaging, as shown above, brings out the internal original fabric versus later dolomite growth zones much more clearly. The blue patches are open pores lined with black bitumen. The presence of bitumen makes it difficult to clearly discern the outlines of dolomite matrix versus open pores under Pl. Cathodoluminescence (above) images the pore/rock boundaries very well.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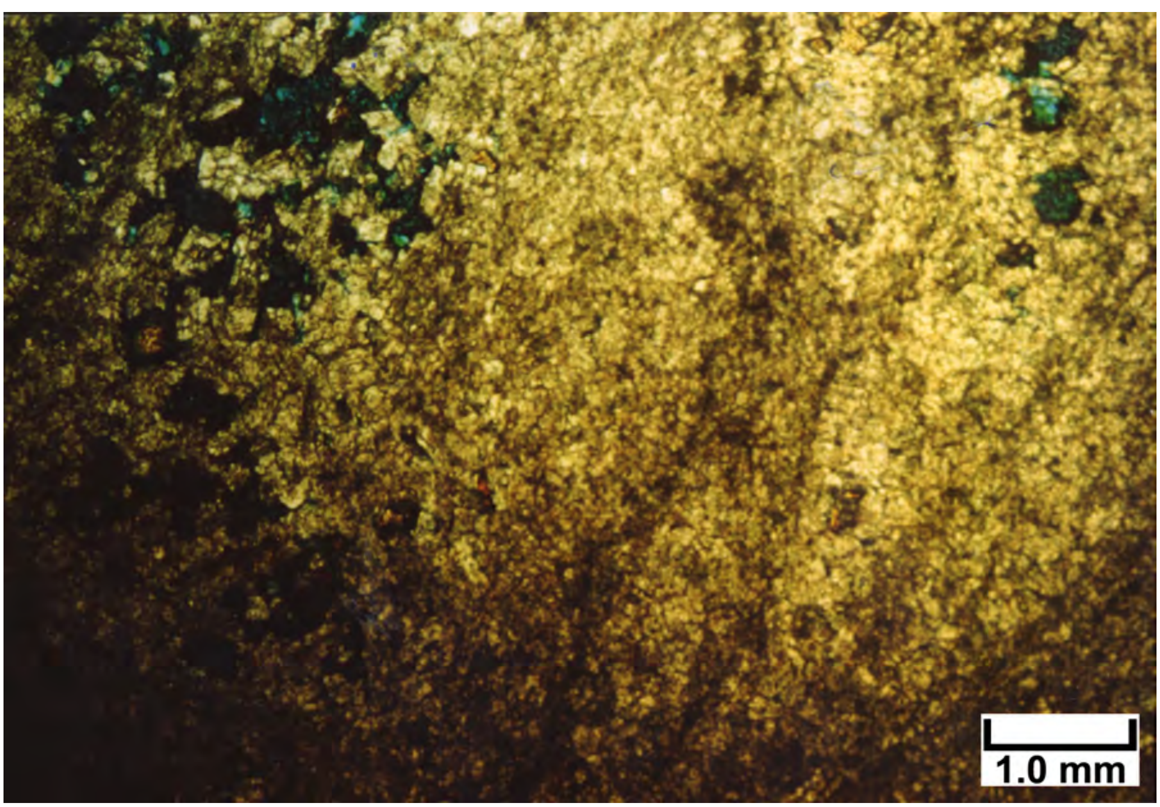
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CHEROKEE FEDERAL 22-14 WELL, CHEROKEE FIELD

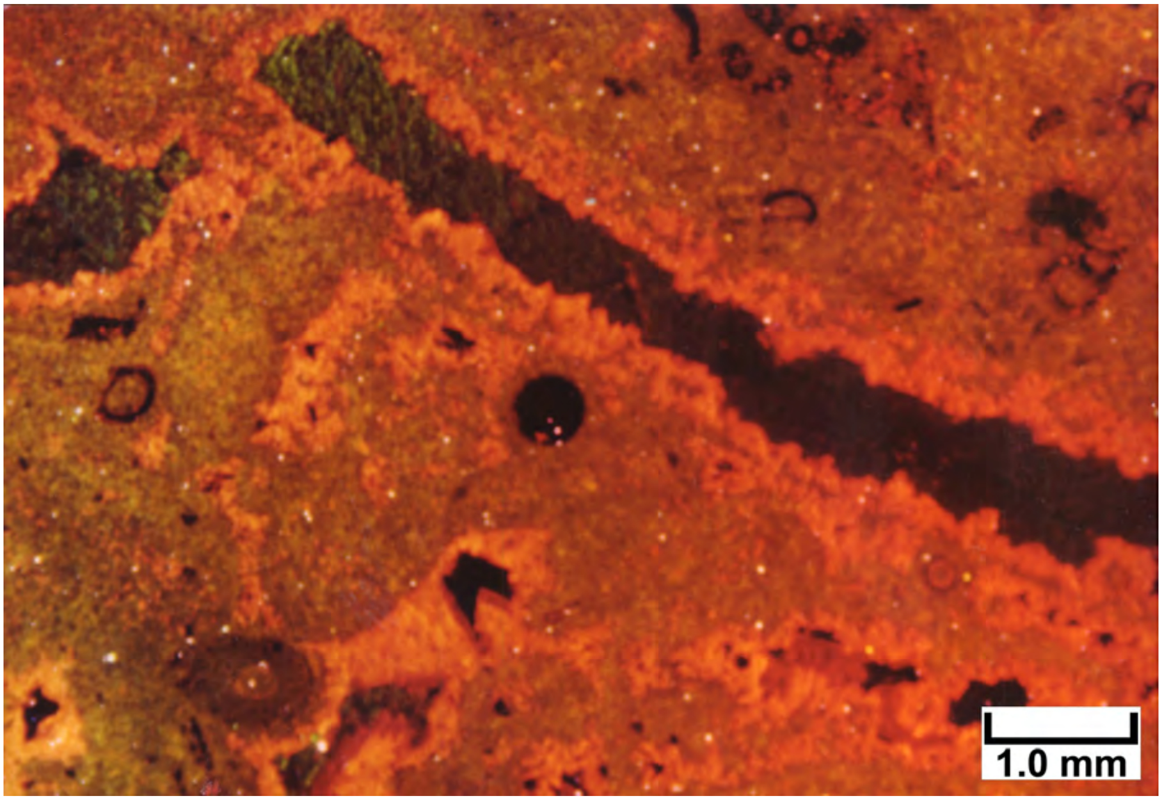
5836.8 feet

Top Photomicrograph

Cathodoluminescence overview of a representative skeletal/peloidal grainstone shows the details of grain preservation as well as different generations of calcite cement. Note the elongate non-luminescent area (from the upper left to right-central portions of this micrograph) which represents a dissolved phylloid-algal plate which is now a moldic pore. Other non-luminescent (black) portions of this view are also open pores or are filled with the same generation of calcite cement. A series of banded bright and dull cement generations represent an earlier generation of pore-filling cements.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Note that the preservation of original grains, leached skeletal grains such as the dissolved phylloid-algal plate, and the multiple generations of cement are not visible under plane light. Without CL, many of these features would be difficult to identify.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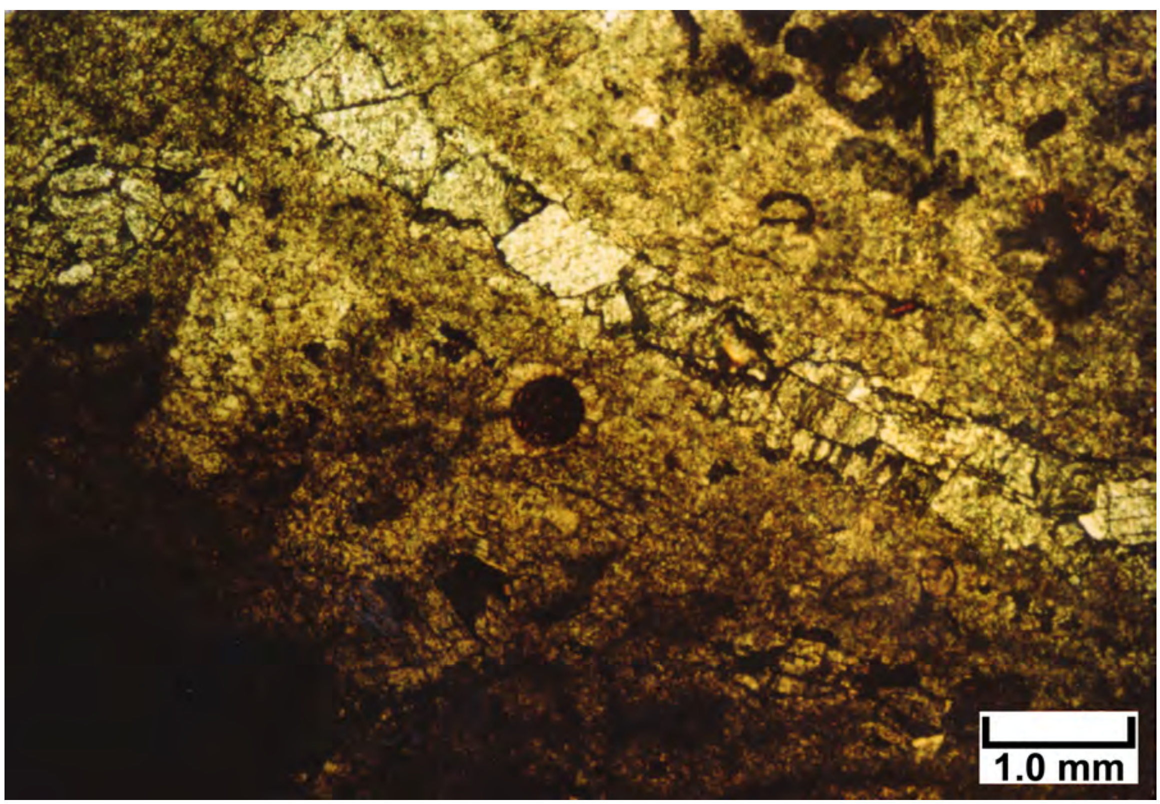
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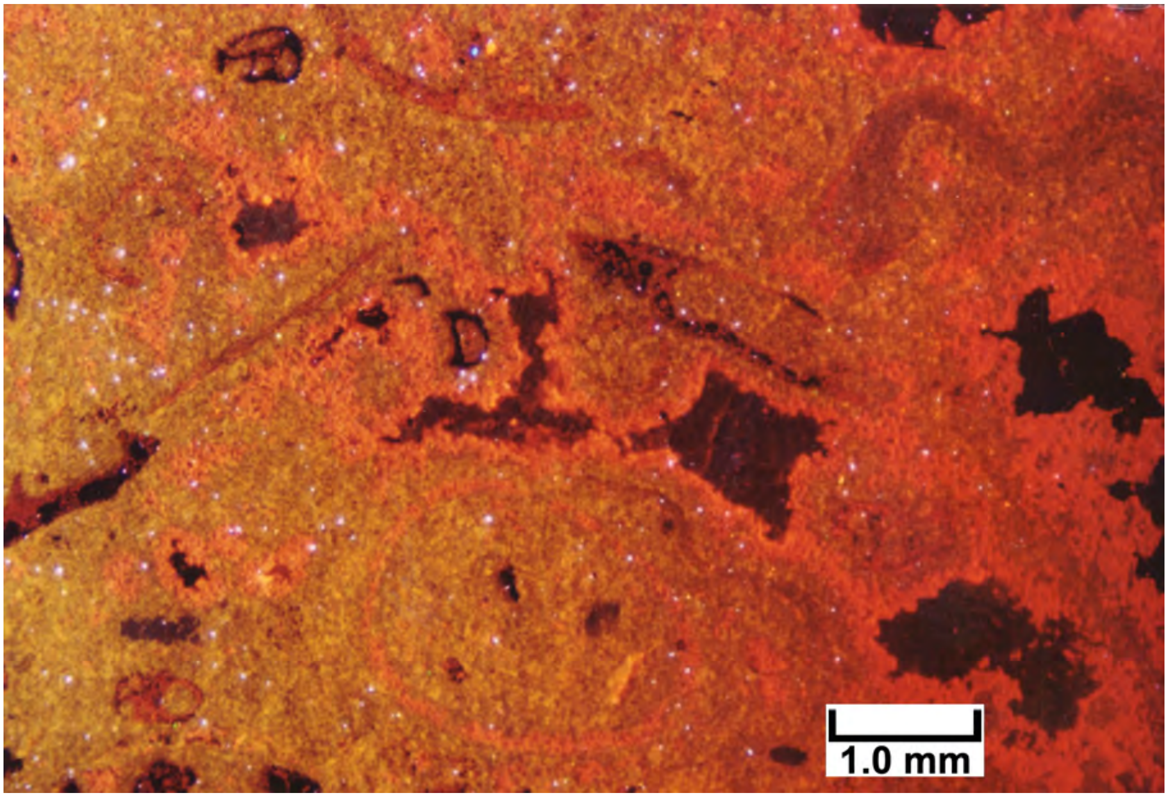
5836.8 feet

Top Photomicrograph

This CL view shows various skeletal grains in the dull red shapes and colors surrounded by banded generations of early pore-filling cements. Note the non-luminescent (black) patches that represent largely secondary pores that have either been filled with equant calcite spar cement, or are isolated, open moldic pores. The numerous light blue specs across this micrograph are mostly detrital quartz silt grains within this carbonate sediment.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Vague outlines of skeletal grains, including broken phylloid-algal plates, brachiopod shells, and bryozoan fragments, are seen in the dark grains. This view does not provide much detail to differentiate various generations of calcite cement seen in CL view above.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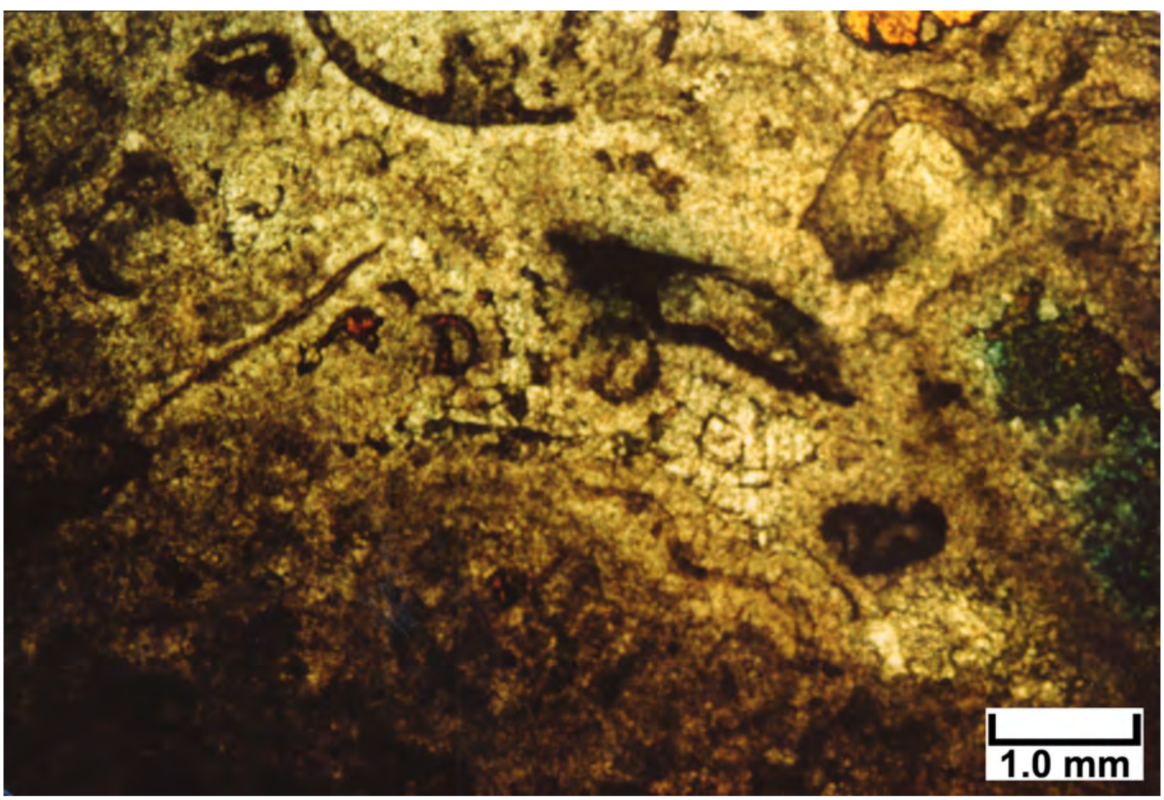
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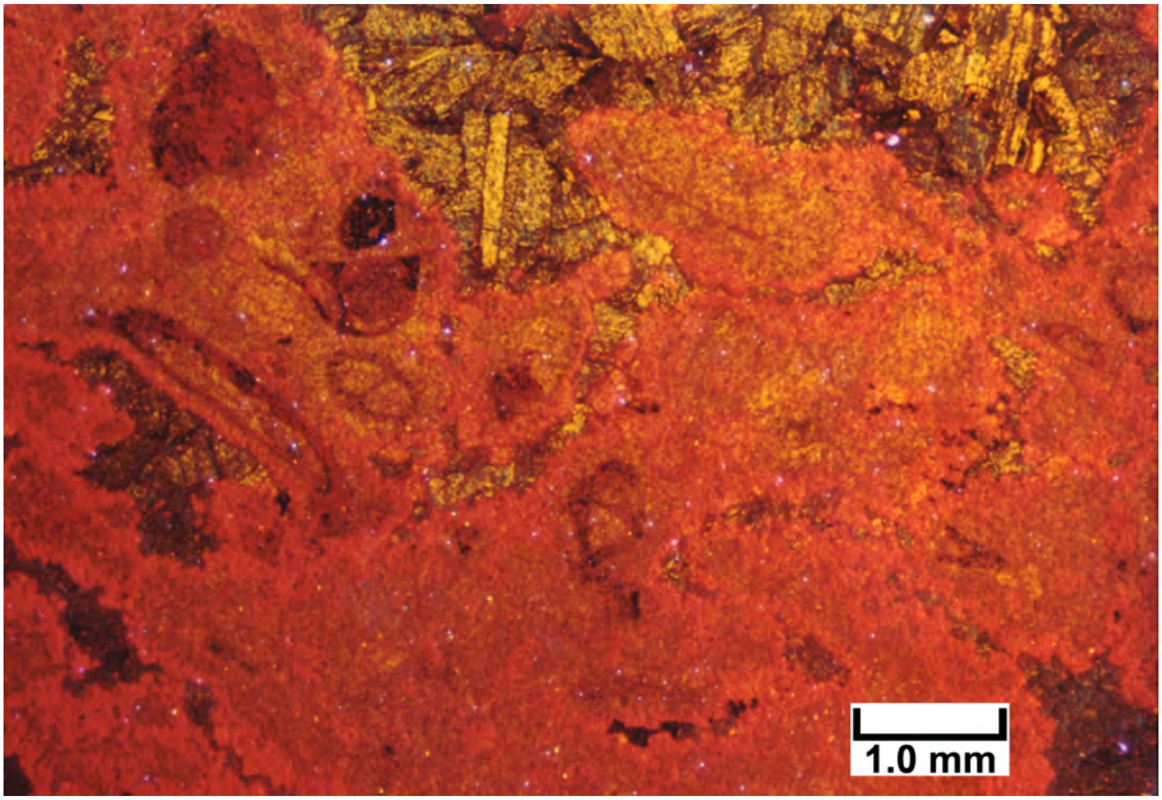
5836.8 feet

Top Photomicrograph

Generations of isopachous cements surrounding skeletal grains are shown here as banded luminescent cements. As in the previous CL micrographs from this depth, the black (non-luminescent) patches consist of late calcite spar filling largely secondary pores, or are open pores. The burnt orange patches across the top of this micrograph consist of late replacement of this limestone by bladed anhydrite.

Bottom Photomicrograph

The same field of view is shown here under Pl at the same magnification. Note that it is virtually impossible to distinguish skeletal grains from cement generations. In addition, details of the late anhydrite replacement are not clear under Pl.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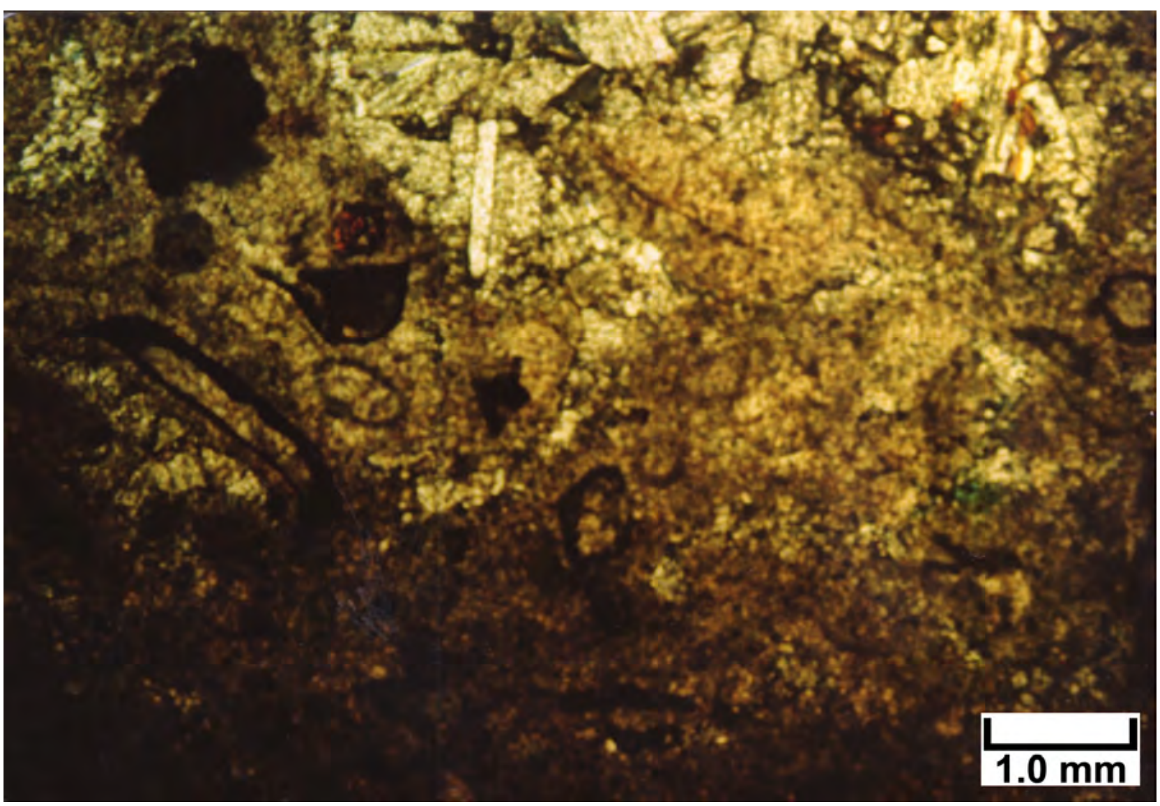
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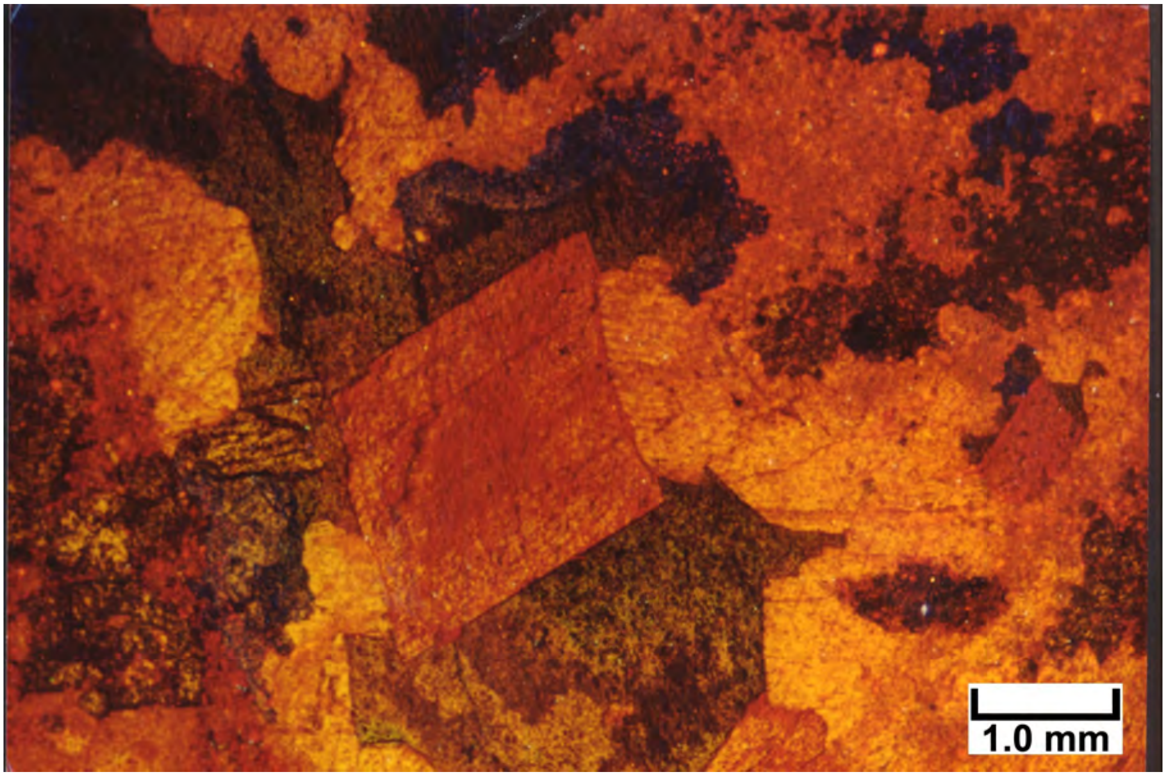
5870 feet

Top Photomicrograph

Most of the large crystals in this CL view consist of dolomite. Note in particular that the large crystal in the center displays strongly curved crystal faces. This "saddle dolomite" (see Radke and Mathis, 1980) as well as the other coarse dolomite crystals with reddish luminescence are probably late, burial or hydrothermal dolomites that precipitated under elevated temperatures.

Bottom Photomicrograph

The same field of view is shown here under cross-polarized light at the same magnification. Note the sweeping extinction within the large crystal in the center, indicative of a strained crystal lattice. The bluish areas surrounding these replacement dolomites are remnants of intercrystalline pores.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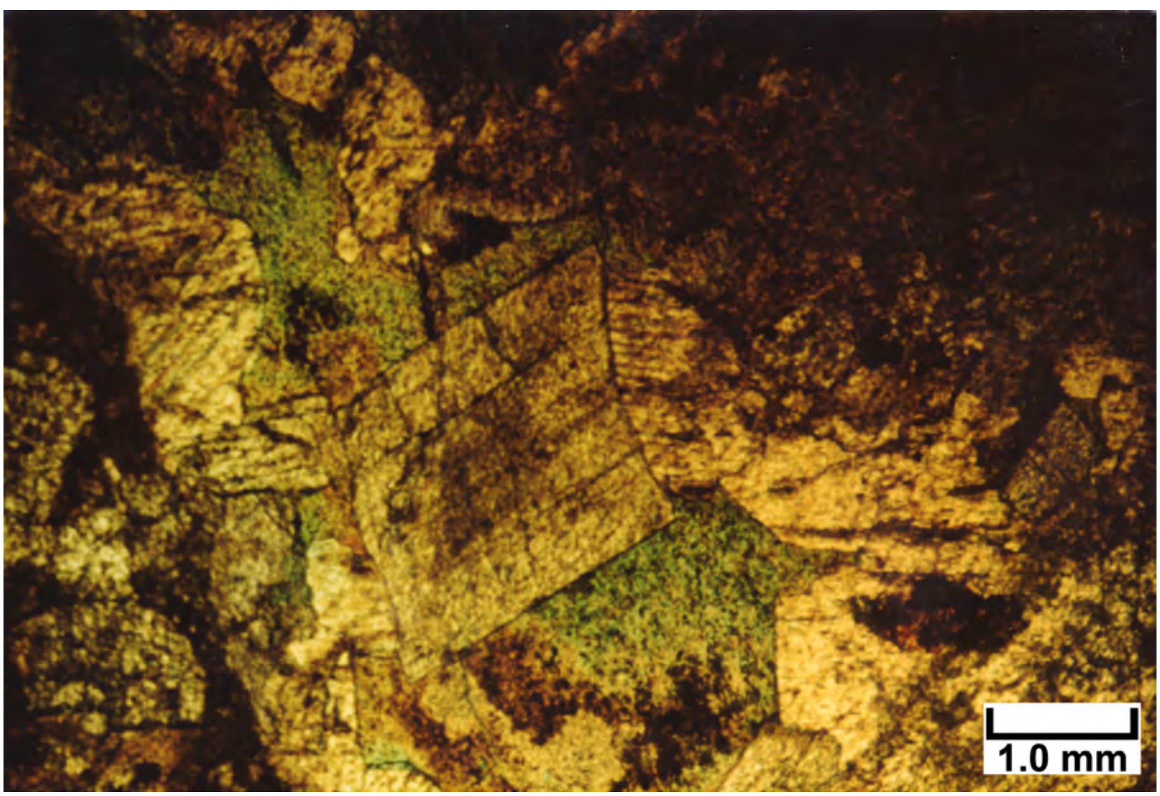
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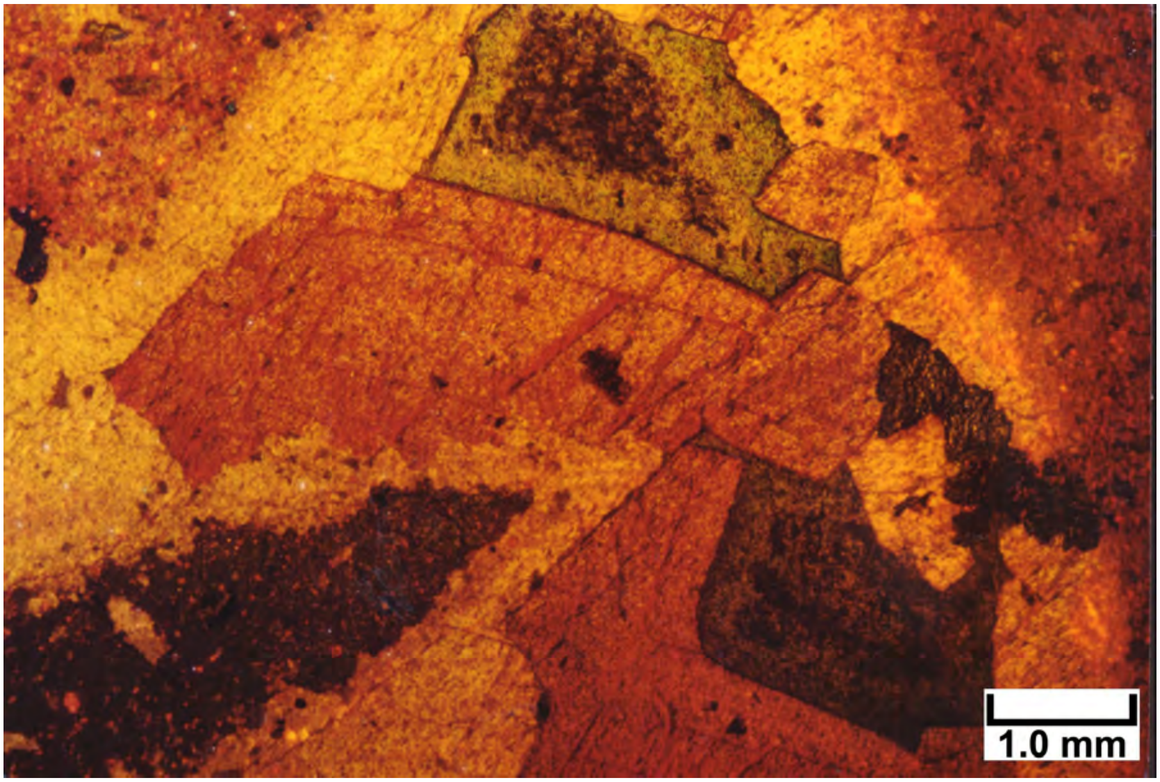
5870 feet

Top Photomicrograph

This CL view shows remnants of a muddy limestone matrix (wackestone) in the lower left and upper right corners of this micrograph that has been partially replaced by coarse dolomite crystals displaying curved faces. These "saddle dolomites" have a distinctive dull red and orange luminescence in which hints of the dolomite growth bands can be seen. Small inclusions of dark-colored, lime, wackestone matrix can be seen scattered throughout the coarse dolomite saddles, indicating that these saddle dolomites are replacing previous carbonates rather than being entirely cements.

Bottom Photomicrograph

The same field of view is shown here under cross-polarized light at the same magnification. Note the intercrystalline pores (blue areas) between some of the saddle dolomites. This view makes it possible to see where dolomite has replaced lime wackestone matrix (in the medium and dark brown areas) and where dolomite is a cement growing into open pores (the clear areas).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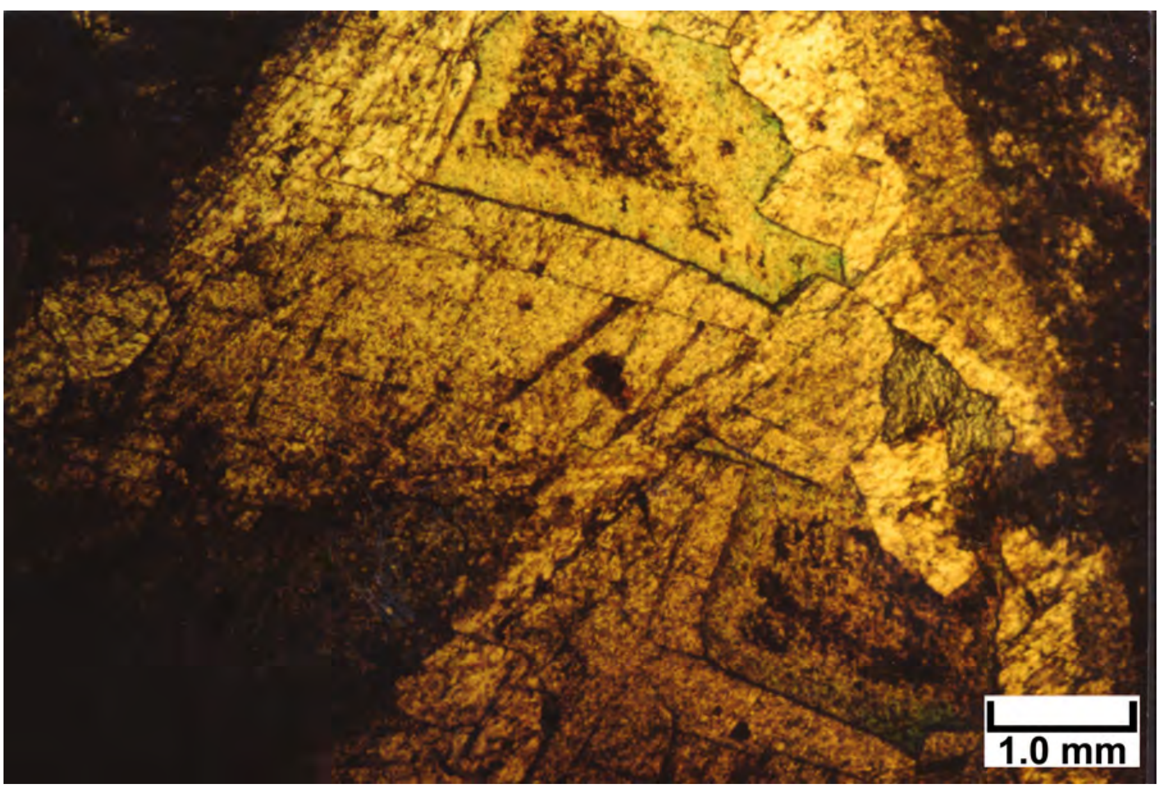
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