APPENDIX I: THIN SECTION EPIFLUORESCENCE AND DESCRIPTIONS, BUG AND CHEROKEE FIELDS, SAN JUAN COUNTY, UTAH

UTAH DNR GEOLOGICAL SURVEY

BUG 7-A WELL,
BUG FIELD

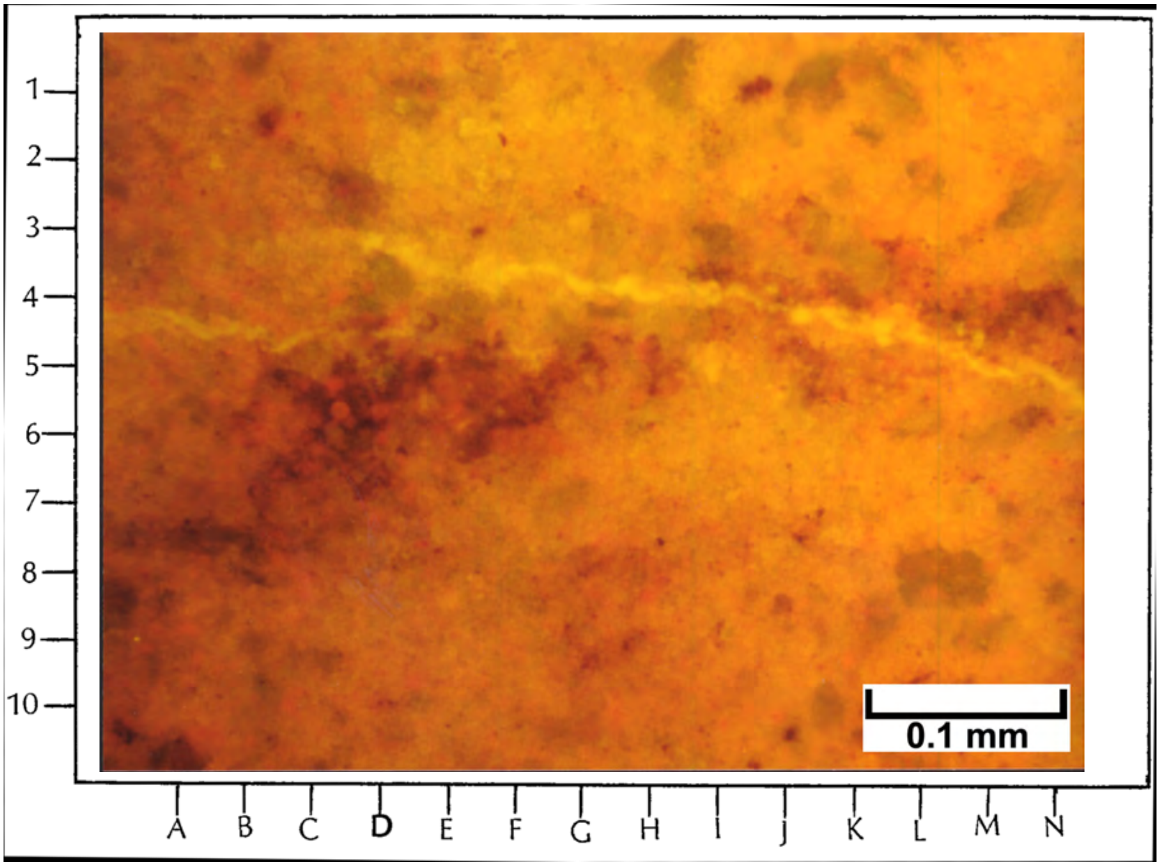
6359.3 feet

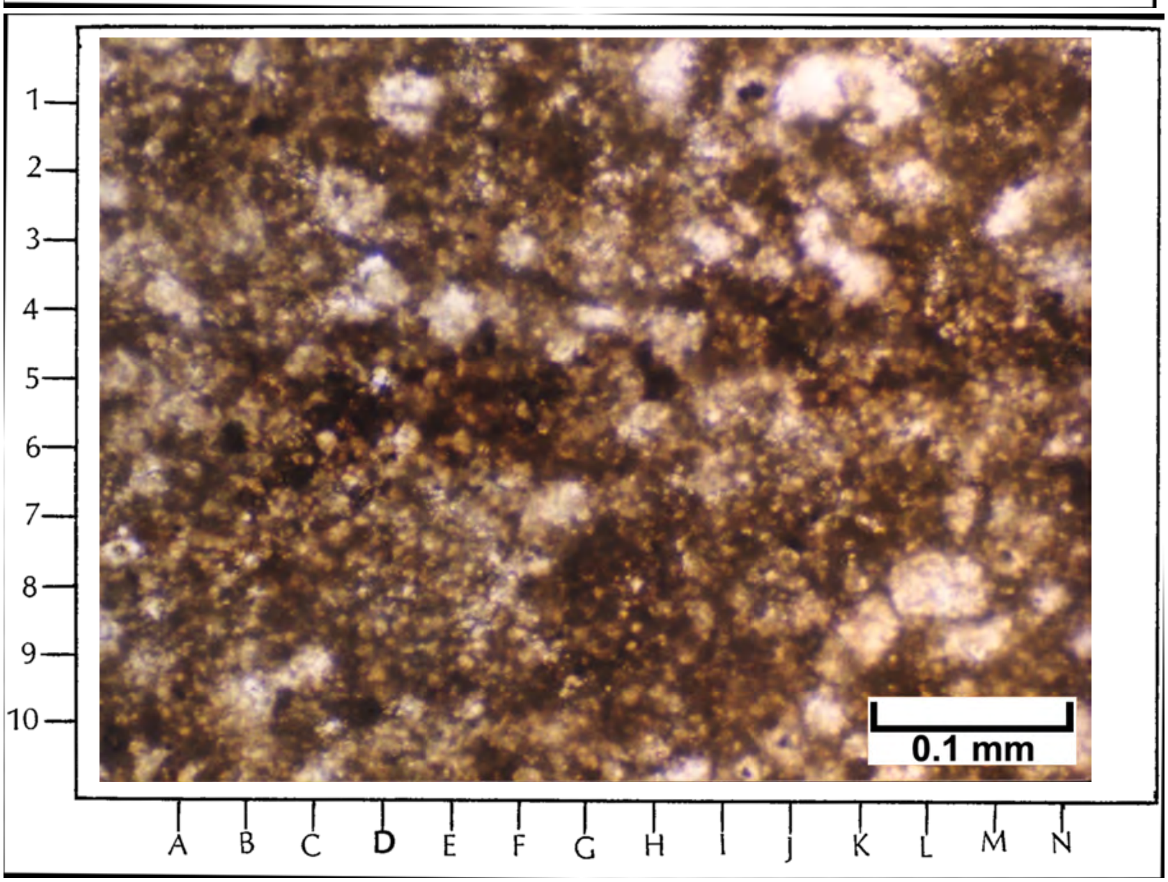
Top Photomicrograph

This dense dolomite matrix displays a number of features that are visible only under EF (compare with Pl below). A representative EF view of a very tight microcrystalline dolomite shows the absence of any significant megascopic matrix porosity. However, the matrix displays a yellowish orange color, indicating probable live oil saturation of this tight dolomite. Notably, there is an open microfracture, with an offset in the upper left center portion of the photomicrograph. It appears bright yellow here due to the fluorescence of “live” hydrocarbons. This microfracture crosses and post-dates a microstylolite marked by the black, jagged pattern across this view from lower left to right center. Most of the rest of the massive (mud-rich) matrix displays a mottled yellow and orange color due to oil saturation in this dolomite. Although there are no readily visible grains in the field of view, there are a few discrete dolomite crystals that appear as the dark green areas.

Bottom Photomicrograph

The same view as above is displayed here under Pl. Some of the medium to dark-brown color of this dolomite may be the result of oil staining as indicated by the yellowish orange color in the EF view above. Note the poorly preserved peloids and possible fossils in this aphanitic to anhedral dolomite. Some of the larger non-planar dolomite crystals appear white in this view. The open, en echelon (offset) fractures and the wispy microstylolites seen in the top image are very indistinct across the length of this photomicrograph.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

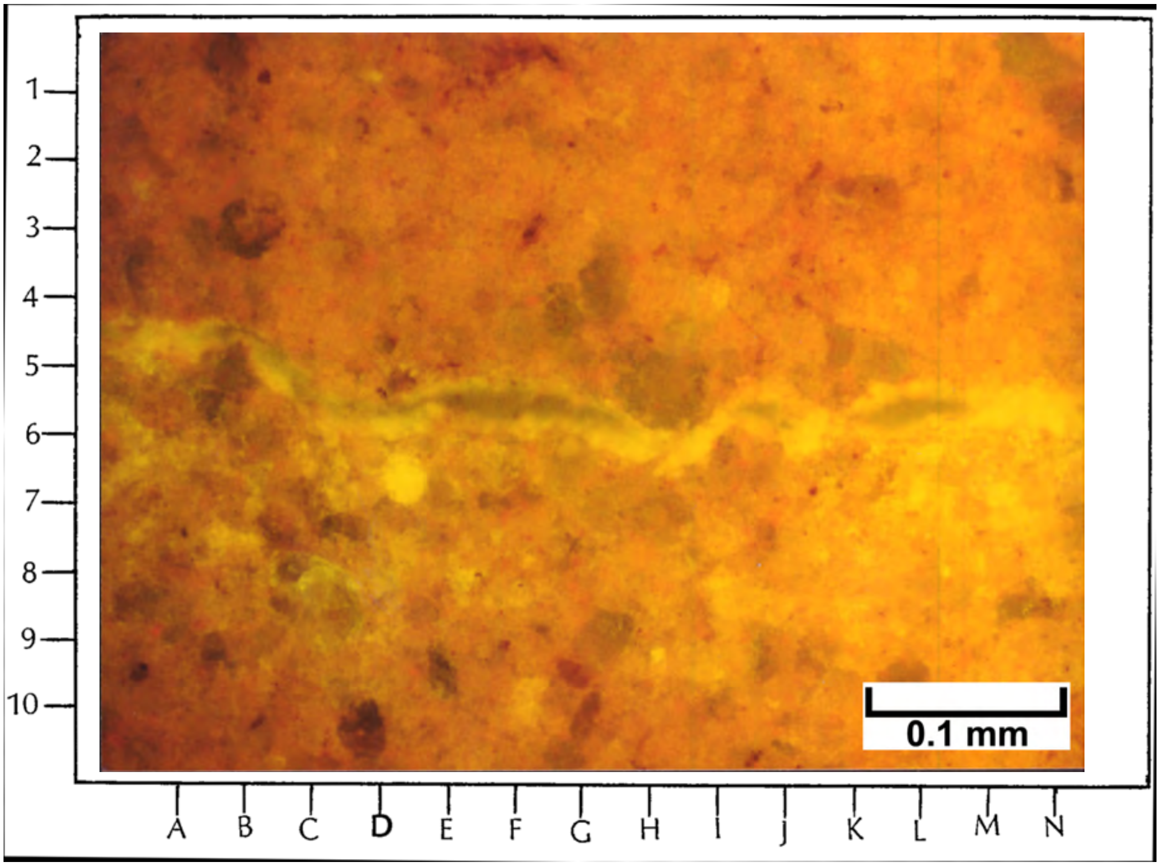
6359.3 feet

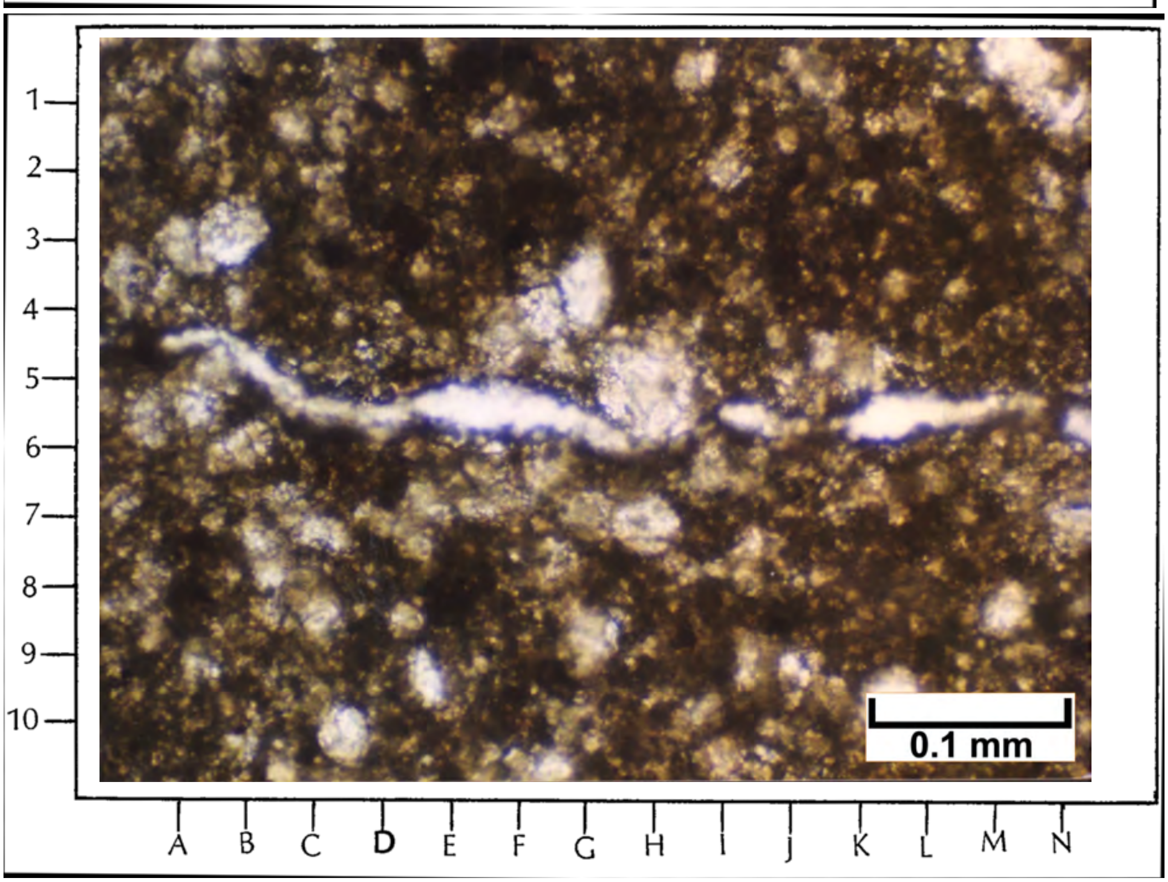
Top Photomicrograph

Epifluorescence of this tight dolomite matrix shows probable good oil saturation within the matrix (as shown in the yellowish orange hues). Relatively unsaturated areas are shown in the darker red and greenish colors. Note the partially healed fracture showing apparent oil staining (in bright yellow) across the length of this photomicrograph (from left center to right center).

Bottom Photomicrograph

The same view at the same magnification as above is shown here under Pl. Note the dark-colored matrix, which may partially be the result of oil staining (see the EF view above). Also observe that the length-wise fracture appears white in this image.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

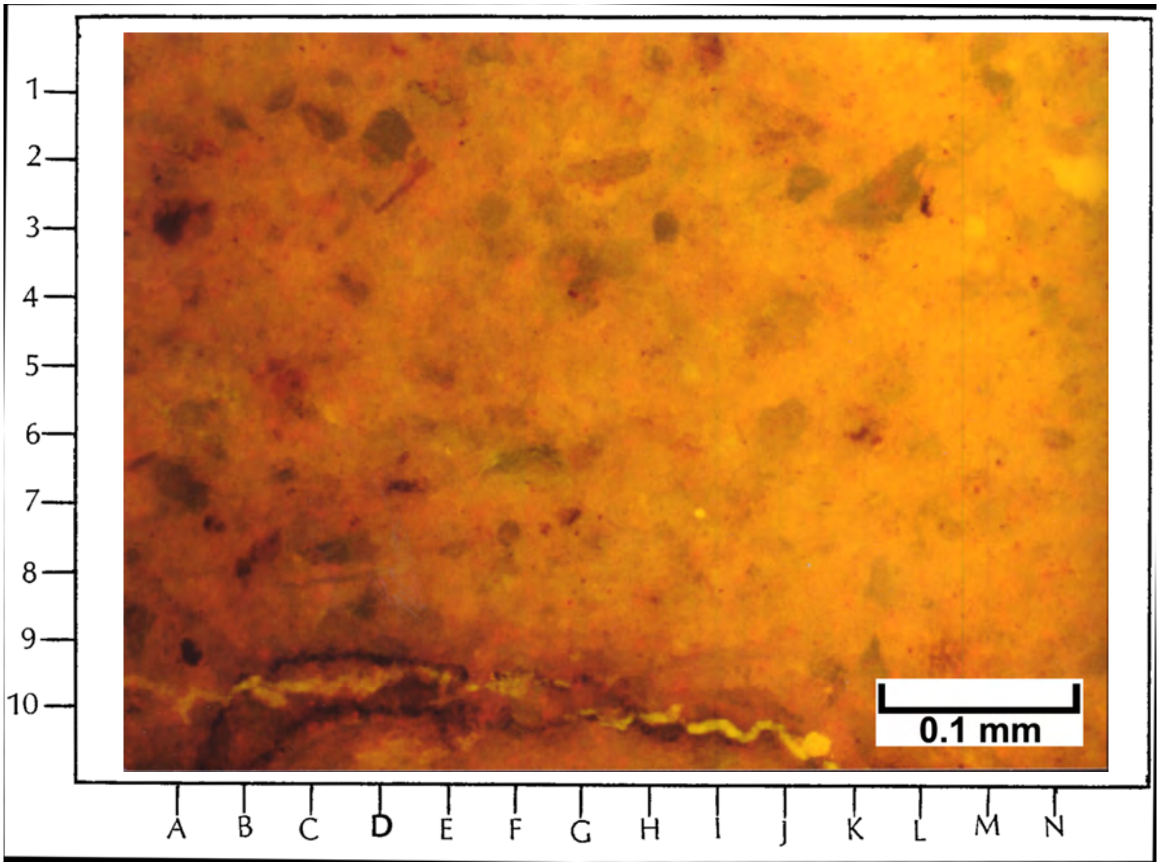
6359.3 feet

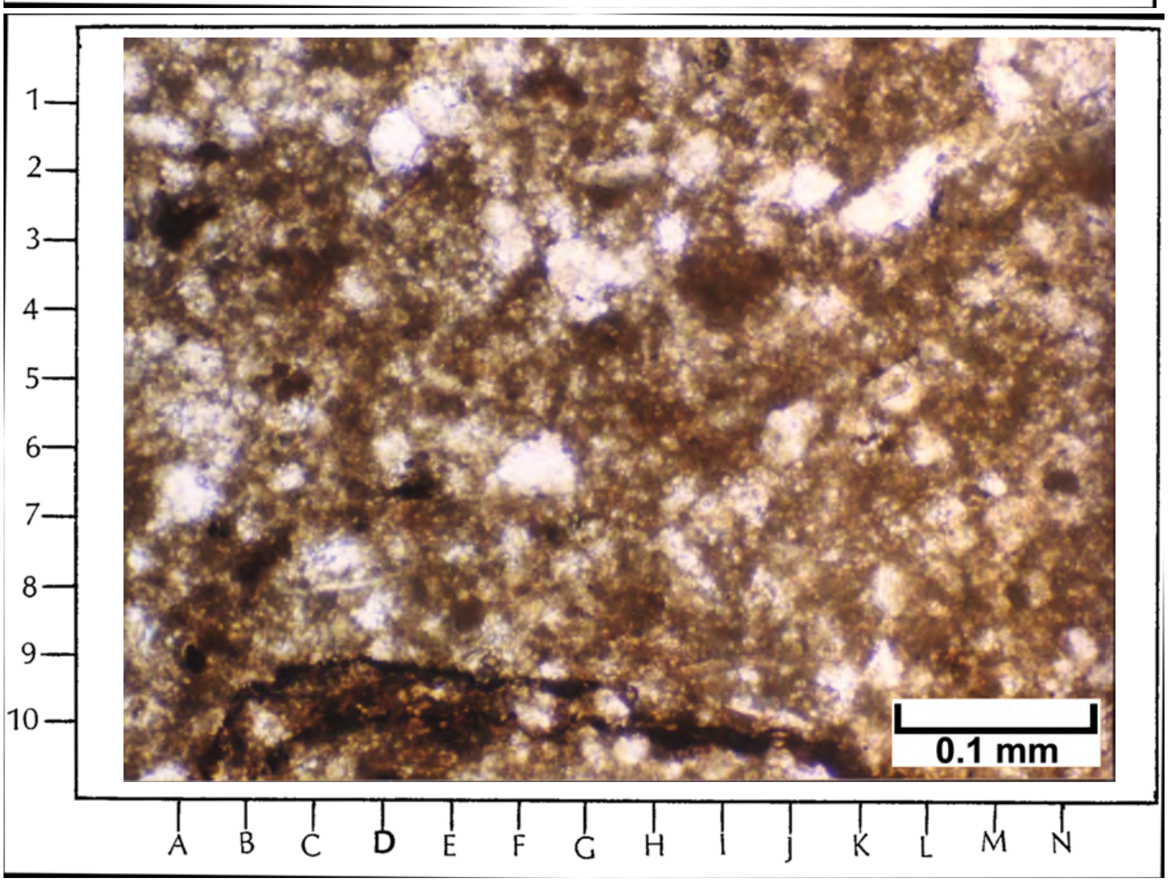
Top Photomicrograph

This is another EF view of a tight area of dolomite matrix that appears to have some oil saturation (as shown) in the yellowish orange hues. Larger individual dolomite crystals can be seen in the dark gray to greenish gray areas. Hints of carbonate grain outlines can also be seen. Note the low-amplitude stylolites and stylo-fractures with the live "oil" staining (in very bright yellow) across the bottom of this photomicrograph. Otherwise, the finely crystalline matrix of this dolomite is very tight.

Bottom Photomicrograph

The same view as above is shown under Pl. Note the mottled white and dark gray colors displayed by this very low-porosity dolomite. The low-amplitude stylolitic and stylo-fractured portions of this sample are very difficult to resolve under Pl.


0.1 mm


0.1 mm

BUG 10 WELL,
BUG FIELD

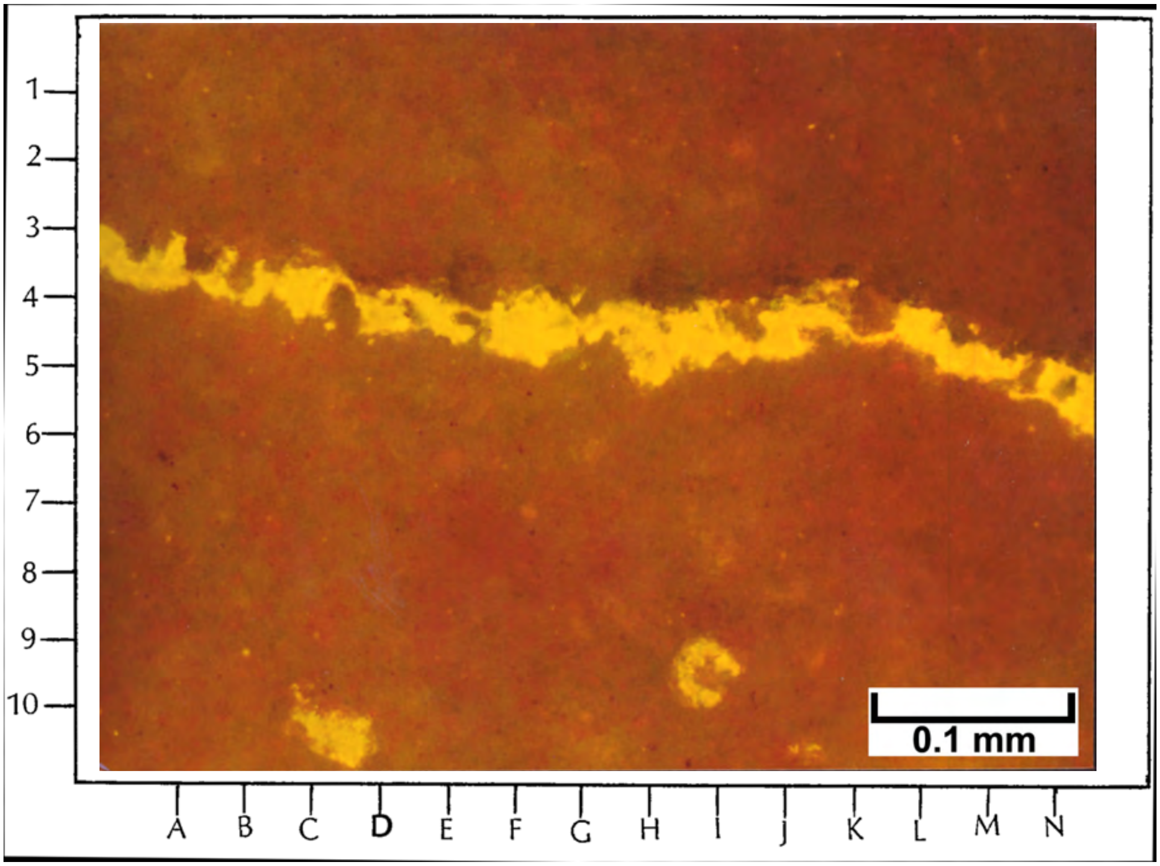
6327.9 feet

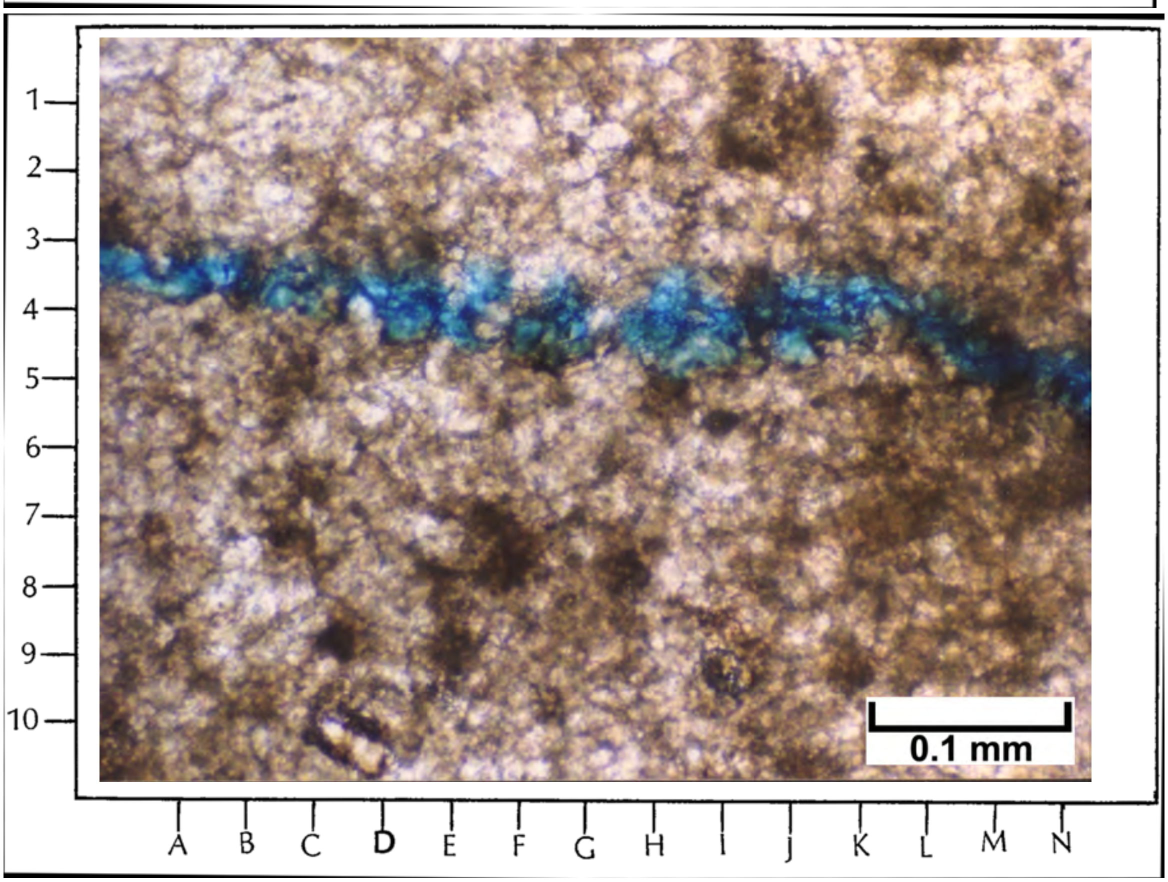
Top Photomicrograph

Isolated pore systems (in bright yellow) shown here are surrounded by dark, non-fluorescent dolomites. Note the open fracture (cutting across the length of this view) that is lined with dolomite crystals (the non-fluorescence crystal outlines). A small number of isolated pores (also in yellow) can be seen "floating" in the dense, tight dolomite matrix.

Bottom Photomicrograph

The same view as above under Pl does not show the clarity of the dolomite/pore relationships as the EF view. Although there is a linear bluish region across this photomicrograph (due to epoxy impregnation of the open fracture), the coarse dolomite crystals lining of the linear fracture cannot be seen here. In addition, it is impossible to see the isolated open pores such as those seen in the top EF photomicrograph.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

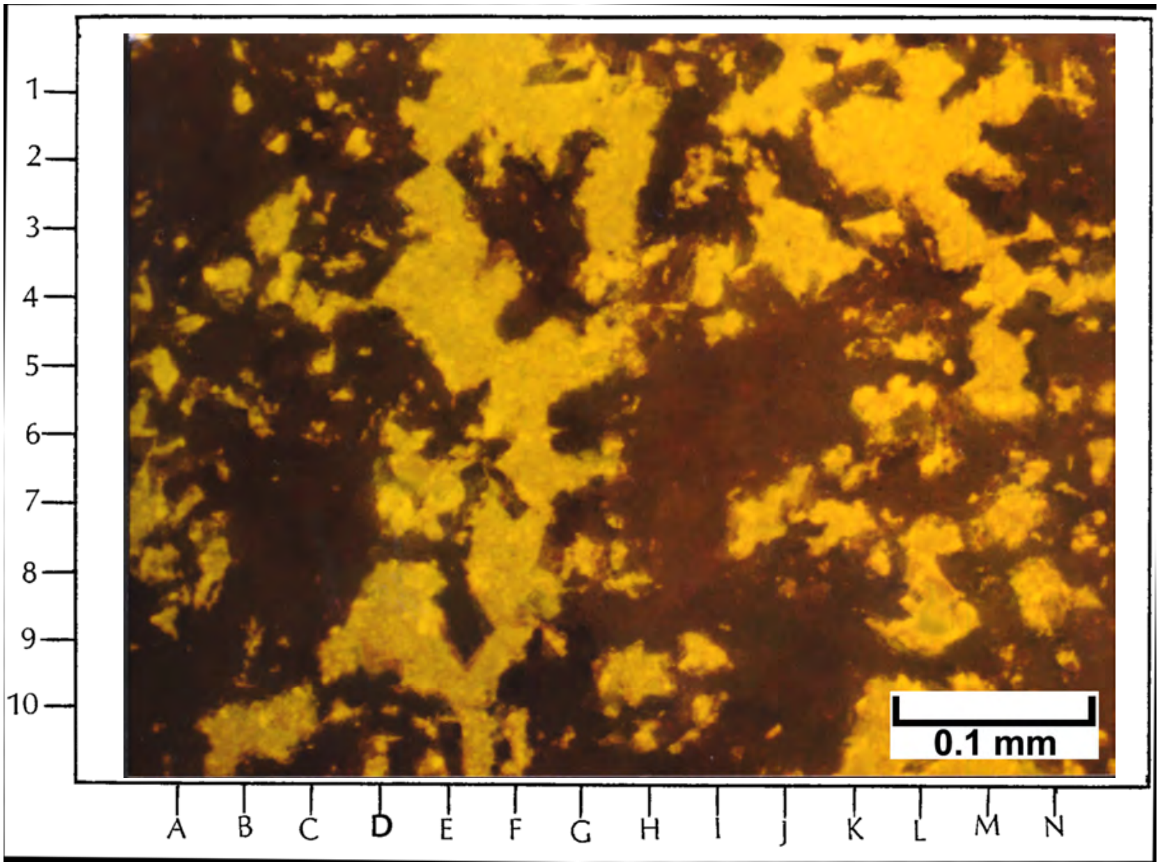
6327.9 feet

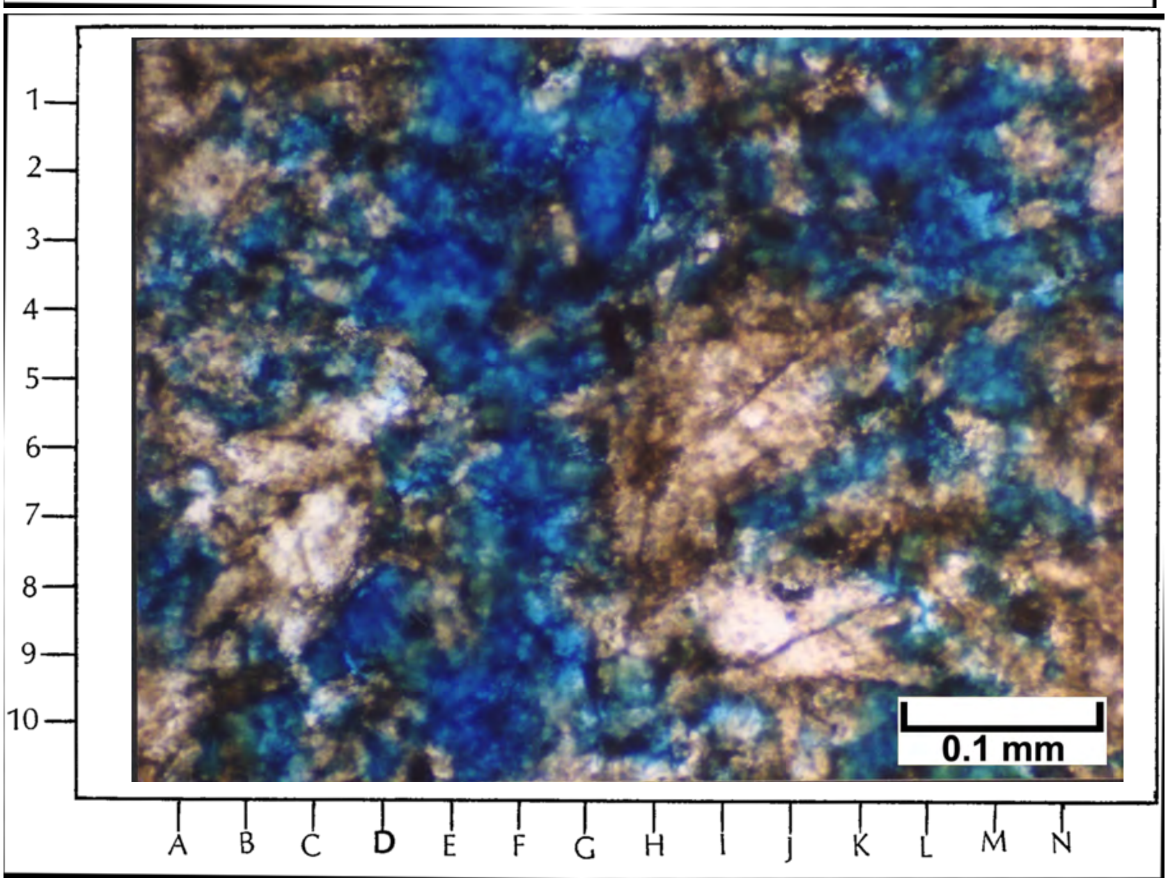
Top Photomicrograph

A heterogeneous micro-box-work of dolomite is displayed here, where the dolomite crystal aggregates appear dark gray and the open pores between the dolomite are bright yellow (due to spiked epoxy and "live oil" lining pores). Some of the pores appear to be well connected while others are isolated by interlocking dolomite crystals. Hence, some of these large pores may be "blind" or lack interconnections. Note that there is very little evidence of intercrystalline porosity within the dense dolomite areas.

Bottom Photomicrograph

The same field of view as above under Pl shows fuzzy relationships between the cross section of pores (impregnated with blue epoxy) and the poorly sorted dolomite crystal matrix. No grains or structures are visible within the dolomites in this image.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A
B
C
D
E
F
G
H
I
J
K
L
M
N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A
B
C
D
E
F
G
H
I
J
K
L
M
N

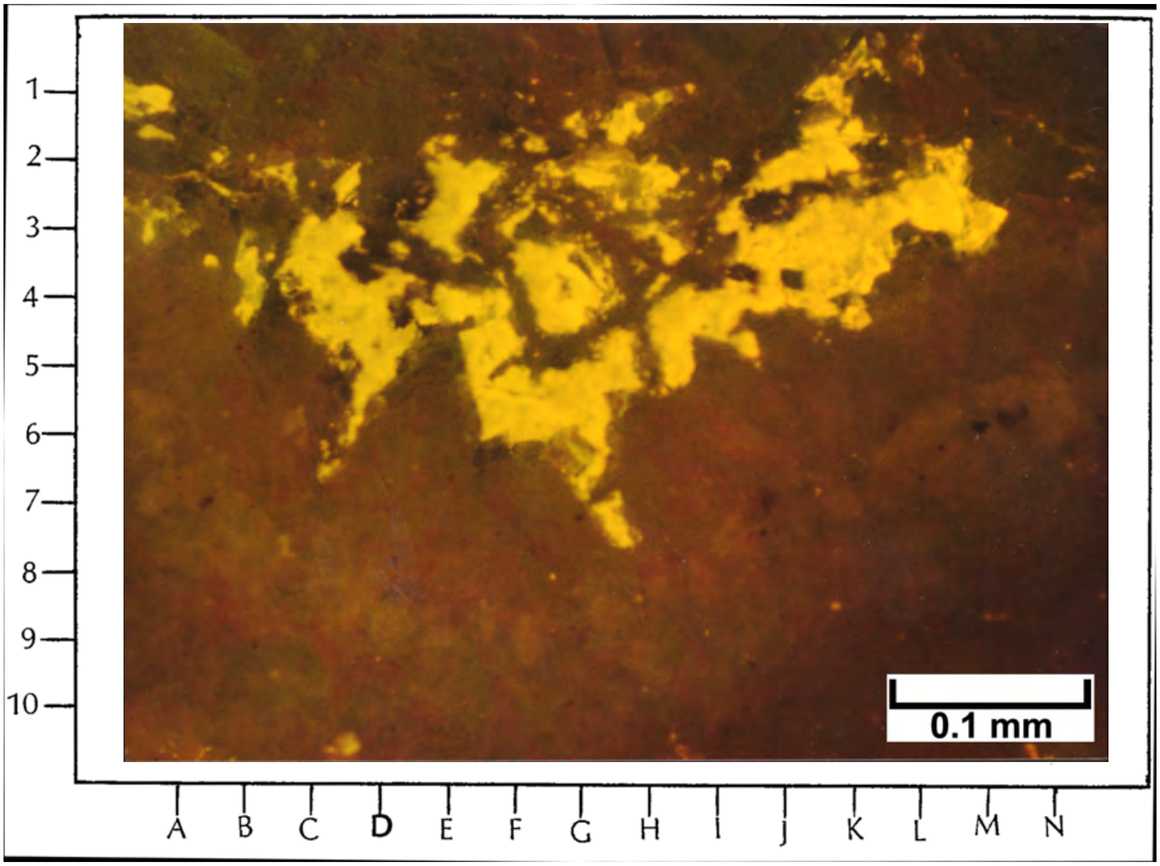
6327.9 feet

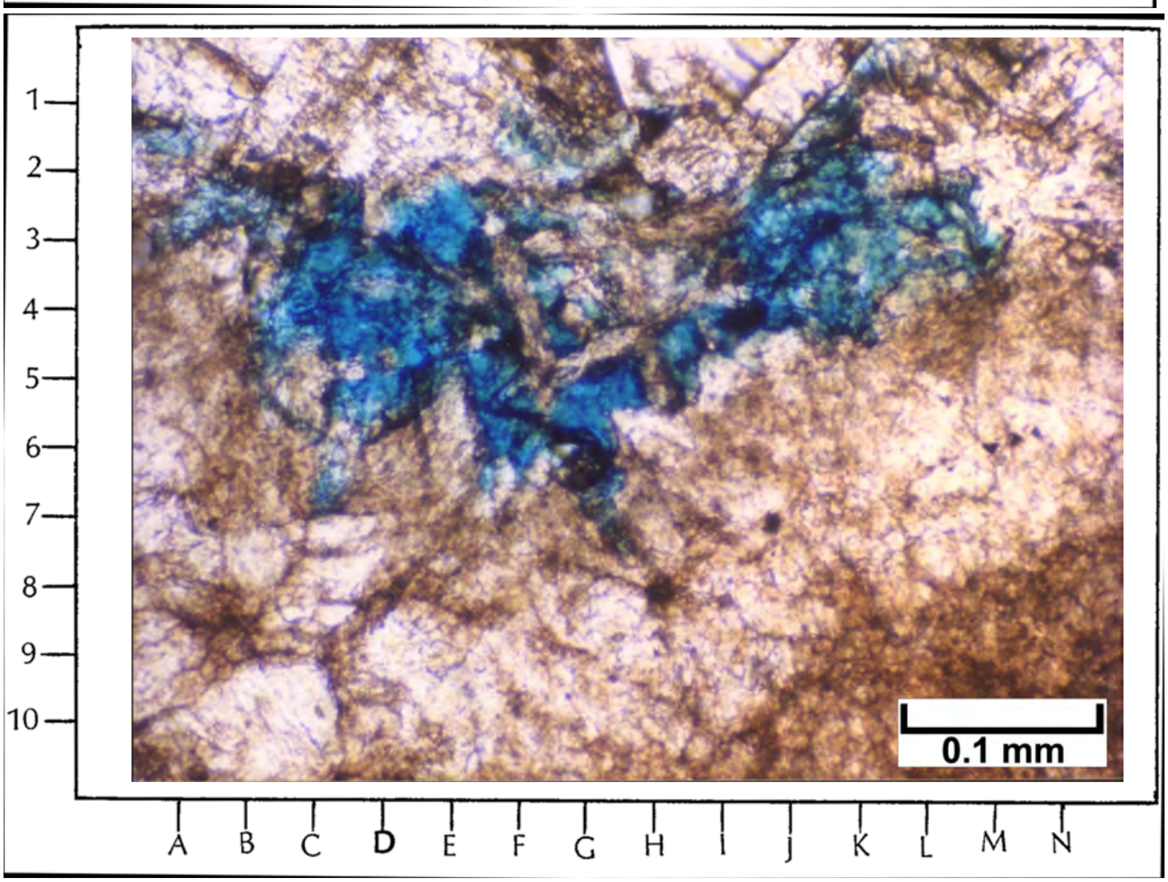
Top Photomicrograph

This EF view shows the distribution of open pore cross sections (in yellow). Some of the brightest yellow patches are probably due to “live oil” still “bleeding” from this reservoir rock. The dark areas that make up most of this photomicrograph are composed of a very tight dolomite matrix that tends to isolate the areas of porosity (in yellow). Note the very angular character of these crystal-pore boundaries. These dolomite crystals create a very delicate micro-box-work separating the pores. Note that some pore throats are wide and open while other pores are “blind” and dead end into dolomite partitions (the non-fluorescence elements between the bright yellow fluorescent areas).

Bottom Photomicrograph

The same view at the same magnification as above is shown in the Pl image. Note that the crystal/pore intersections are not as sharp or as “in-focus” as the EF view above. The blue-dyed epoxy that impregnates pore space is not as easy to view as the clearly defined yellow spaces in the top EF image.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A
B
C
D
E
F
G
H
I
J
K
L
M
N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A
B
C
D
E
F
G
H
I
J
K
L
M
N

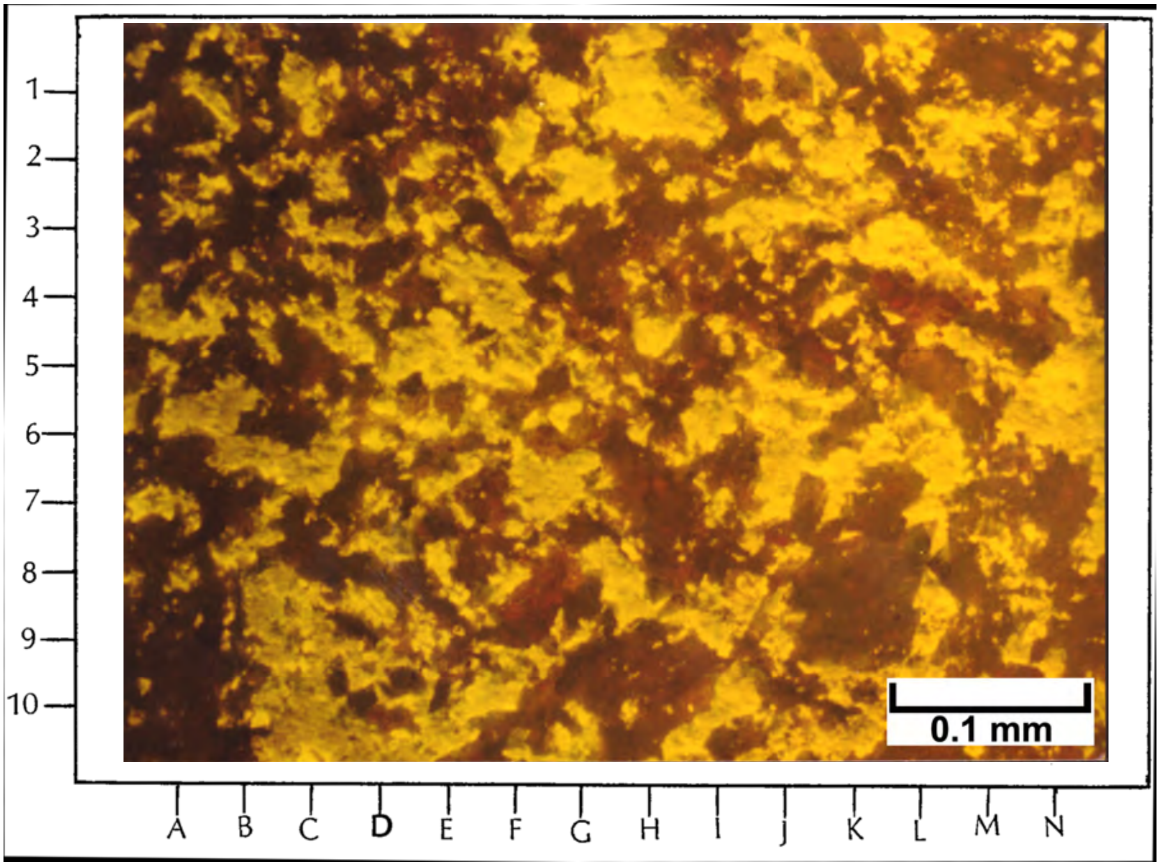
6327.9 feet

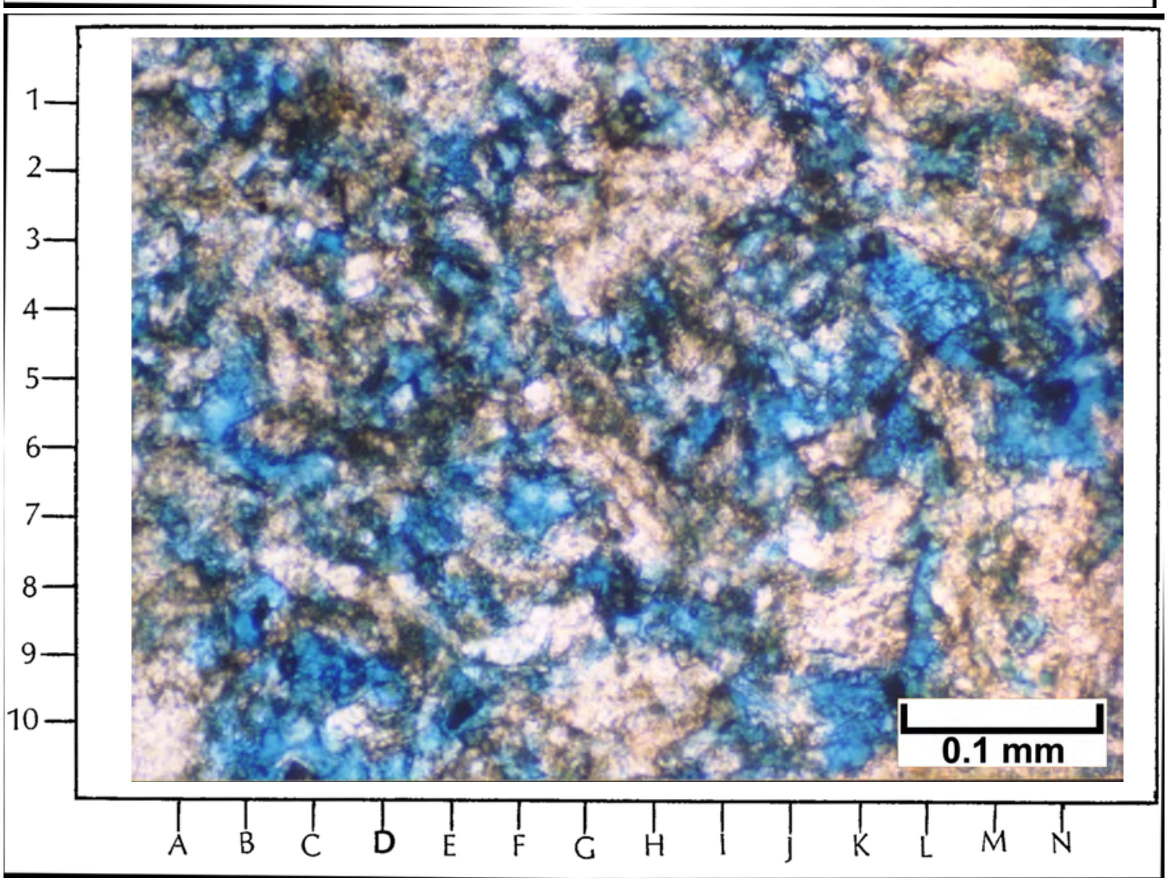
Top Photomicrograph

This overview EF photomicrograph shows a very complex network of micro-box-work structure throughout the entire field of view. The yellow areas show cross sections of open pores impregnated with epoxy and lined with some residual oil. The remaining dark areas in this field of view are non-porous dolomite crystal aggregates. In this view, most pores appear to be well connected, but some are isolated or “blind.”

Bottom Photomicrograph

A Pl image of the same field of view as above shows pores in blue and dolomite crystals in white and brown. Note that the dolomite crystals appear to be uniformly dense or difficult to resolve, but the pore space/dolomite contacts are clearly defined under EF.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

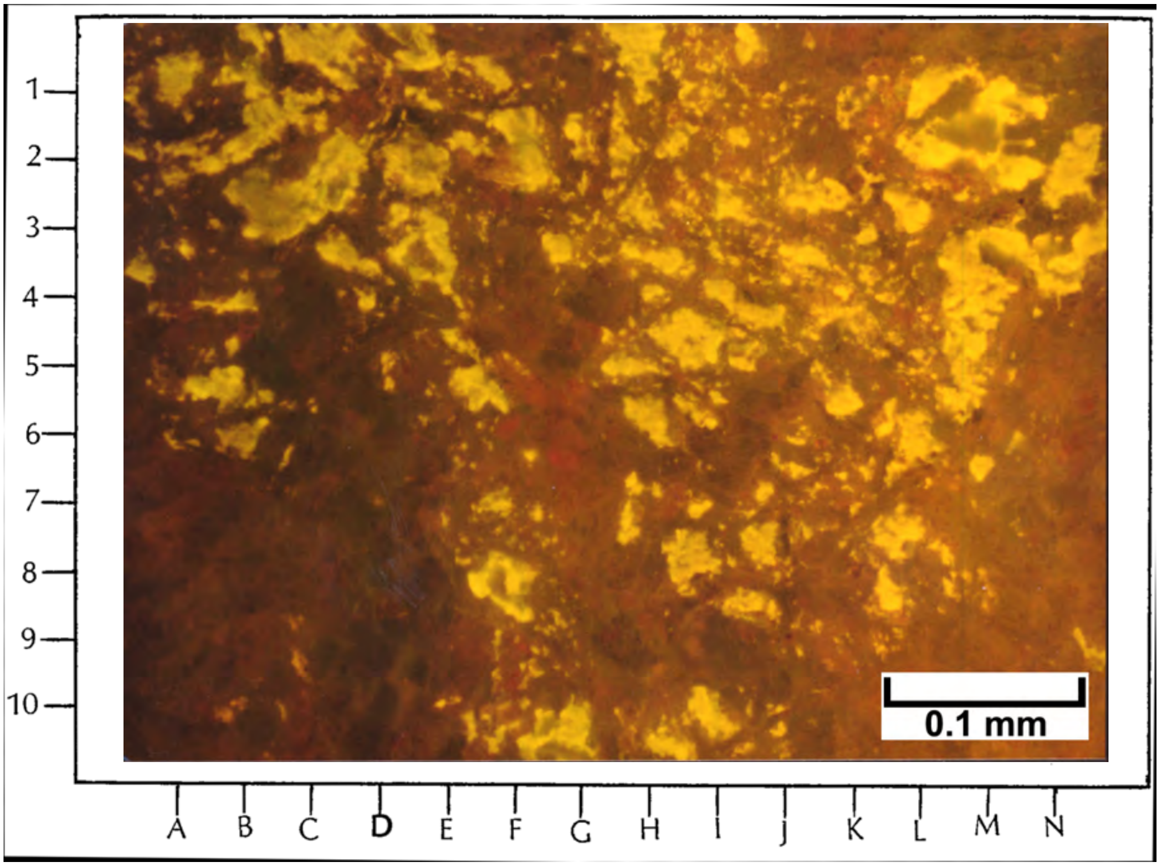
6327.9 feet

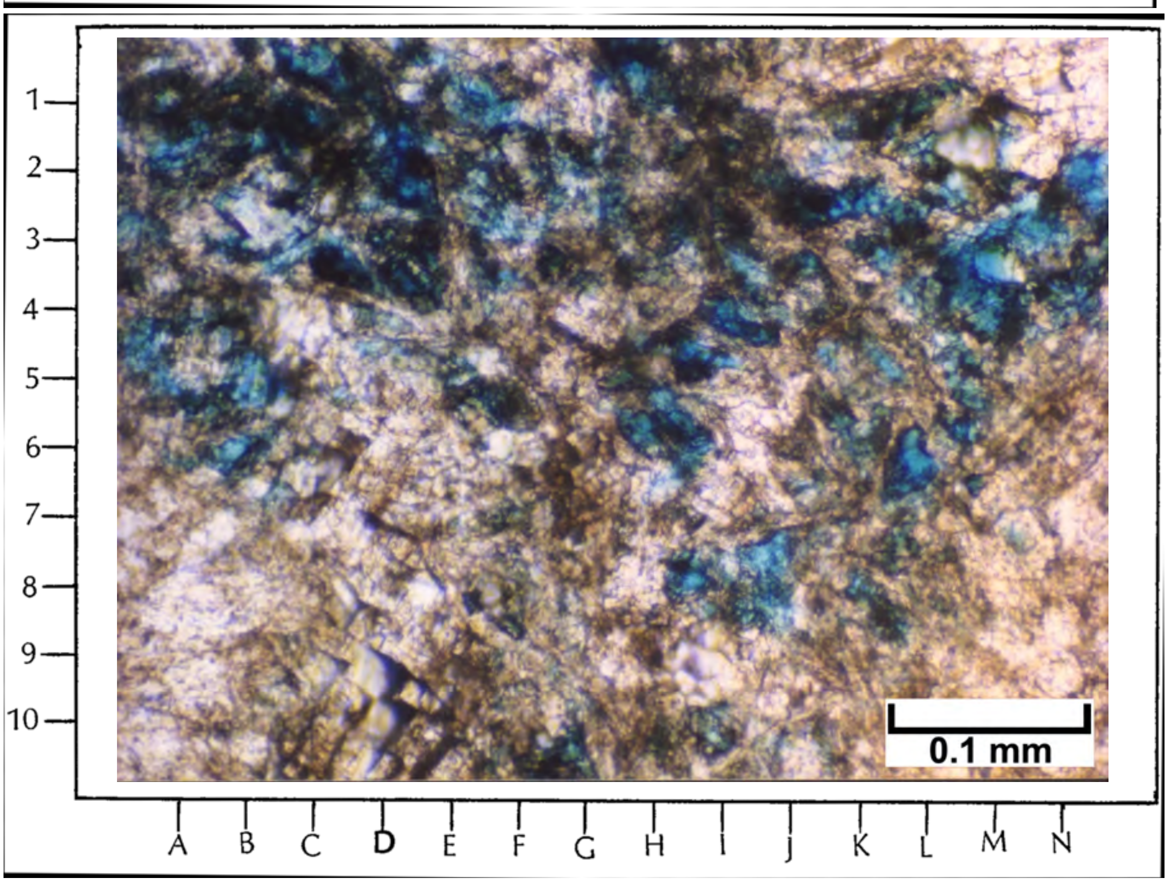
Top Photomicrograph

An extensive pore system (in bright yellow) shown here is surrounded by dark, non-fluorescent dolomite exhibiting a wide variety of shapes, including blunt-ended blades of dolomite as well as interlocking partitions. The open pores occur between a loose micro-box-work of hollow crystals and solid dolomite crystal aggregates, thus contributing considerable heterogeneity and some isolation to this pore system.

Bottom Photomicrograph

The same view as above under Pl does not show the clarity of the dolomite/pore relationships as does the EF view. Note that the boundaries between open pores and the dolomite partitions making up this micro-box-work are not very easy to see under Pl. The pores (in blue) clearly appear to be partly of a dissolution origin as shown by the corroded margins of many of the dolomite crystals and crystal aggregates.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

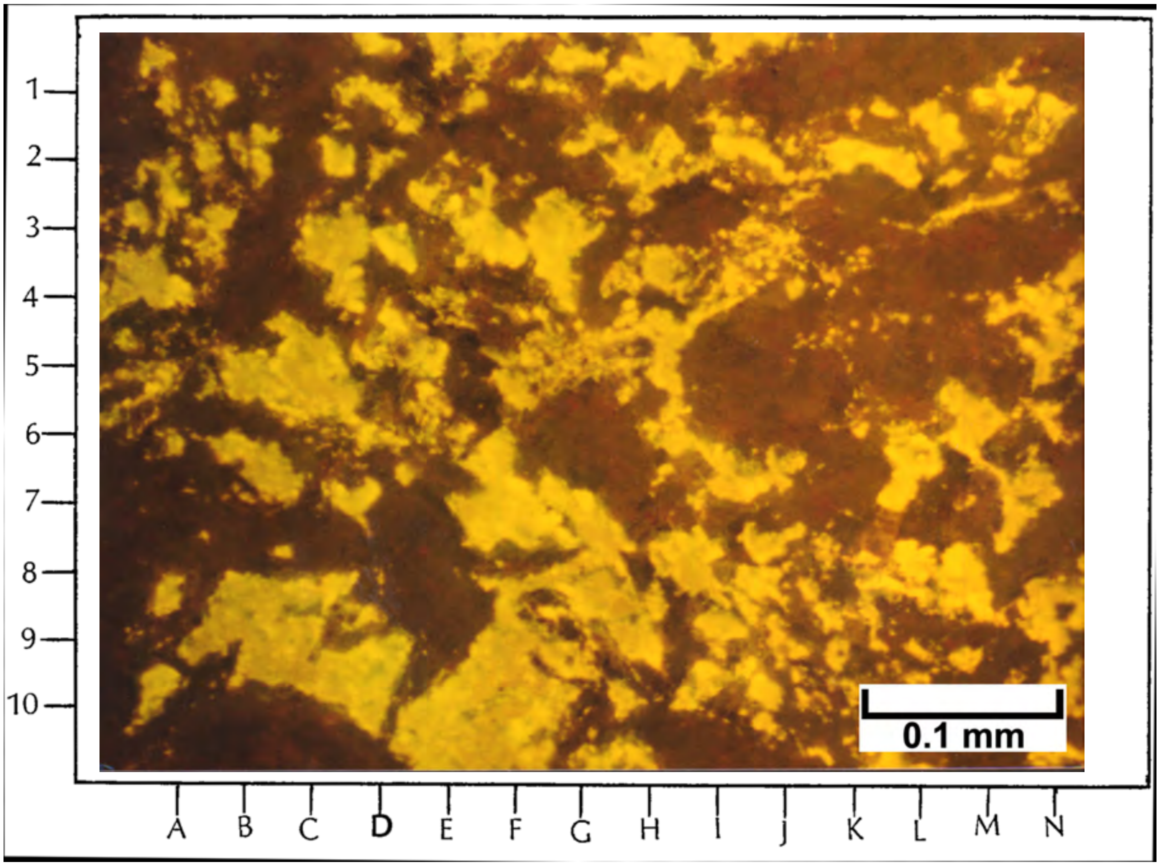
6327.9 feet

Top Photomicrograph

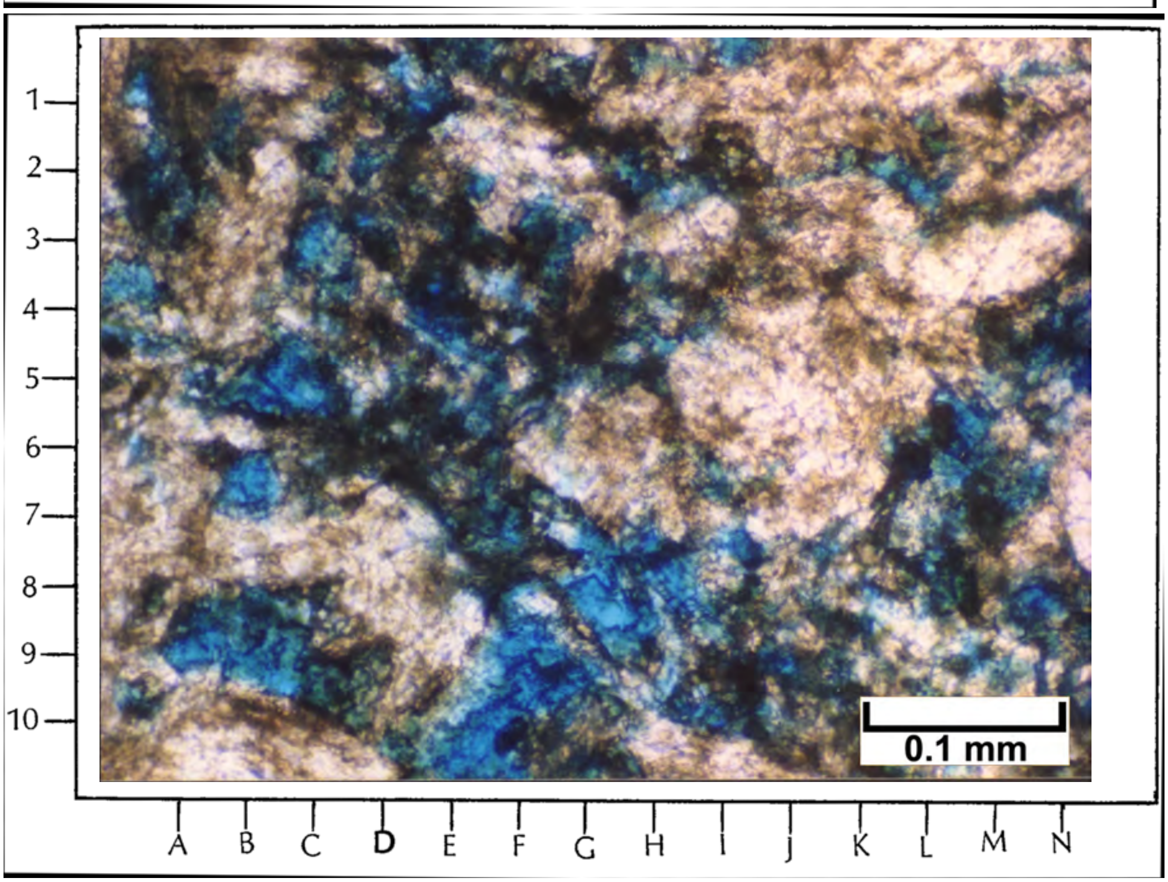
Epifluorescence shows an interconnected micro-box-work of interlocking dolomite crystal aggregates (in dark brown) that serves to isolate open pores (in bright yellow). Note the different apparent thicknesses of the elements of dolomite. This micro-box-work adds considerable heterogeneity to this oil-productive reservoir dolomite. Isolation of open pores is common within this micro-box-work dolomite.

Bottom Photomicrograph

The same view as above is shown here under Pl. Even though the blue areas show porosity here, the visible boundaries between interconnected dolomite crystals and pore outlines are less distinct than in the EF view above.



1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N



1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

BUG 16 WELL,
BUG FIELD

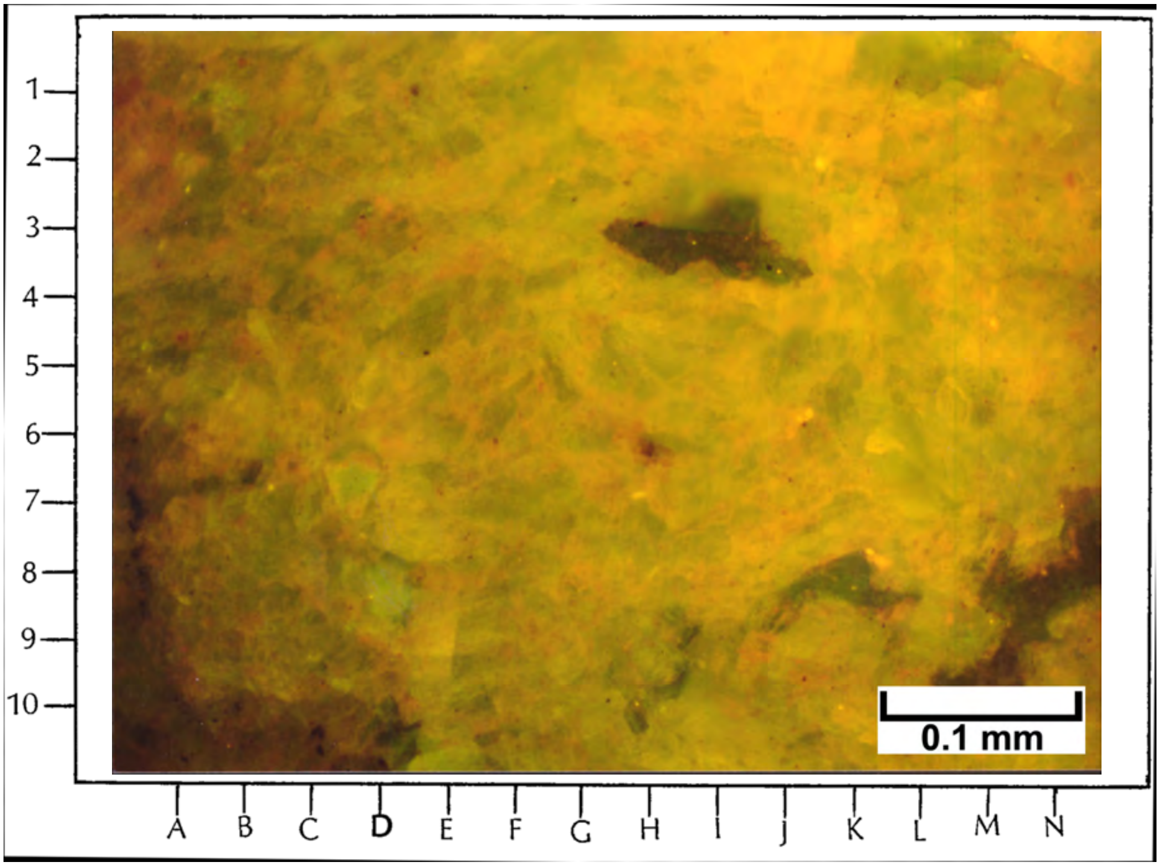
6299.3 feet

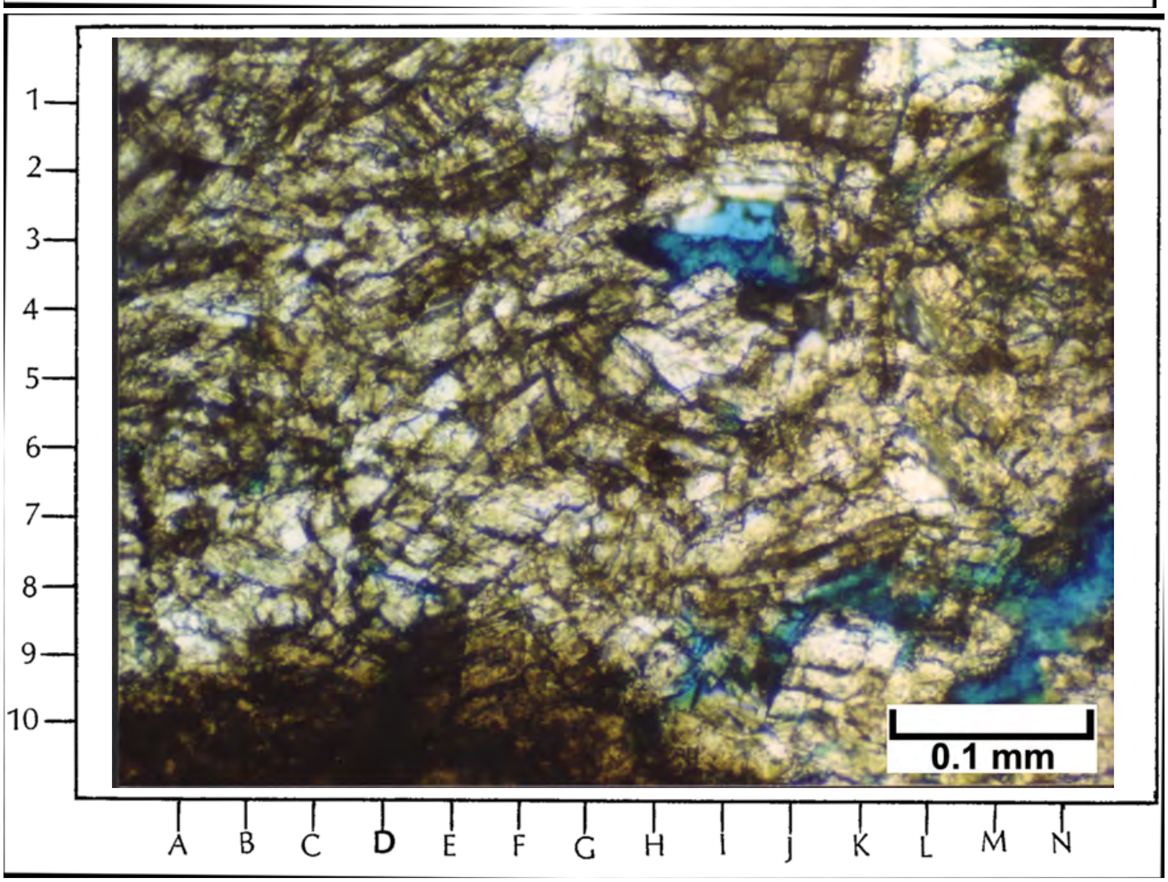
Top Photomicrograph

This portion of the sample displays very tight, moderately coarse, interlocking dolomite crystals with low visible porosity. Note the intense yellow to orangish yellow fluorescence that appears to surround the dolomite subcrystals and microfractures. This yellow fluorescence is probably due to the presence of "live" and/or relict hydrocarbons within the tight intercrystalline spaces. Some of the black and reddish colors in this view may be the result of bitumen lining some of the few isolated open pores.

Bottom Photomicrograph

The same photomicrograph as above is imaged here under Pl. The dark gray areas within the interlocking dolomite crystals are probably due to organic matter or oil staining. This staining makes it possible to see the subcrystal boundaries and probable microfractures within them. The small amount of open-pore space in this view is shown in blue, with black bitumen linings.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

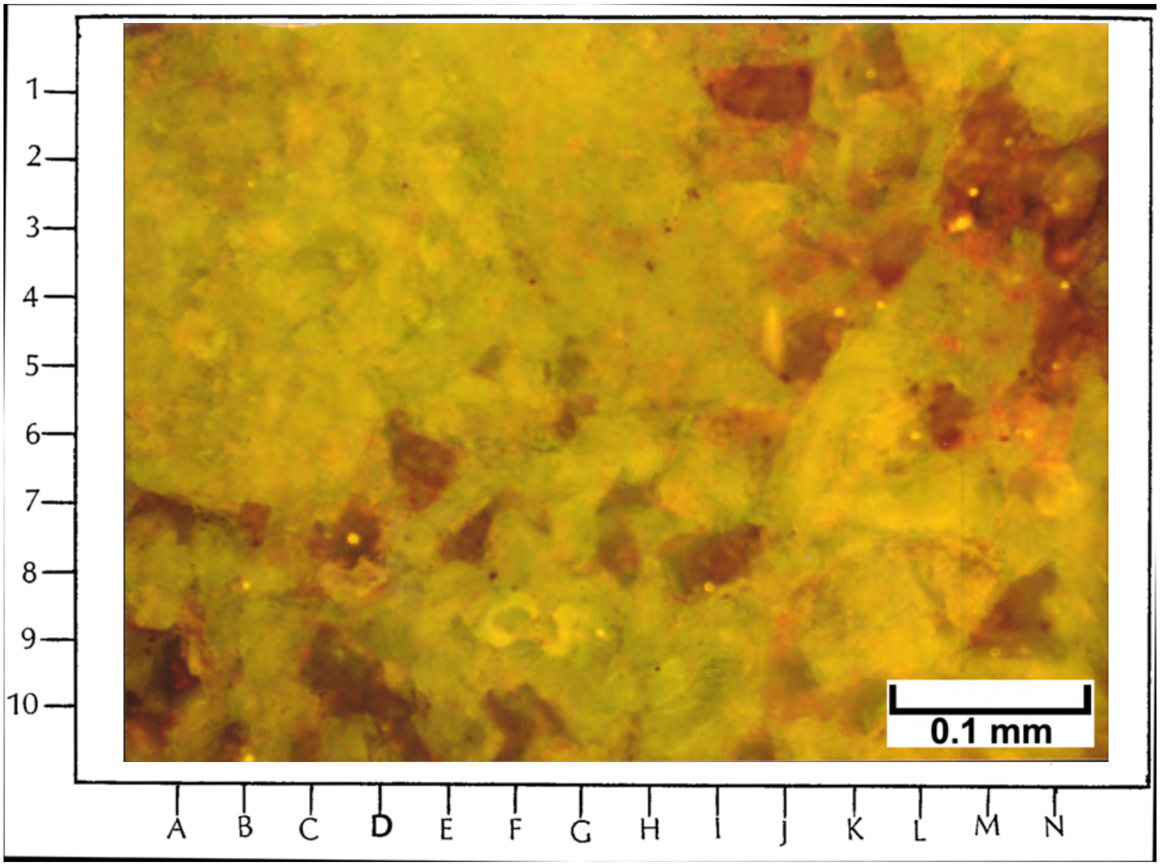
<u>6299.3 feet</u>

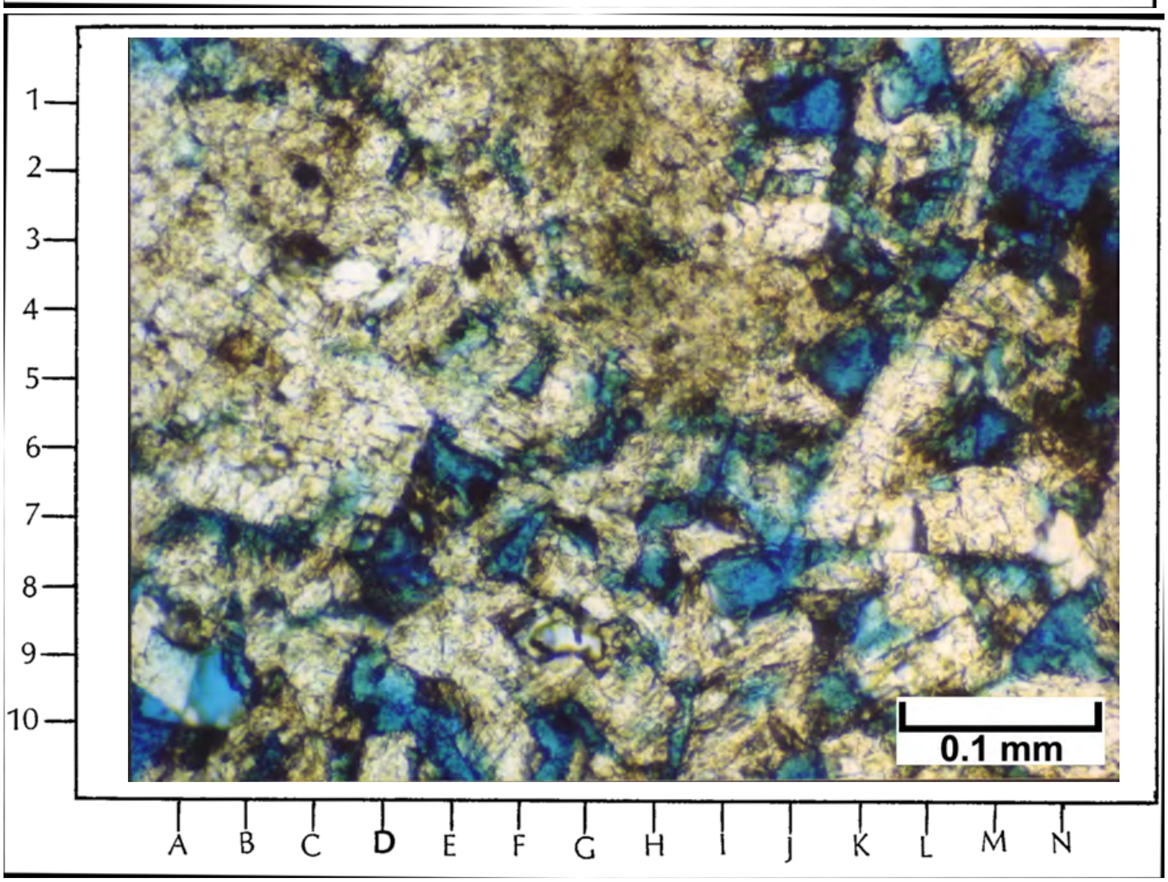
Top Photomicrograph

The EF view shows reddish fluorescence and non-fluorescence (black areas) where open pores and bitumen-lined pores have been impregnated with epoxy. The range of yellow fluorescence colors occurs within dolomites containing organic matter and live oils. Some of the dolomite crystals display very good crystal zonation as shown by the fluorescence patterns.

Bottom Photomicrograph

The Pl view shows epoxy-impregnated pores in blue, and dolomite crystals in the white to light brown areas. Note the outlines of crystals and pores are not as crisp as in the EF image above. In addition, the zonation of dolomite crystals and their organic content cannot be seen as well as in the EF view.


1 2 3 4 5 6 7 8 9 10
A B C D E F G H I J K L M N
0.1 mm


1 2 3 4 5 6 7 8 9 10
A B C D E F G H I J K L M N
0.1 mm

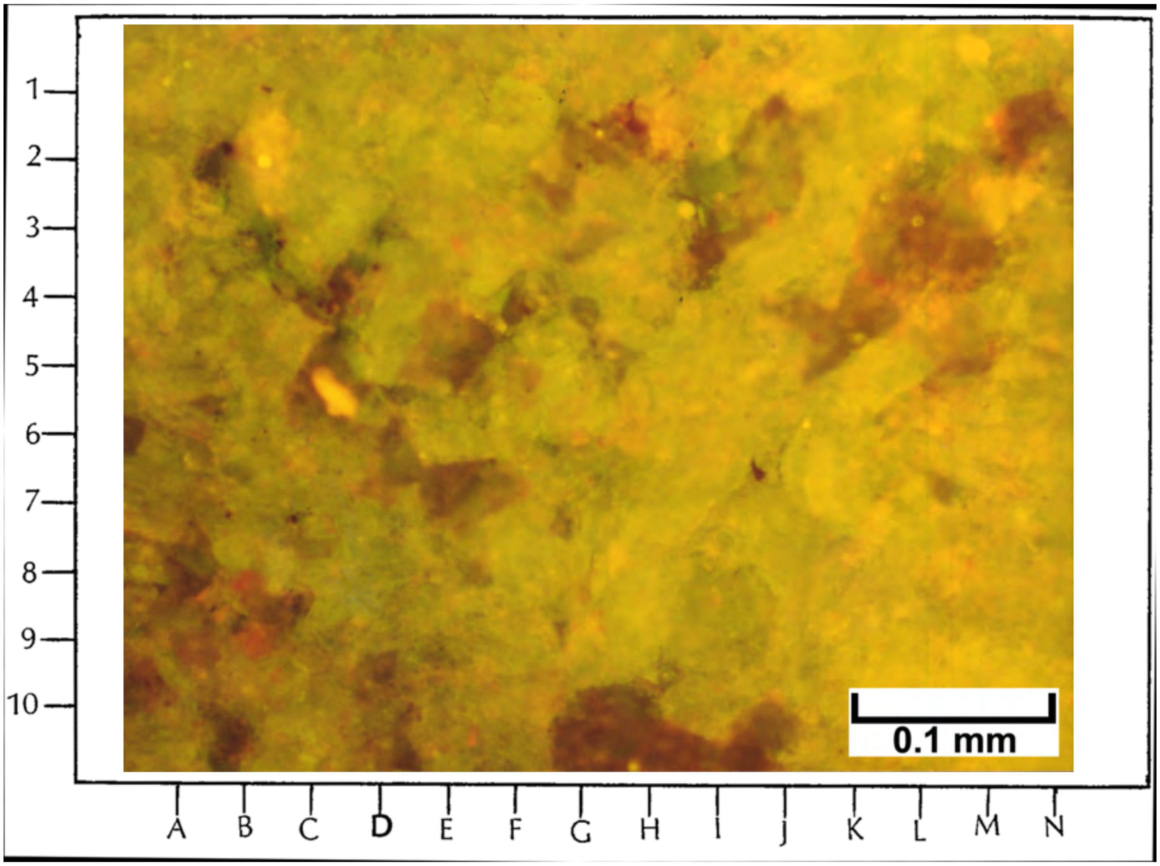
6299.3 feet

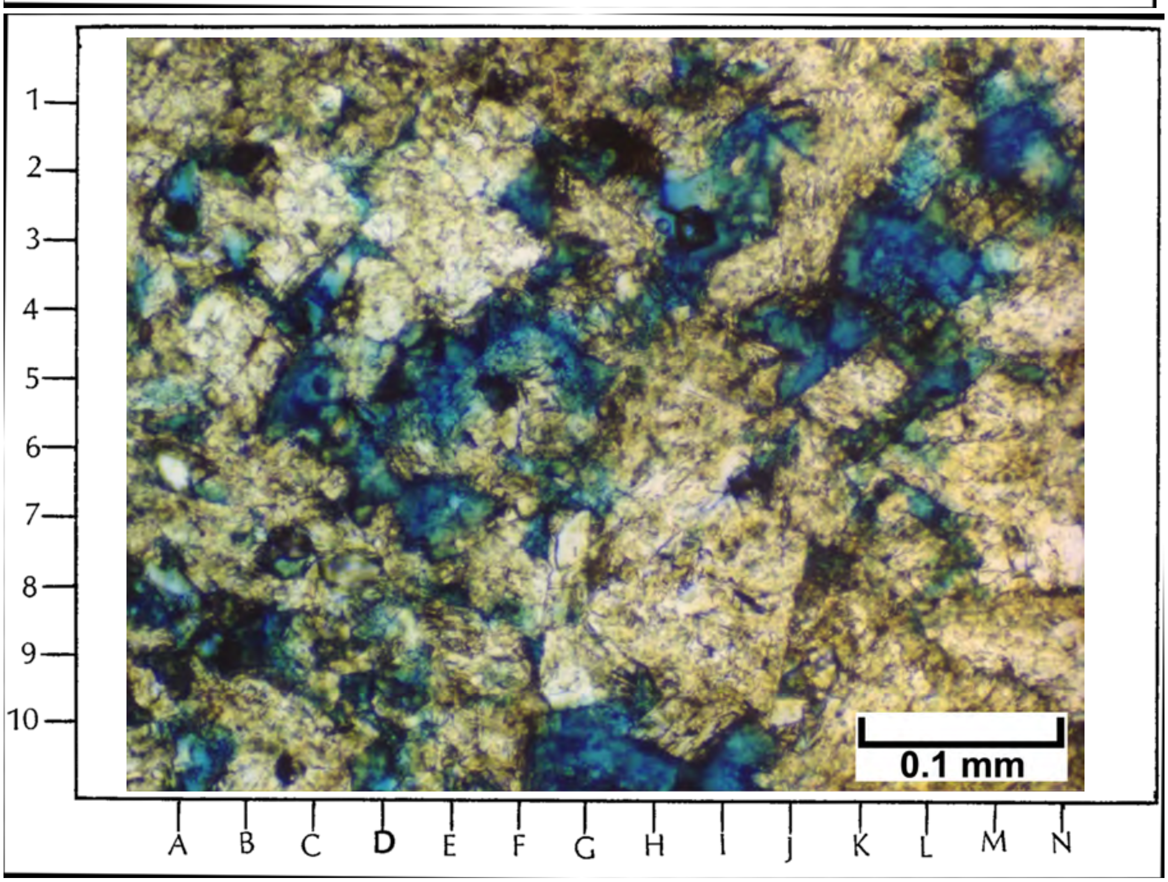
Top Photomicrograph

This EF view nicely shows another typical matrix view of fine- to medium-sized dolomite crystals that are very precisely imaged here. Many of these crystals appear to show good growth zones (the alternating green and yellow patterns within individual dolomite crystals). Possible “ghosts” or remnants of carbonate grain precursors to these dolomites can also be seen within some of the larger dolomite crystals. The reddish black areas are open pores.

Bottom Photomicrograph

This Pl view shows the same view as above at the same magnification. Note that this view does not provide much definition or show any internal zonation of the interlocking dolomite crystals within this sample. In addition, the outlines of pore boundaries are indistinct, despite the impregnation of these pores with blue-dyed epoxy.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

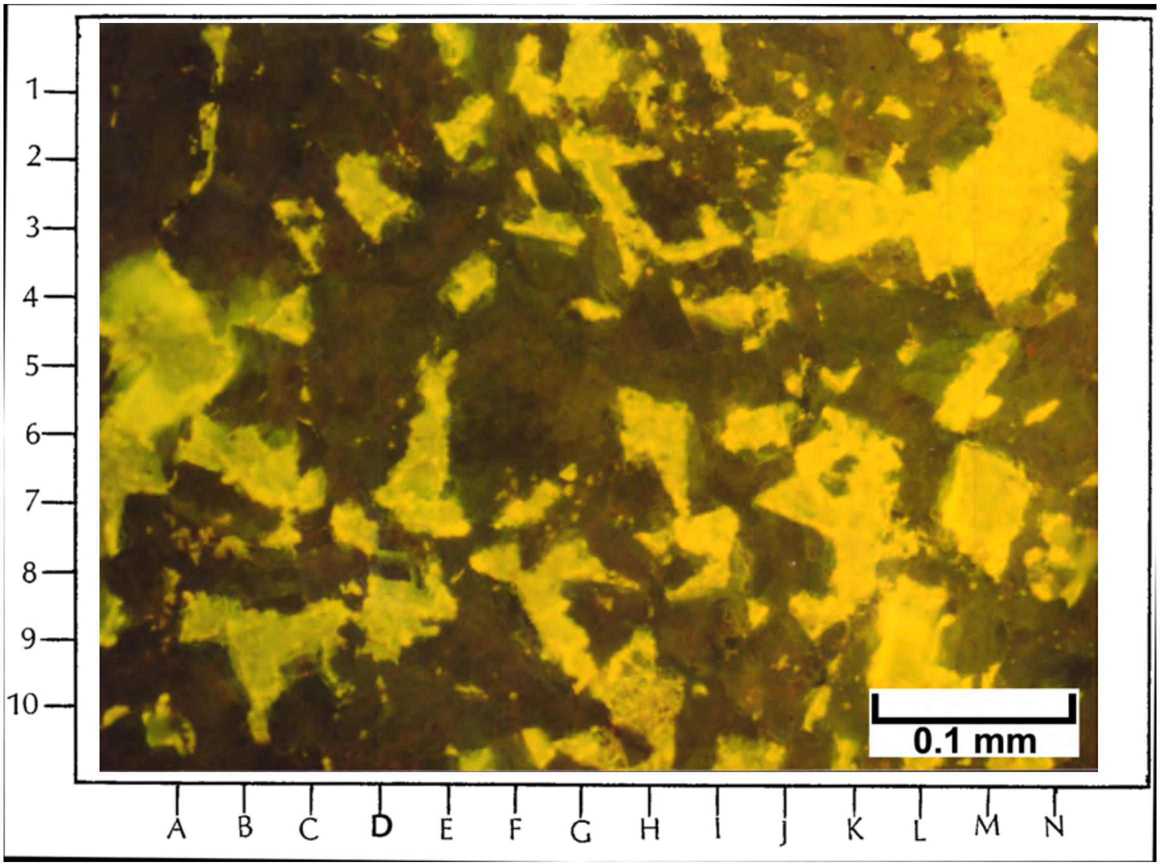
<u>6300.5 feet</u>

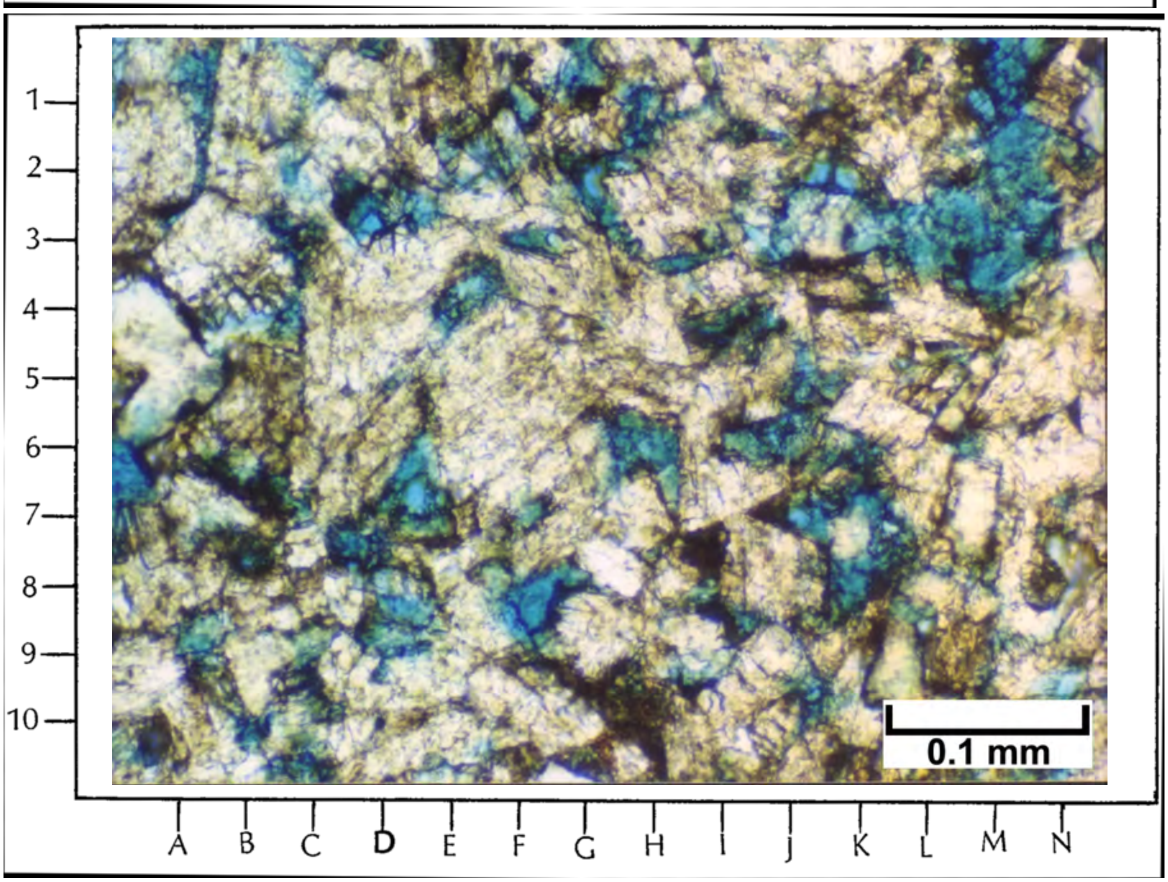
Top Photomicrograph

This EF view nicely displays rhombic and highly angular pores that fluoresce bright yellow. The rhombic dolomite crystals and crystal aggregates are dull gray and gray green in color. Note the sharp contacts between the dolomite crystals and the intercrystalline pores. This image is probably representative of a cross-sectional view of a typical sucrosic dolomite from the lower Desert Creek interval at Bug field.

Bottom Photomicrograph

This Pl view shows the same view as above at the same magnification. Although this view shows the sucrosic dolomite crystals well (in the white to light brown areas), the definition of pore/dolomite contacts is indistinct, in part because of bitumen linings. Pore outlines are much easier to see in the EF image.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A
B
C
D
E
F
G
H
I
J
K
L
M
N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A
B
C
D
E
F
G
H
I
J
K
L
M
N

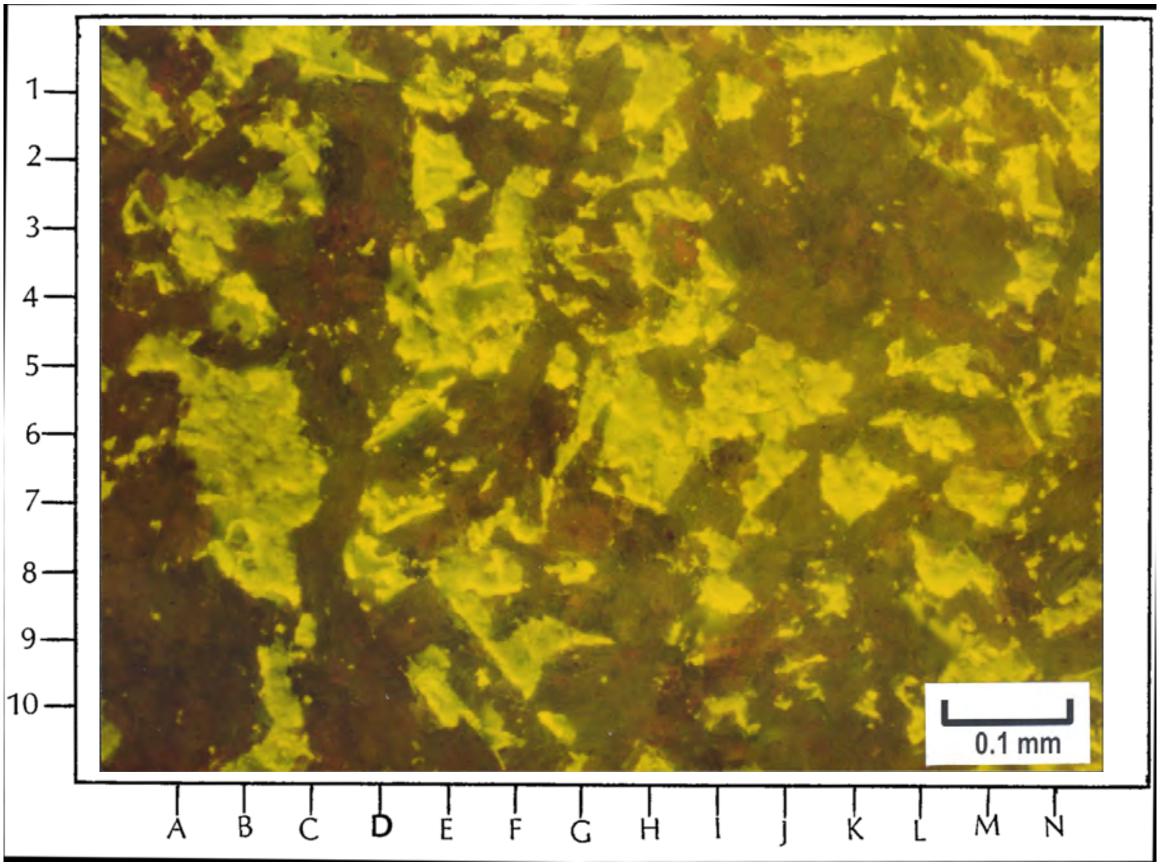
6300.5 feet

Top Photomicrograph

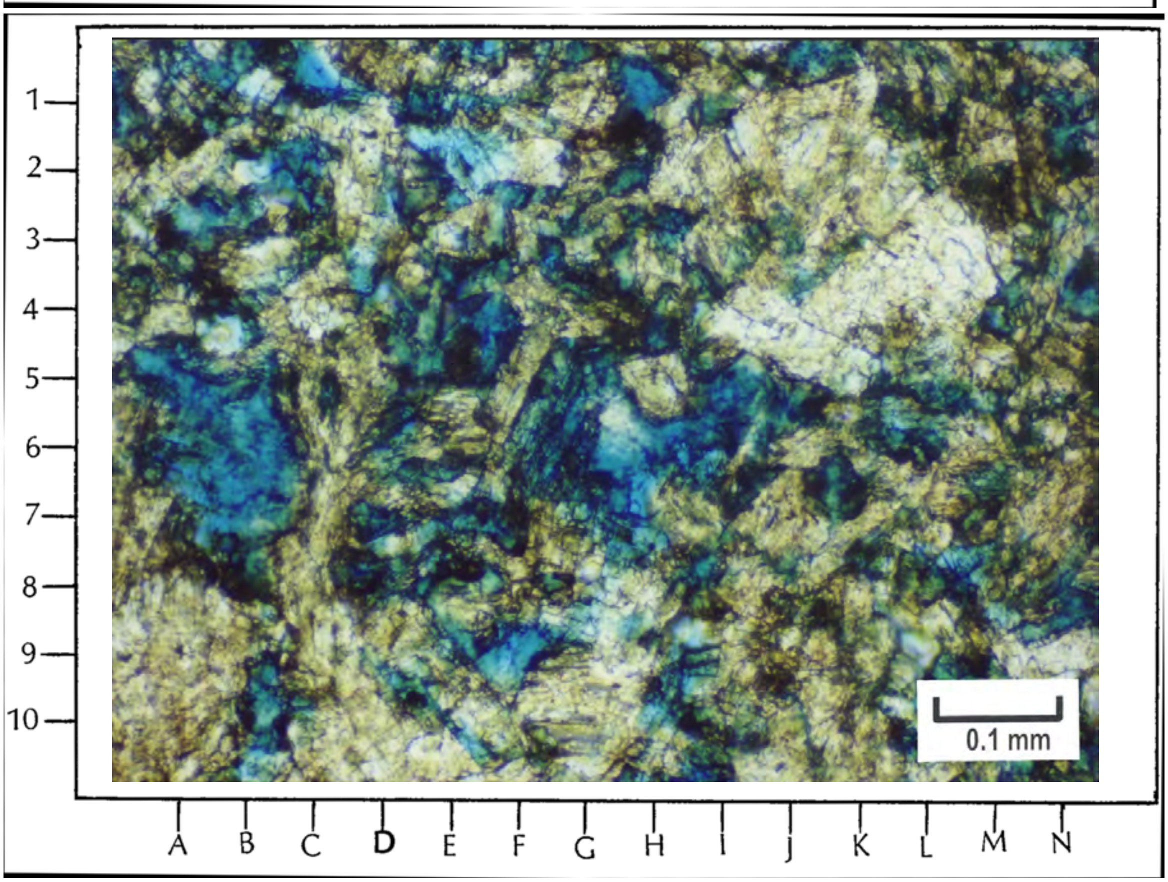
This EF photomicrograph shows an area with a complex network of micro-box-work structure throughout the entire field of view. The yellow areas show cross sections of open pores impregnated with epoxy and lined with some residual oil. The remaining dark areas in this field of view are non-porous dolomite crystal aggregates as well as some late anhydrite pore fillings. In this view, many of the pores appear to be isolated or "blind." Therefore, drainage of oil from this type of pore system may be inefficient.

Bottom Photomicrograph

This Pl view shows the same view as above at the same magnification. Note that it is difficult to resolve the contacts between pores and rock matrix. The brownish areas in this view are composed of dolomite while the white tabular crystals on the right portion of this photomicrograph are composed of anhydrite.



1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N



1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

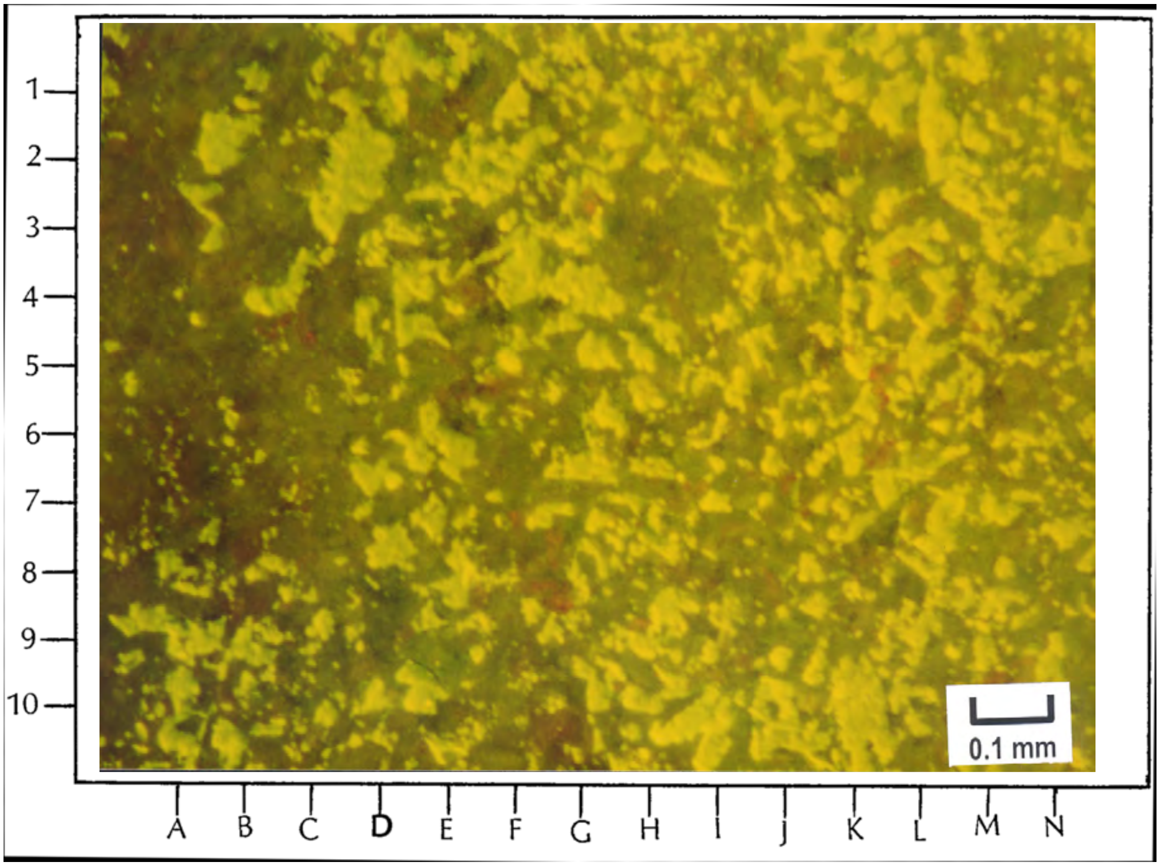
6300.5 feet

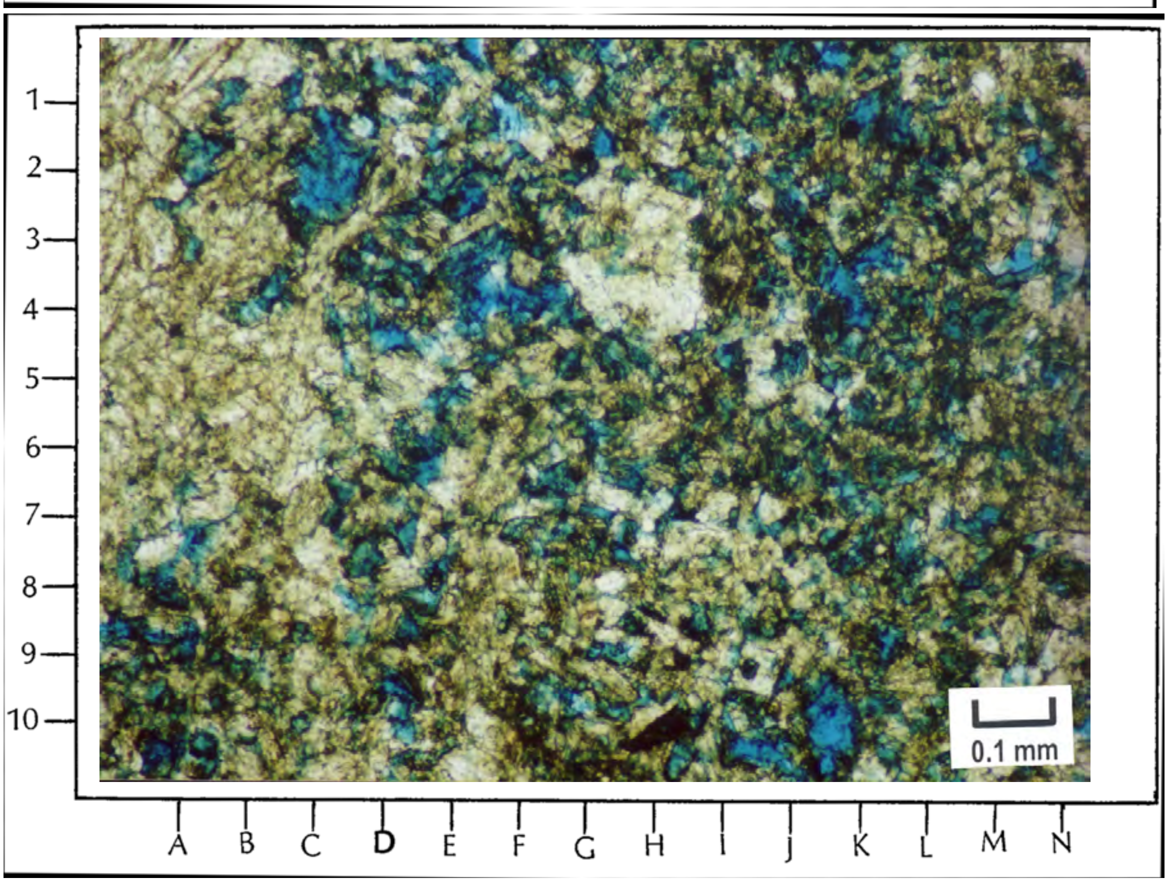
Top Photomicrograph

This EF overview of a complex network of micro-box-work structure displays cross sections of open pores impregnated with epoxy and lined with some residual oil. The remaining dark areas in this field of view are non-porous dolomite crystal aggregates as well as some late anhydrite pore fillings. As in the previous set of photomicrographs, many of the pores appear to be isolated or "blind." Thus, many of these pores may not be well connected for good oil drainage.

Bottom Photomicrograph

This Pl view shows the same view as above at the same magnification. The blue areas in this image are pores filled with blue-dyed epoxy. However, the nature of the contacts between the pores and the rock matrix are not easy to see. Dolomite appears as the light brown areas and later anhydrite pore fillings are white.


1
2
3
4
5
6
7
8
9
10
A B C D E F G H I J K L M N
0.1 mm


1
2
3
4
5
6
7
8
9
10
A B C D E F G H I J K L M N
0.1 mm

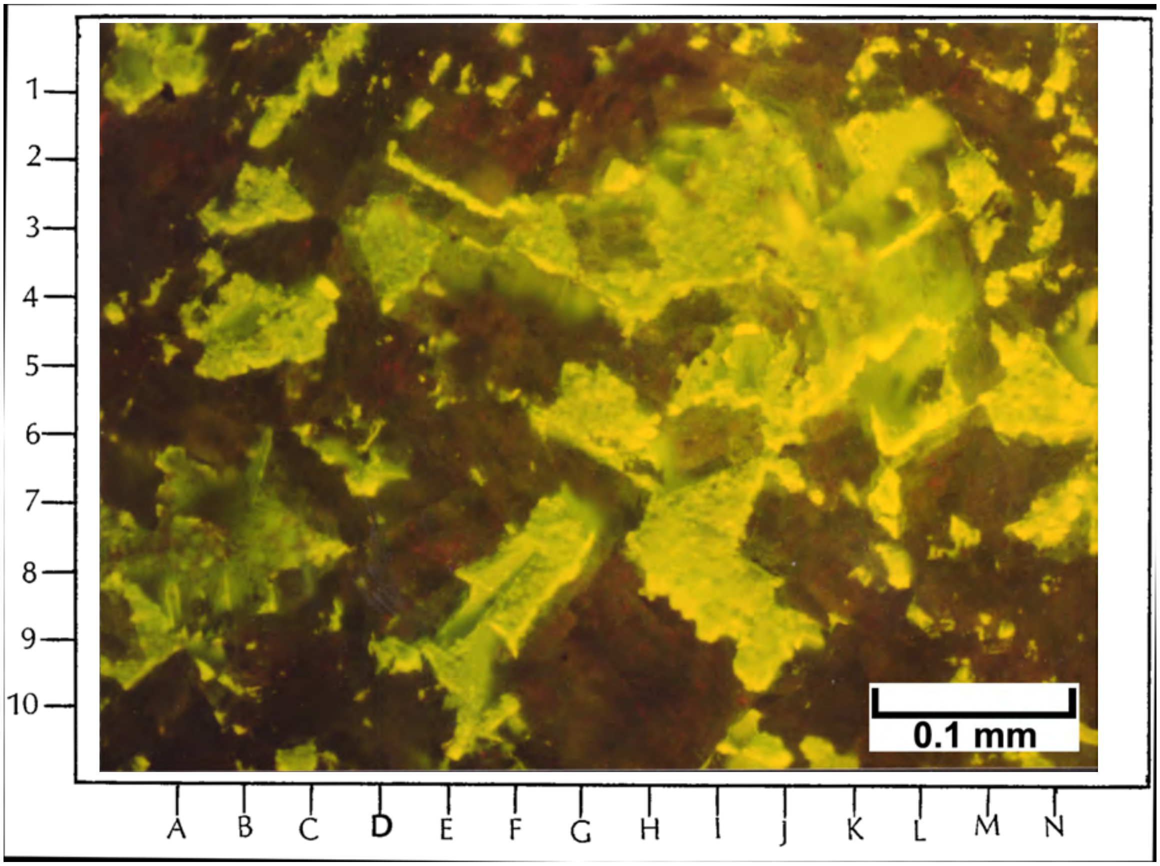
6300.5 feet

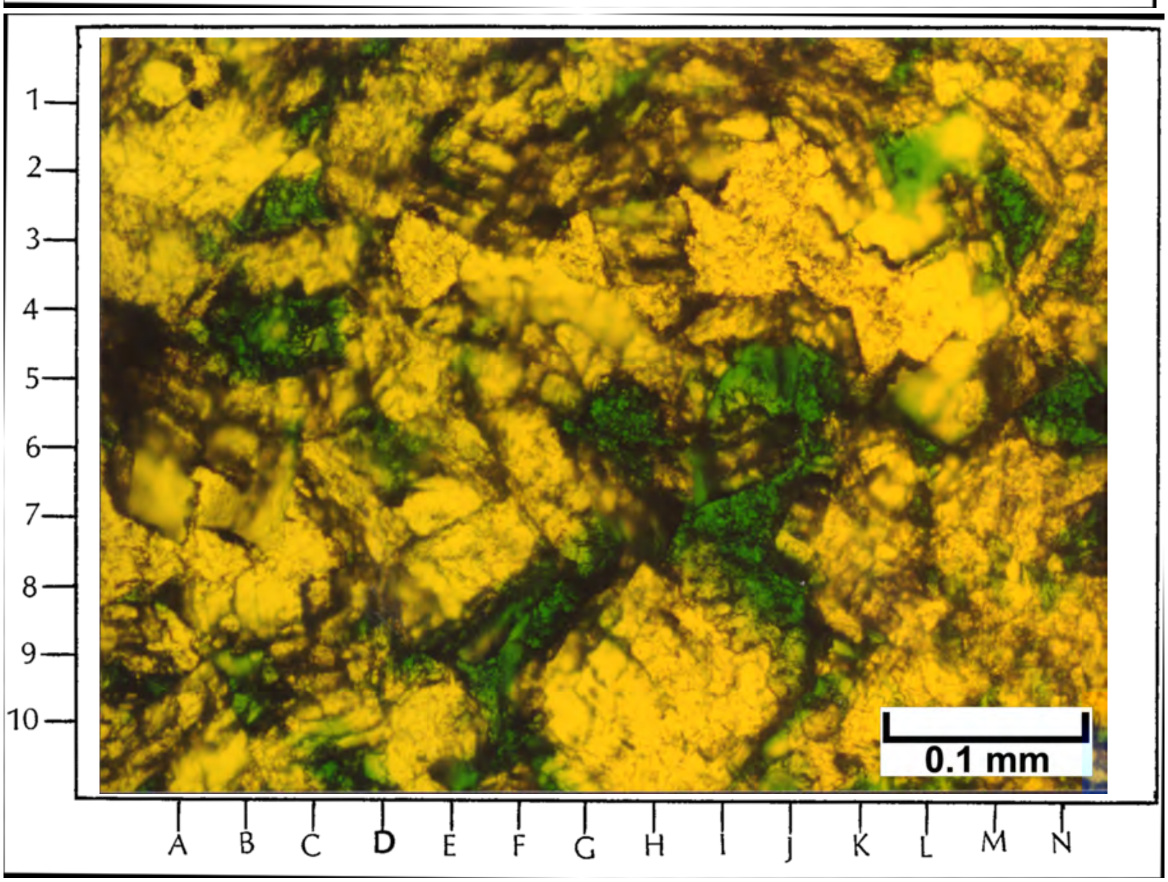
Top Photomicrograph

This highly magnified EF view makes it easy to see the highly corroded or scalloped margins of most dolomite crystals. In this view, the dolomite is dark-gray green in color while the pores are greenish yellow. Films of live oil appear as the intense or bright yellow rims along many of the dolomite crystal/pore contacts. The corroded dolomite rhomb contacts indicate that there has been some partial dissolution of dolomite rhombs.

Bottom Photomicrograph

This Pl view shows the same view as above at the same magnification. Note that the outlines of pores are indistinct, despite the impregnation of these pores with blue-dyed epoxy. In addition, it is not possible to see the corroded dolomite rhomb margins with Pl microscopy.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

CHEROKEE FEDERAL 22-14 WELL, CHEROKEE FIELD

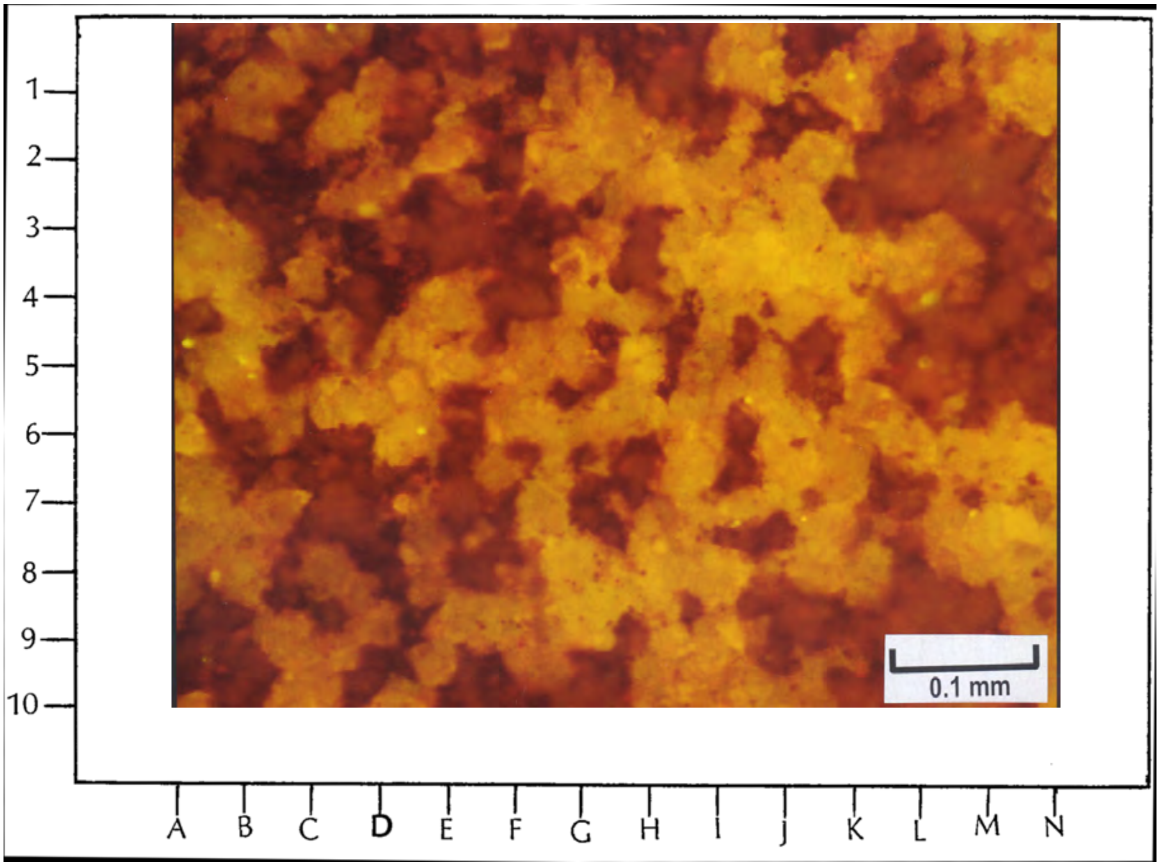
5768.7 feet

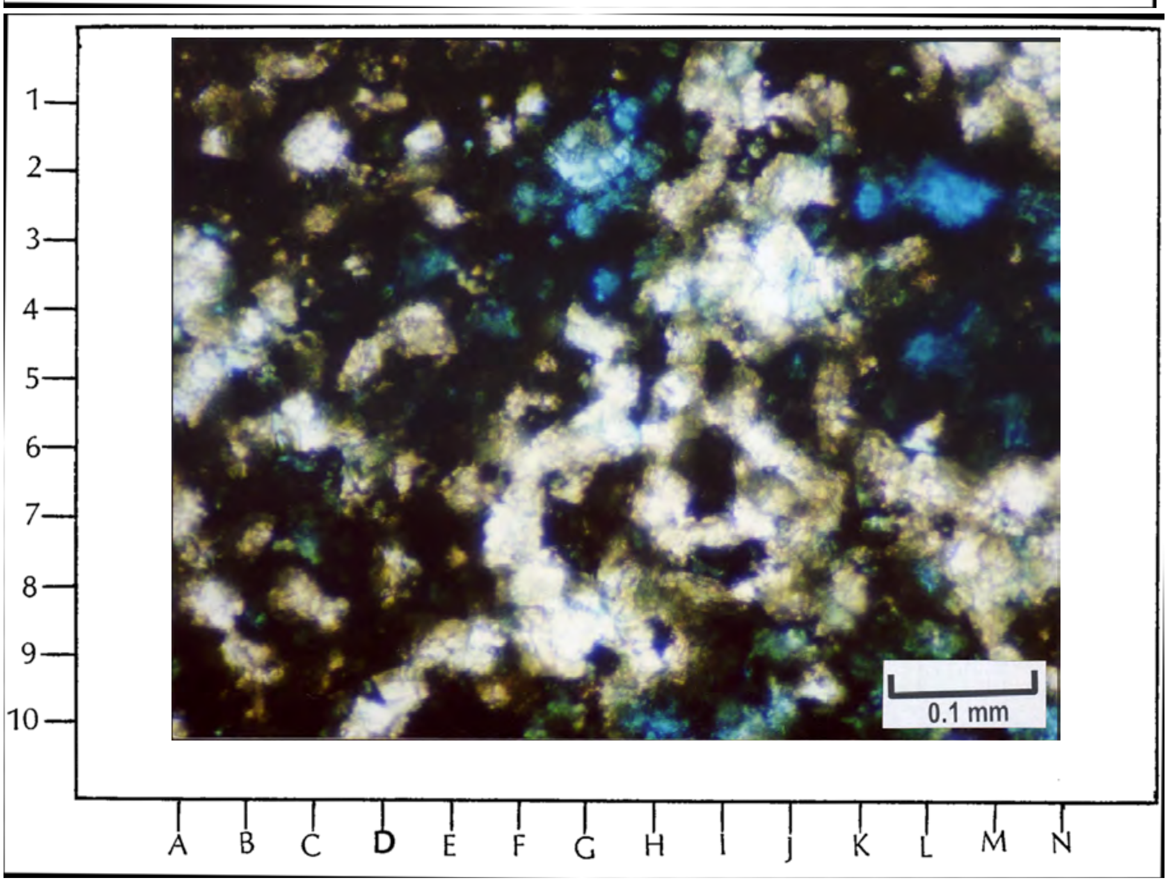
Top Photomicrograph

Epifluorescence under moderate magnification of a representative area of microporosity shows outlines of small dolomite crystals (fluorescing yellow here due to oil staining). The reddish areas are pores with abundant bitumen linings and plugging (see below). Fluorescence petrography makes it possible to clearly see the dolomite crystals versus the pore space. Occasionally, very small rhombic outlines of dolomite crystals can be resolved (see, for instance, E-9, G-4, and N-1). Most of the pores appear in cross section to be poorly size-sorted and of dissolution origin. Many of these pores appear to be completely surrounded by an interlocking network of dolomite crystals (see, for instance, H-3, H-6.5, and J-4).

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. Note that the black (and opaque) areas composed of bitumen mask the crystal boundaries of the dolomite as well as individual pore outlines. The white and gray areas are remnants of the dolomite matrix that are not masked by the bitumen. Only a small amount of pore space (blue-dyed areas) can be seen in this view compared to the fluorescence photomicrograph above.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

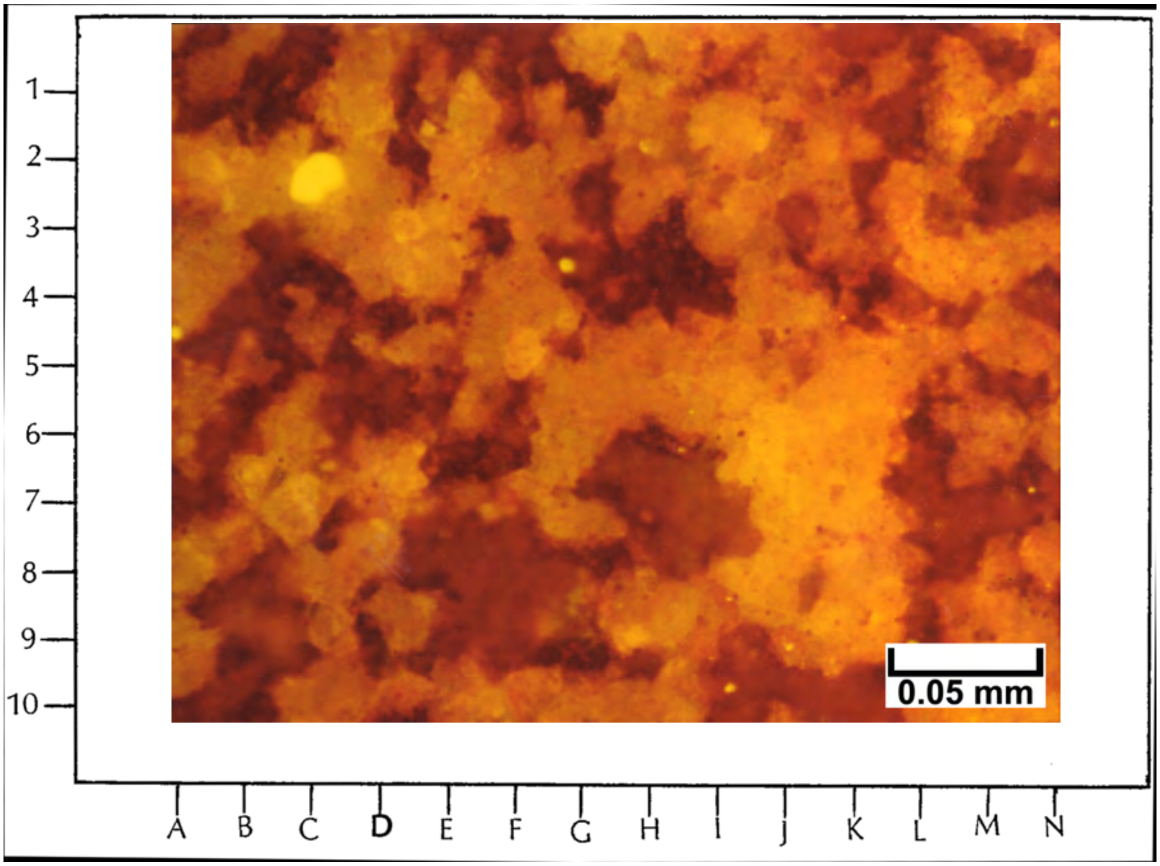
5768.7 feet

Top Photomicrograph

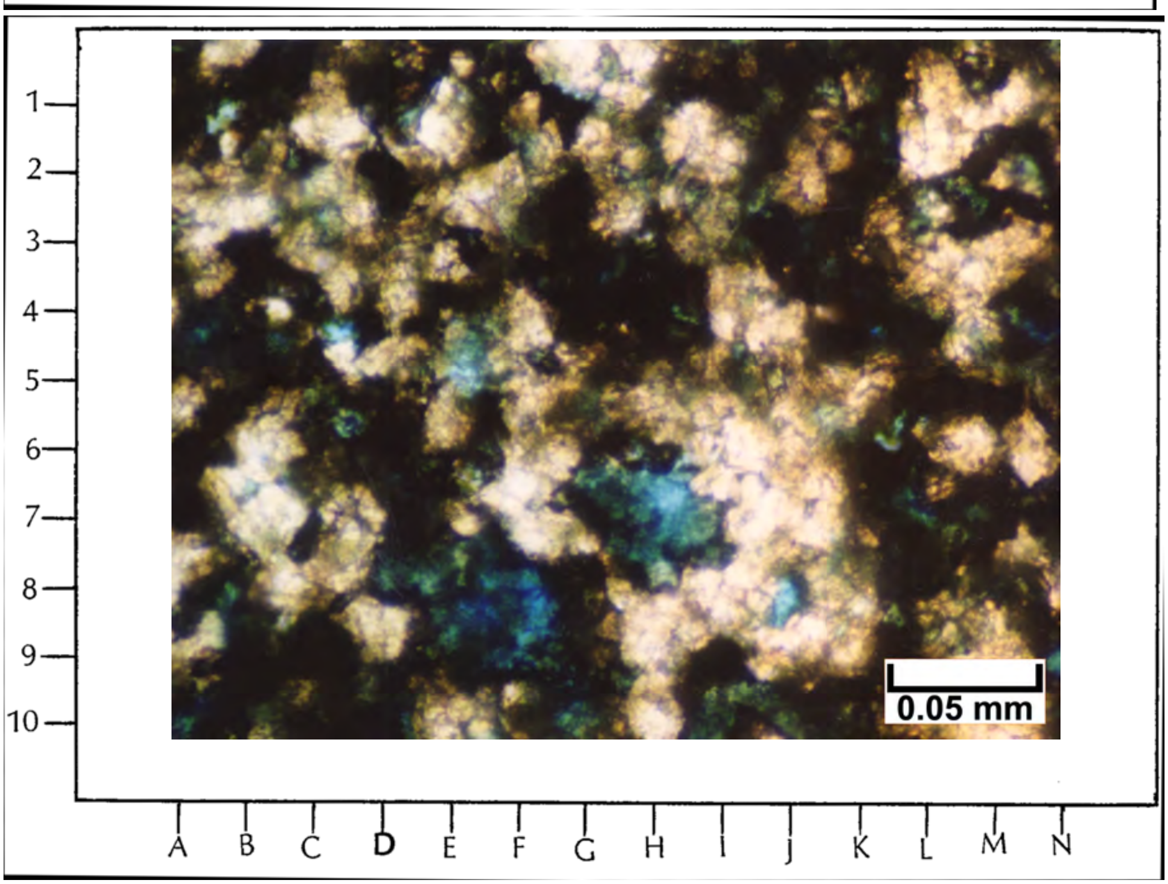
High-magnification EF of a bitumen-rich portion of this thin section shows quite distinct dolomite crystal outlines (in the dim to moderate yellow shades) among the interlocking dolomite network. Most of the pores (red in this view) are not well connected. Most of this microporosity appears to be of dissolution origin and micromoldic in type. (The bright yellow spot at C-2 is a surface contamination.)

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. Black bitumen within this sample makes it difficult to image the large amount of pore space that can be observed under EF (see photomicrograph above). Hence, this standard transmitted light view provides a significant underestimate of available pore space within this dolomite.



1
2
3
4
5
6
7
8
9
10
0.05 mm
A B C D E F G H I J K L M N



1
2
3
4
5
6
7
8
9
10
0.05 mm
A B C D E F G H I J K L M N

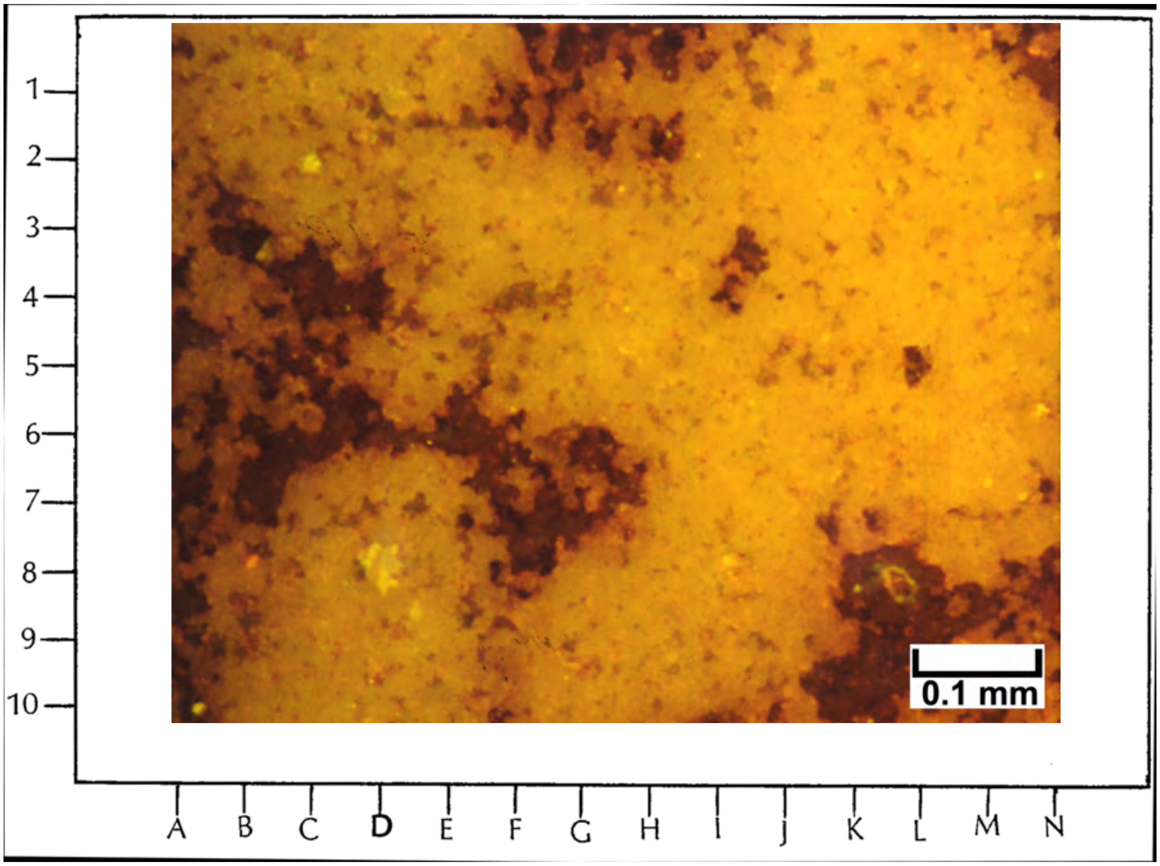
5768.7 feet

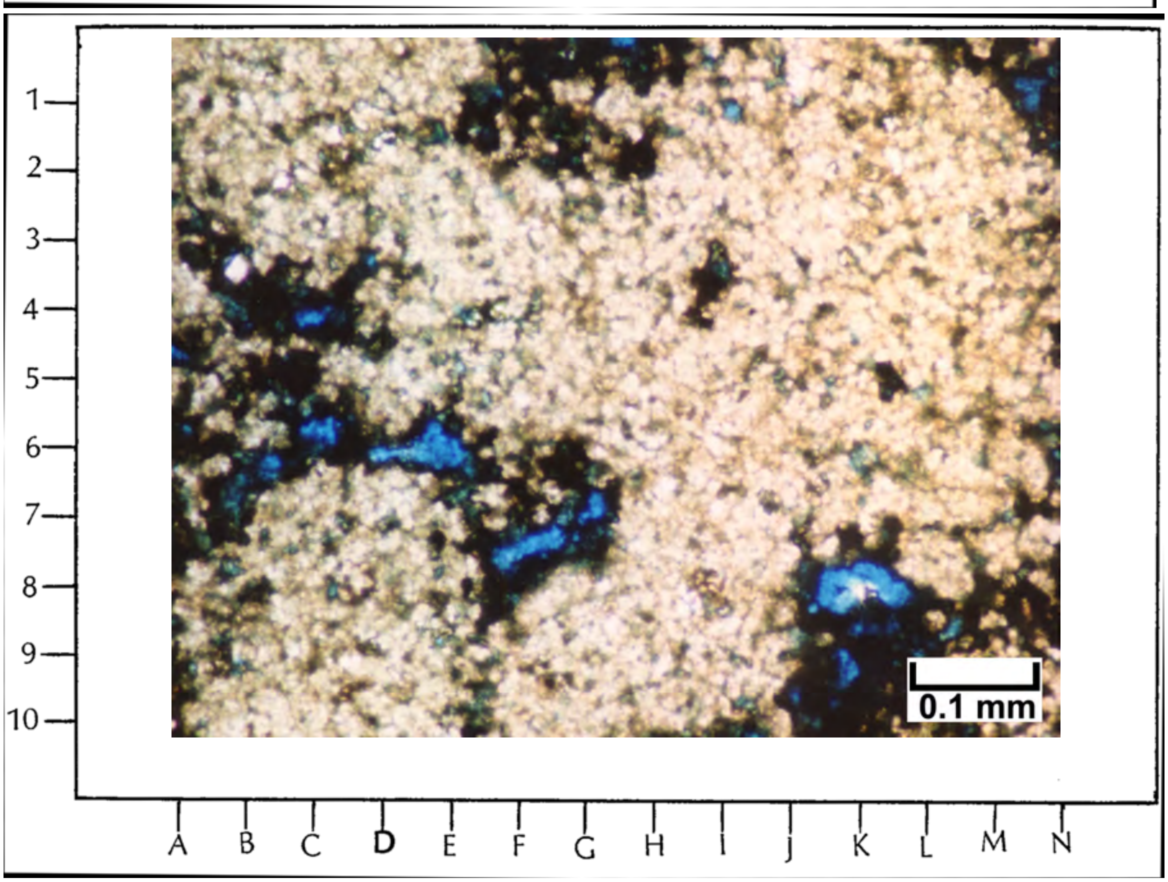
Top Photomicrograph

This EF image under moderate magnification of a representative area shows the patchiness of porosity in this dolomite. The masses of generally tight, interlocking dolomite are identifiable as the dull yellowish and greenish shades. Most of the open pore space appears dark red in this view, although a few pores in the areas of tighter, interlocking dolomite are bright yellow due to live oil that has bled into these isolated spaces (see, for instance, C-2, D-7.5, I-7.5, and M-6).

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same moderate magnification. The blue areas show open pores where they have not been plugged or lined with black bitumen. Note that the amount of blue is far less than the pore spaces imaged above under EF.


1
2
3
4
5
6
7
8
9
10
A B C D E F G H I J K L M N
0.1 mm


1
2
3
4
5
6
7
8
9
10
A B C D E F G H I J K L M N
0.1 mm

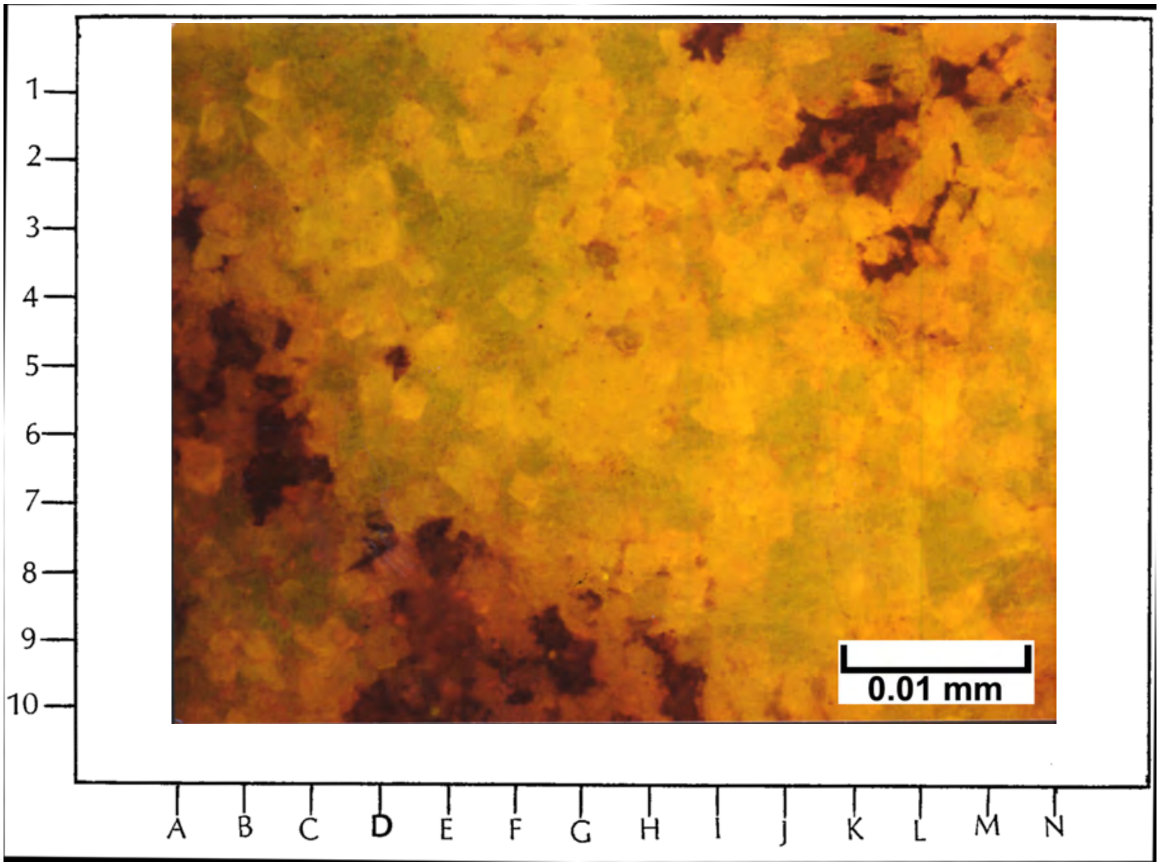
5768.7 feet

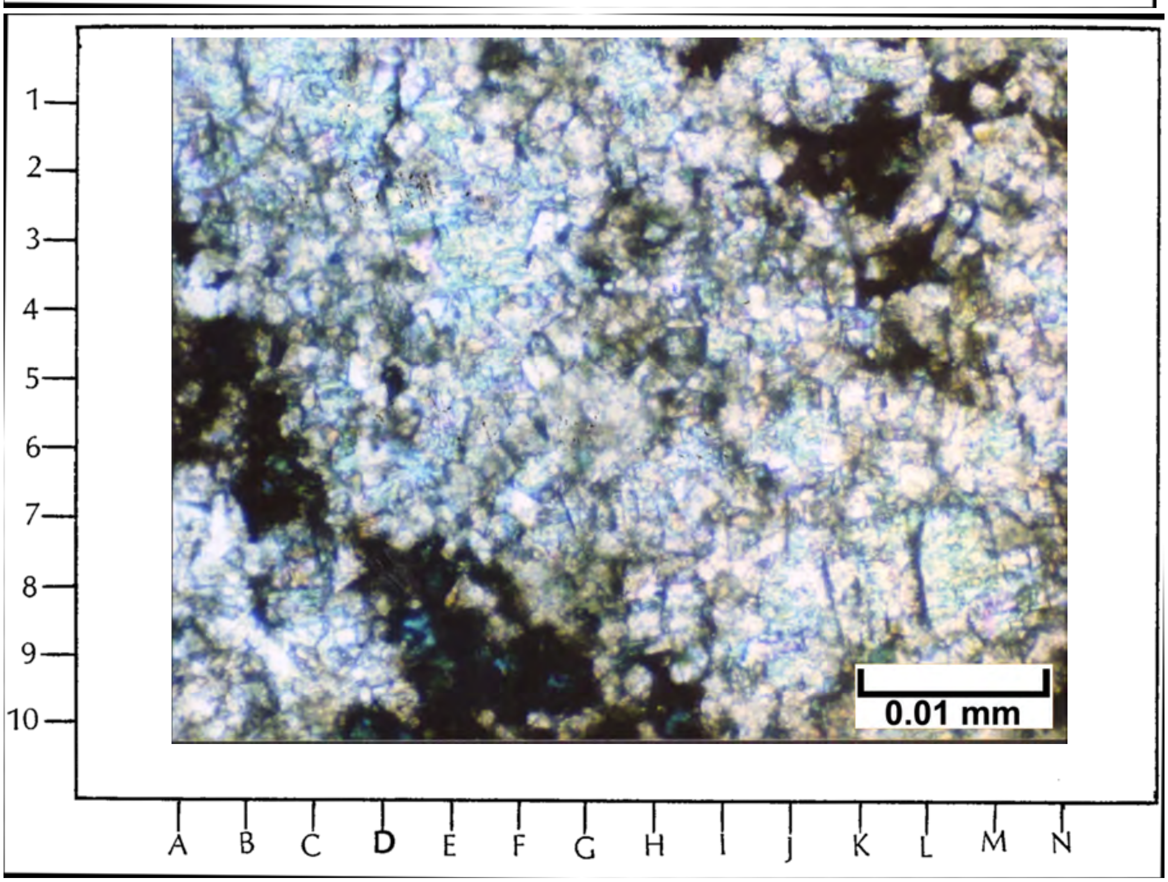
Top Photomicrograph

This area of the sample shows a dolomite matrix (fluorescing yellow due to probable saturation with live oil) that has been cemented with anhydrite (displaying greenish fluorescence). Most of the anhydrite resides where earlier pore space existed. The dark reddish areas are open pores lined with variable amount of black bitumen.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. In this area of anhydritic dolomite, there is no visible porosity that would be recognizable with the blue-dyed epoxy that has been impregnated into open pores. The black bitumen masks some of the pore space that EF images above.


1
2
3
4
5
6
7
8
9
10
0.01 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.01 mm
A B C D E F G H I J K L M N

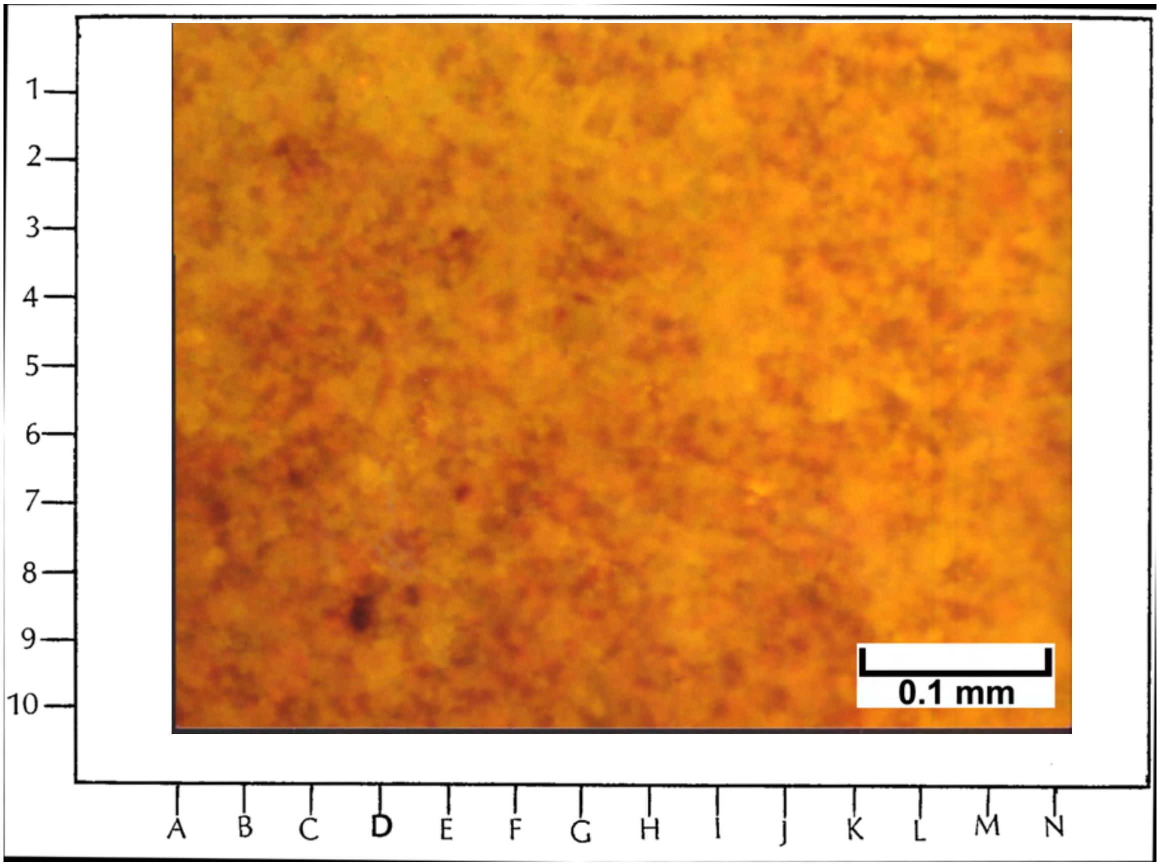
5778.1 feet

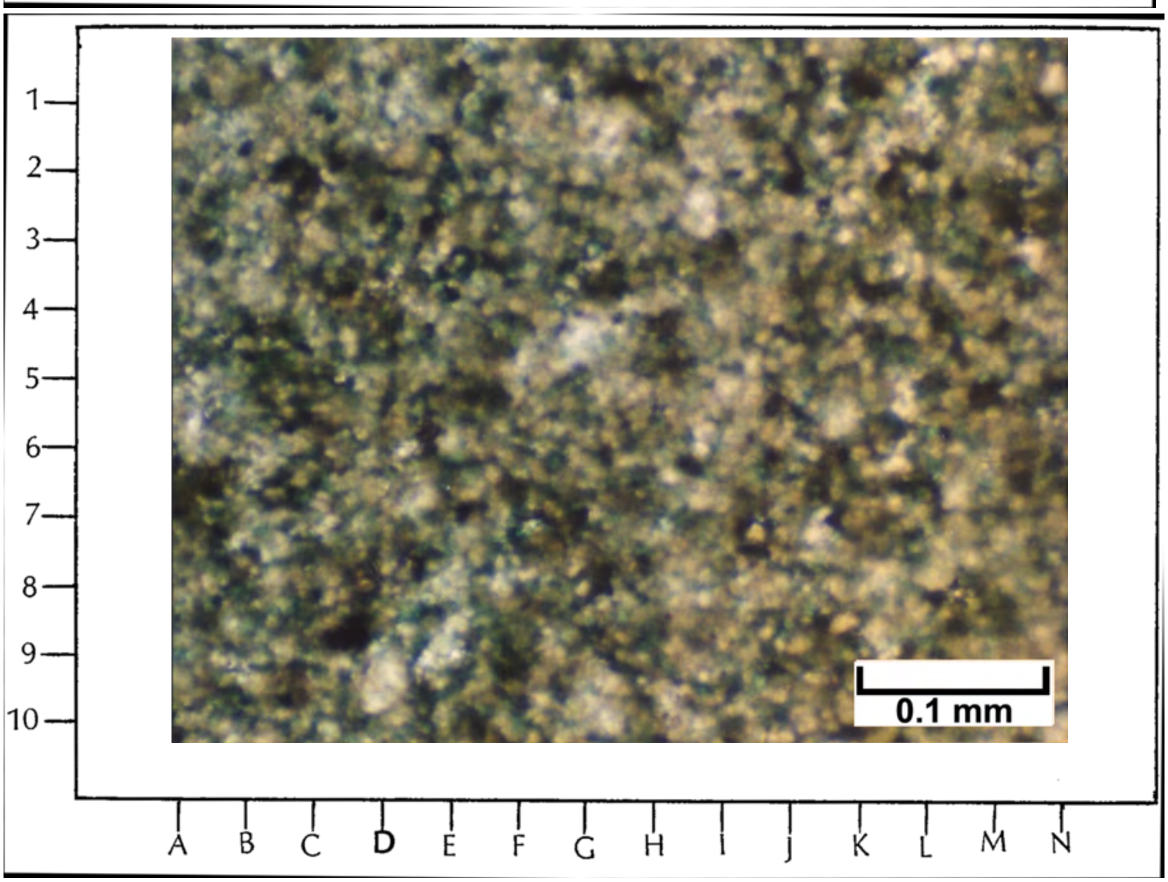
Top Photomicrograph

A representative EF photomicrograph of a dense dolomitic limestone under moderate magnification distinguishes porosity from oil-stained matrix. The reddish areas represent the epoxy-impregnated pores within this sample. The yellow areas are the oil-stained carbonate mineral matrix. Note that the fluorescence image helps to identify occult carbonate grains such as probable fossils (for example G-2, H-2, and J-9), small peloids (for example C-1, I-5, K-8, and so forth) that are not visible in the Pl image below. This dense limestone was deposited as a bioclastic-peloidal grainstone to packstone.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. This portion of the sample has been artificially stained with Alizarin Red-S solution. The pink areas are calcite while the white and gray areas are mostly dolomite. The indistinct black patches are indicative of some bitumen plugging within microporous spaces. The bluish areas within this view are due to the impregnation of blue-dyed epoxy into the micropores. However, it is impossible to see any of the carbonate components, the depositional texture, or the open pores without use of EF lighting as shown above.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

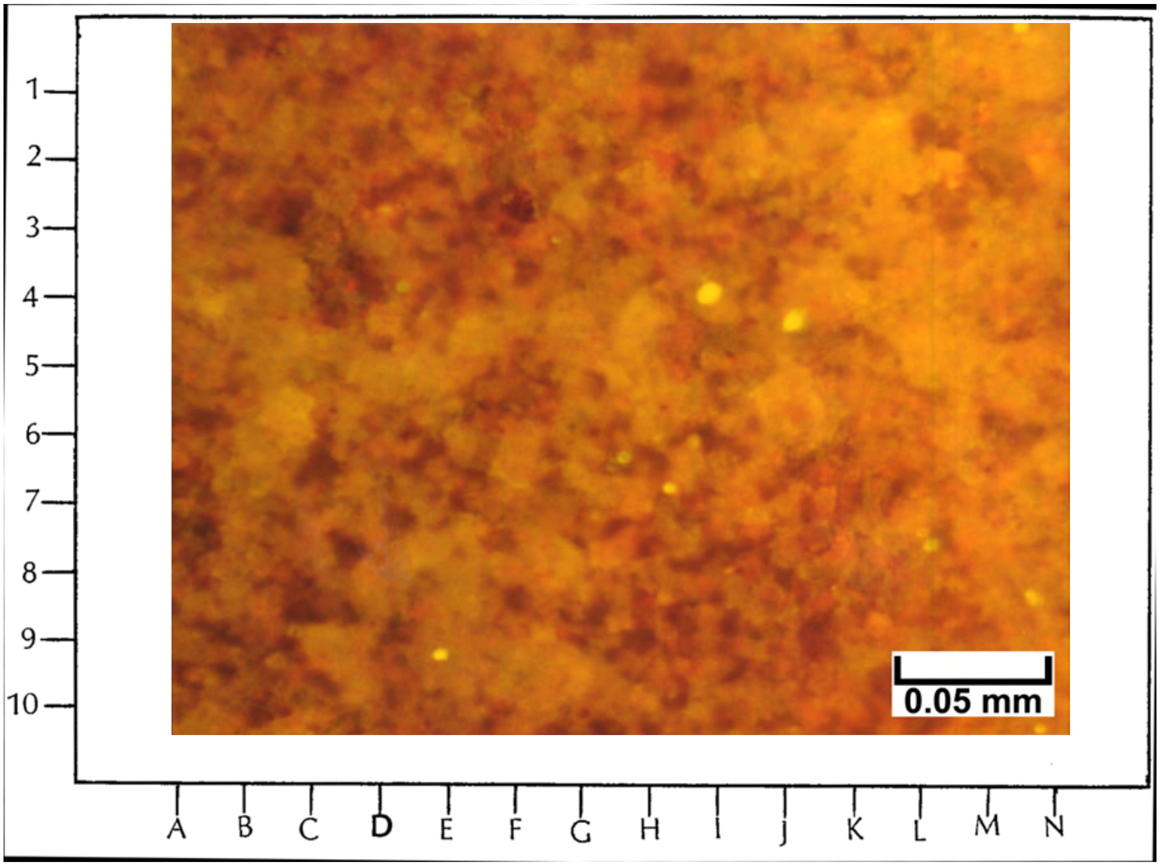
5778.1 feet

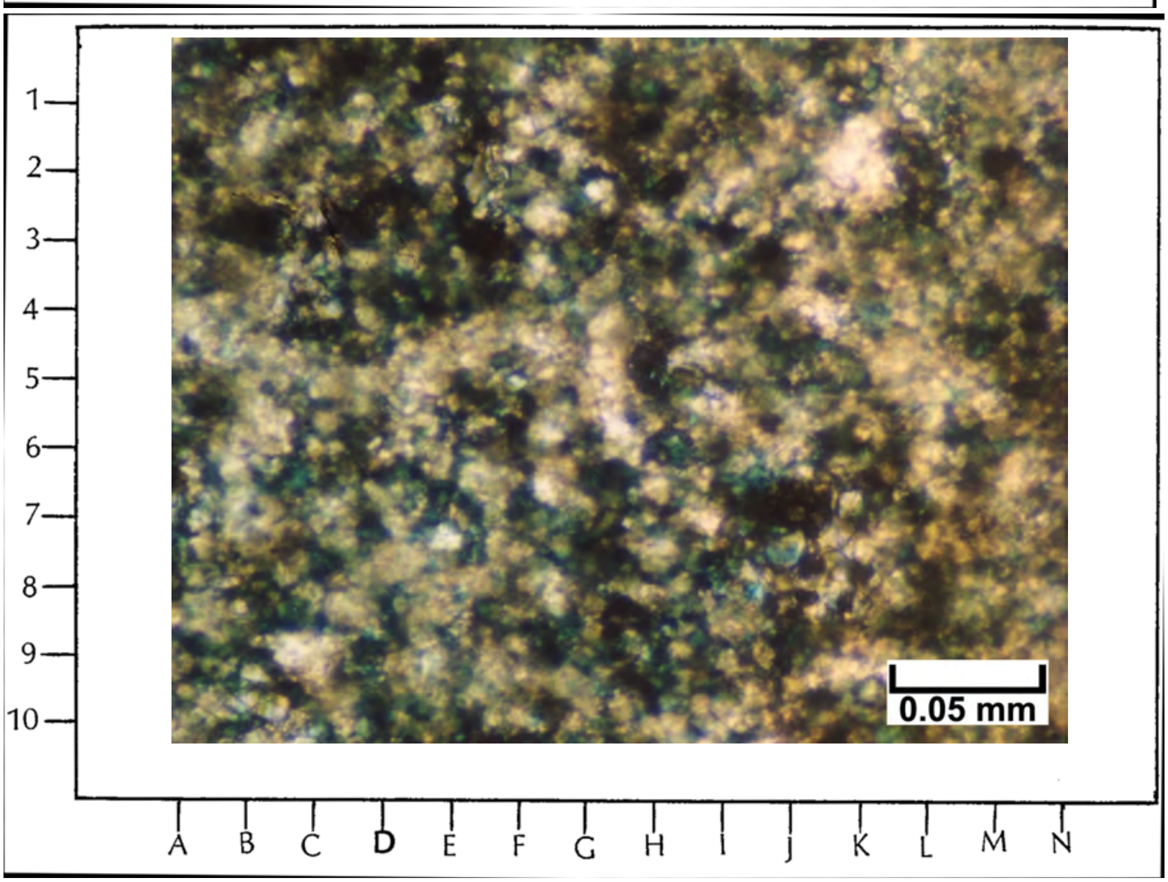
Top Photomicrograph

A representative EF photomicrograph under higher magnification than the previous photo pair nicely shows many of the grain outlines of the peloids and skeletal debris that make up this calcarenite (grainstone to packstone). The overprinting of dolomitization on this lithology can be seen as the abundant, small, rhombic crystal outlines (for example D-4, I-2, and J-7). The reddish and dark-colored areas of this photomicrograph are mostly pores, some of which contain bitumen linings. (The bright yellow spots in this view are surface contaminants.)

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. The bluish color across this sample is due to blue-dyed epoxy filling some of the open microporosity. The black or opaque areas are indicative of abundant bitumen throughout the micropore system.


1
2
3
4
5
6
7
8
9
10
0.05 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.05 mm
A B C D E F G H I J K L M N

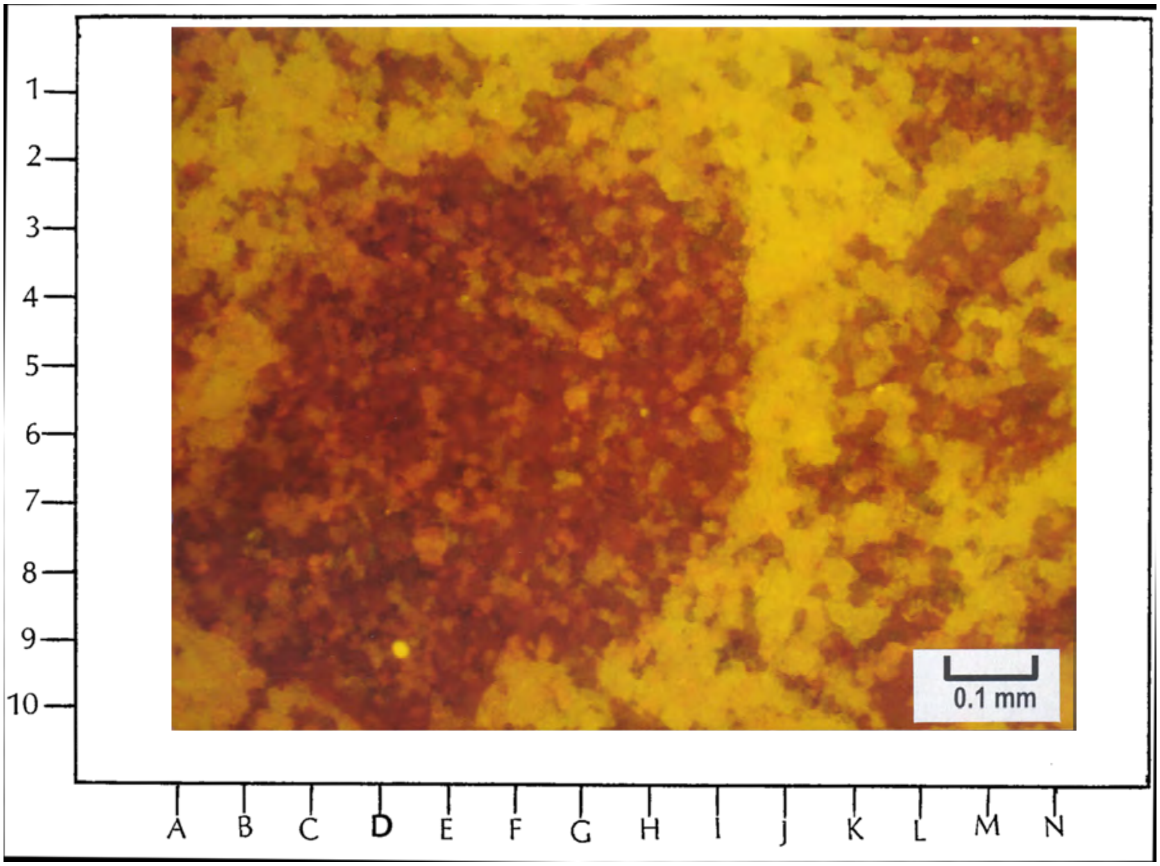
<u>**5783.5 feet**</u>

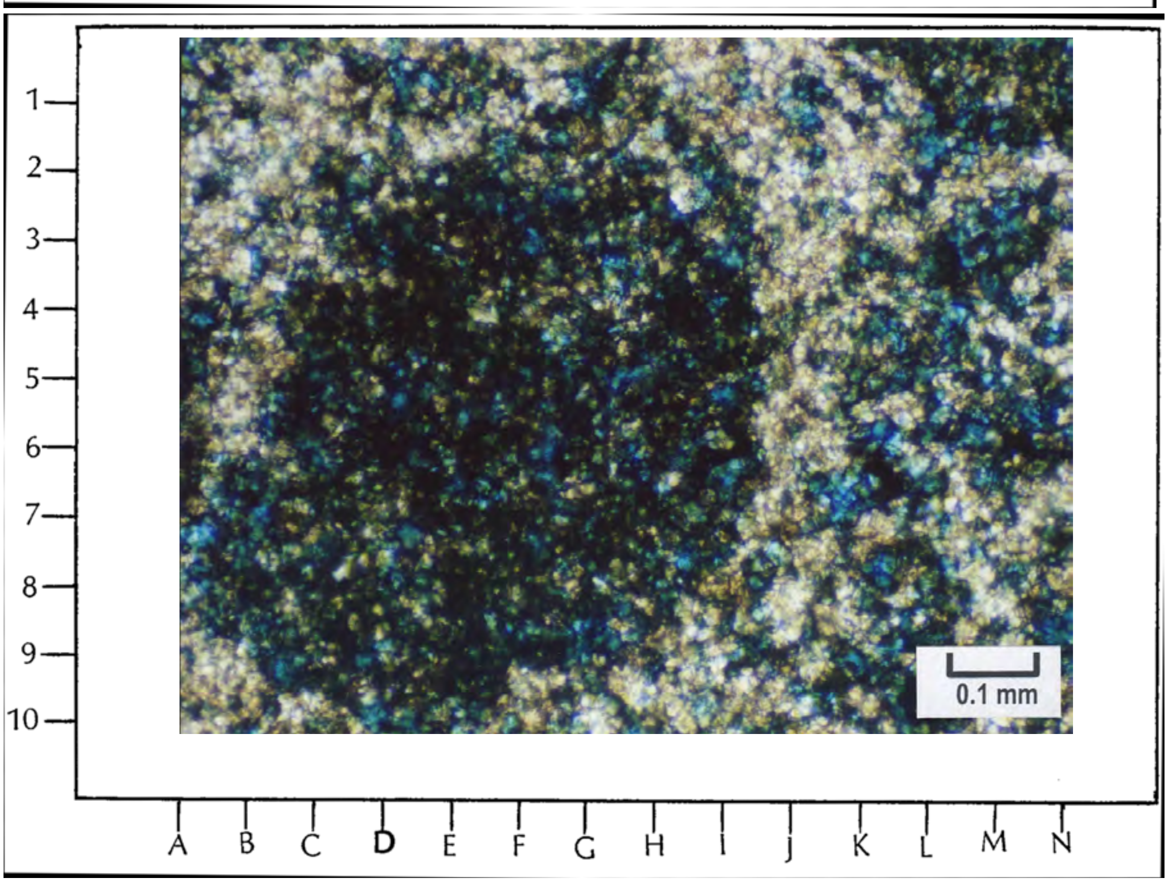
Top Photomicrograph

Epifluorescence in this field of view shows a very heterogeneous distribution of porosity. Here, the open-pores spaces are mostly in the red colors. Note the large, circular patch of red between B-9 and H-3. Here, pores are small, but appear to be well connected. Elsewhere, the reddish areas denoting porosity are much more patchy. Note also the areas with concentrated yellow colors. These are tighter dolomites which appear bright yellow due to the presence of trapped live oil. Within some of these tighter dolomites, it is possible to see “ghosts” of small rounded peloids (see, for instance, B-2, H-9, and H-2 to K-3).

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. The presence of small amounts of black bitumen within the small pores of this sample makes it exceedingly difficult to identify pore boundaries. Only small amounts of the blue-colored epoxy that has been artificially impregnated into the pore spaces are visible in this view. The circular cross section of the concentrated area of microporosity between B-9 and H-3 may well have been a badly corroded large fossil such as a fusulinid. Note that the amount of porosity in cross section as well as the depositional texture of the tight dolomite “bridge” between I-1 and I-9 is much easier to determine in the fluorescent image above.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

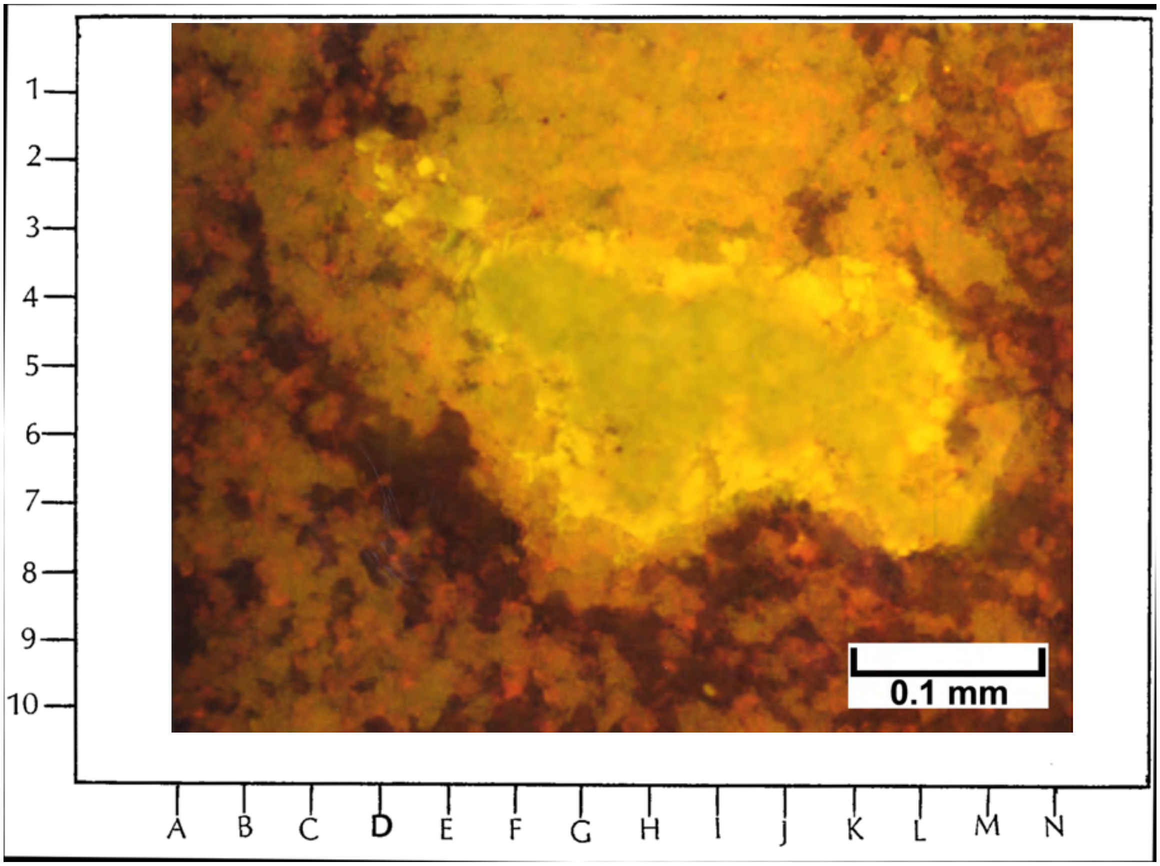
5783.5 feet

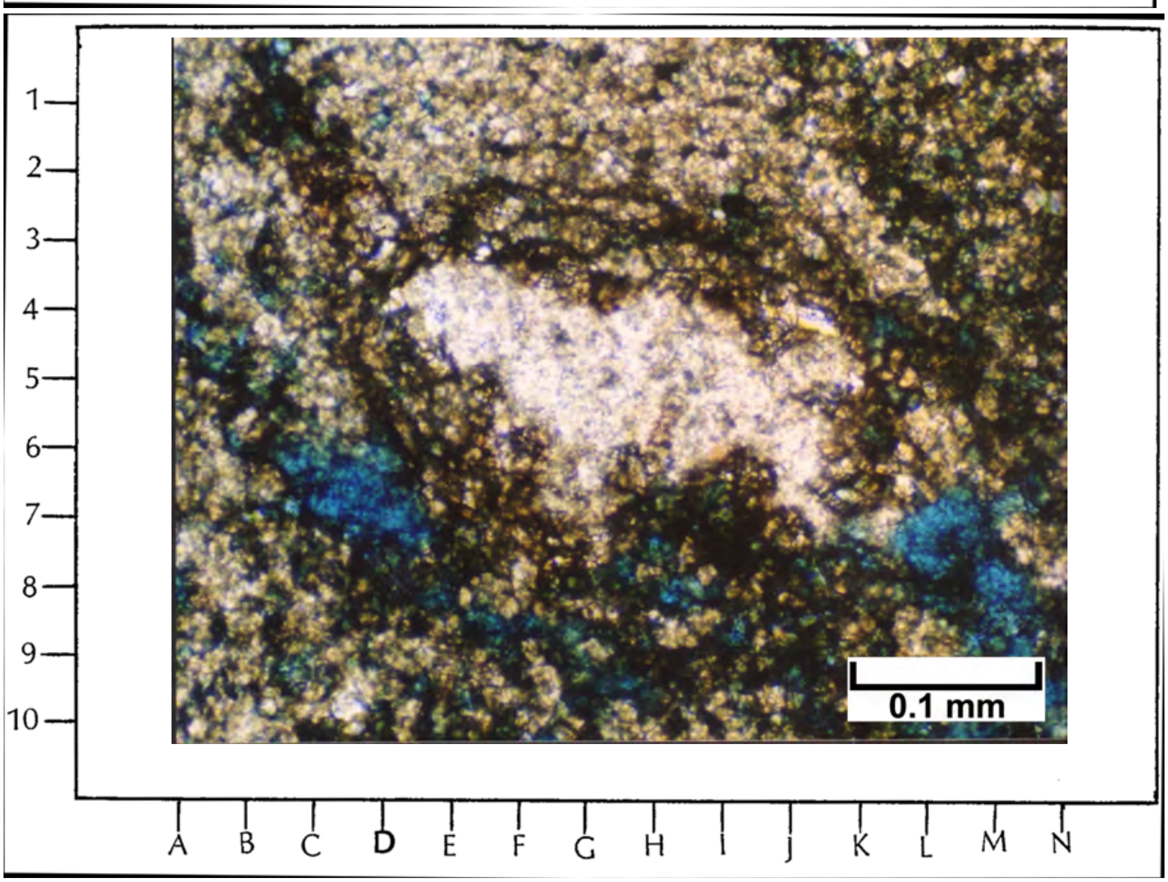
Top Photomicrograph

A wide range of information can be seen in this EF image. The amoeboid greenish-yellow feature in the center (from F-4 to M-7) is a small nodule of anhydrite surrounded by finely crystalline dolomite. The bright yellow rim around the anhydrite is due to live oil bleeding out of the dolomite and trapped against the impervious nodule. The dull yellow areas throughout the remainder of this image consist of dolomite containing small amount of fluorescing oils. The solid patch of dull fluorescence across the top of this photomicrograph (from E-2 to K-2) is a tight area with interlocking dolomite crystals. The black and dark red areas show where the open pore spaces occur, including pores with some bitumen coatings. Finally, the orangish areas are most likely weakly fluorescing portions of bitumen.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. Even though it is possible to identify the white nodule of anhydrite in the center of this field of view, the details of pore distribution as well as the fluorescence of live oils and bitumen distribution are not easy to see in this transmitted-light image.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

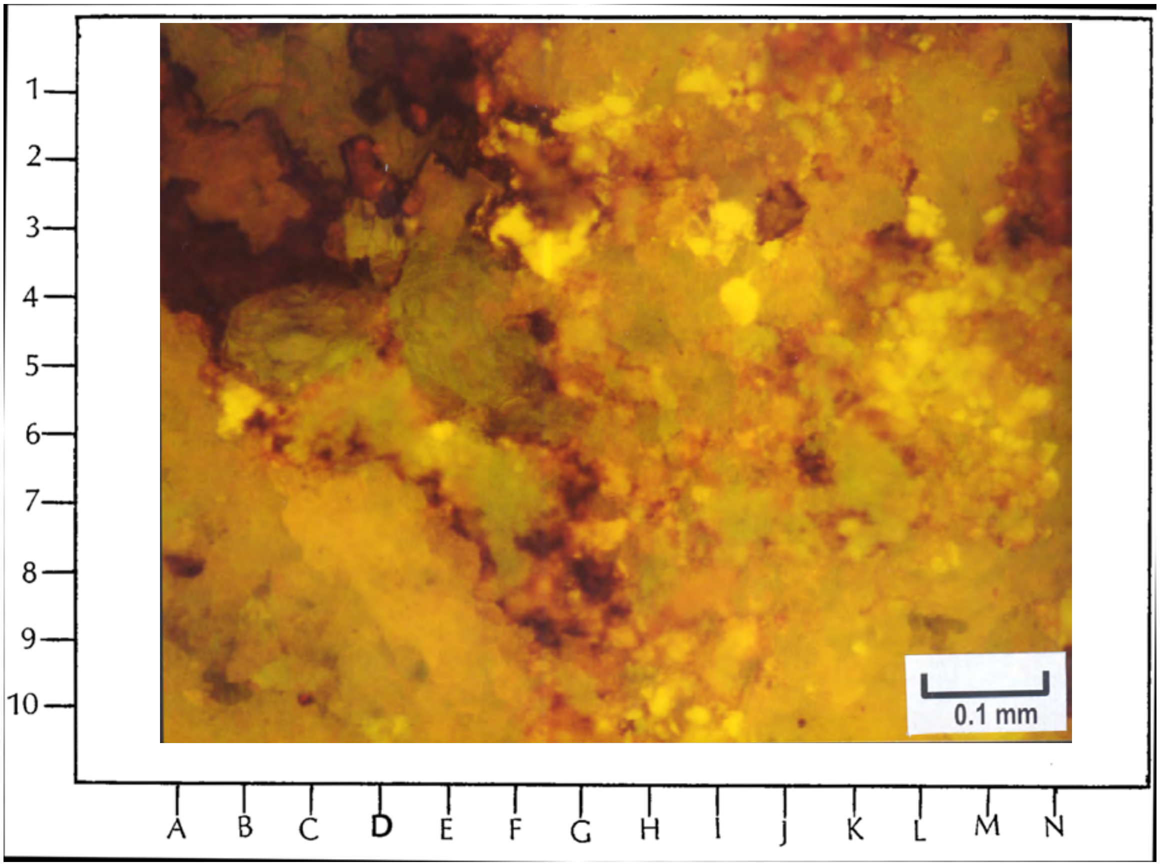
5783.5 feet

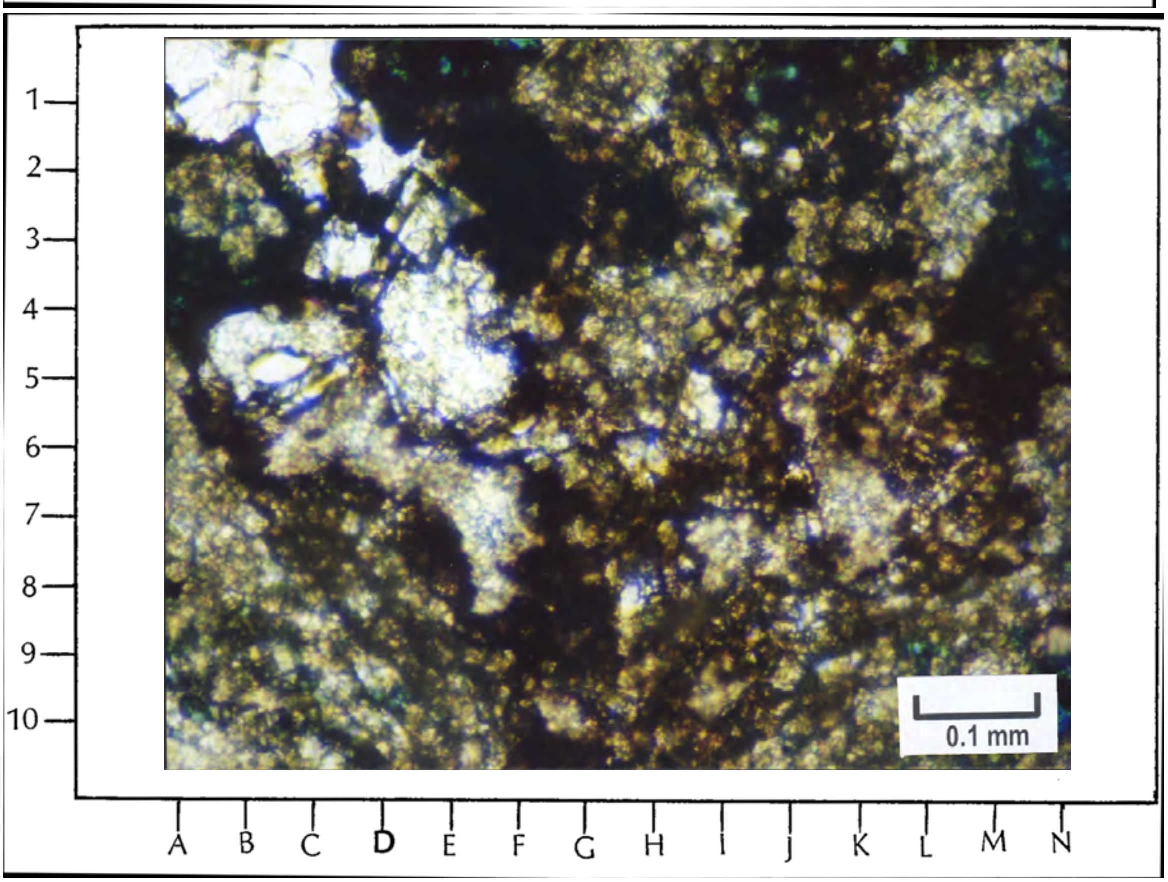
Top Photomicrograph

The patterns of fluorescence visible in this image provide a great deal of information when compared to the plane-polarized light view shown below. This image shows a concentration of microstylolites due to pressure solution between dolomites in dull yellow and patches of anhydritic dolomite in green. One of these stylolitic traces can be seen between C-6 and F-8. Note the large dolomite rhombs that can be seen at D-3 and F-2.5. Ghosts of former fossils and other carbonate grains of indeterminate origin can be seen at several places (for example D-7, L-8, and L-2). The small bright patches throughout this view are areas where oil is locally trapped in very tight places.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. Very little detail can be ascertained from this traditional transmitted light view due to the poor preservation within this area of tight dolomite with abundant black bitumen that masks rock details. The fluorescence view above significantly improves resolution of rock fabric from this type of rock.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

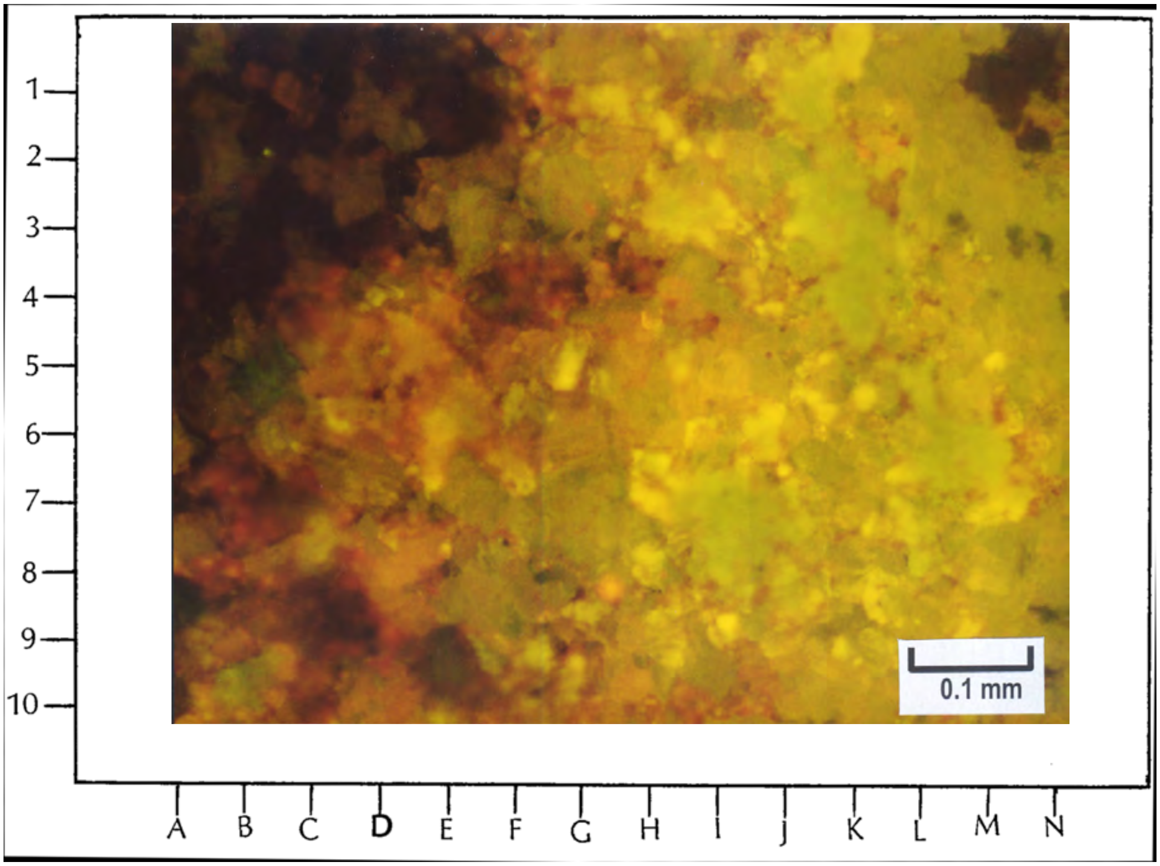
5783.5 feet

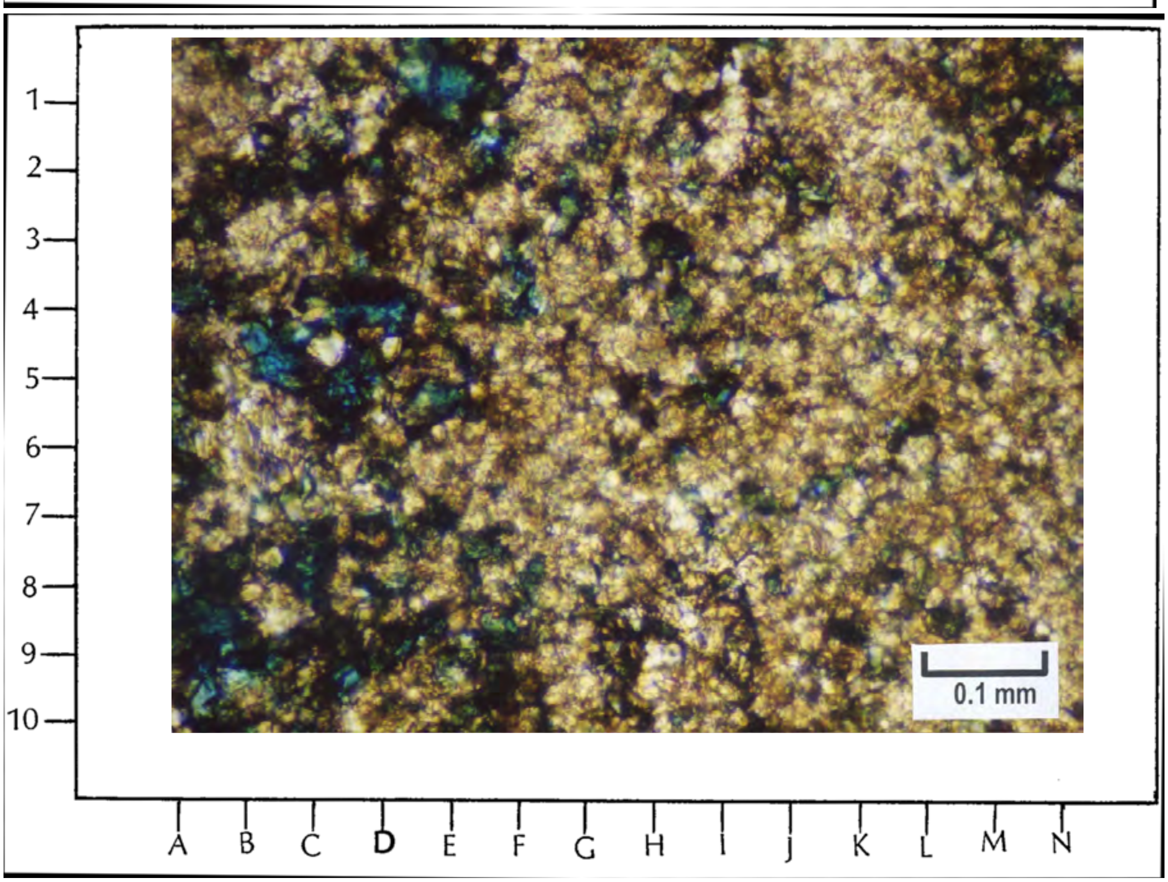
Top Photomicrograph

Large rhombs of dolomite replacement can be seen as the green crystals (for example E-3, G-7, K-4, and L-6) and the smaller yellow (oil-stained) crystals (for example G-2, H-7, and I-6). Open pores can be detected as the reddish areas throughout this field of view, indicating some small amounts of intercrystalline porosity.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. When comparing this photomicrograph to the one above, note that very little detail can be ascertained about the dolomite crystal size or pore distribution in this transmitted light image. One would not suspect that large dolomite rhombs with some attendant intercrystalline pore spaces were present in this lithology.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

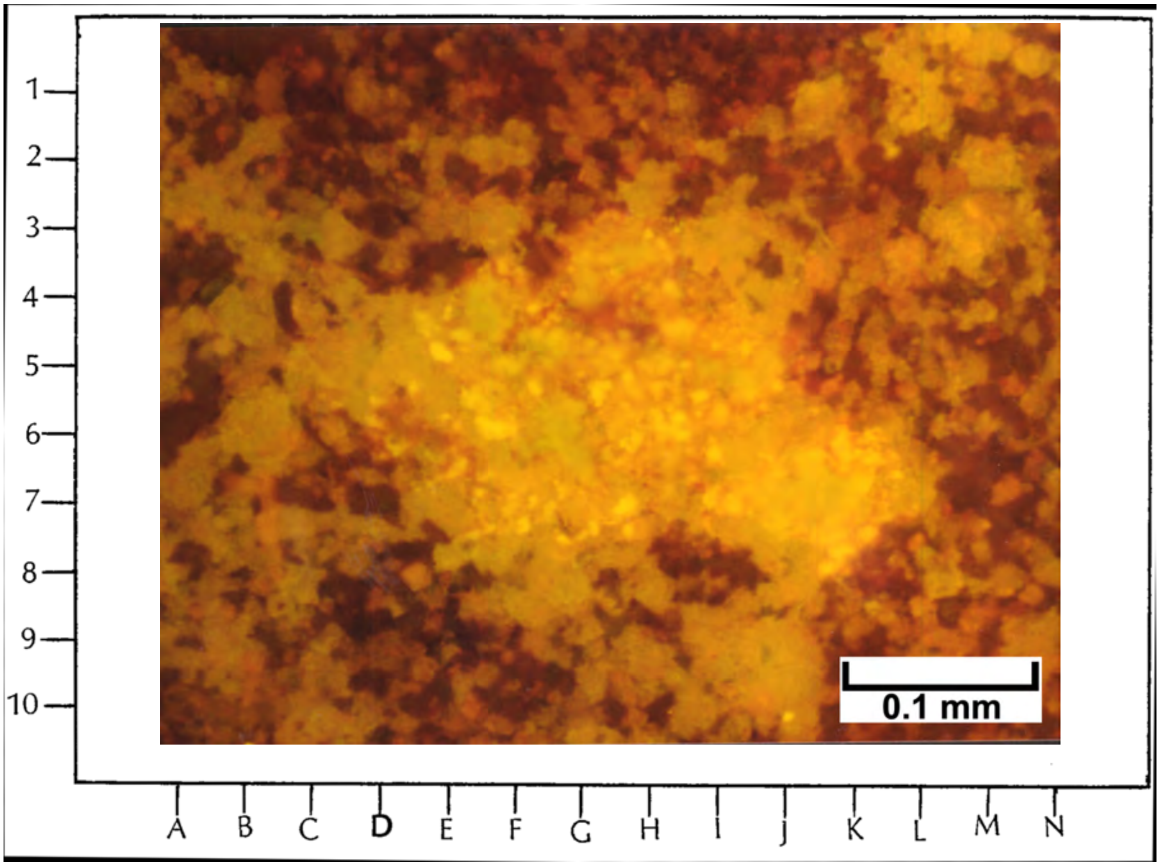
<u>**5783.5 feet**</u>

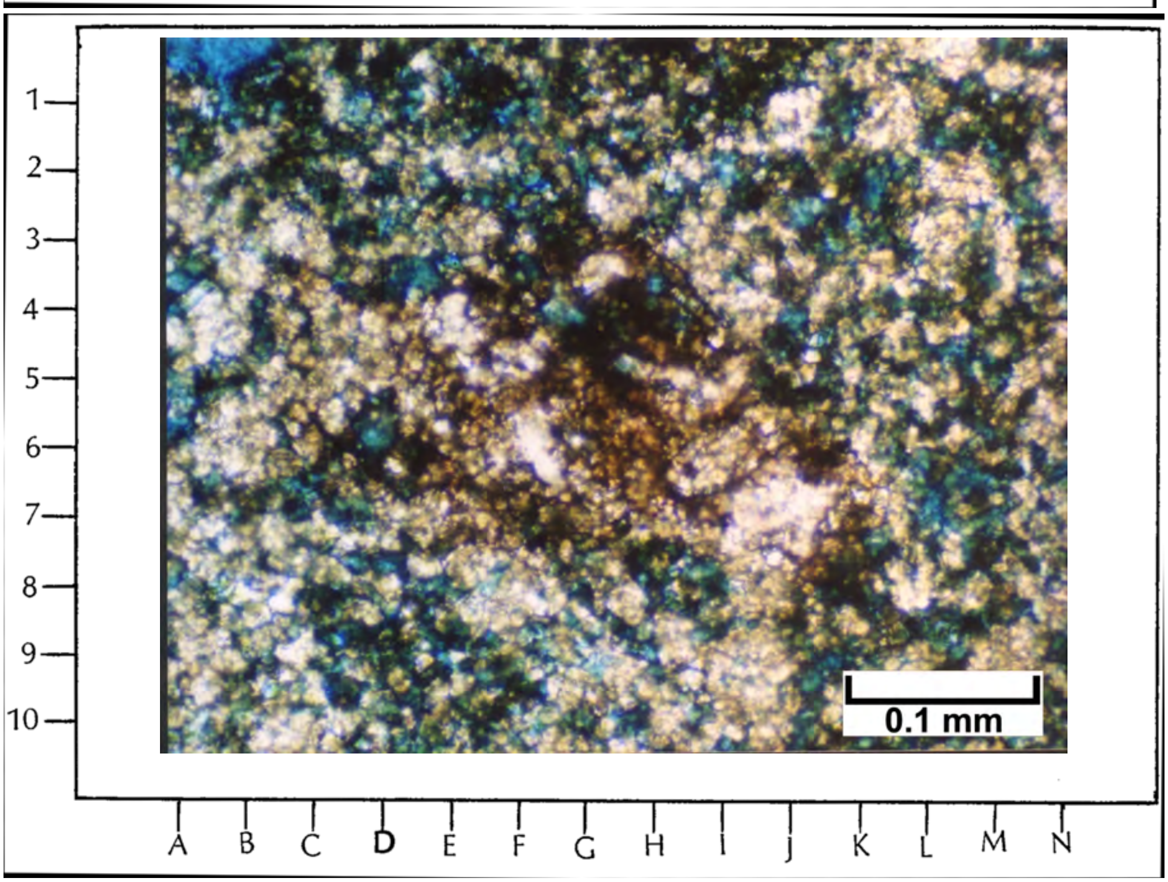
Top Photomicrograph

The colors shown here due to fluorescence provide some insight into the relative permeability of this dolomitic limestone as well as a visualization of the pore system. The central patch with bright yellow colors in this image represents an area of low permeability due to the concentration of live oil (in the brightest yellow colors) around the margins of the greenish yellow dolomite crystals. The reddish network in this image consists of better-connected and more permeable pores in which almost all of the live oil has been drained or evaporated from the pores. Note the intercrystalline, "microsucrosic" appearance of the dolomite crystals (in dull yellow) that are surrounded by the reddish pore network.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. This transmitted light image would be a difficult one with which to assess reservoir quality, that is permeability and pore distribution. Although there is an abundant amount of blue-dyed epoxy visible in this cross section, it is difficult to clearly resolve individual pore intersections. Only the brownish oil stain in the central region of this image would provide a hint of the low permeability region within this sample.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

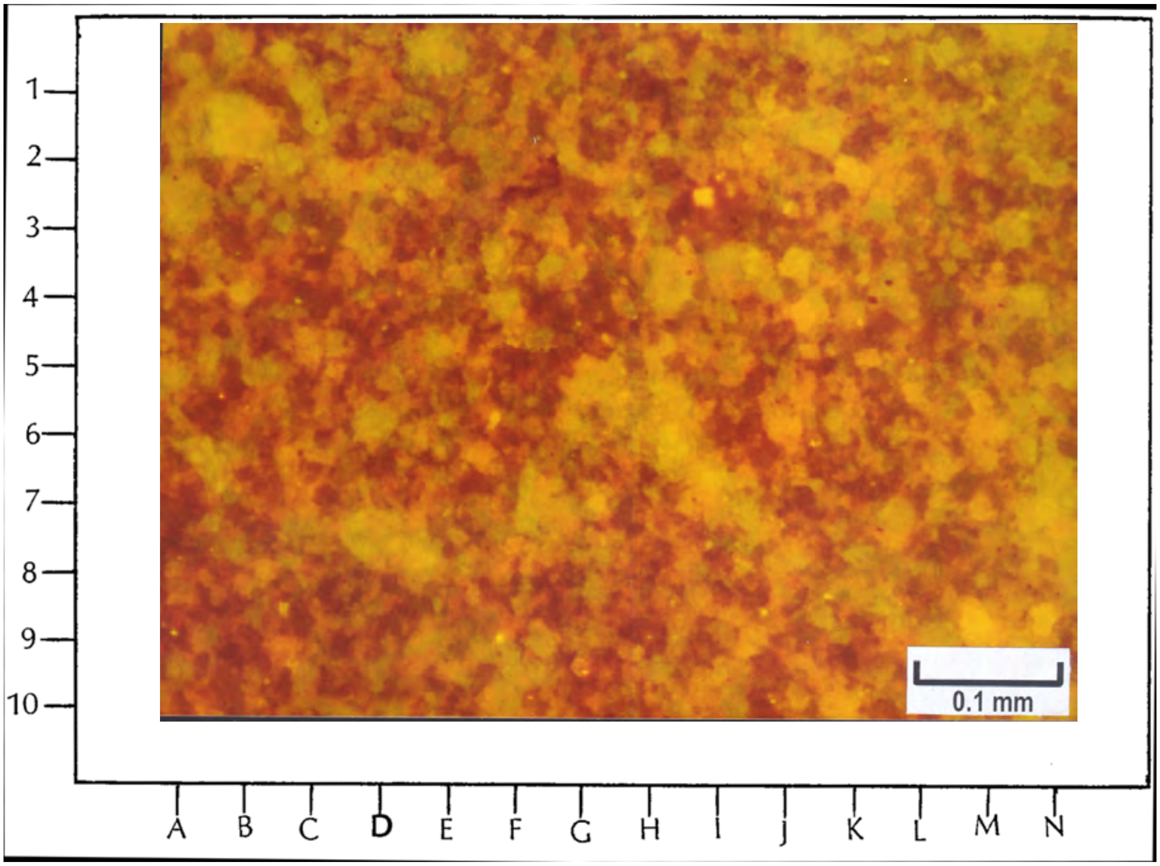
5801.3 feet

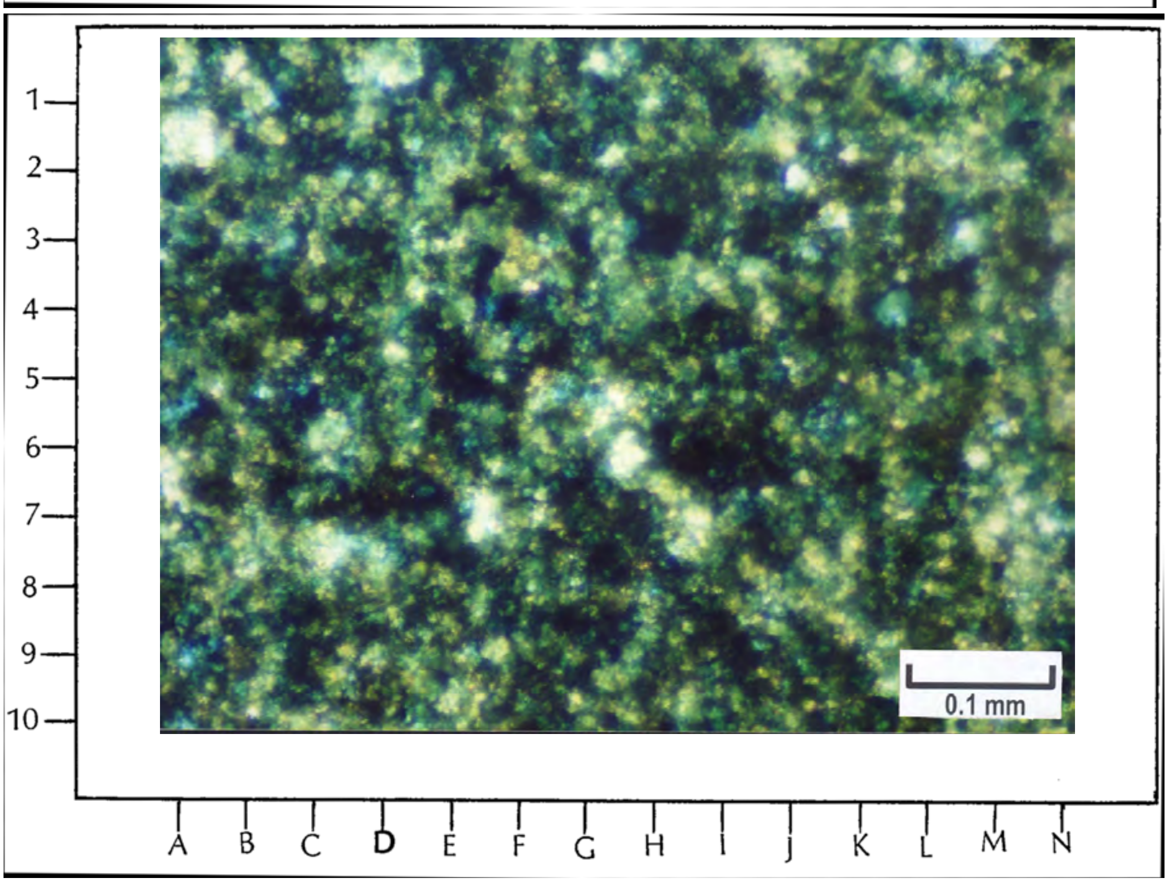
Top Photomicrograph

Abundant pore space can be seen in this fluorescence image, where the epoxy-impregnated pores appear red. Despite the heterogeneity of the distribution of pores, most of this microporosity seems to be moderately well connected. The greenish yellow and yellow colors in this image are from matrix areas composed of dolomite and limestone. The brightest yellow areas reflect staining of the matrix by live oil. Note the hints of earlier sand-sized carbonate grains (for example F-1.5, H-2, and L-5) and occasional isolated larger dolomite rhombs (for example B-1.5, G-7, and K-2).

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. Note that the details of the pore sizes and shapes cannot be seen in this transmitted light photomicrograph. Abundant black bitumen throughout this microporous network makes it nearly impossible to see the amount of visible porosity. At best, the microporosity in this image shows up as an indistinct "blue haze." In addition, it is not possible to see any hints of original grains or the sizes of dolomite crystals.


1
2
3
4
5
6
7
8
9
10
A B C D E F G H I J K L M N
0.1 mm


1
2
3
4
5
6
7
8
9
10
A B C D E F G H I J K L M N
0.1 mm

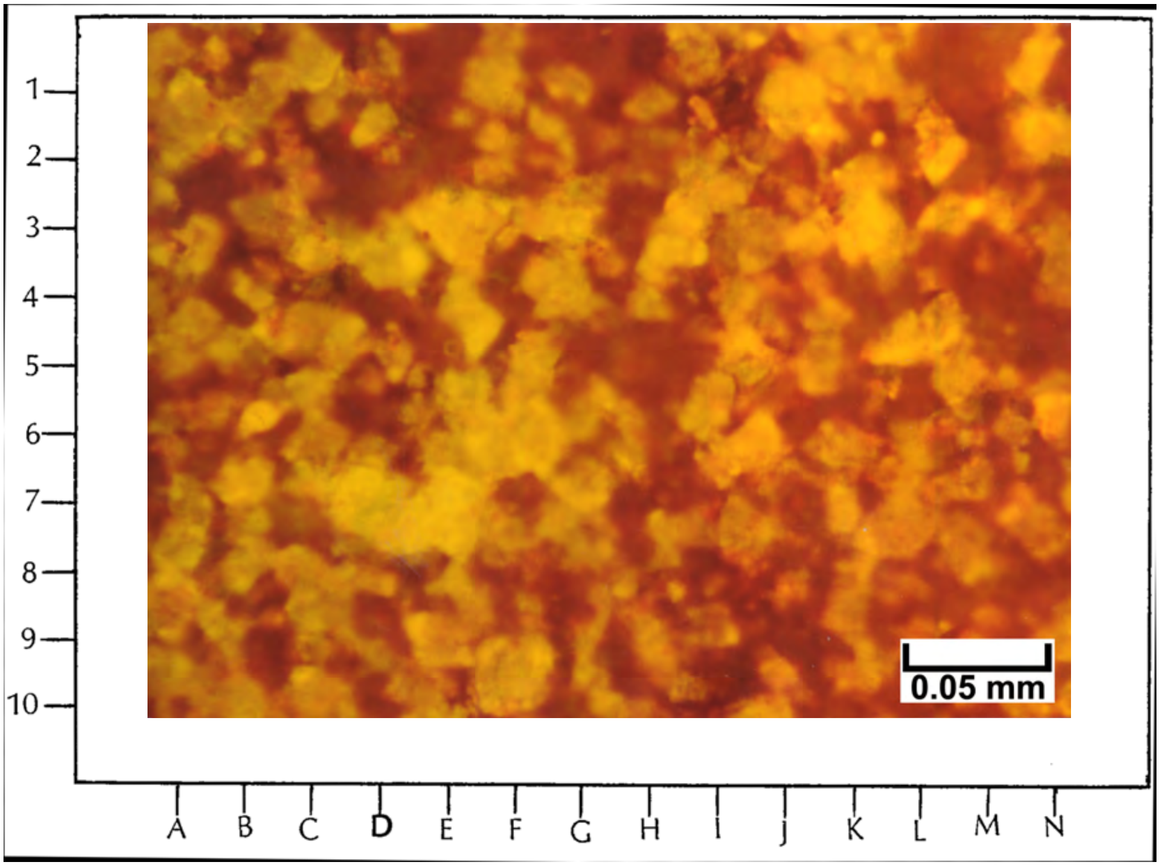
5801.3 feet

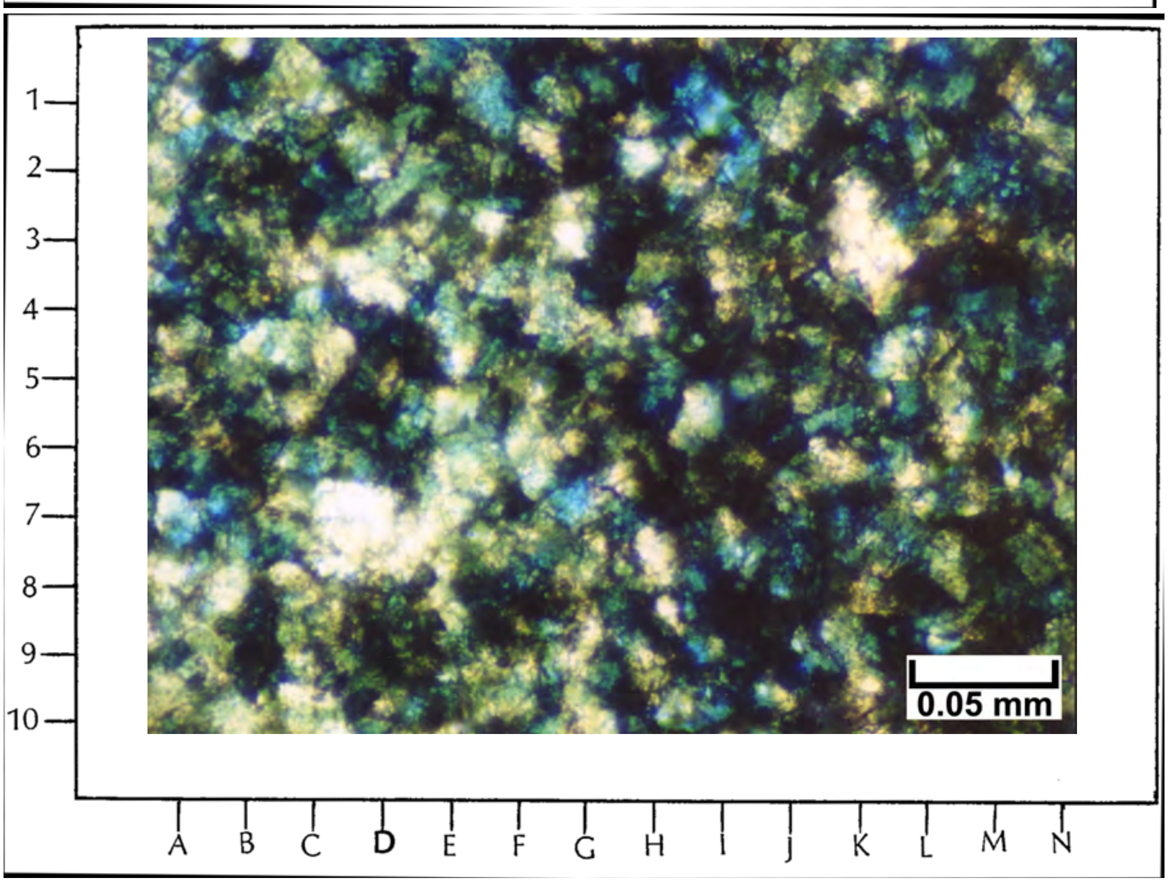
Top Photomicrograph

This high magnification fluorescence view nicely shows the individual mini-rhombs of dolomite making up the matrix of this sample. Note that some of the areas of dolomite fluoresce a brighter yellow due to live oil entrapment in areas of lower permeability. In general, most of the mini-rhombs of dolomite are dull yellow to light green due to the fairly uniform permeability throughout most of this sample. The reddish and dark-colored areas of this image show the open pores. Overall, this sample shows nice micro-intercrystalline porosity within a "microsucrosic" dolomite. The presence of black bitumen (see the photomicrograph below) does not seem to completely plug the pores as shown by the red fluorescing epoxy that has been impregnated into open-pore space.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. Very little detail can be discerned in this transmitted-light view compared to the fluorescent photomicrograph above. The black and opaque nature of bitumen linings within some pores overwhelms the image such that more pore boundaries are difficult to see.


1
2
3
4
5
6
7
8
9
10
0.05 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.05 mm
A B C D E F G H I J K L M N

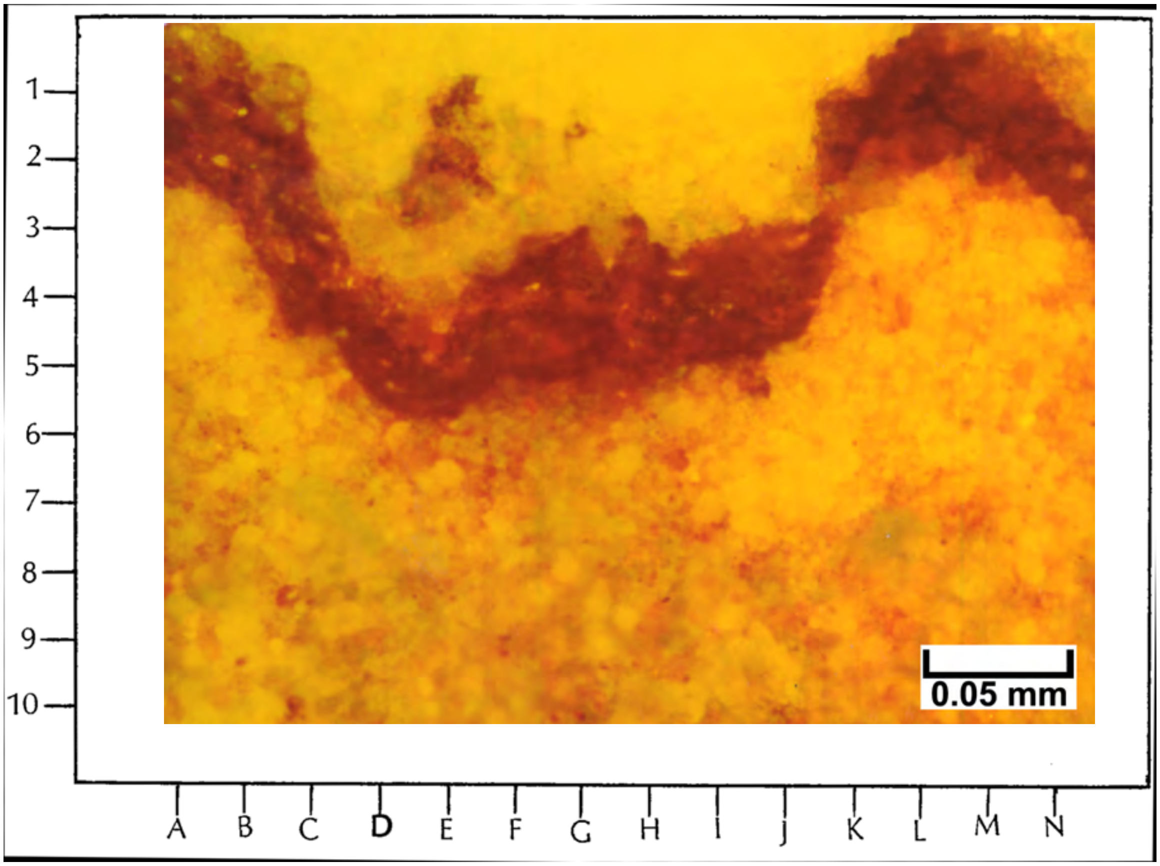
5801.3 feet

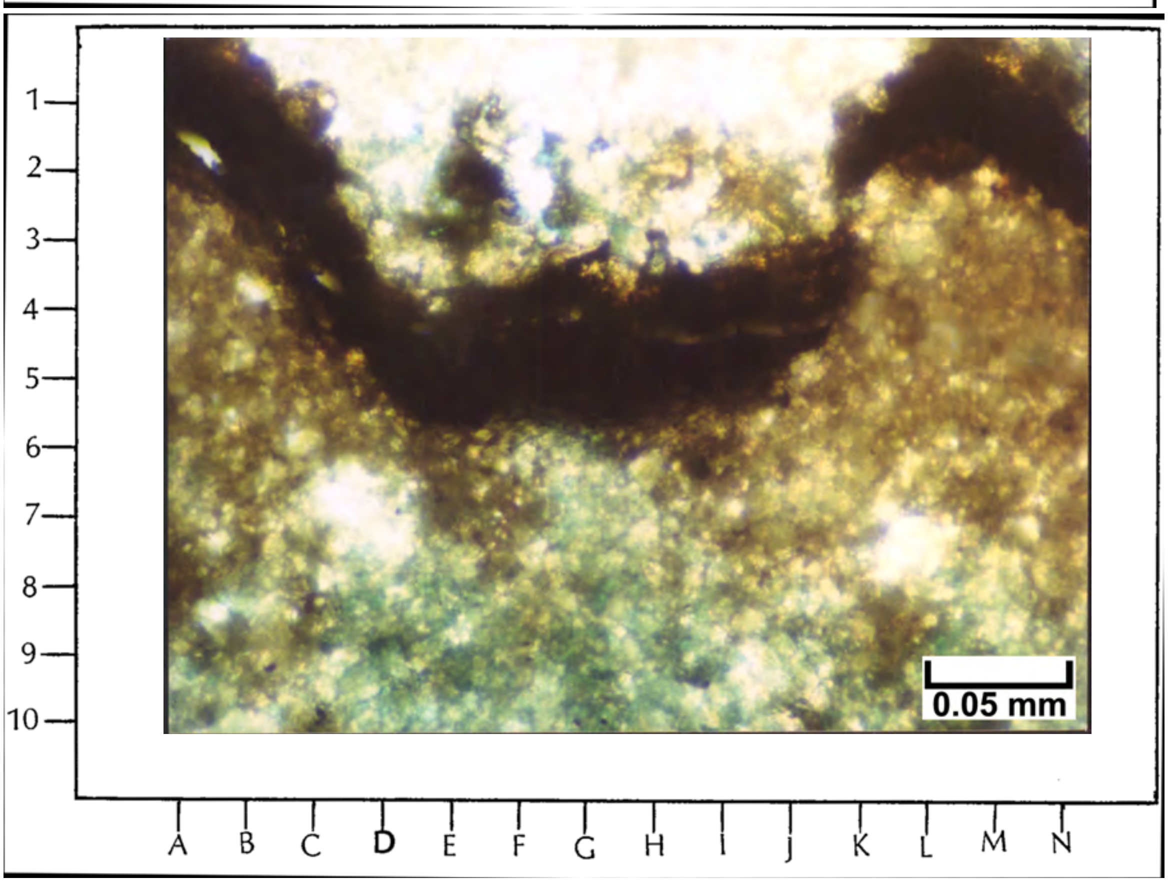
Top Photomicrograph

This image shows a permeability barrier along a pressure-solution or stylolitic seam with non-fluorescing insoluble residues. On either side of this stylolite, there is evidence of some matrix microporosity (in the reddish areas as well as relict carbonate grains within this limestone). A few dolomite crystals can also be seen as the occasional greenish areas in this image.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. The black material concentrated across the upper portion of this photomicrograph is the insoluble residue along the stylolitic seam. Hints of some of the matrix microporosity can be seen in the bluish color of the image along the bottom. Note that it is not possible to resolve any textural or compositional detail of this sample like the fluorescence photomicrograph at the top provides.


0.05 mm
1
2
3
4
5
6
7
8
9
10
A B C D E F G H I J K L M N


0.05 mm
1
2
3
4
5
6
7
8
9
10
A B C D E F G H I J K L M N

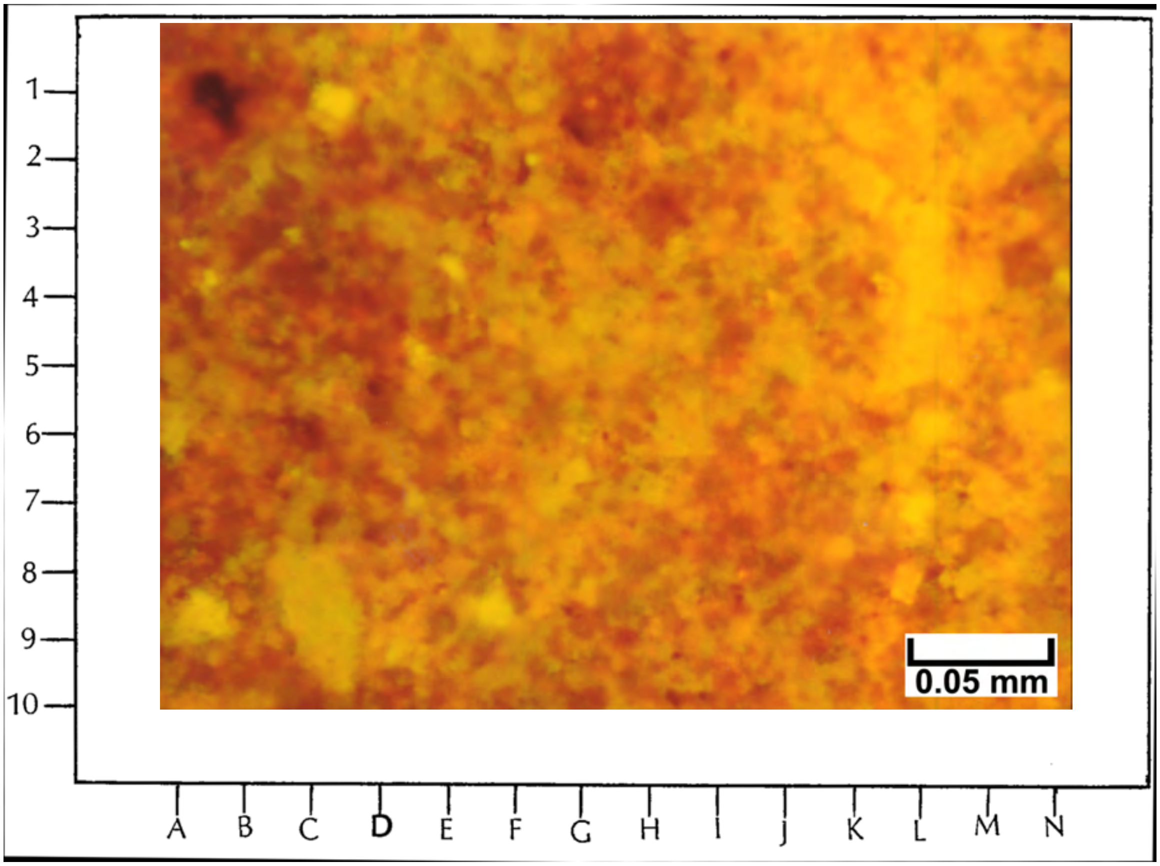
5813.8 feet

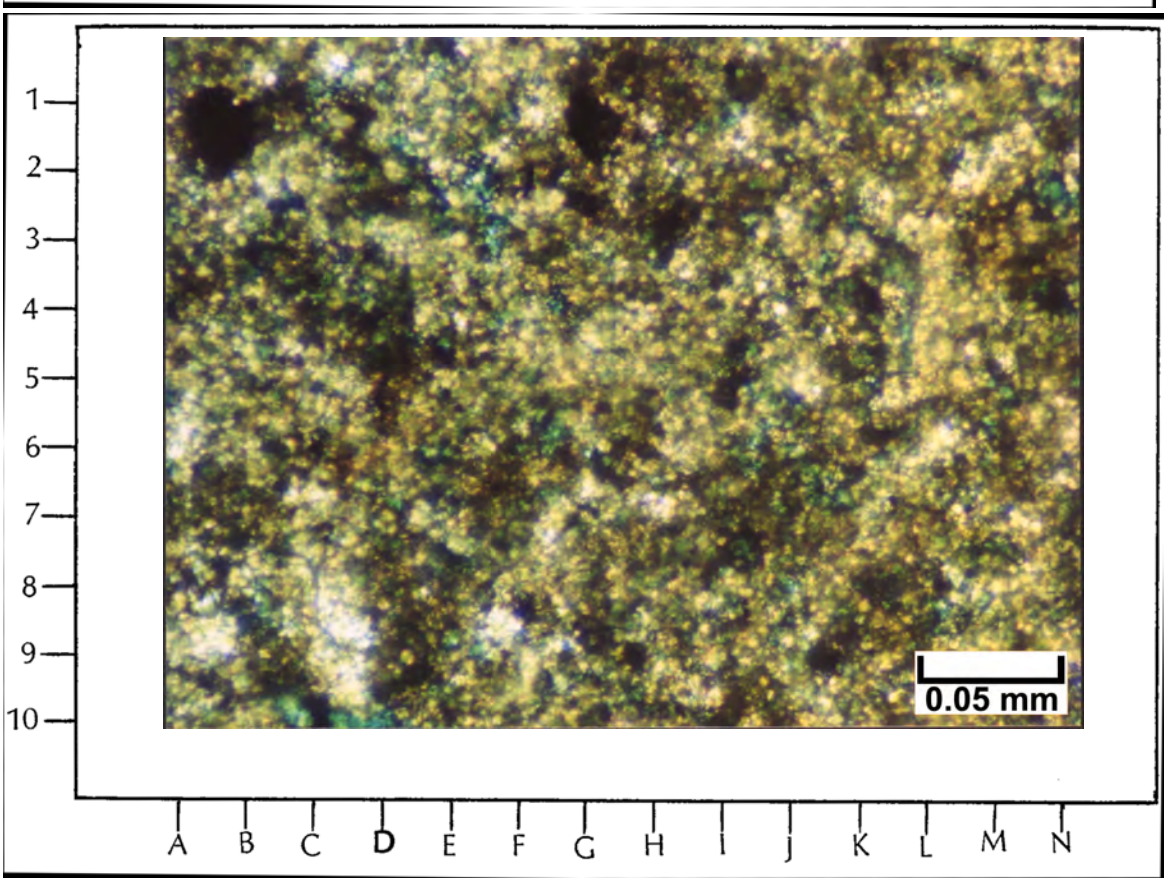
Top Photomicrograph

This sample shows a representative area with significant amounts of microporosity with bitumen linings which fluoresce red and orange in this image. The dolomitic limestone matrix in this specimen fluoresces yellow (where oil-stained) and green. There are a few small patches of tight matrix surrounded by pervasive microporosity throughout.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. This lighting does not image the extensive microporosity in this sample very well even though there are some hints of blue-dyed epoxy here and there. The porosity does not show up very well under transmitted light because the pores are much smaller than the thickness of the thin section. In addition, opaque bitumen linings block light from passing through some of the pores to the observer.


1
2
3
4
5
6
7
8
9
10
0.05 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.05 mm
A B C D E F G H I J K L M N

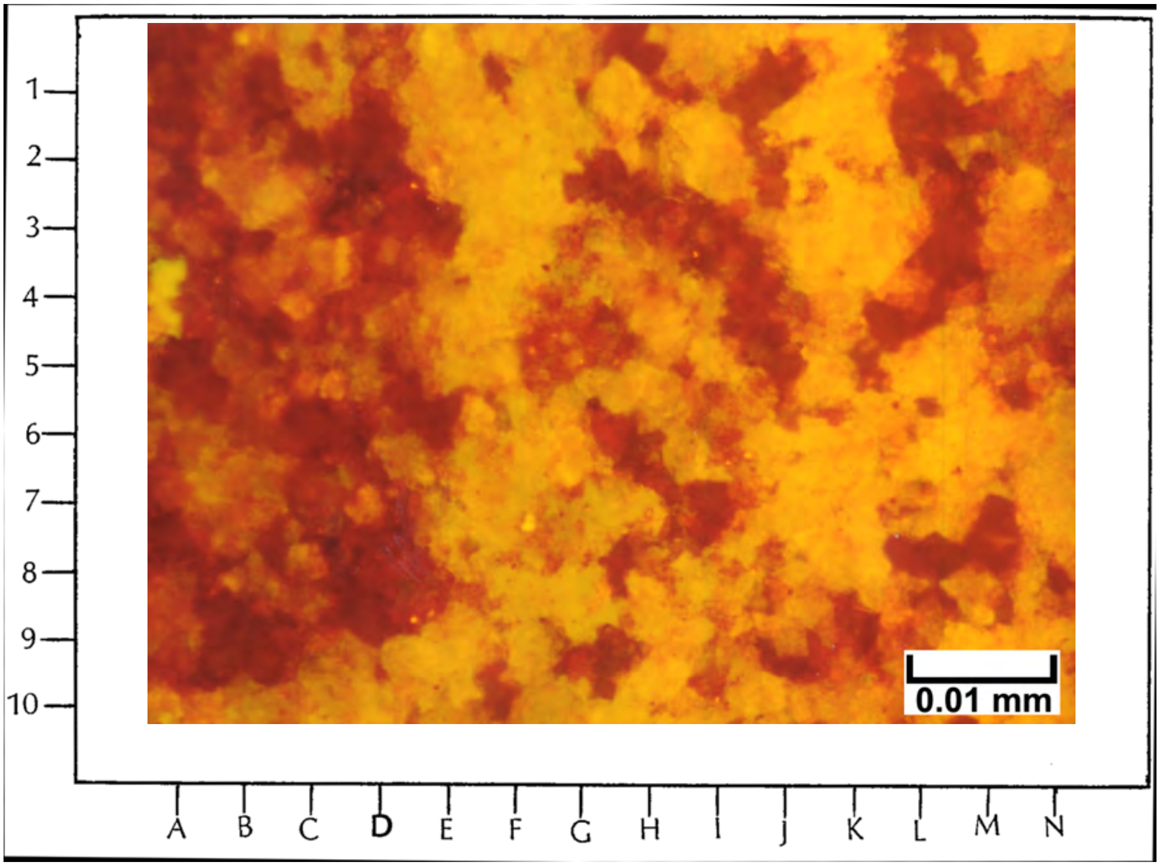
5831.8 feet

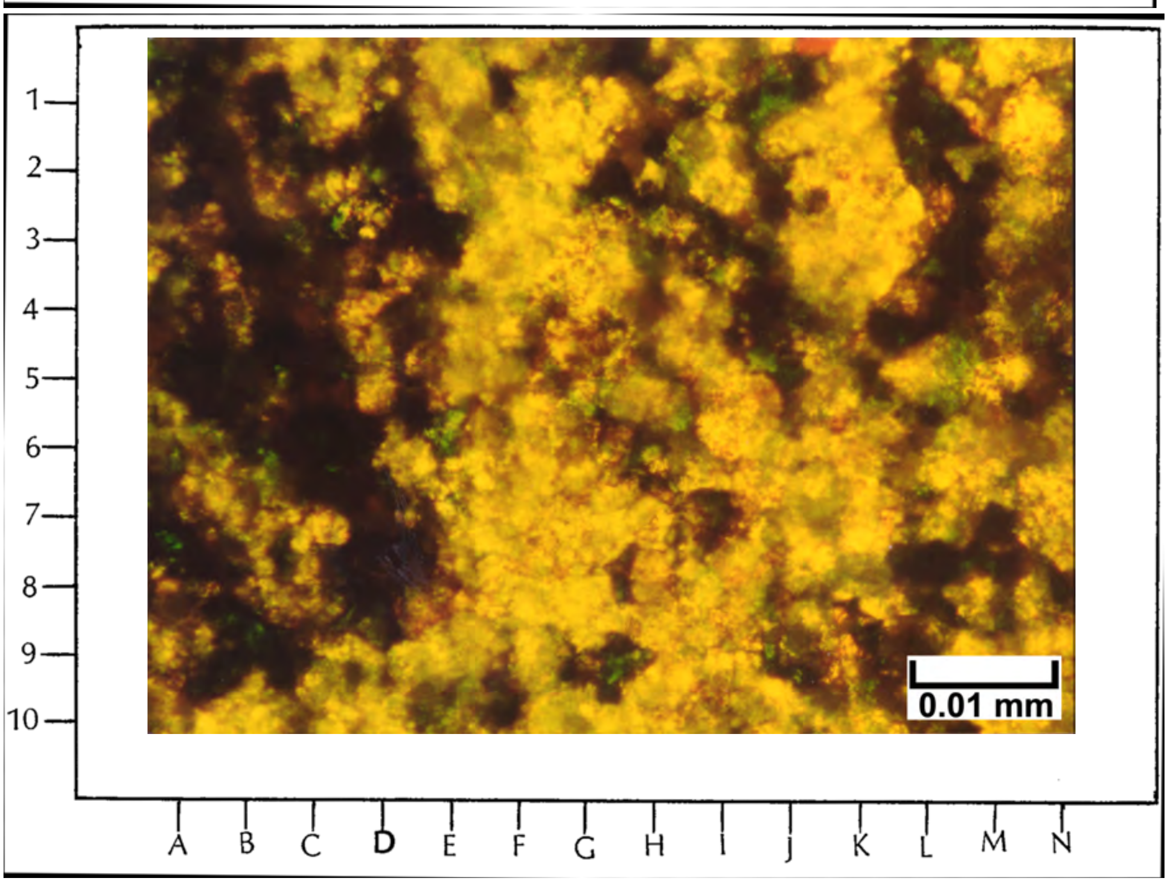
Top Photomicrograph

This sample comes from a limestone sample in an area that displays abundant pore space as indicated by the areas of red-fluorescing epoxy. Note that the left side displays well-connected areas of open pores while the right side shows a slightly dolomitic limestone with more isolated pores. The yellow-fluorescing areas are oil-stained carbonates surrounding the radiating pore networks in red. The presence of abundant bitumen in this sample (see below) does not seem to plug the pore space in any significant way.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. There is not much visible pore space under this lighting (a paucity of blue-dyed epoxy). Compare this photomicrograph with the fluorescence image above, where the red-colored areas show the open-pore spaces. The black (opaque) bitumen linings around most pores apparently block light from passing through some of the pores to the observer. (The red-brown areas in this bottom image are residues from artificial staining by Alizarin Red-S solution).


1
2
3
4
5
6
7
8
9
10
0.01 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.01 mm
A B C D E F G H I J K L M N

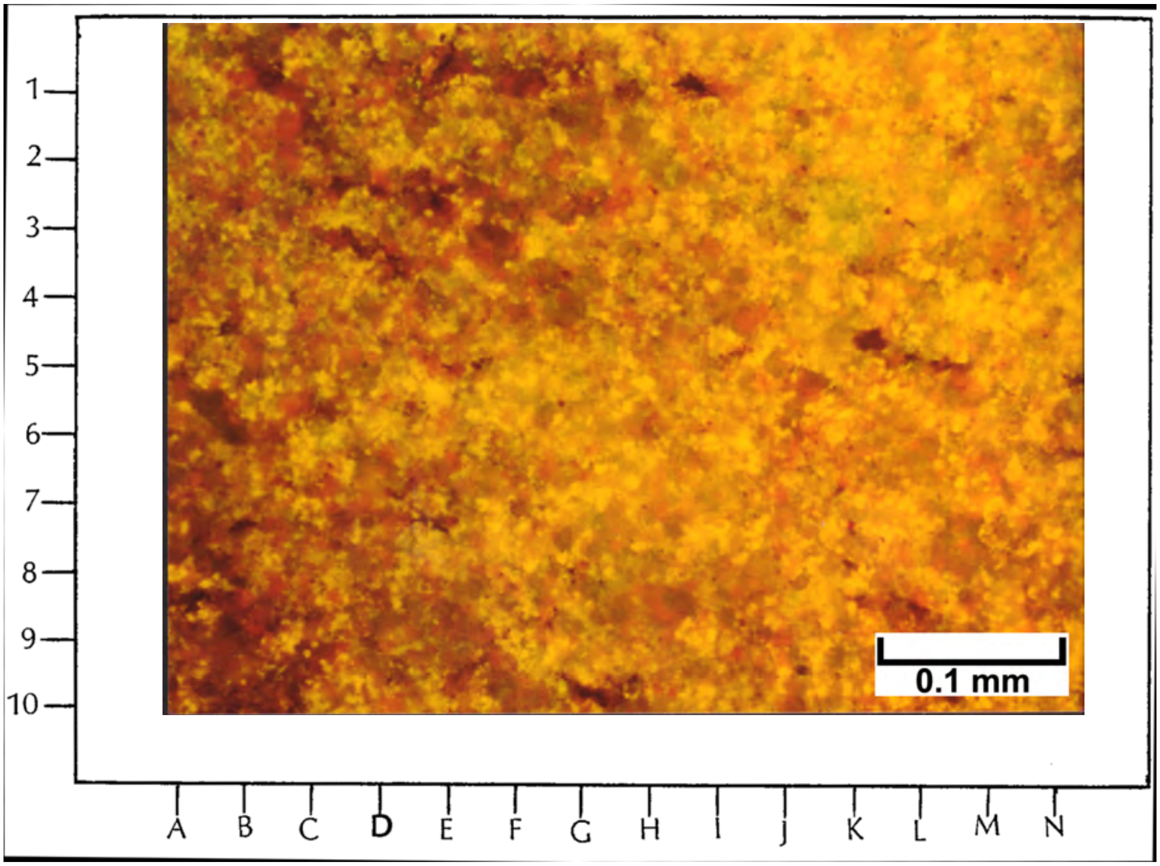
5864.1 feet

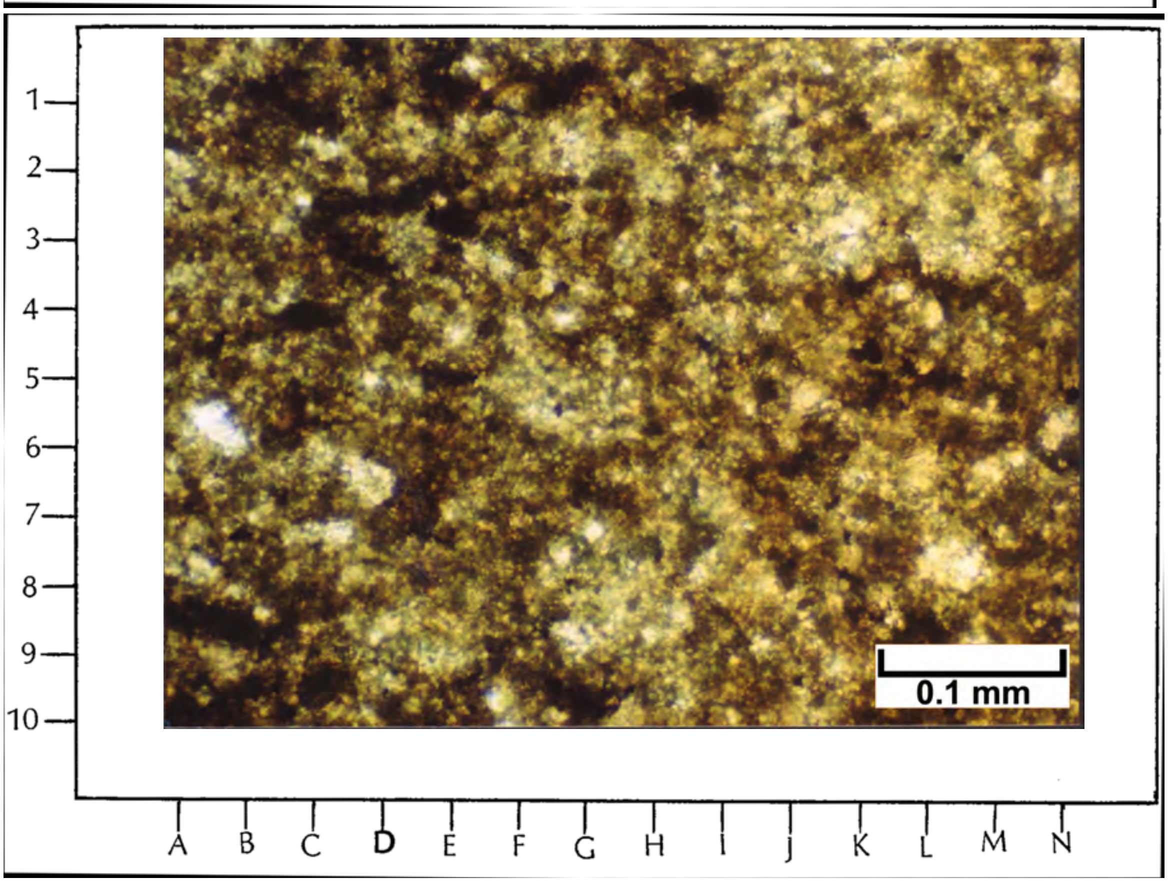
Top Photomicrograph

This sample comes from a rather tight limestone than has no visible matrix porosity under transmitted lighting (see photomicrograph below). However, under fluorescence microscopy, there is some red fluorescence from spiked epoxy that has been impregnated into matrix pore spaces. Therefore, the scattered red spots in this image show the presence of some porosity. The abundant bright yellow specks across the image are probably the result of live oil staining throughout this relatively low-porosity sample. Note the dull green areas which show some relict preservation of the peloids (for example E-3, F-4, and L-8) that were the principal constituent of this carbonate sediment.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. There is no visible matrix porosity in this image (that is no blue colors) despite the appearance of some areas of fluorescing epoxy-filled pores in the image above. In addition, the peloids that can be seen in the fluorescence view are very difficult to make out in this transmitted light view.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

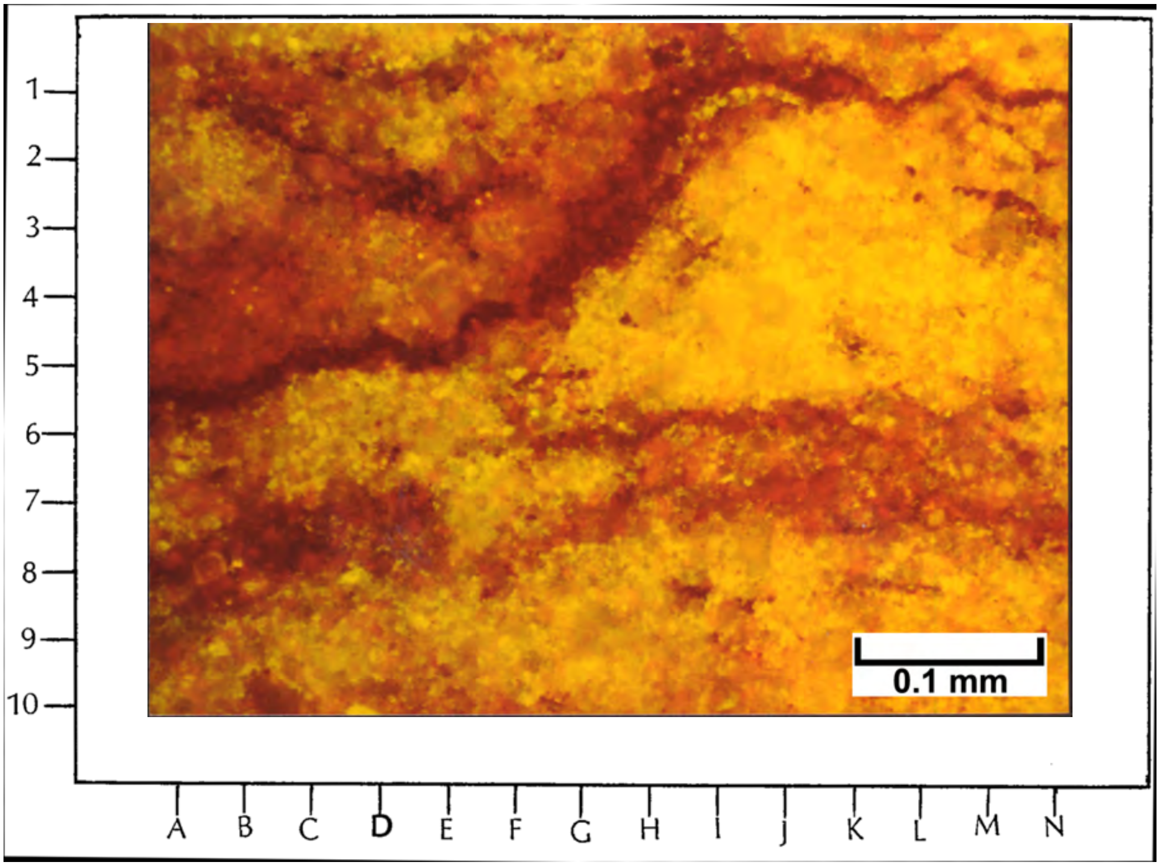
<u>5864.1 feet</u>

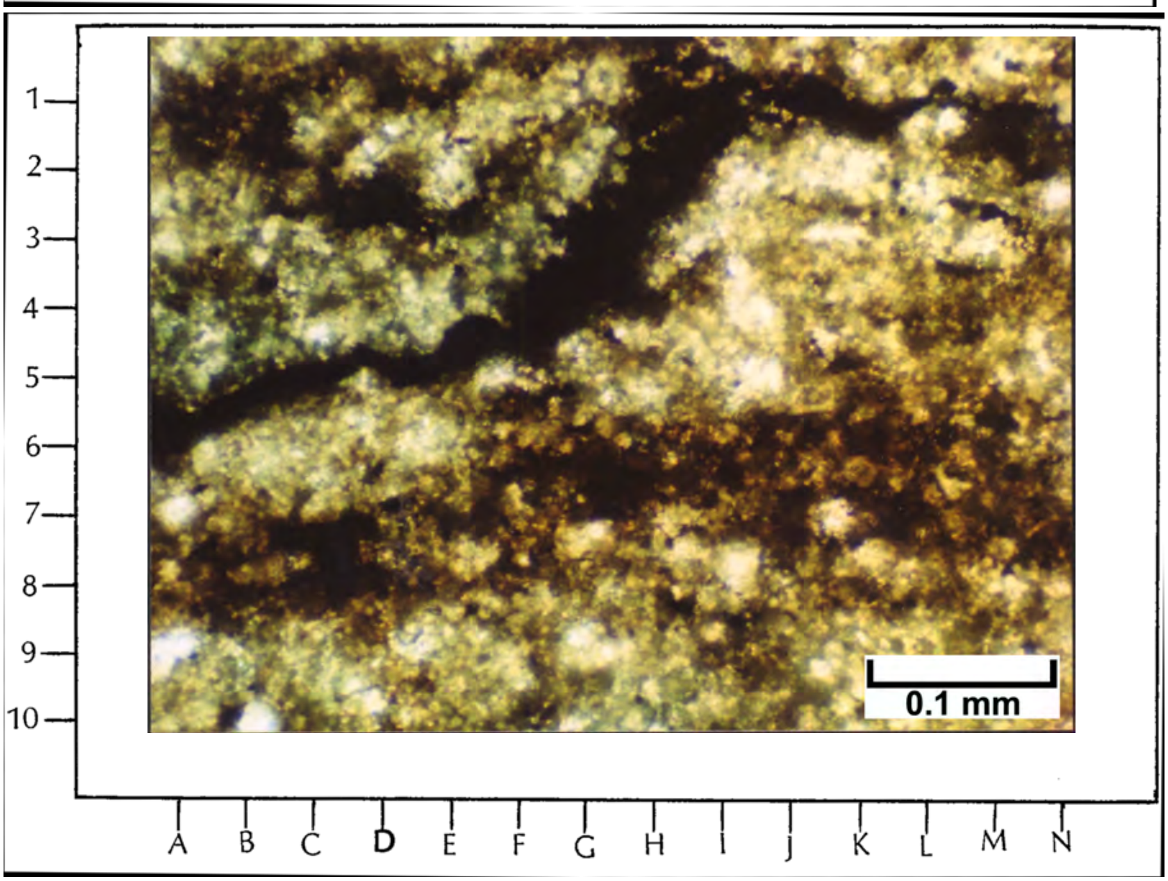
Top Photomicrograph

This sample shows significant heterogeneity in porosity distribution, especially in the vicinity of wispy stylolitic seams. The darkest areas (dark brown in color here) are mostly concentrations of insoluble residues along the stylolites. The red areas represent fluorescence of epoxy-impregnated microporosity. Note in particular the abundant pore spaces in the upper left corner of this photomicrograph, immediately above a relatively thick stylolitic seam. The bright yellow areas represent the fluorescence of mostly live oil surrounding tight rock matrix. Hence, the stylolitic seams in this field of view appear to segregate relatively porous versus very tight rock matrix. These stylolitic seams provide important permeability barriers to fluid flow between the relatively porous and the tight rock compartments.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. The stylolitic seams of pressure-solution origin shows up as the sinuous black patterns in this image. However, there is no visible matrix porosity under this lighting. The dense limestone matrix appears in this view to be equally tight between each stylolitic seam. However, the EF image above clearly shows significant variations in the open-pore space distribution.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

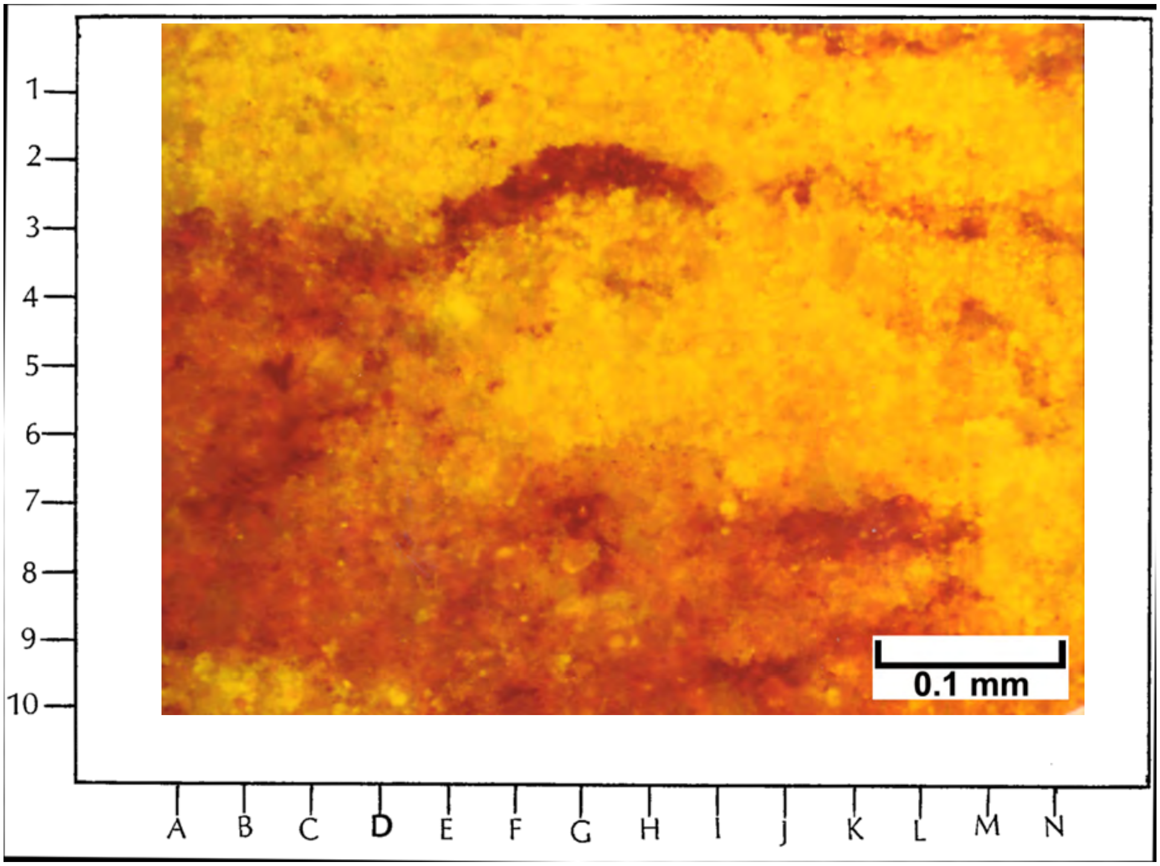
5864.1 feet

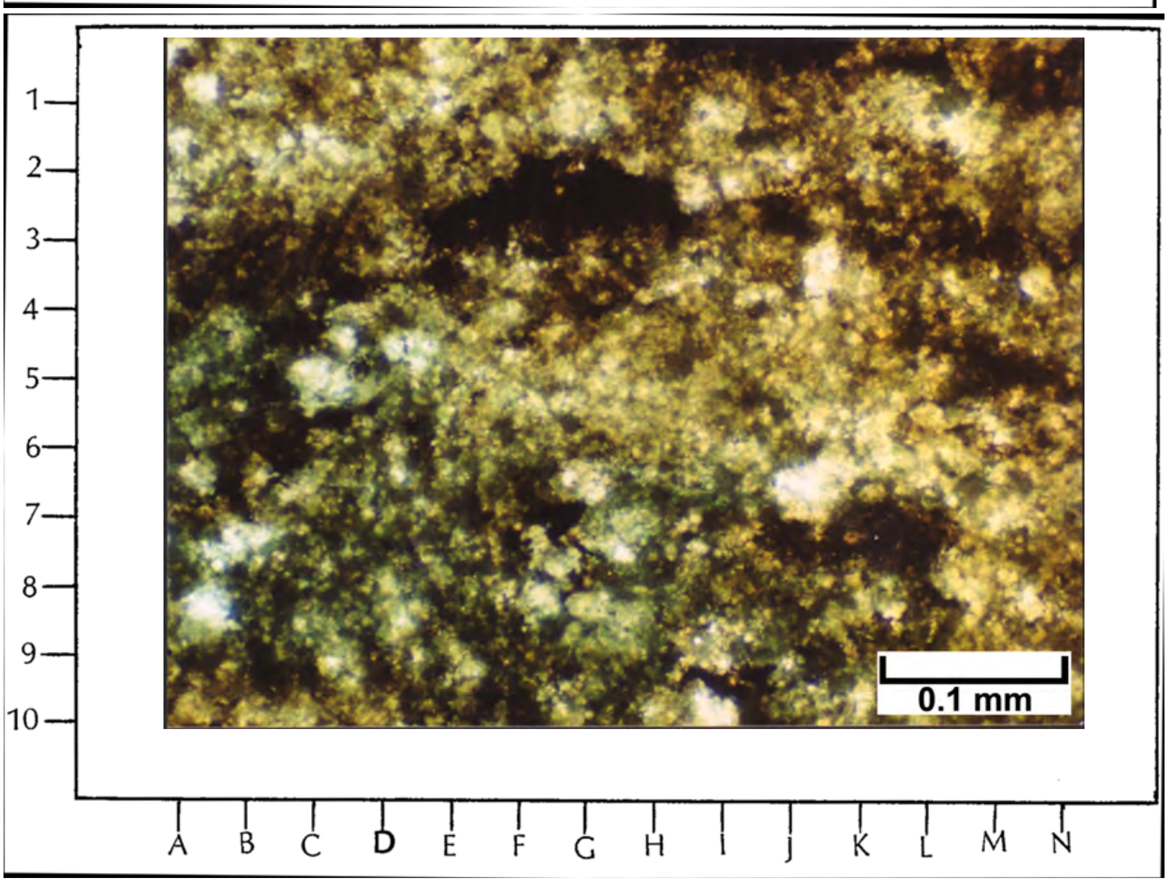
Top Photomicrograph

Epifluorescence of another representative portion of this stylolitic limestone sample shows significant matrix porosity in the lower left part of this image (in the reddish areas) and much tighter rock (in yellow) across the top and in the upper right part of the photomicrograph. The dark brown areas are wispy stylolitic seams with variable amounts of insoluble residues. The matrix porosity appears red here because of the fluorescence response of epoxy that has been impregnated into the pore spaces during sample preparation.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. None of the porosity imaged under fluorescence (see top photomicrograph) is visible under this lighting. The lower left portion of this field of view shows significant amounts of pore space under fluorescence, but is very dark colored due to opaque bitumen pore linings in this area. In other words, the black areas in the lower left are mostly located where pore space still exists and where epoxy was impregnated for this thin section work.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

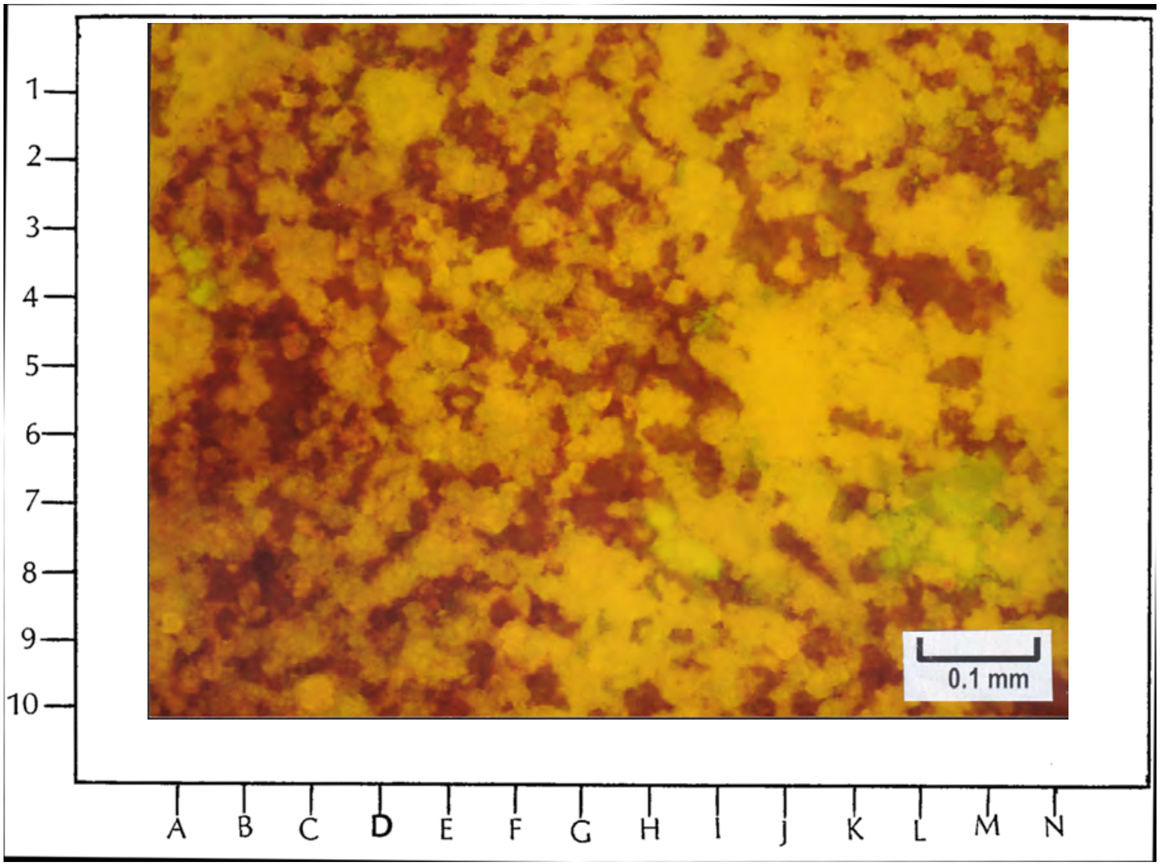
5773.9 feet

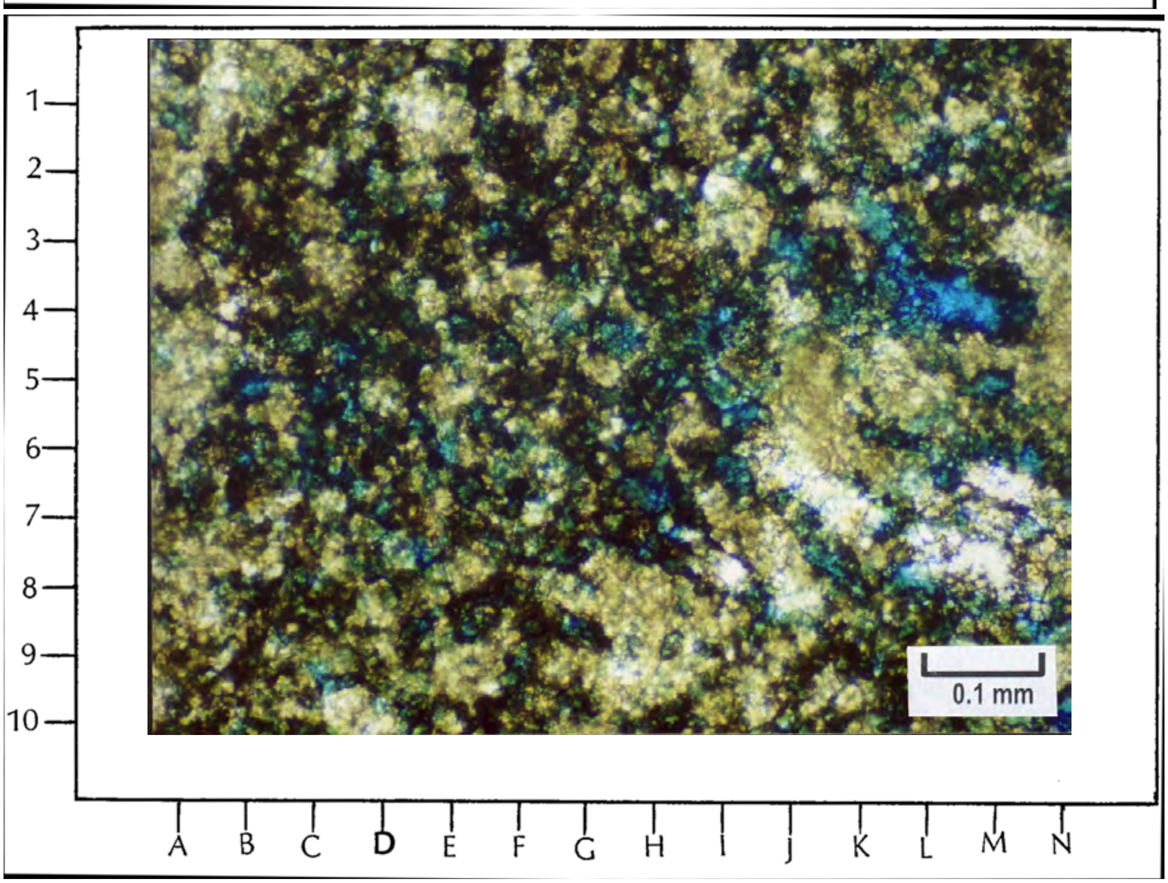
Top Photomicrograph

This representative EF photomicrograph nicely shows the distribution and shapes of open pores which appear here in the shades of red. Many of these pores are somewhat elongate and are moldic in origin. Most result from the dissolution of small phylloid-algal plates and possibly other fossil skeletons. Many of these dissolution pores appear to be well connected. The yellow areas are oil-stained carbonates which are mostly composed of limestone here. The light green areas (for example B-3.5 and M-7) are patches of anhydrite cementation.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. Note that the areas of visible blue-dye colored epoxy are not abundant or as distinct as the areas in red within the fluorescence photomicrograph above. Without the aid of the fluorescence view, the amount of visible open-pore space would be underestimated in the Pl image.


0.1 mm
1
2
3
4
5
6
7
8
9
10
A B C D E F G H I J K L M N


0.1 mm
1
2
3
4
5
6
7
8
9
10
A B C D E F G H I J K L M N

CHEROKEE FEDERAL 33-14 WELL, CHEROKEE FIELD

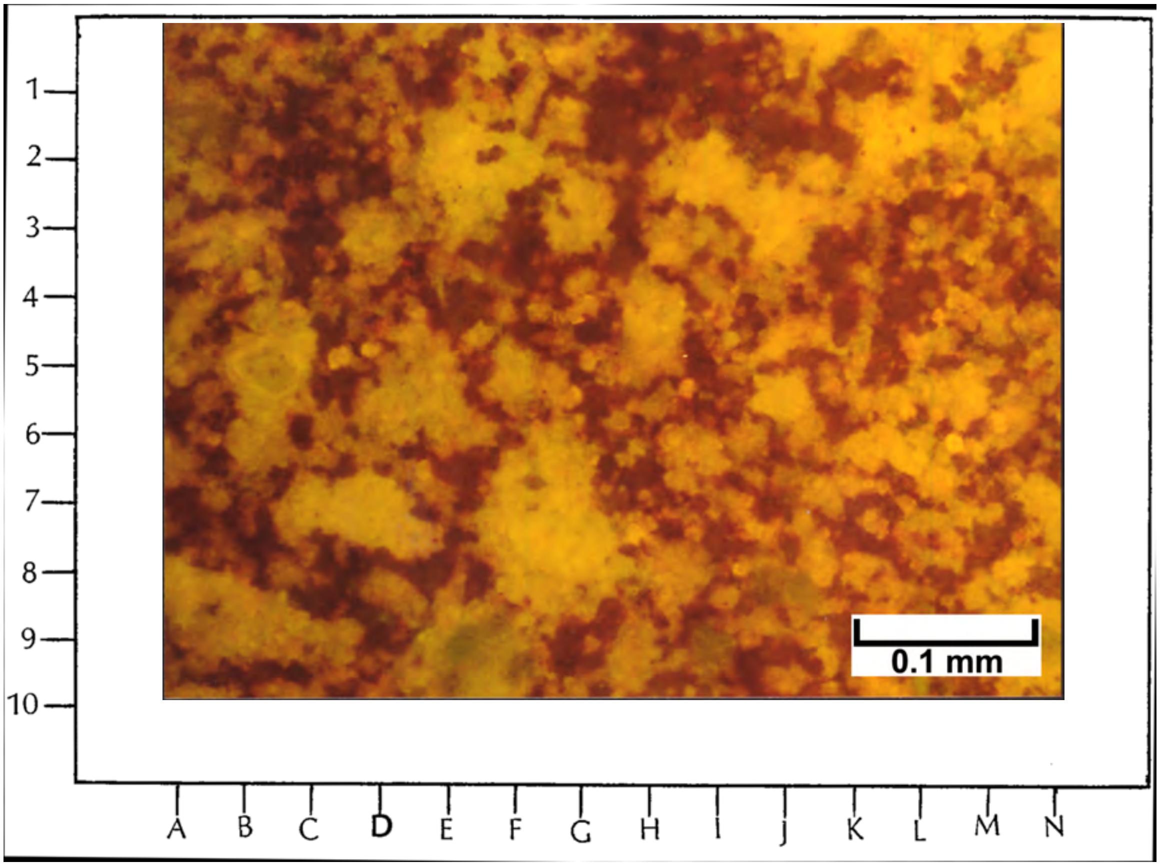
5773.9 feet

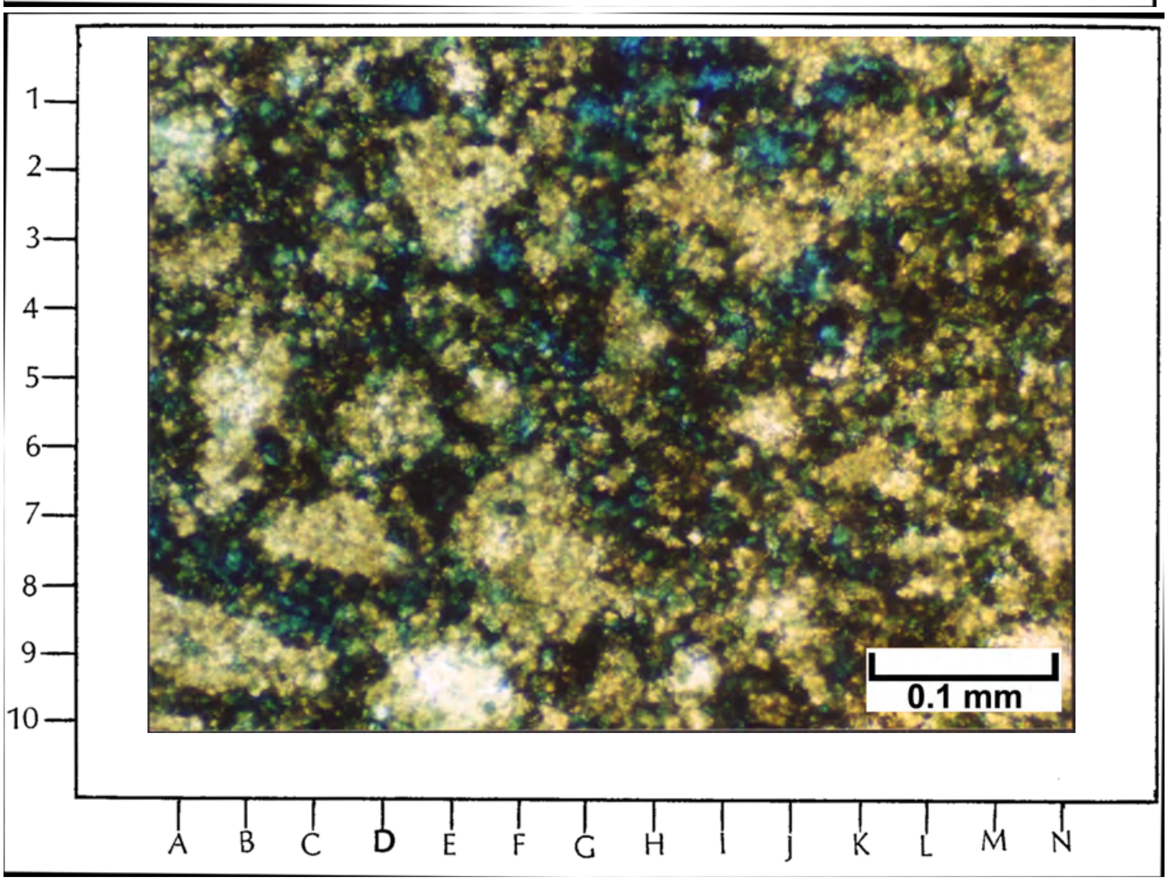
Top Photomicrograph

This heterogeneous sample shows poorly sorted patches of tight carbonate matrix (in bright yellow and green fluorescence) separated by open-pore systems (in red fluorescence) under moderate magnification. Note that there are remnants of former grains that can be seen within the tighter (yellow) areas. For instance, observe the outlines of former fossil grains at F-1, I-3, M-3, and so forth) as well as probable peloids or ooids (for example J-9.5, L-8, and N-9). Most of the porosity in this view (in red) is probably from partial dissolution of earlier grains and cements.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. The blue areas (dyed-impregnated pores) show only part of the porosity imaged in the fluorescence view above. The black portions of this view mask some of the open pores by bitumen linings. In addition, the Pl view does not provide a sharp image of the pore boundaries or the relict grains within the carbonate sediment.


0.1 mm


0.1 mm

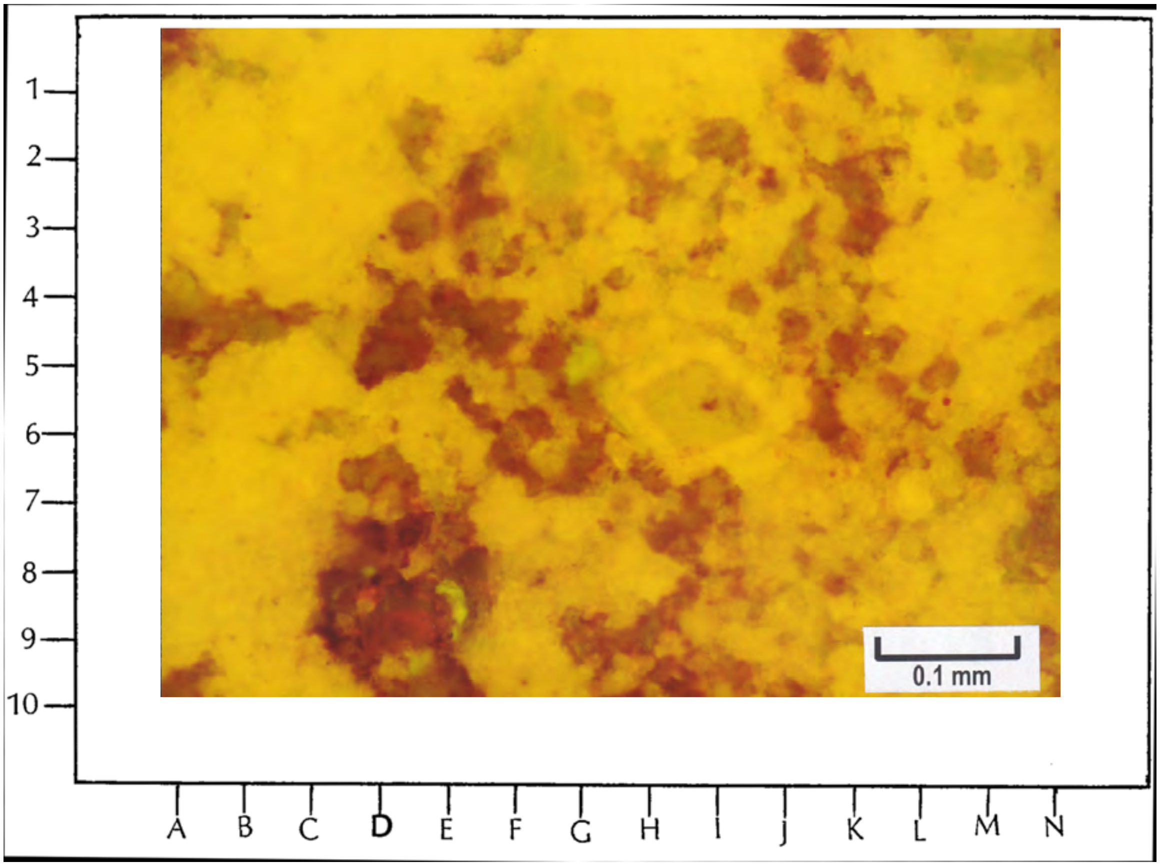
5773.9 feet

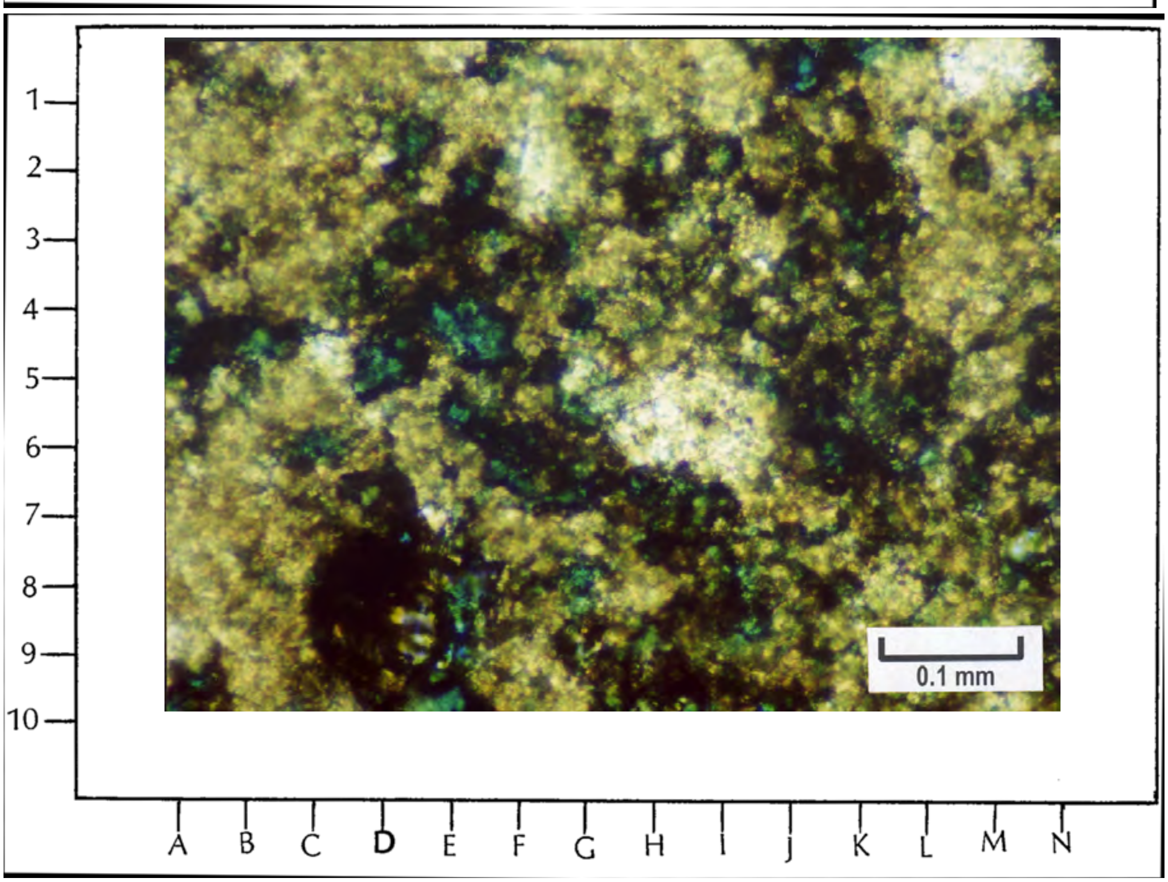
Top Photomicrograph

This fluorescence view is from a relative low porosity part of the sample. The bright yellow areas are tight portions of the carbonate matrix that show fluorescence due to live oil staining around the microcrystalline matrix and crystal faces. Isolated patches of pores occur as the red fluorescence of the impregnated epoxy. Note the nicely zoned dolomite crystal at I-6 that has replaced some of the carbonate matrix.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. The blue areas (dyed-impregnated pores) show only part of the porosity imaged in the fluorescence view above. The black portions of this view mask some of the open pores by bitumen linings. In addition, the Pl view does not provide a sharp image of the pore boundaries or the relict grains within the carbonate sediment.


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N


1
2
3
4
5
6
7
8
9
10
0.1 mm
A B C D E F G H I J K L M N

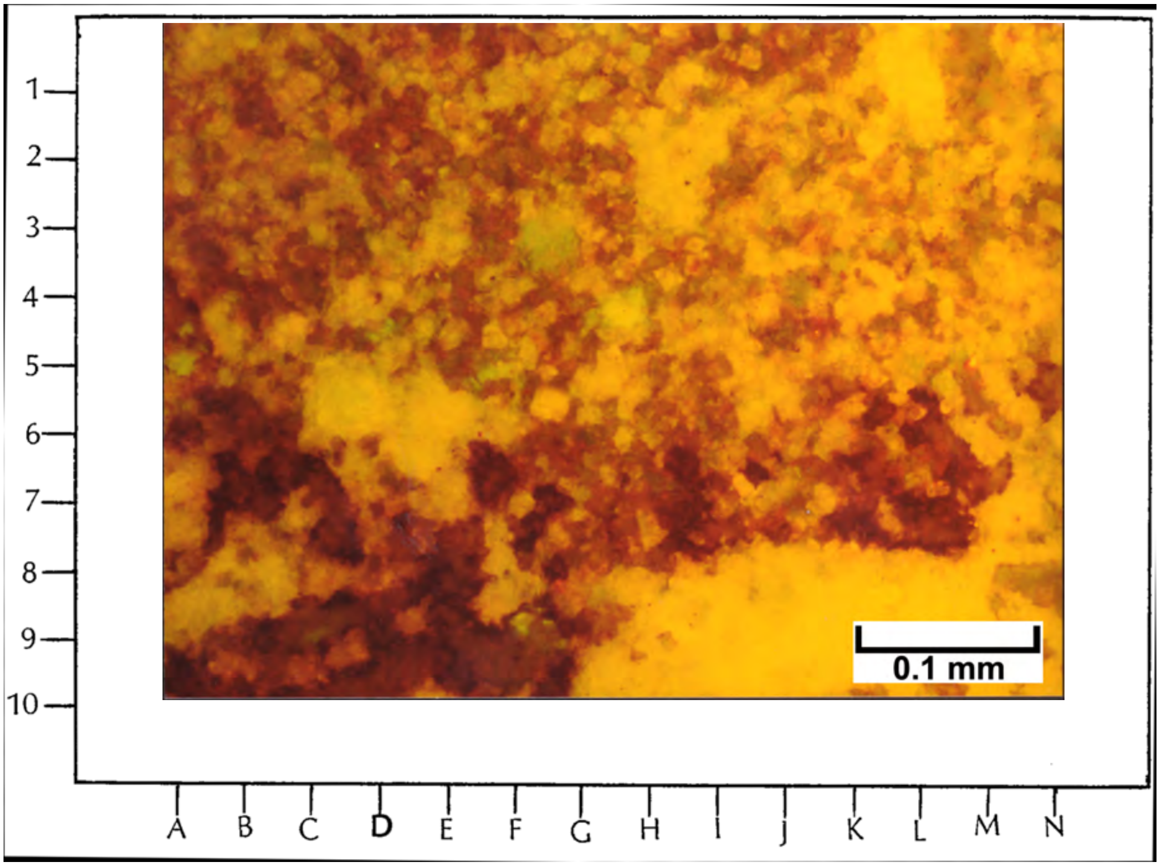
<u>5773.9 feet</u>

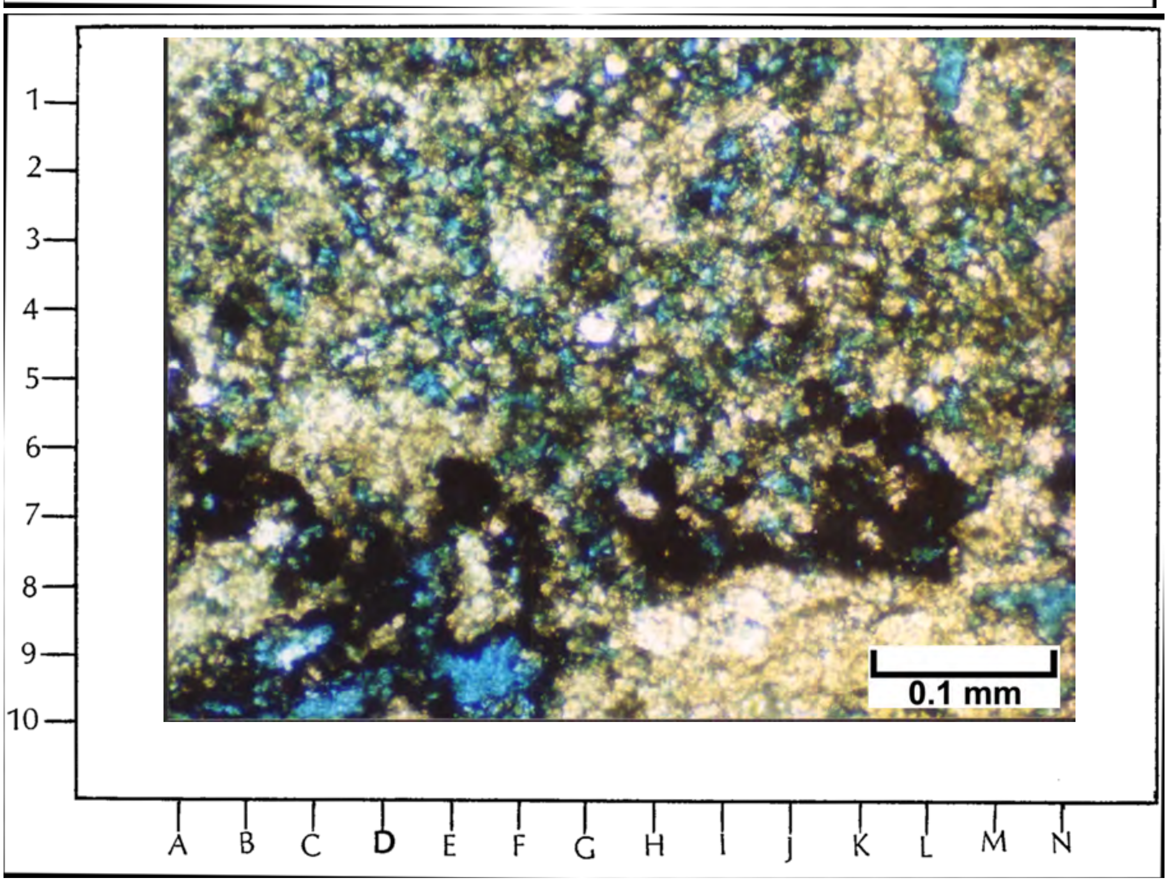
Top Photomicrograph

The red fluorescence in this view shows the open-pore spaces within this slightly dolomitic limestone. The darkest red colors (for example B-7, F-8, I-7, and M-8) are due to local concentrations of bitumen lining some of these pores. Remnants of possible fossil grains can be seen at C-2.5, K-2, and M-6. The bright yellow patch between H-9 and N-9 represents a very tight portion of the carbonate matrix that fluoresces because of trapped live oil within an area of very low permeability.

Bottom Photomicrograph

The same field of view as above is shown under Pl at the same magnification. Significant portions of this image show porosity (in blue), but much of the additional porosity is invisible due to opaque linings of bitumen which blocks the viewing of the other impregnated pores. Also, the pore outlines and shapes are much more difficult to see than in the fluorescence microscopy view above.


0.1 mm
1 2 3 4 5 6 7 8 9 10
A B C D E F G H I J K L M N


0.1 mm
1 2 3 4 5 6 7 8 9 10
A B C D E F G H I J K L M N