[PS]Petrography of the Marcellus Shale in Well WV6, Monongalia County, West Virginia*

Harvey Eastman[1]

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Abstract

Well WV6 was drilled as part of the Eastern Gas Shale Project (EGSP) at the National Energy and Technology Laboratory site in Morgantown, West Virginia. The purpose was to provide core of the Marcellus Shale and perform well testing related to the hydrocarbon production potential of the formation. The well was completed in April 1978 and the core was logged and preserved for future studies. Numerous studies of the core have been made with regard to the organic content and production potential, but no detailed petrographic study was ever performed.

The purpose of the current study was to document the determinable mineralogy in thin section and to evaluate textures and potential natural fracturing within the shale to support a program to use depleted Marcellus shale wells for CO_2 storage. For this study, 23 thin sections were made from a depth of 7387 ft near the base of the Mahantango Formation to a depth of 7506 ft in the underlying Onondaga Limestone, including the Marcellus Shale, which occurs from 7396 ft to 7500 ft depth. The thin sections were studied using a Nikon Optiphot petrographic microscope and a Leica M-series Microscope.

Results of the study indicate a transitional change between the Onondaga Limestone to the Marcellus Shale, with the upper several feet of the Onondaga composed of biogenic and fossiliferous limestone mixed with dolomitic shale. Above the Onondaga, the Marcellus grades from a sequence of interbedded fossiliferous limestones and silty, limy shales to a more clay-rich, illitic mudstone above about 7450 ft depth. The clays and pyrite are fairly consistent throughout the sequence with some variation in the amount of pyrite. Preliminary X-ray diffraction results suggest a high proportion of illite and significant chlorite in the clays.

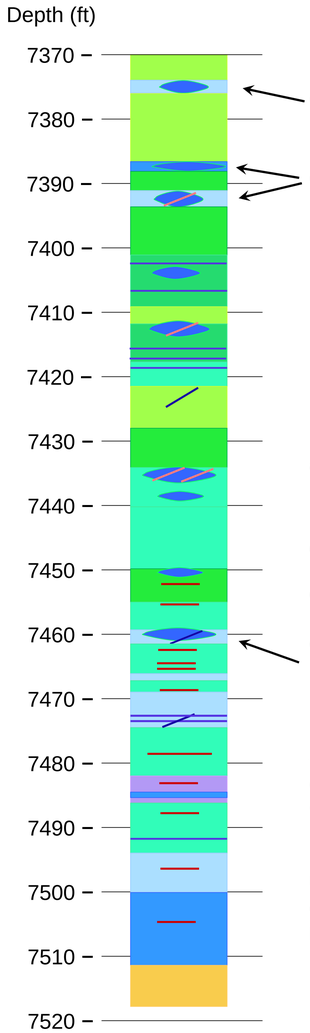
It is apparent from this study that the lower 50 feet of the Marcellus Shale at this location in West Virginia is calcareous, often dolomitic, with significant limestone below about 7480 ft depth. The upper 50 feet still contains significant fossil debris and carbonate grains, but the shale is less limy overall. Most of the fossil debris above about 7420 ft depth is in concretionary limestone units separated by relatively fossil-free and

carbonate-free, illitic mudstone. This sequence of lithology, when combined with other data, has implications regarding the optimum production interval in the shale.

The results of this study will be combined with other research to evaluate the potential for carbon dioxide storage in depleted wells in northern West Virginia and surrounding areas. The effect of the introduction of CO_2 on the mineralogy is key to CO_2 storage and enhanced natural gas recovery potential in the Marcellus shale.

Geology of the Marcellus Shale in Well WV6, Monongalia County, West Virginia – Harvey S. Eastman, PhD

Lithologic Log (7370 to 7517 ft. depth)



Black, thinly laminated, generally non- calcareous, silty shale or mudstone.

Gray, shaly limestone concretion, fossiliferous.

Mahantango Formation

Black, thinly laminated, generally non- calcareous, silty shale.

Gray, shaly limestone concretions, fossiliferous, often with septa of calcite-dolomite-gypsum.

Black, thinly laminated, generally non- calcareous shale.

Marcellus Shale

Black, thinly laminated, fossiliferous, silty shale with gray, shaly limestone concretions.

Black, thinly laminated, generally non- calcareous, silty shale.
Black silty shale, thickly laminated, with limestone concretions as above. Calcareous layers.

Black, thinly laminated, fossiliferous shale or mudstone with silt and carbonate grains.

Black, thinly laminated, generally non-calcareous, silty shale.

Black, thinly laminated, generally non-calcareous shale. Occasional bands with calcite strands and carbonate grains.

Black silty shale, laminated, with limestone concretions with calcite-dolomite-gypsum septa.

Black, thinly laminated, fossiliferous shale with silt and carbonate grains, generally non-calcareous.

Black, thinly laminated, non-fossiliferous shale with silt and carbonate grains, non- to weakly calcareous. Limestone concretion at 7450 ft. Pyritic with calcite strands at 7455 ft.

Black, thinly laminated, fossiliferous shale with silt and carbonate grains, non- to weakly calcareous. Very pyritic 7459 to 7466 ft, occasionally with gypsum.
Fossiliferous shaly, pyritic, shaly limestone with calcite veinlets.

Dark gray to black, thin to medium laminated to thin bedded, generally calcareous, silty shale. Fossiliferous and often pyritic. Purcell limestone equivalent? (Note geophysical logs.)

Dark gray to black, thinly laminated, less fossiliferous shale with silt and carbonate grains, non- to weakly calcareous. Pyritic lenses and bands.

Gray to black, thin to medium laminated, generally calcareous, silty shale, silty lime wackestone (silt-fossils), and shaly limestone, often very pyritic with pyrite lenses and bands.

Black, thinly laminated, weakly to moderately calcareous, silty shale with pyrite lenses.

Dark to very dark gray, thin bedded, fossiliferous calcareous, silty shale with pyrite lenses and nodules. Phosphatic fossils (collophane).

Gray to black, thin bedded, intermixed biogenic limestone and shale, fossiliferous with abundant pyrite and dolomite. Lighter gray with less shale below 7506 ft.

Onondaga Formation

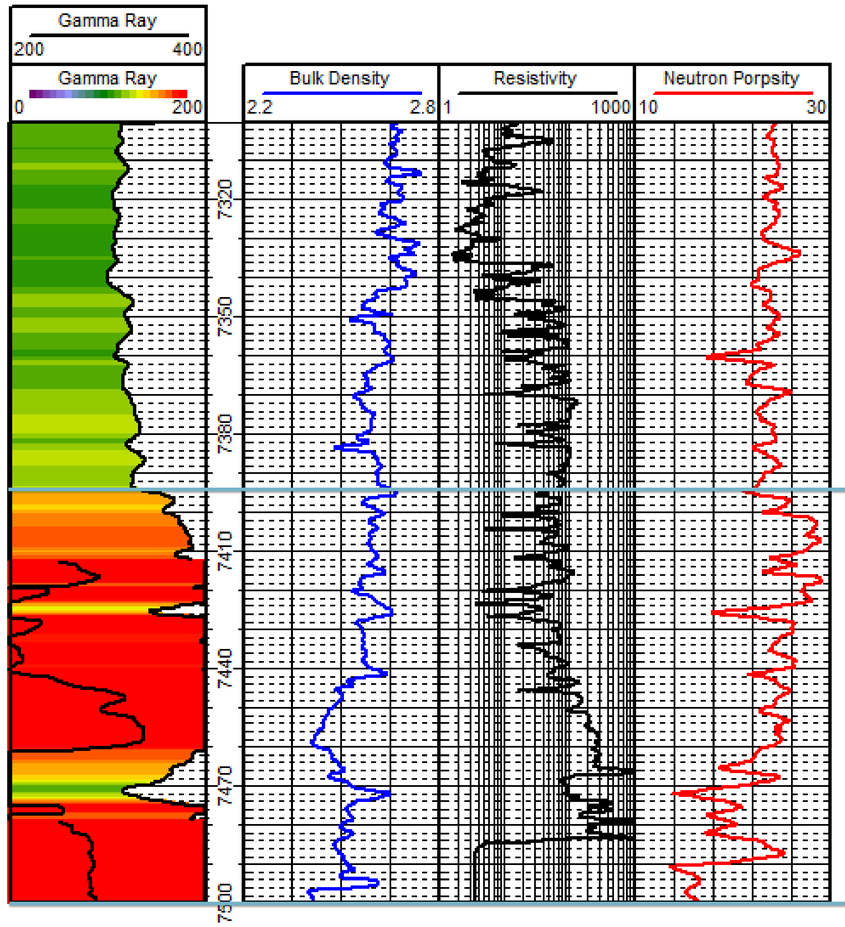
Medium to light gray and olive gray, thick-bedded chert.
Irregular calcareous zones.

Lithologic Legend

- *Calcareous Mudstone, fossiliferous*
- *Silty, Illitic Mudstone or Shale*
- *Thinly laminated illitic Mudstone or Shale*
- *Carbonate-grain Mudstone or Shale*
- *Limestone, shaly and fossiliferous*
- *Lime Wackestone fossiliferous*
- *Chert*
- *Limestone Concretion*
- *Limestone Bed*
- *Calcite Veinlet(s)*
- *Calcite-Dolomite-Gypsum Septa*
- *Pyrite lenses and bands*

Lithology based, in part, on Phase II report by Cliffs Minerals (1980).

Geophysical Logs (7300 – 7500 ft. depth)



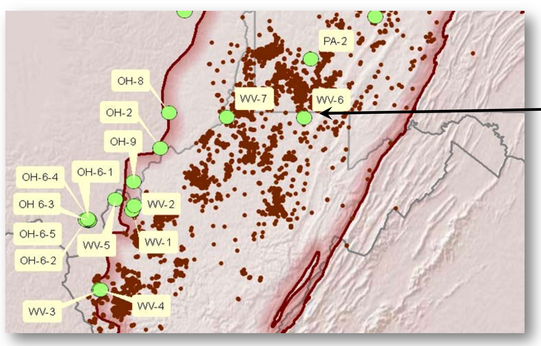
Mahantango Formation

Marcellus Shale (~7394')

Onondaga Formation (7500')

The gamma and bulk density logs penetrate below 7500 ft. The gamma drops significantly at 7506 ft, and the bulk density increases at 7504 ft. (Cliffs Minerals, 1980)

Eastern Gas Shale Project Well Locations
West Virginia and adjacent areas of Ohio and Pennsylvania



WV6

AAPG Annual Convention, May 20-22, 2013
Pittsburgh, PA

Petrography of the Marcellus Shale in Well WV6, Monongalia County, West Virginia – Part I

Harvey S. Eastman, PhD

Mahantango Formation

TS-7387 ft.

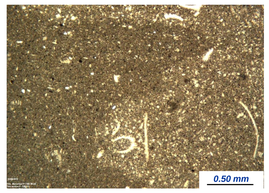


Image 7387-031. Mahantango Formation. Bioturbated, micritic to finely crystalline, shaly limestone concretion, silty with fossil fragments.

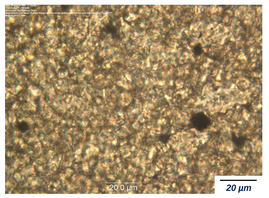


Image 7387-067. Detail of clays on calcite grain boundaries in finely crystalline, pyritic, shaly limestone. Opaque crystals are of microcrystalline pyrite.

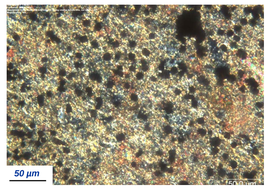


Image 7387-008. Pyritic band in a layer of illitic, limy shale. Cross polars.

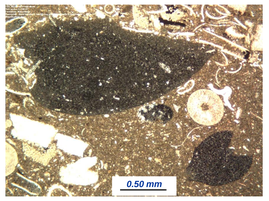


Image 7387-029. Dark nodules of organic-rich, siliceous mud in a fossil-rich layer in shaly, fossiliferous limestone.

TS-7388 ft.

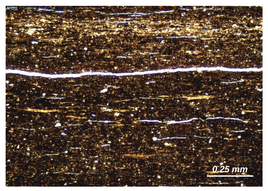


Image 7388-004. Pale band and pale lenses within thinly laminated, black, silty shale.

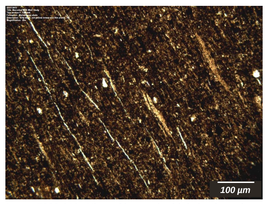


Image 7388-010. View of lenses in thinly laminated, black, silty shale.

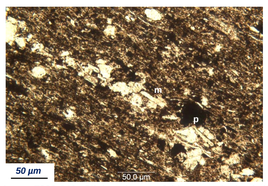


Image 7388-040. Silt lens (quartz, feldspar, and mica (m)) with pyrite (p) in thinly laminated shale.

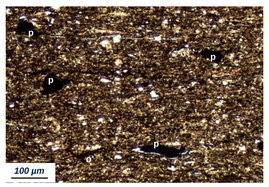


Image 7388-028. Pyrite nodules (p) in shale. Dark streaks are generally organic-rich lenses (o).

TS-7393 ft.

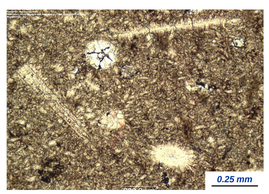


Image 7393-014. Finely crystalline, fossiliferous, shaly limestone with organics.

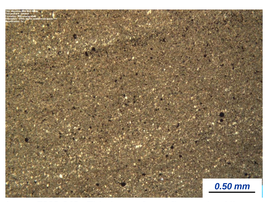


Image 7393-043. Thin layer of very fine-grained limy shale with scattered pyrite and silt.

The base of the Mahantango formation consists of thinly laminated, silty shales with calcareous units that include concretions of limestone. The shales can be organic-rich and a significant amount of organics is present in the limestone concretions in nodules of cherty material. Thin sections of concretions in the Mahantango (TS-7387 and TS-7393) indicate that they are fossiliferous with fossils concentrated in bands as well as scattered throughout the section. The limestone is shaly and pyritic, often with abundant illite oriented along laminae. Septa are common within these concretions and contain calcite, dolomite, siderite, ankerite, and gypsum.

Thin sections of the shale (TS-7388 and TS-7394) show thin laminations of organic-rich, illitic, silty shale, generally pyritic, with thin, silt-rich bands that often contain less organic material. This shale is generally non-calcareous. Pyrite is present as micro-crystals, framboidal aggregates, and irregular nodules.

The top of the Marcellus is a thinly laminated, silty, pyritic shale, organic-rich, with calcareous units that also include concretions of limestone. This shale is represented in thin section TS-7409.5 as a black, thinly laminated, non-calcareous, silty, pyritic shale. The organics occur with the clays, particularly illite and chlorite, in streaks and bands a few tens of microns thick each with small lenses of organic-poor material.

The limestone concretions are represented in sections TS-7405 and TS-7413. These concretions are similar to those of the lower Mahantango, containing shaly limestone with septa of calcite, dolomite, ankerite, siderite, and gypsum. The calcite grains within the concretion vary from 20µ to 50µ in size and are commonly rectangular and oriented perpendicular to fossils and other features within the concretion. Clays are present between most calcite grains and organics are common in interstices between calcite grains. The concretion at 7413 ft includes a band of silty, calcareous sandstone with abundant pyrite crystals.

TS-7409.5 ft.

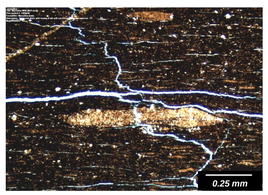


Image 7409.5-032. Lens of organic-poor shale, silty with clay. Organics are banded parallel to laminae with intervening partings of clay. Second lens at the top.

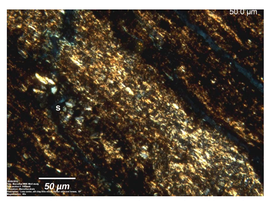


Image 7409.5-039. Cross polars. Portion of lens of organic-poor illitic shale, showing abundant illite-mica flakes, and a silt aggregate (s).

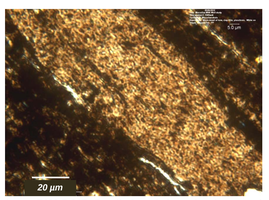


Image 7409.5-047. Detail of a pale lens showing strands of chlorite-clay.

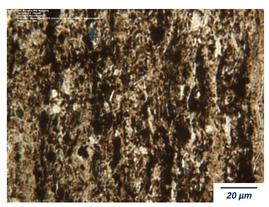


Image 7409.5-029. Thin part of slide showing organic bands mixed with clay, chlorite, and illite in the shale.

Marcellus Shale

TS-7394 ft.

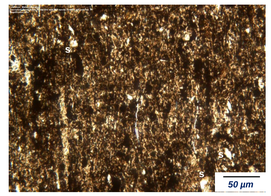


Image 7394-008. Detail of organics in shale. Organic-poor lens to left. Scattered silt grains (s).

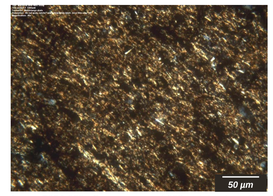


Image 7394-009. Cross polars of 008, rotated to better show illite and clays. Silt particles are gray to dark gray. Illite and mica flakes are as white plates 15µ to 30µ long.

TS-7405 ft.

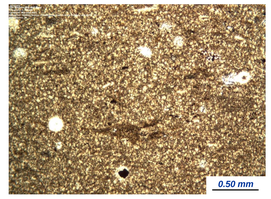


Image 7405-018. Clay-rich clasts aligned along bedding in shaly, fossiliferous limestone. Pyrite in fossil near bottom.

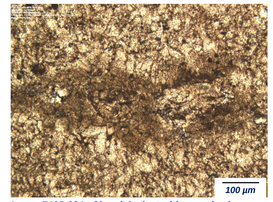


Image 7405-024. Clay-rich clast with organics in limestone. Note alignment of calcite grains relative to the clast.

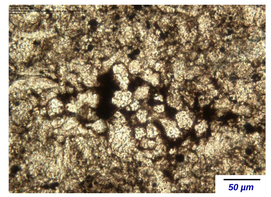


Image 7405-032. Organics in interstices in a clot of coarser calcite crystals.

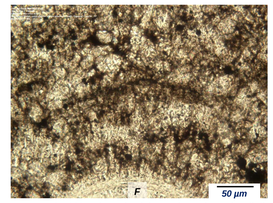


Image 7405-023. View of calcite grains oriented radially around a fossil (F) with organics and clays along grain boundaries.

TS-7413 ft.

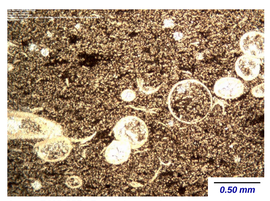


Image 7413-005. Band of larger fossil fragments approximately along bedding. Scattered clay clasts elongated roughly parallel to bedding.

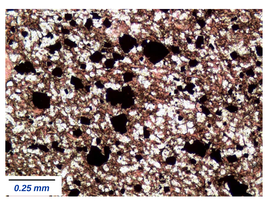


Image 7413-053. Pyritic, very fine-grained, limy sandstone or sandy limestone. Fine grained sand (white) and calcite (red) and fine to medium grained pyrite crystals and crystal agglomerates.

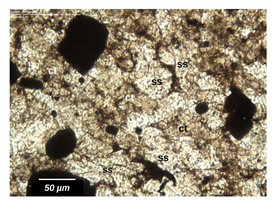


Image 7413-056. Detail of pyrite and sand grains (ss) with calcite (ct). Clay and chlorite on grain boundaries.

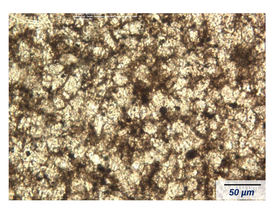


Image 7413-016. Detail of finely crystalline limestone with calcite grains 15µ to 40µ in size and with chlorite and clay on grain boundaries.

AAPG Annual Convention, May 20-22, 2013
Pittsburgh, PA

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Petrography of the Marcellus Shale in Well WV6, Part II – Harvey S. Eastman, PhD

Marcellus Shale

TS-7421 ft.

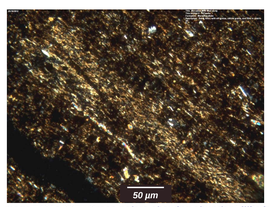

Image 7421a-027. Cross polars showing abundant illite in organic-poor bands along with gray silt and bright carbonate grains.

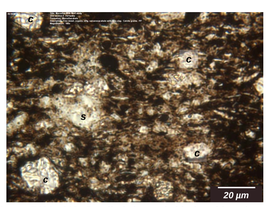

Image 7421a-019. Detail of clay and chlorite with carbonate (c) and silt grains (s) and with organics. The carbonate grain to lower left is probably dolomite or ankerite.

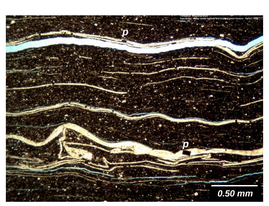

Image 7421a-005. Calcite strands, wavy to folded with pyrite crystals (p). Shale laminae follow the calcite strands as do fractures (blue-white).

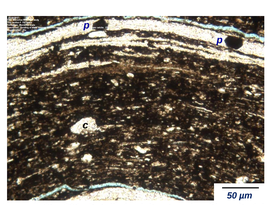

Image 7421a-021. Detail of calcite strands with pyrite (p) and parallel shale laminae, silty with carbonate grains (c). Thin carbonate lenses are also common in the shale.

TS-7430 ft.

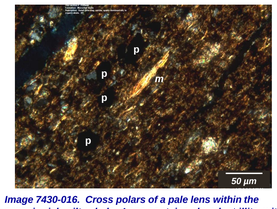

Image 7430-016. Cross polars of a pale lens within the organic-rich, silty shale. Lens contains abundant illite, with mica (m), silt, clay, and chlorite. Pyrite nodules (p) often align along specific laminae.

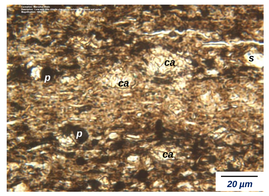

Image 7430-030. Detail of an organic-poor lens showing illite flakes and a clay-chlorite matrix. Grains of carbonate (ca) and silt (s) are common. Disseminated microcrystalline pyrite (p).

TS-7431 ft.

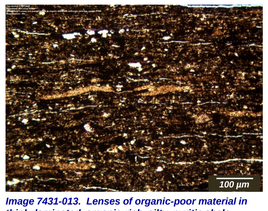

Image 7431-013. Lenses of organic-poor material in thinly laminated, organic-rich, silty, pyritic shale.

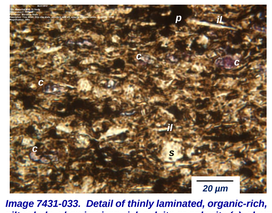

Image 7431-033. Detail of thinly laminated, organic-rich, silty shale, showing iron-rich calcite or ankerite (c), clays, chlorite, illite (il), silt (s), and pyrite (p).

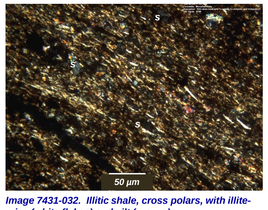

Image 7431-032. Illitic shale, cross polars, with illite-mica (white flakes) and silt (gray, s).

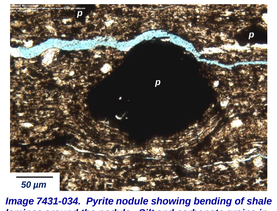

Image 7431-034. Pyrite nodule showing bending of shale laminae around the nodule. Silt and carbonate grains in organic shale. Pyrite (p) also to upper right and at top.

Below 7413 ft, the shale continues as a thinly laminated, weakly calcareous, pyritic, silty shale with abundant organics as is represented in sections TS-7421, TS-7430, and TS-7431. This shale contains moderate to abundant carbonate grains, both calcite and dolomite, and bands with long calcite strands or stylolites, often with scattered pyrite crystals. Pyrite within the shale occurs as microcrystals, framboidal aggregates, or as nodules that formed within the laminated shale.

A thin section taken at 7435 ft (TS-7435) is at the margin of a limestone concretion and is very pyritic particularly near the boundary with the shale. The limestone is of fine-grained calcite with clays and chlorite along grain boundaries. Fossils are common and often pyrite crystals partly replace the fossils.

Below 7435 ft, the shale is similar to that above that depth but is often a bit more calcareous with abundant calcite, dolomite, and ankerite grains (TS-7441 and TS-7445). Additional limestone concretions are also present, as at 7438 ft depth. Silt particles are common but usually less abundant than the carbonate grains. Calcite strands or stylolites are common, particularly in section TS-7455, and these strands have extensive replacement by pyrite and quartz. Some pyrite nodules are over a millimeter in size. Another limestone concretion is present just below 7459 ft (TS-7459.6) with abundant pyrite often as a replacement of fossils. Organics are variably abundant along with clays between the calcite grains.

TS-7455 ft.

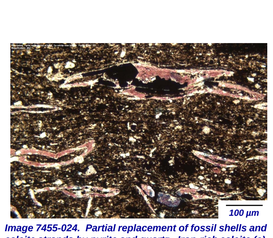

Image 7455-024. Partial replacement of fossil shells and calcite strands by pyrite and quartz. Iron-rich calcite (c) at bottom.

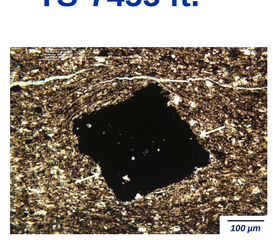

Image 7455-010. Pyrite nodule, roughly crystalline, in laminated shale, with laminae bent around the nodule. Fractures partly follow the laminae. Arrows aligned along crack in pyrite.

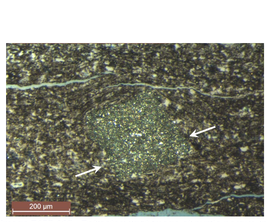

Image 7455-110. Reflected light image of pyrite nodule in 010. Note fracture along crystal plane of pyrite (arrow) filled with shale. The nodule appears to be formed of microcrystalline pyrite that has coalesced into a macro-crystalline shape.

TS-7459.6 ft.

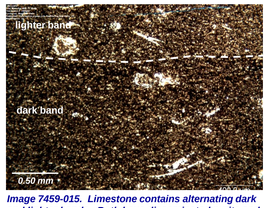

Image 7459-015. Limestone contains alternating dark and lighter bands. Both have disseminated pyrite and organics, with more organics in the darker bands.

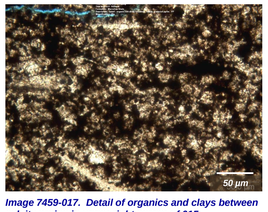

Image 7459-017. Detail of organics and clays between calcite grains in upper right corner of 015.

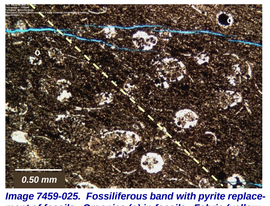

Image 7459-025. Fossiliferous band with pyrite replacement of fossils. Organics (o) in fossils. Fabric (yellow dashed line) is at a 35° angle to bedding, which is parallel to the fractures (blue).

Image 7459-103. Pyrite (p) in fossil with limestone matrix and organics (black). Limestone was originally a lime mud that filled fossil cavities. Oblique reflected light.

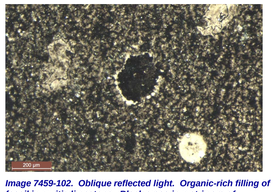

Image 7459-102. Oblique reflected light. Organic-rich filling of fossil in pyritic limestone. Black areas in matrix are of organics and clays. See 7459-017 and upper right of 7459-025.

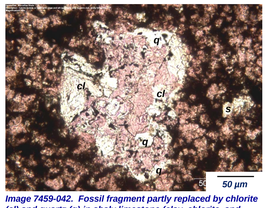

Image 7459-042. Fossil fragment partly replaced by chlorite (cl) and quartz (q) in shaly limestone (clay, chlorite, and organics). Silt grain (s) to right.

Marcellus Shale

TS-7435 ft.

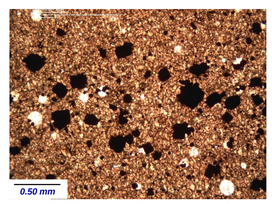

Image 7435-001. Finely crystalline, shaly limestone concretion, fossiliferous (white) and pyritic with fine- to medium-grained pyrite crystals and crystal aggregates (black).

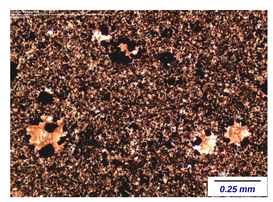

Image 7435-017. Coarser grained pyrite crystals in fossil fragments with very fine-grained pyrite in the limestone matrix near margin with shale.

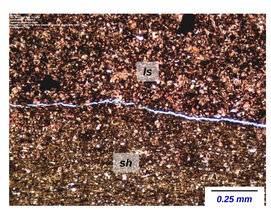

Image 7435-021. Limestone (ls) – shale (sh) boundary. Lime-stone as in 017. Shale is illitic and silty with carbonate grains. Pyrite is fine- to very fine-grained.

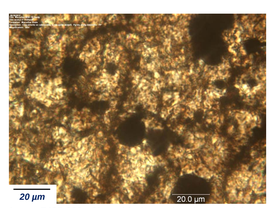

Image 7435-038. Clay, chlorite, and pyrite on calcite grain boundaries. Some chlorite appears to grow into the calcite from the grain boundary.

TS-7441 ft.

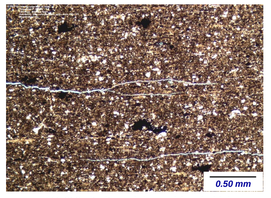

Image 7441-010. Pyrite nodules and framboidal aggregates in thinly laminated, silty, carbonate-grain shale.

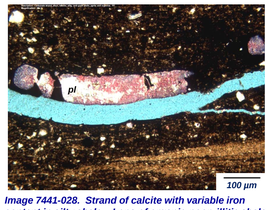

Image 7441-028. Strand of calcite with variable iron content in silty shale. Lens of organic-poor, illitic shale near bottom. pl – plucked grain

TS-7446 ft.

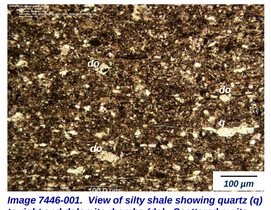

Image 7446-001. View of silty shale showing quartz (q) to right and dolomite rhombs (do). Scattered pyrite (black). Chloritic clay matrix with illite and organics.

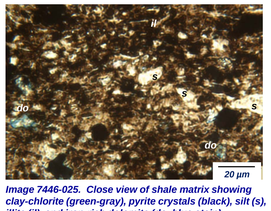

Image 7446-025. Close view of shale matrix showing clay-chlorite (green-gray), pyrite crystals (black), silt (s), illite (il), and iron-rich dolomite (do, blue stain).

TS-7446 ft.

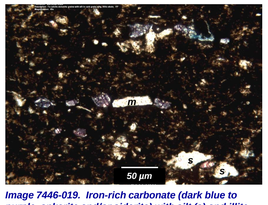

Image 7446-019. Iron-rich carbonate (dark blue to purple, ankerite and/or siderite) with silt (s) and illite-mica (m) in organic-rich, pyritic shale.

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Petrography of the Marcellus Shale in Well WV6, Part III – Harvey S. Eastman, PhD

Marcellus Shale

TS-7463 ft.

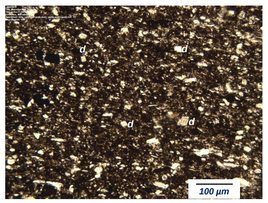

Image 7463-013. Silty, carbonate-grain, pyritic mudstone. Rhombic shapes are dolomite (e.g., d).

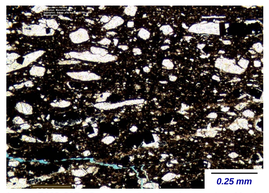

Image 7463-007. Gypsum with abundant pyrite. Much of the pyrite is intergrown with the gypsum, apparently as a replacement.

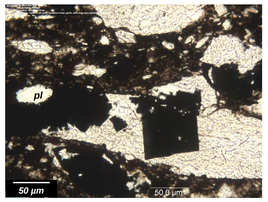

Image 7463-020. Gypsum crystals with embedded pyrite crystals, both subhedral to euhedral. pl – plucked.

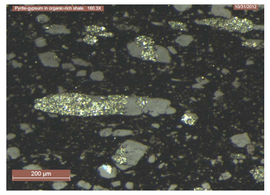

Image 7463-102. Pyrite in gypsum in organic-rich shale. Pyrite appears to be a replacement of gypsum. Oblique reflected light.

TS-7465 ft.

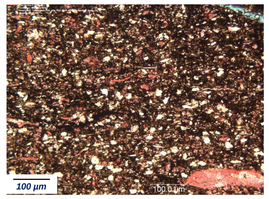

Image 7465-007. Silty, carbonate-grain shale with illite and pyrite. Scattered fossil fragments.

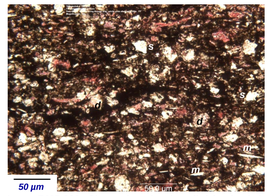

Image 7465-009. Closer view showing silt (s), mica (m), calcite (red), and dolomite (d) grains. Organics present as streaks and filling interstices between grains.

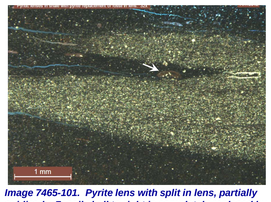

Image 7465-101. Pyrite lens with split in lens, partially oxidized. Fossil shell to right is completely replaced by pyrite. Partly pyritized fossil near center (arrow). Oblique reflected light.

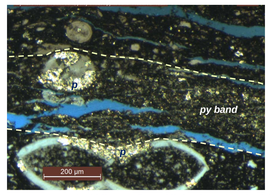

Image 7465-110. Oblique reflected light view of pyrite (p) replacement of fossils and partly oxidized pyrite (py) band with fracturing, in part, due to oxidation of pyrite.

TS-7468 ft.

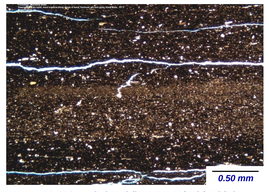

Image 7469-002. Pale band (less organics) in thinly laminated, silty, carbonate-grain mudstone. Pale band has variable amounts of organics (darker and lighter zones).

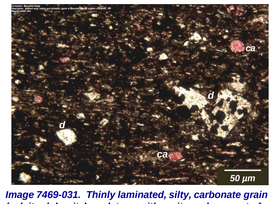

Image 7469-031. Thinly laminated, silty, carbonate grain (calcite-dolomite) mudstone with pyrite replacement of dolomite, and with illite, mica flakes, and calcite plates. Calcite grains (ca) are as more rounded shapes, dolomite (d) are as rhombs.

Below 7460 ft, the shale is more pyritic and with more calcareous zones and bands of fossil-rich silty, calcareous shale. In one section, TS-7463, a band of pyrite with gypsum is present. The gypsum appears to be primary with included crystals of pyrite. In TS-7465, pyrite lenses and thin pyritic laminae are present along with extensive replacement of fossils with pyrite, often nucleating on the fossil shell. The shale matrix is calcareous with abundant grains of calcite and dolomite.

A less calcareous unit is represented in TS-7469, an organic-rich, silty, thinly laminated shale with carbonate grains, dolomite and calcite. Though not sectioned, limy shales are evident in the interval between 7470 and 7475 ft and have been correlated with similar calcareous units in outcrop.

At 7482 ft depth (TS-7482), the shale is calcareous and fossiliferous with silty to sandy fossil-rich bands and extensive pyrite replacement within the fossils. Pyrite lenses are still present consisting of micro-crystalline pyrite coalesced into lenses often with larger crystal shapes within the lenses. Below that depth is a fossiliferous limestone unit (TS-7485), again pyritic, with hydrocarbons on fractures. The limestone is clayey and there is some quartz replacement of the fossils, particularly near the hydrocarbons.

The Marcellus becomes increasingly limy toward its lower boundary, grading into the Onondaga Formation. The gradation continues within the Onondaga with interlaminated shale and thinly laminated limestone with abundant dolomite rhombs within both rock types (TS-7505 and TS-7506). Hydrocarbons and pyrite are present between and within limestone laminae and pyrite commonly partly replaces fossils. Hydrocarbons occur along specific laminae in the shale and pyrite is disseminated or occurs as nodules or lenses within the shale.

Onondaga Formation

TS-7505 ft.

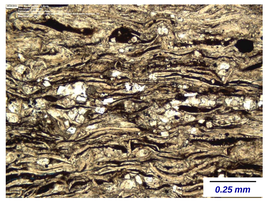

Image 7505-004. Biogenic limestone with organics and pyrite between laminae. Abundant dolomite rhombs.

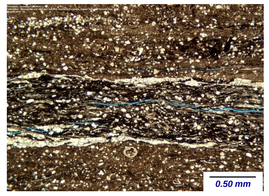

Image 7505-011. Band of organic-rich, biogenic limestone with dolomite rhombs between shale layers. The shale also has pockets of organics, abundant dolomite rhombs, and scattered silt particles.

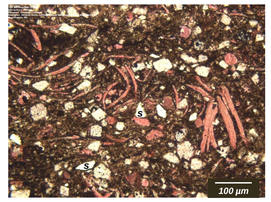

Image 7505-019. Fossiliferous shale with dolomite rhombs and calcite grains, and organics. Scattered silt (s).

TS-7506 ft.

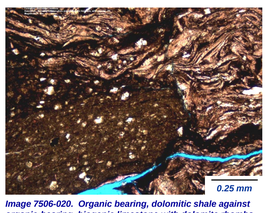

Image 7506-020. Organic bearing, dolomitic shale against organic-bearing, biogenic limestone with dolomite rhombs. Bedding trend is roughly horizontal.

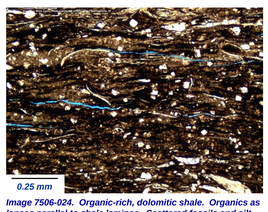

Image 7506-024. Organic-rich, dolomitic shale. Organics as lenses parallel to shale laminae. Scattered fossils and silt.

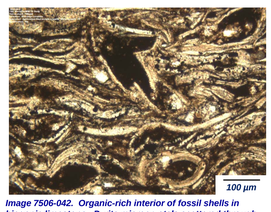

Image 7506-042. Organic-rich interior of fossil shells in biogenic limestone. Pyrite microcrystals scattered through the limestone and in the interstices with the organics.

Marcellus Shale

TS-7482 ft.

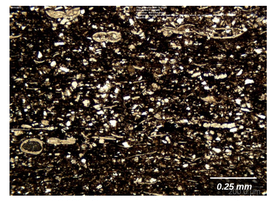

Image 7482-029. Organic-rich, fossiliferous, pyritic mudstone. Abundant coarse silt and carbonate grains with fossil fragments.

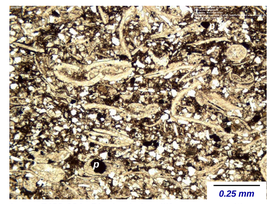

Image 7482-024. Bioclastic fossiliferous zone with pyrite, silt, and carbonate grains (dolomite and calcite). Larger pyrite crystals (p) are common in fossils.

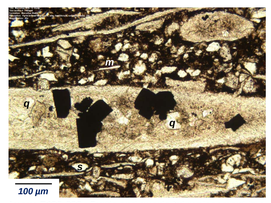

Image 7482-022. Pyrite and quartz (q) replacement in a fossil. Matrix of coarse silt (s), mica (m), and carbonate grains, with pyrite, fossil fragments, organics, and clays.

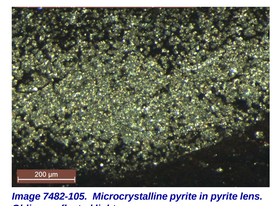

Image 7482-105. Microcrystalline pyrite in pyrite lens. Oblique reflected light.

TS-7485 ft.

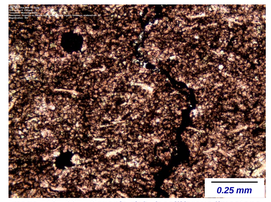

Image 7485-027. Organic-rich, fossiliferous limestone with an irregular, vertical-trending hydrocarbon-filled fracture and nearby fossils filled with hydrocarbons.

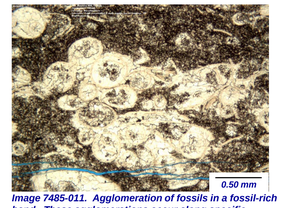

Image 7485-011. Agglomeration of fossils in a fossil-rich band. These agglomerations occur along specific laminae in the limestone.

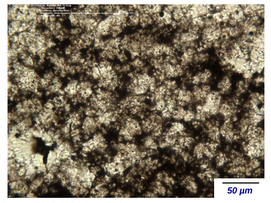

Image 7485-020. Detail of hydrocarbon and clay distribution in shaly limestone, primarily along calcite grain boundaries.

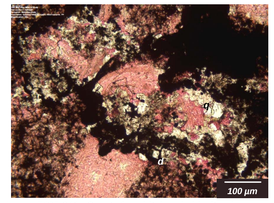

Image 7485-041. Quartz (q, white) and chlorite-clay (greenish gray) replacement of fossils adjacent to a hydrocarbon-filled fracture. Hydrocarbons also present between the fossils with pyrite. Traces of dolomite (d).

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