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CONE IN CONE CONCRETIONS OF THE STANLEY GROUP IN SOUTHEASTERN OKLAHOMA

By

Kyle Ayres, B.S.

Presented to the Faculty of the Graduate School of

Stephen F. Austin State University

In Partial Fulfillment

Of the Requirements

For the Degree of

Master of Science

STEPHEN F. AUSTIN STATE UNIVERSITY

May, 2016

CONE IN CONE CONCRETIONS OF THE STANLEY GROUP IN

SOUTHEASTERN OKLAHOMA

By

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ABSTRACT

Cone in cone concretions found in the Stanley Group of Southeastern Oklahoma have a variety of external and internal attributes which allow diagenetic and theoretical models of formation to be hypothesized. Stanley Group carbonate cone in cone concretions are initially formed in sulfur reducing horizons at shallow burial depths in a poorly circulated possibly deep trough containing siliceous sediments and organic matter. Collected concretions near the town of Smithville, Oklahoma displayed four different external morphologies and four variations of mineral constituents. All concretions contained microscopic cones which initiated diffusion and/or fluid patterns and is an early cementation process that directly altered the sediment compared to the surrounding deposits. The patterns initiated ultimately controlled and recorded diagenic alterations to mineral content and structure of the concretions. Concretion mineralogy consisted of microgranular calcite, twinned lamellae calcite and siliceous precipitates which dissolved carbonates from the inside out.

AKNOWLEDGEMENTS

I would first like to thank my wife and daughters for their support and encouragement while undertaking this endeavor. A big thank goes to my Dad and Jodi Hill for their assistance and support kayaking the rivers and completing field work. I would also like to thank my advisor Dr. Nielson for his advice and lessons on sedimentological processes and for sparking my interest in all things geological. Without his cooperation and assistance, this project would have never been achieved. I would like to thank Dr. Stafford for his valuable lessons on carbonates and hydrology, and for taking the time to listen and answer questions. A round of thanks goes to Dr. Brown, Dr. Farrish, and Dr. Becnel for serving on my committee, but the biggest thanks goes to God for creating this magnificent world and for his love of mankind.

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INTRODUCTION

The Stanley Group, also known as the Stanley Shale is a widespread marine sedimentary deposit, which stretches from Mexico to Mississippi. The Ouachita Mountains of southeastern Oklahoma and western Arkansas are comprised of the Stanley Group and contain cone in cone concretions within shale layers. These cone in cone concretions vary in mineral composition and physical appearance indicating a complex depositional and diagenetic history. The objective of this study is to characterize the types of cone in cone concretions, interpret early to late stage diagenetic alterations of these concretions, identify the source of carbonate, and to reconstruct a theoretical model of the sedimentary environment that gave rise to these concretions.

Samples were collected within shale layers near the town of Smithville, Oklahoma which is approximately 25 miles north of Broken Bow Lake along highway 259 (Fig. 1). Outcrops of shale were identified along the two main tributaries draining into Broken Bow Lake; the Eagle Fork and Mountain Fork Rivers. Although the study area was comprised of numerous shale and sandstone layers, only six locales were found to contain significant cone in cone concretions, all of which were shale layers, but this does not designate an absence or presence of cone in cone structures elsewhere.

Figure 1. Index map of study area, approximately 25 miles north of Broken Bow Lake in McCurtain County, OK.

A significant observation while locating cone in cone concretions was obvious clusters along particular bedding planes indicating specific sediment horizons prone to carbonate production, cementation, and preservation within the sedimentary body (Fig. 2). Another notable feature is the resistance to weathering compared to the surrounding shale. A significant number of rocks within talus piles that accumulated along shale outcrops consisted of concretions of some form. This is an indicator that early diagenetic cementation caused by microbial processes within sediment horizons allowed carbonate concretions to resist weathering more readily than the surrounding shale.

Figure 2. Cone in cone concretion clusters along specific shale beds.

LITERATURE REVIEW

Ouachita Orogeny

The Ouachita Mountains in southeastern Oklahoma and western Arkansas are outcrops of the Ouachita Fold Belt. These mountains are a series of folded and faulted marine Paleozoic sedimentary deposits stretching from Mississippi to southwest Texas in the Marathon region although in most of Texas they are hidden in the subsurface. Handschy et al. (1987) described Ouachita orogenic rocks extending another 450 miles into Mexico, although these rocks are not well covered in the literature. From Mississippi to Marathon, Texas, this belt stretches for a 1000 miles with 80% being in the subsurface (Hatcher, 1989). Not surprisingly, the exposed Ouachita Mountains of Oklahoma and Arkansas and the Marathon region of southwest Texas are the most well studied zones of this fold belt.

The evolution of the Ouachita Mountains can be divided into four main stages that coincide with changing depositional and tectonic environments (Fig. 3; Golonka et al., 2006). The first stage was initiated by rifting of the Precordilleran terrane off of North America and formation of the Ouachita Trough/Basin at the end of the Precambrian. Stage two is characterized by subduction along the active margin of the Ouachita Trough, with partial closing of the oceanic basin by the Sabine terrane and/or Yucatan plate moving north, and development of the main flysch basin on the platform. This occurred during the early Mississippian and was the beginning of late Paleozoic terrane accretion. Stage three is characterized by the convergence of the North American and South

American and the Sabine/Yucatan terranes, with continuing formation of accretionary prisms during the Late Carboniferous. Collision between the South American and Yucatan plates with the North American plate formed the supercontinent Pangea during the Permian and created a decollement surface beneath the Paleozoic deposits of the Ouachita Trough (Hatcher 2010). During the collision, these Paleozoic units were thrusted above transitional/oceanic crust on the seaboard-side and continental crust on the inboard-side of the North American plate. Keller and others (1989) interpreted seismic surveys as showing little to no crustal shortening of continental crust beneath the Paleozoic sedimentary rocks (Fig. 4). Thus, the deformation was primarily thin-skinned. It is estimated that Paleozoic rocks were thrust as much as 80 km northward (Golonka 2006). This likely represent thrust faulting between the Paleozoic sediments and the transitional/continental crust, indicating that the colliding terrane overrode the transitional crust as it approached the Laurentian continental basement. This fits with the concept of transitional crust underlying Mesozoic and Cenozoic sediments of the Gulf coastal plains in Texas, Louisiana, Mississippi and Alabama. In Arkansas and Oklahoma the most northerly extent of the Ouachita Orogeny is the Arkoma Basin, which represents a foreland basin that developed due to flexural downwarping of the lithosphere as South America approached the southern margin of Laurentia (Houseknecht 1986).

Stage four exhibits thrusting and inversion (relative uplift) of the sedimentary basin with final formation of the Arkoma foreland basin. Stage four is also the point when Pangea was amassing which would last nearly 100 million years.

Rifting of Pangea creating the Gulf of Mexico, todays passive margins, developed during the Triassic (Woods and Addington 1973), and resulted in the transgressive Jurassic, Cretaceous, and Cenozoic deposits of the Gulf coast basin partly covering the Ouachita region (Golonka 2006).

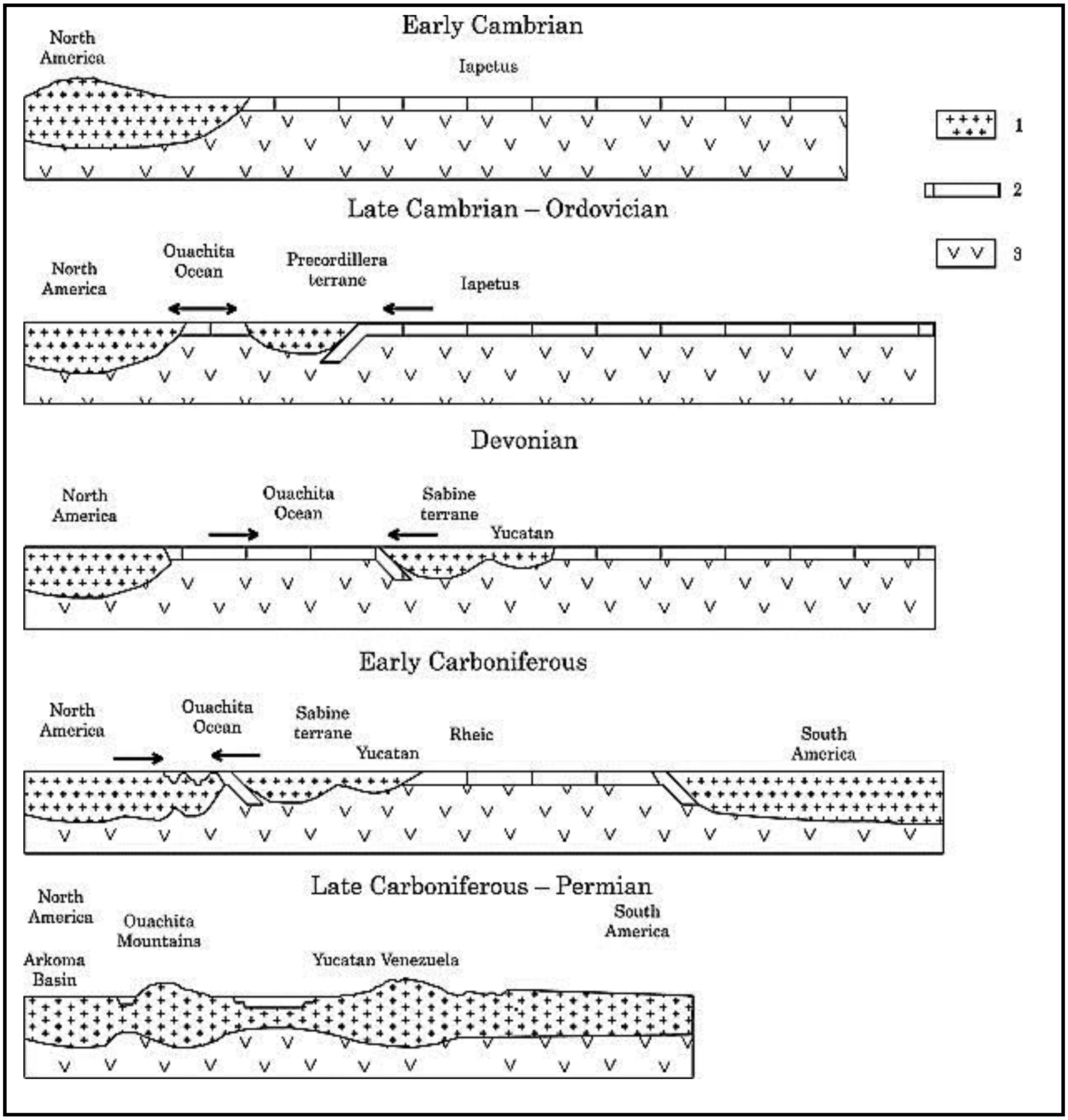

Figure 3.
Highly schematic (not to scale) plate-tectonic profiles (modified from Golonka and Slaczka, 2000) showing the development of the southern margin of Laurentia from the Cambrian to the Permian.
1= North America, Ouachitas, Yucatan, South America Continental crust (including obducted, allochthonous rocks and sedimentary cover)
2 = oceanic crust (including deposits)
3 = upper mantle. (From Golonka et al. 2006.)

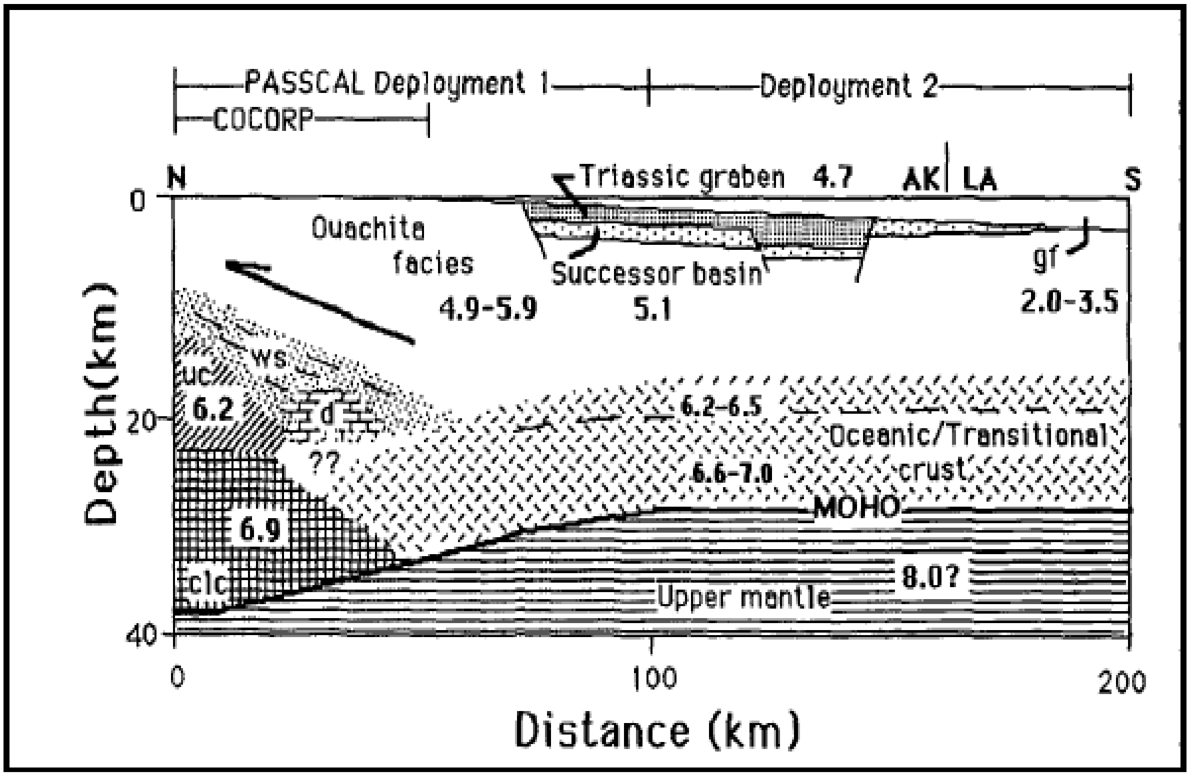

Figure 4. Interpretative model derived for seismic profile. Uc-Upper continental crust; clc-lower continental crust; d-domal structure; ws-wedged shaped sequence of reflectors; gf-Gulf coastal plain (Mesozoic-Cenozoic) strata. Numbers indicate average P-wave velocities in km/s. (From Keller et al. 1989)

Stratigraphy of the Ouachita Trough Deposits

Cambrian to Devonian Deposits

Sediments of the Ouachita Trough deposited during the Cambrian, Ordovician, Silurian, and Devonian are composed of pelagic accumulations of mostly siliceous sediment (Cline 1960, 1966, and Morris 1974). These sediments accumulated along the southeast margin of the North American Craton also known as Laurentia (Hatcher 1989).

The total thickness of this sedimentary package has been estimated at 5,000 feet (there has been a considerable amount of discussion about this due to incomplete outcrops, few marker beds, and incomplete to no well data). These early marine accumulations were slowly deposited in a starved marine basin with the dominate lithologies being black shales, cherts, novaculites, and sandstones.

Mississippian Deposits

The Mississippian Stanley Group in southeastern Oklahoma is a marine siliceous sedimentary deposit underlain by the Arkansas Novaculite. It is overlain by the Pennsylvanian Jackfork Group which is comprised of marine siliceous sandstones and shales.

The Stanley Group is a mixture of marine sediment from an encroaching arc terrane and Laurentia. This mixture of sediment was deposited as turbidites, fan deposits and pyroclastic tuffaceous material originating south of the Ouachita basin (Morris 1989). The Stanley Group is composed of black to olive gray shale and slate, with cyclic beds of sandstone and siltstone, and some chert and tuff. This series of rhythmic sedimentary strata is indicative of flysch deposition in deep marine quiet waters of foreland basins in a developing orogen. Cone in cone concretions are abundant in some localities, especially in shale units. The southern Ouachitas typically have thicker and more numerous sandstone and tuffaceous beds as opposed to the northern Ouachitas (Morris 1974) supporting the paleocurrent assumption of the sediment supply originating from the south. Sedimentary beds of tuffaceous material appear at least four times near the base, with only two beds near the top. Average thickness of the Stanley Group is approximately 3,000 to 4,000 meters (9842.5 to 13123.4 feet) (Morris 1989).

The Stanley Group is comprised of three formations: Tenmile Creek, Moyers Creek, and Chickasaw Creek Formations (Fig. 5.). The Ten Mile Creek Formation lies above the Arkansas Novaculite and the contact is considered to be largely unconformable in some areas in Oklahoma (King 1961), but is gradational and conformable in some areas of Arkansas (Miser and Purdue 1929, Goldstein and Hendricks 1962, Veile and Thomas 1989). This pattern may represent a temporary break of sedimentation as opposed to an erosional unconformity (King 1961, Noble 1993). The Ten Mile Creek Formation contains shale, sandstone, and four thick distinctive tuff beds with two minor ones. The Tenmile Creek Formation is the thickest of the three formations at 8,500 feet.

The Moyers Creek Formation lies conformably above the Tenmile Creek and is approximately 1100 feet thick (Johnson 1968). Sandstone beds compose a greater proportion of beds in this formation compared to the Tenmile Creek. (Cline 1960). The upper most formation of the Stanley Group is the Chickasaw Creek which lies conformably above the Moyers Creek Formation and below the Jackfork Group. The thickness ranges from 75 to 350 feet (Johnson 1968). Thin beds of tuffaceous sandstones are also present (Laudon 1959, Hart 1962, Seeley 1962). Conformably lying above the Stanley Group is the Pennsylvanian Jackfork Group.

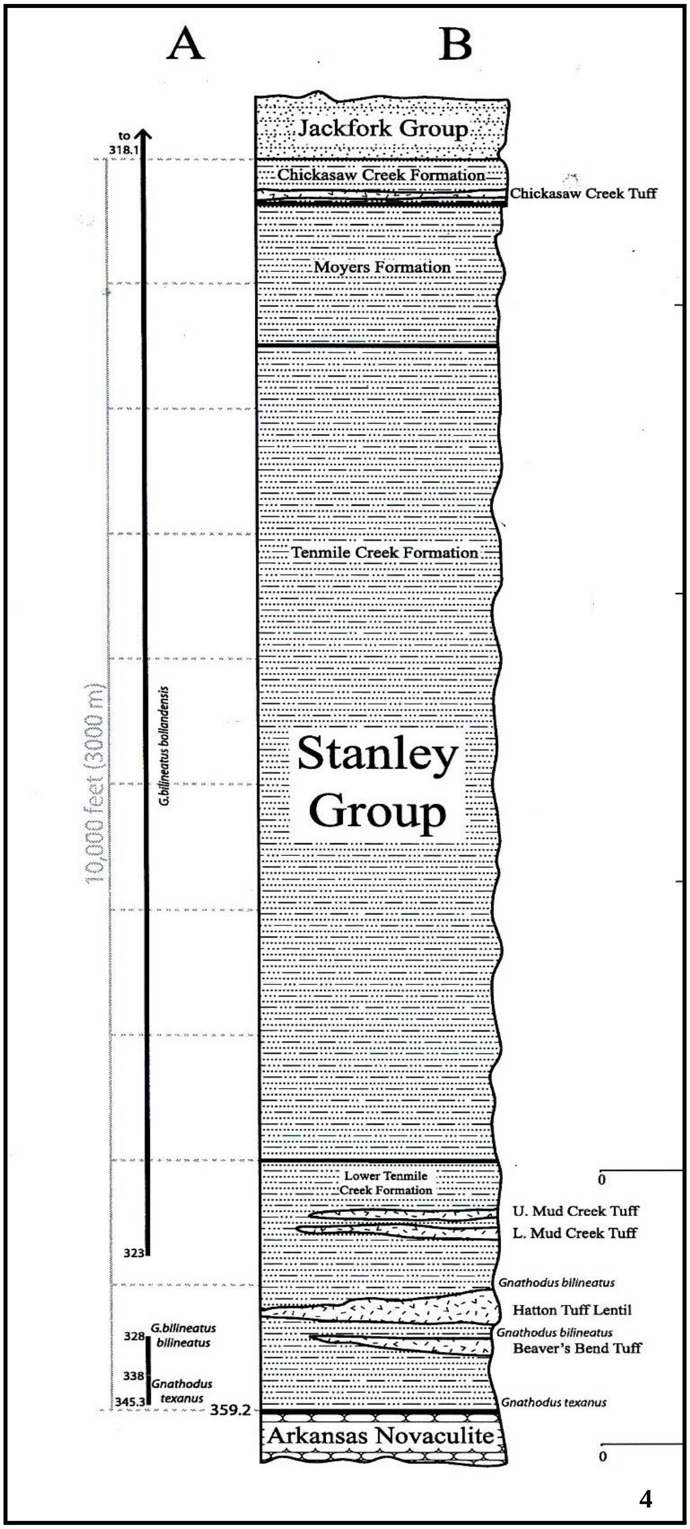

Figure 5. Modified Stratigraphic column of the Stanley Group from Shaulis et al. 2012.
A) The age ranges for the base and top of the Stanley Group.
B) The stratigraphic column of the Stanley Group (after Niem 1976) showing the approximate stratigraphic location of tuffs within the Stanley Group, plus the approximate location of conodonts found in relation to the tuffs.

Pennsylvanian Deposits

The sedimentary packages deposited during the Pennsylvanian contain 12,000+ feet of marine interbedded dark shales, tuffaceous beds, and sandstones (Laudon 1961). These include the Pennsylvanian Jackfork and Atoka Groups (Cline 1960, 1966, and Morris 1974). Cline (1966) and Morris (1974) concluded from paleocurrent studies that by the late Mississippian and early Pennsylvanian, rising tectonic areas to the south and southeast were hinterlands that provided great quantities of coarse clastics into the rapidly subsiding Ouachita basin.

METHODS

Thirty-one cone in cone concretions where collected from six locales along the Eagle Fork and Mountain Fork Rivers within the study area. Twelve thin sections were produced from 10 cone in cone concretions based on gross physical differences. Due to friability of these concretions, epoxy was applied to the exterior/crust of the concretions before sectioning on a rock saw to eliminate loss of exterior structures. A total of 17 concretions were bisected and polished before determining the most beneficial for thin sections. From the 17 bisected concretions 10 were selected for billet production. Billets were sent to Tulsa Sections for vacuum impregnation with blue epoxy, polished and prepared into thin sections. Nine 1 x 2 inch (25.4 x 50.8 mm) and three 2 x 3 inch (50.8 x 76.2 mm) microscopic slides were produced. Each billet was given the original catalog number for that concretion plus an abbreviation to describe the exact position of the billet within the concretion. Catalog numbers include the locale site, 1 through 6, a letter indicating the order in which they were cataloged (e.g. A, B, C, etc.), and the positioning within the concretion from which the billet was cut. Positioning is identified as either E for edge of concretion, T for top of concretion (for those too thick to acquire crust to crust sections), B for bottom of concretion (for those too thick to acquire crust to crust sections), or M for middle (for those that full crust to crust cross sectioning was possible) (e.g. 2A-M). Each slide was examined for textural properties, diagenetic features, and sedimentary structures. Concretion descriptions can be found in Appendix A.

RESULTS AND DISCUSSION

Macroscopic Descriptions

The collected concretions exhibit a fairly broad range of forms so that no two concretions are identical, but most follow a general configuration. The 3 dimensional objects are either flattened orthorhombic elliptoids or spheroids with some degree of tapering near the edges resembling a disc. Overall there are 4 semi-distinct variations in internal/external morphology of the concretions, excluding the effects of weathering. Before characterizing these concretions, the orientation of the concretions and their conal structures within the shale layer must be described. All concretions were found between bedding planes of shale with the shortest concretion axis (z) perpendicular to bedding (Fig. 7A), so no external cone axis was truly parallel with the bedding plane (Fig 7B). An inversion center or center of symmetry is applicable to all types of these concretions and can be referred to as the core center. Shale beds were either obviously contorted around the concretion or slightly bent indicating early cementation before compaction of the shale.

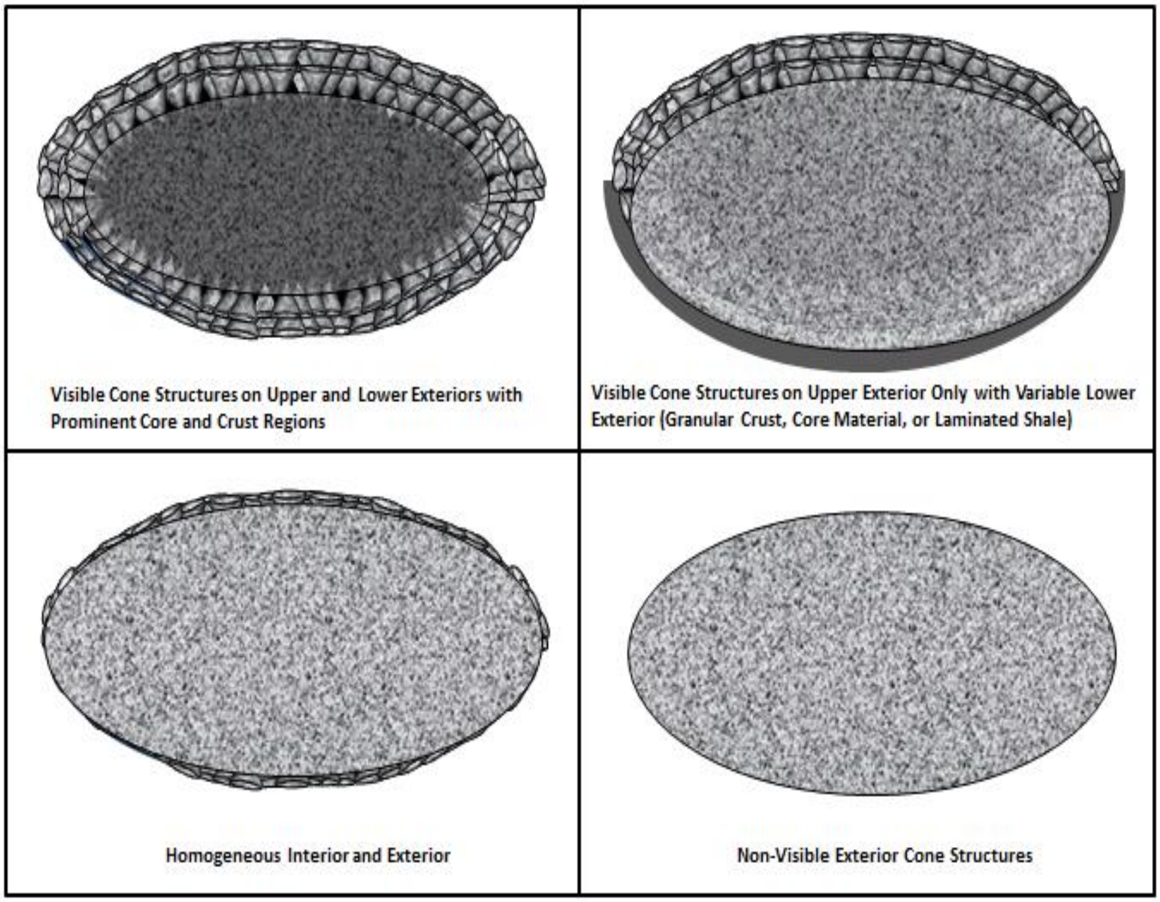

Figure 6. Four macroscopic variations of cone in cone concretions.

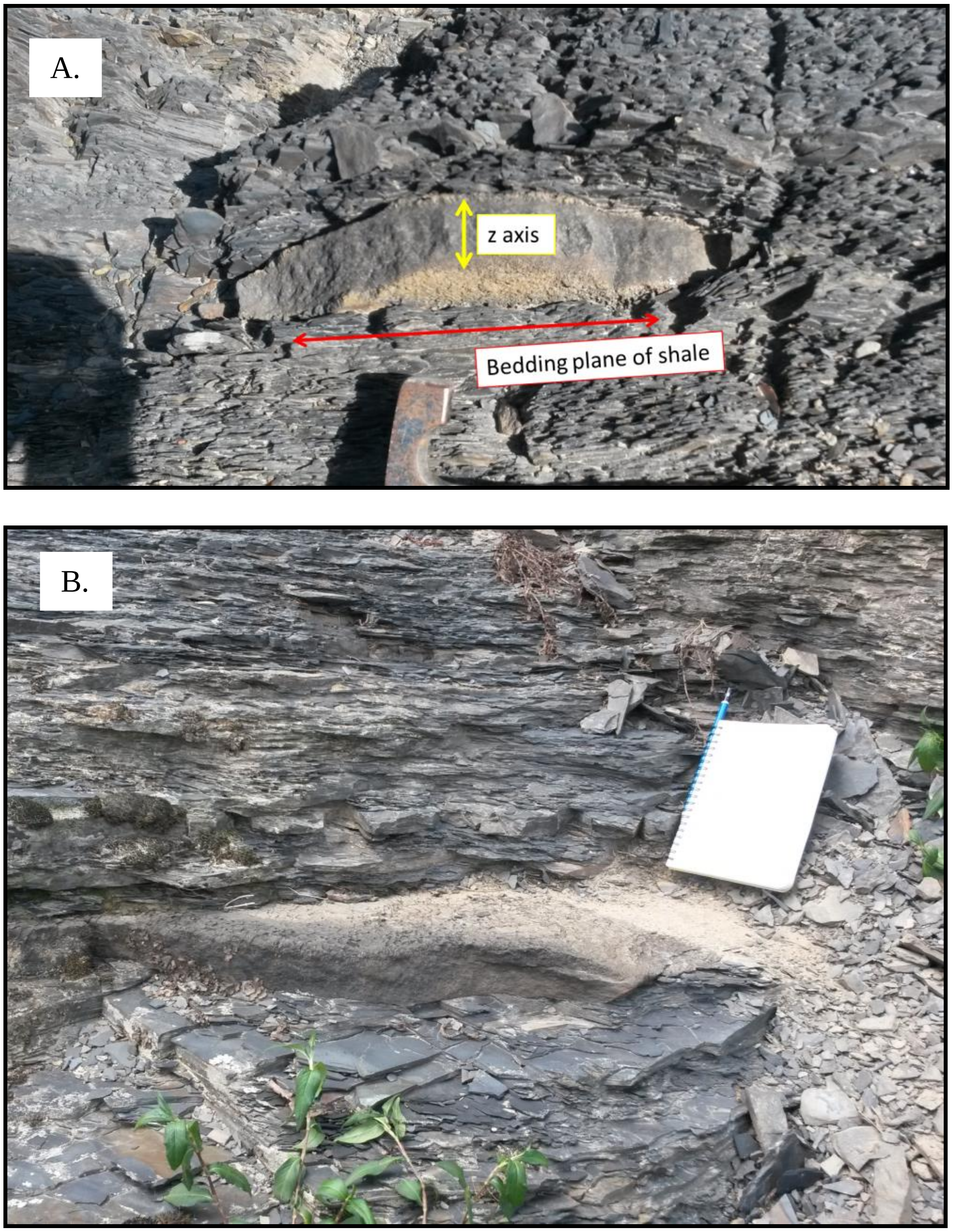

Figure 7A. A- Demonstrates orientation of the z axis of the concretion within the shale beds. B- Demonstrates the orientation of concretion within shale beds

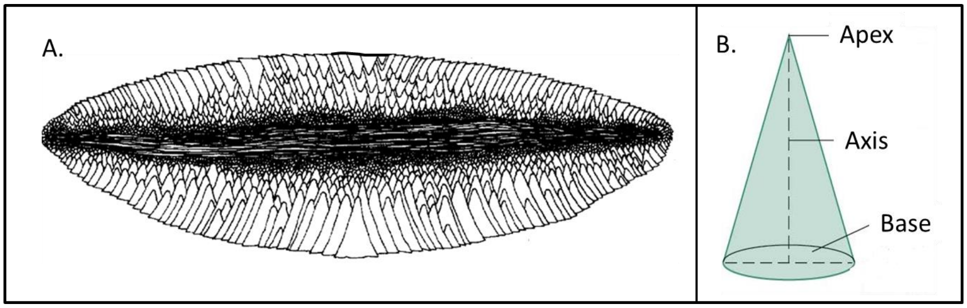

Figure 7B. A- Drawing of a typical cross section of cone in cone concretion (Modified from R. Gilman and W. J. Metzger 1967). B- Cone structure demonstrating the axis apex and base.

Visible Cone Structures on Upper and Lower Exteriors

The first type of concretion exhibits an external layer (crust) with visible cone in cone structures with apexes pointing inward to the core center. The core does not contain grossly visible cones and is darker than crustal zones although the boundary is not always well defined. This type is considered well developed and is the characteristic cone in cone concretion (Fig. 8). They can be further described as having an upper and lower hemisphere; the upper hemisphere contains visible cones with the apexes pointing downward toward the core center and the lower hemisphere containing visible cones with the apexes pointing upward toward the core center. All concretions of this type have larger cone structures on the upper hemisphere indicating the right side up position of the stratigraphic column.

Figure 8. Clearly defined interior and exterior boundaries with grossly visible cone structures in the exterior

Visible Cone Structures on Upper Exterior Only with Variable Lower Exterior

The second type of cone in cone concretion exhibits an external crust and core similar to the above mentioned type. The main difference occurs in the lower hemisphere, where visible cone in cone structures are not grossly identified. There's a textural dissimilarity between the upper and lower crust. Some of these types exhibit a lower crust texture that is granular and thin, measuring a maximum of 0.7 cm (Fig 9). The granular lower crust extends to the boundary of the lower and upper hemisphere. A well defined border between the core and lower crust in these types of concretions is appreciated. Some type of change in sediment horizon could be implicated in this type of granular crust formation. Other types which fall into this category simply do not exhibit a lower crust but have laminated shale units draped along the bottom hemisphere indicating partial development of the lower hemisphere crust (Fig. 10).

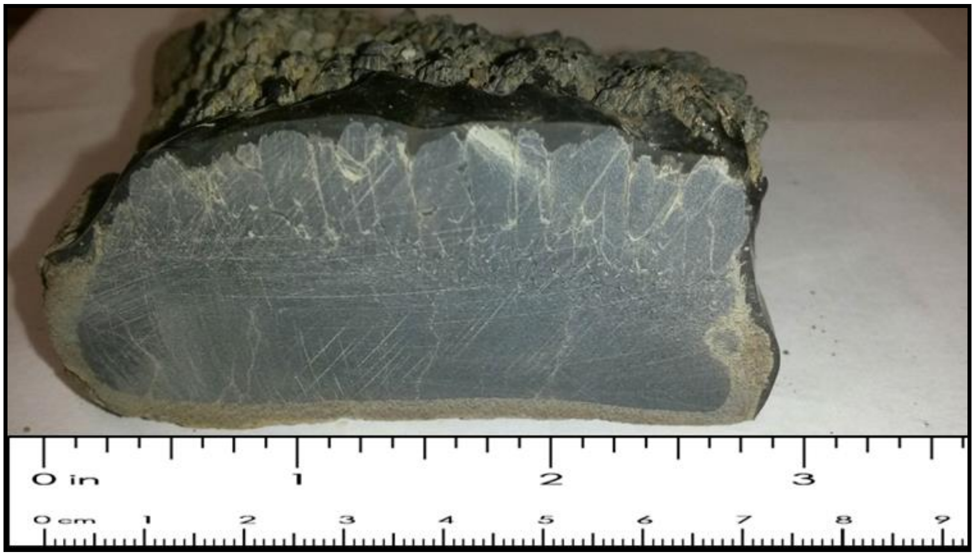

Figure 9. Granular crust seen in the lower hemisphere. Concretion 2A.

Figure 10. Shale laminations seen in the lower hemisphere. Concretion 1A.

Homogeneous Interior and Exterior

A third type collected exhibits conal structures on the exterior but there is no clear boundary between core and crust. Although these have been classified as a third type there is some similarities to the previous two; as some do not exhibit cones in the lower hemisphere and in their absence laminated shale are in place. In cross section the concretion appears to be one solid accumulation of minerals as there is no color variation or border recognizable. This type is attributed to a homogeneous composition and a single event accumulating carbonate minerals. These are typically much thinner/smaller than the previous two types (Fig. 11).

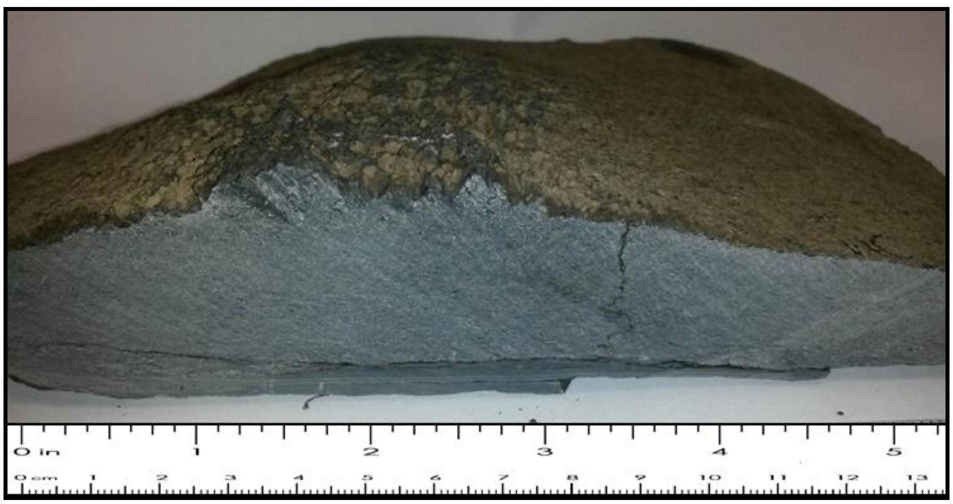

Figure 11. Homogeneous interior and exterior. Concretion 3A. Scale in inches.

Non-Visible Exterior Cone Structures

The Fourth type of cone in cone concretion does not exhibit visible external cones on the crust/exterior. Only when sectioning these oblate spheroidal concretions does cone in cone structures become observable either by microscopic examination or macroscopically (Fig. 12). Boundaries between core and crust are not easily recognizable. This type could represent early stages of concretion formation, lacked the necessary components to fully develop, and/or was subjected to other diagenetic alterations.

Figure 12. Non-visible exterior cone structures. Concretion 5A. Scale in inches

Microscopic evaluation

Petrographic analysis of 10 cone in cone concretions revealed a considerable amount of variations, especially concerning mineralogy and texture, but these variations reveal growth stages of concretion formation and possibly the processes involved to initiate basic carbonate precipitation. Invariably all concretions exhibited cone in cone structures to some extent, although they ranged from microscopic to large cones measuring over 1.25 inches (3.17cm). Conal structures were observed in all cores and most crusts. Two categories of concretions are recognized; visible and non-visible cone in cone structures. Both categories will be described by their interior and exterior characteristics. Mineral constituents will be described separately.

<u>Non-visible cone in cone structures</u>

Very few concretions were collected that did not exhibit external cone in cone structures, the main principle being they were unrecognizable as cone in cone concretions. Two of the thirty-one concretions collected are in this category and were collected because of their symmetrical flattened spheroid appearance. Examination from the inner core to the exterior reveals the following: a central thin lens of dark clay like material with a lighter zone encompassing this thin lens. The lighter zone inter-fingers into a darker matrix rich zone and a partial enclosing crust surrounding the darker matrix (Fig. 13).

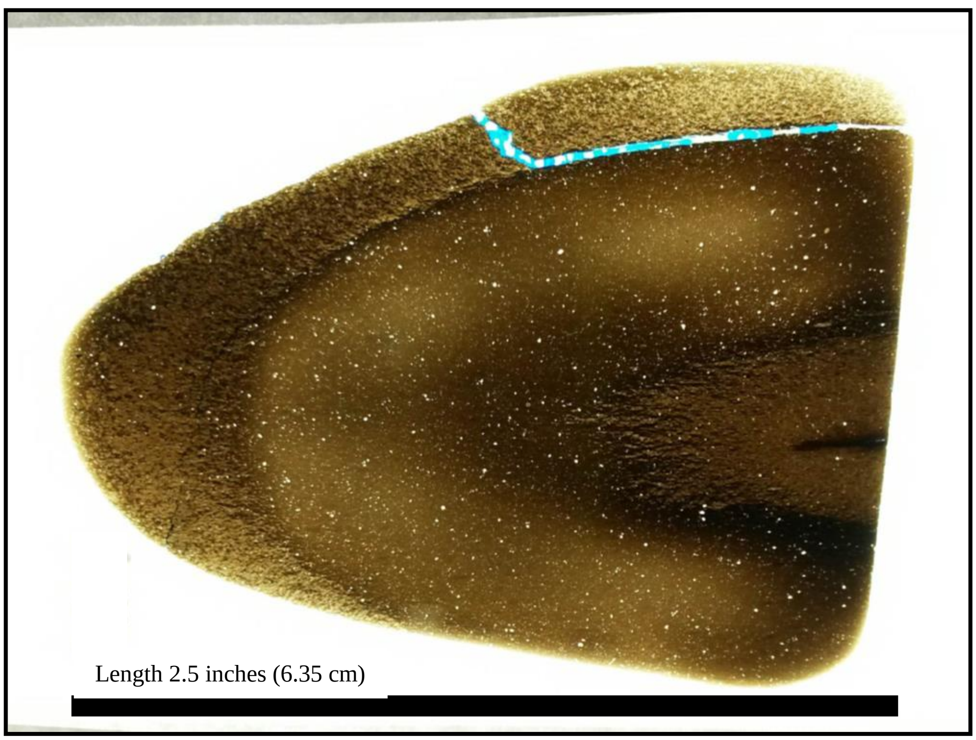

Figure 13. Thin section photograph exhibiting thin dark inner core, lighter zone inter-fingering into a clay rich interior, and a partial encompassing exterior crust. Concretion 1IE.

Interior. The thin lens of the inner core material appears to be an organic rich deposit undergoing reduction. On the exterior of the dark lens a reddish brownish diffusion precipitate rims this zone representing hematitic staining or precipitation. The lighter inter-fingering zone consist of precipitated cones slowly migrating laterally away from the inner core and producing lenticular bands of matrix between the accumulated minerals (Fig. 14). The precipitation of these minerals is lateral more than vertical indicating pressure and/or migration along bedding planes of the shale matrix. The microscopic cones that are distinguishable have axes perpendicular to the lateral migration, but there is no preference of cone bases in either up or down position. (Fig. 15).

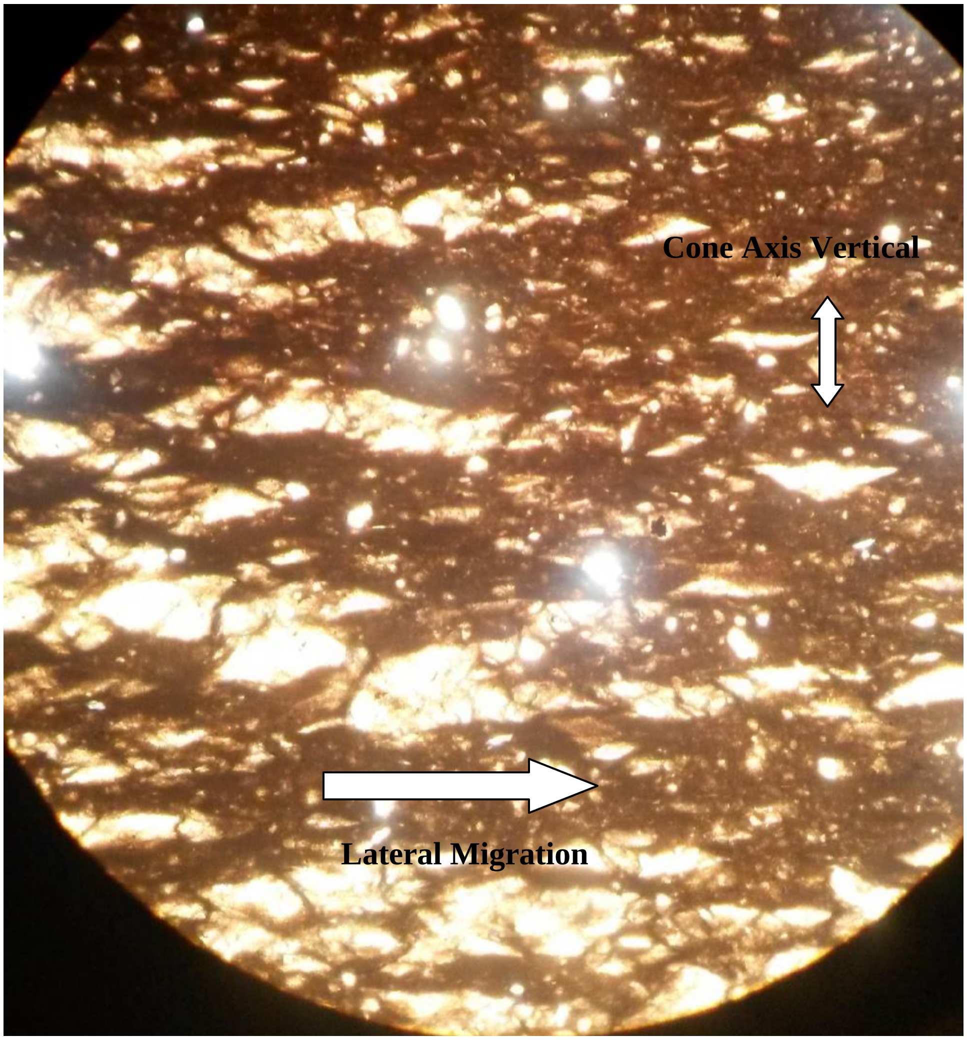

Figure 14. Photomicrograph of lighter zone that inter-fingers into the dark interior clay region showing mineral accumulation with formation of lenticular bands. Mineral accumulation is lateral from left to right. Few recognizable cone structures are seen. (50x) Concretion 1IE

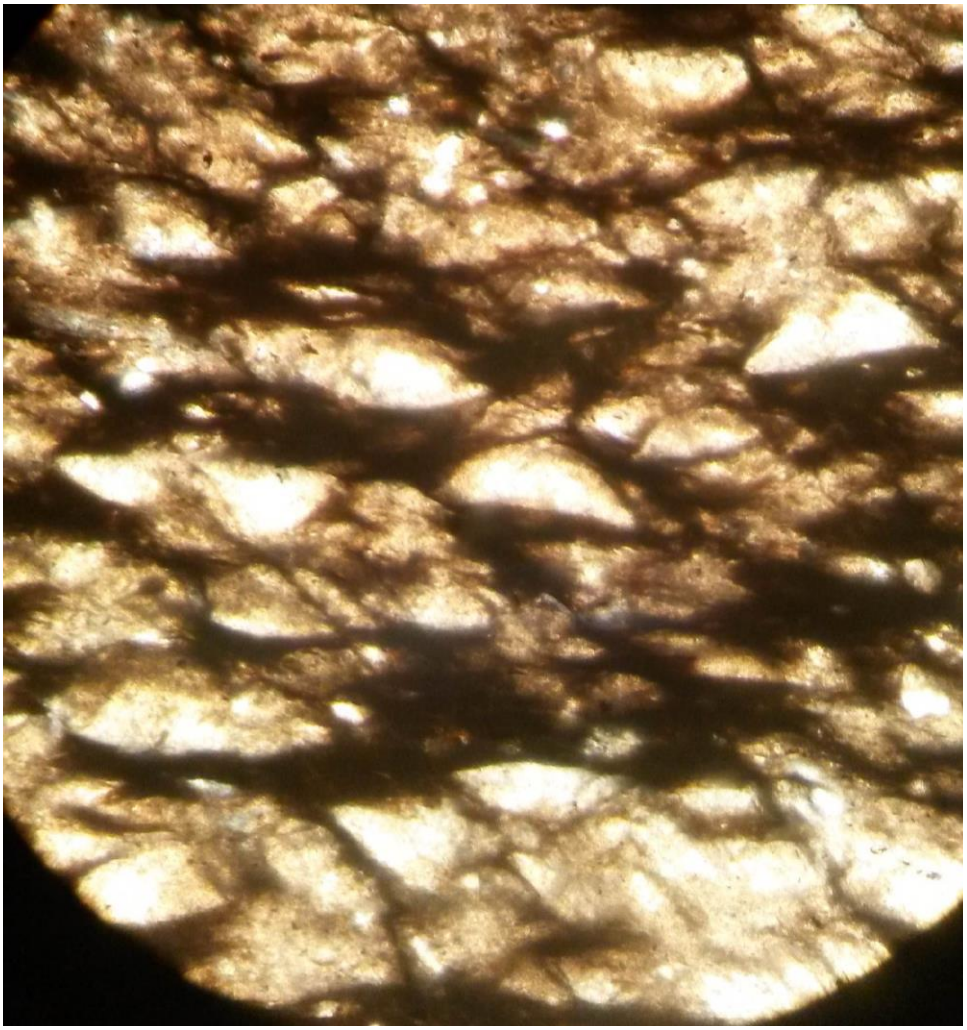

Figure 15. Photomicrograph of lighter zone that inter-fingers into the dark interior clay region with cone axis vertical but perpendicular to lenticular bands consisting of dark areas. Preferred orientation of cone bases not appreciated. (100x). Concretion 1IE

The dark interior matrix surrounding the lighter zone is composed of un-laminated shale with abundant quartz clast. Cubic structures likely representing pyrite is seen in a few quartz clasts (Fig. 16). Siliceous spicules, and other possible biogenic structures are rare. Mineral precipitation producing distinct lenticular waves/bands are not seen within the dark matrix outside of the inter-fingering zone. This does not imply an absence of mineral precipitation, it only implies a lack of mineral precipitation in sufficient quantities to produce lenticular bands.

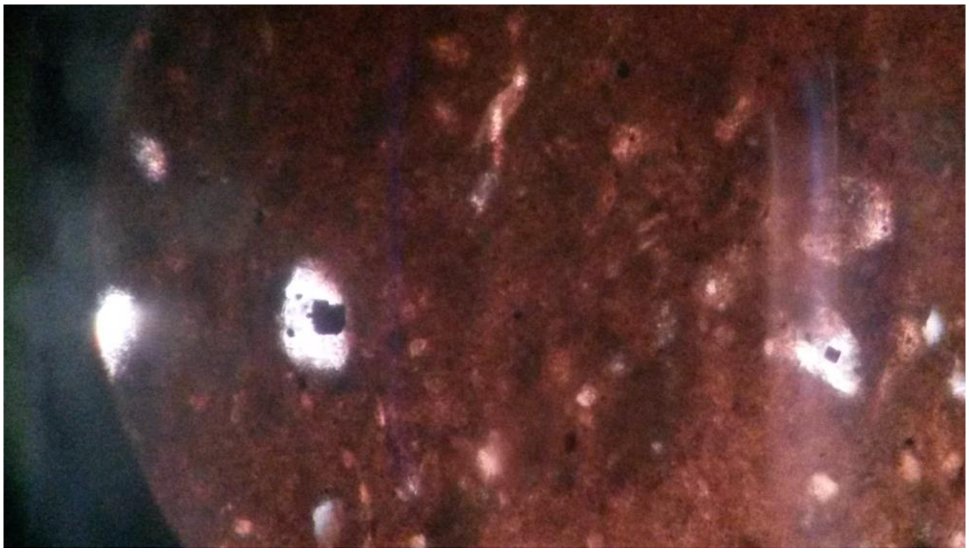

Figure 16. Photomicrograph of dark interior clay region showing quartz clast containing pyrite cubes. (100x) Concretion 1IE

Exterior. The outer crust is only prevalent on the top and sides of the concretion, the bottom crust retains dark matrix material as the exterior. The outer crust of the upper portion exhibits a distinguishable and friable boundary between the matrix and crust (Fig. 17). It exhibits microscopic cone-like structures with semi-lenticular bands of clay material. These cones are typically oriented with their bases pointing outward. The boundary or transition zone becomes much less distinct along the tapered edges. Mineral precipitates and early forming lenticular bands distort the transitional zone and increase the overall thickness of the edges (Fig. 18). Structures are much less developed in the crust near the outside tapered edge of the concretion and exhibit almost no cone structures or lenticular bands as opposed to those in the transitional zone or inner crust area.

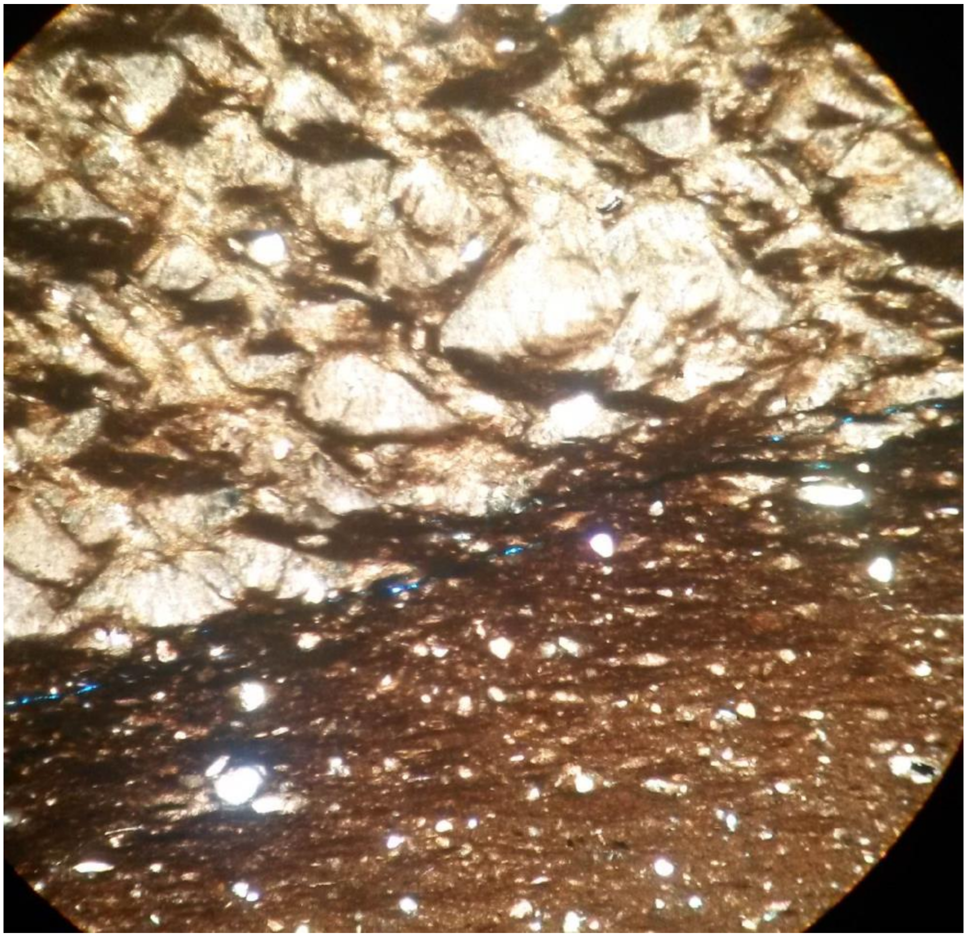

Figure 17. Photomicrograph of boundary between dark interior clay region and the exterior crust. This is directly above (vertical) the dark thin lens at the core center. (40x). Concretion 1IE

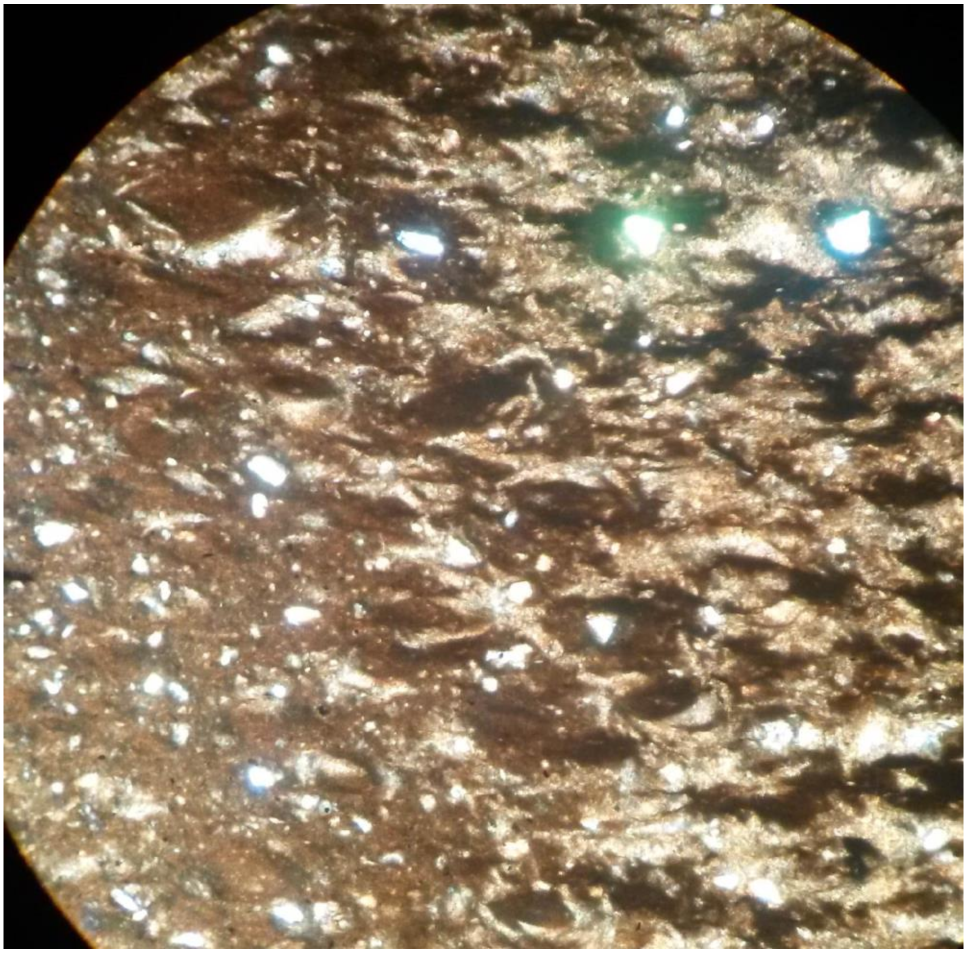

Figure 18. Photomicrograph of boundary between the dark interior clay region and the exterior crust. This view is horizontal from the dark thin lens and at the concretion edge exhibiting a transitional edge boundary. (40x). Concretion 1IE

Visible Cone in Cone Concretions

Interior. Concretions that exhibited visible external cone structures contained microscopic cone structures within their interiors. Microscopic cones range in the micrometer scale and are not grossly visible. Other prominent features seen interiorly consist of clay size material as drapes around cones (cone shells), lenticular bands, semi-linear lines (lineations), and interstitial clay particulates within the cones (Fig 19). Although the term drape is applied, it does not imply secondary migration of clay size material onto the exterior of the microscopic cones, it represents authigenic clay material that parted and enveloped the carbonate during precipitation of the cones and will be referred to as cone shells. Some other features that were noted but not common include burrows, quartz clast replacement of calcite and hydrothermal quartz veins.

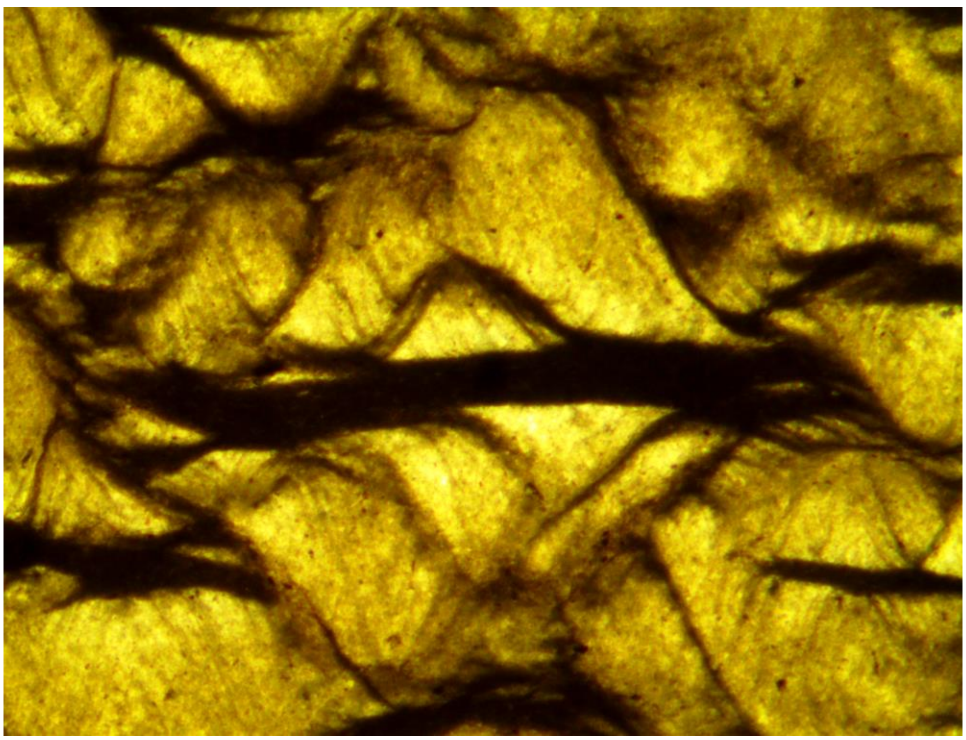

Figure 19. Microscopic cones of the interior exhibiting cone shells, lenticular bands, opposing cones, and interstitial clay particulates. (100x). Concretion 1D.

Interior Cones. Microscopic cones vary in size and mineral composition but they essentially do not vary in orientation of cone axis. Axes are orientated with the z axis of the concretion and in the direction of the core center. Cones near the core center are mostly vertical with tilting seen near the tapered lateral edges. An unexpected finding was the orientation of bases and apexes in the interior; in the exterior, cone bases are always seen on the surface with apexes pointing inward toward the core center. Cones close to the core center have little preference to direction of cone bases and apexes (Fig. 20). Moving outward toward the exterior, cones begin to exhibit more preference with bases pointing toward the exterior. This is especially true for upper hemispheres, lower hemispheres contain more variation. Clay rings described by Tarr in 1922 and later as annular rings are not prominent features seen in the interior.

Figure 20. Opposing cones with lenticular banding and clay lineations, mostly perpendicular to cone shells. (100x).

Microscopic cones can either be homogeneous in texture or contain semi-linear parallel lines of clay within the cone. Although they appear linear which is 2-dimensional, they are 3-dimensional and are parallel to cone shells or intersect the cone shells perpendicularly. There can be a slight bend in this lineation near the base of the cone arising from the lenticular band for those lineations that intersect cone shells perpendicularly. This likely represents true secondary migration of clay material during dissolution of the parent mineral. Concretions that have the least amount of diagenetic alteration have lineations that are parallel with the cone shells and indicate clay parting during original formation of the cones and create a cone within cone feature (nested cone). The clay lineations also may delineate a particular diagenetic time in which dissolution and re-precipitation is occurring so that a single cone may have contained cycles of parallel and perpendicular lineations throughout its diagenetic life.

Interior Lenticular Bands. Lenticular bands are common and range in length and thickness but never run the entire length of the concretion. Even though lenticular bands are common, concretions with smaller external cone in cone structures exhibit more lenticular banding than those with large external cones.

Lenticular bands are dark and consist of clay size material and commonly are seen as rectangular shapes. The long axis of the lenticular band is normally parallel with the long axis of the concretion. Lenticular bands and cones bases are nested against each other. The boundary can be straight, concave, convex, or a combination of these. Often the cone bases appear to push into the lenticular band making it concaved. Lenticular bands often separate two cones with their apexes facing opposite directions (Fig 20).

Exterior Cones. Microscopic examination of the exterior cones reveal one characteristic common to all concretions; cone bases point outward while the apex points inward toward the core center. Exterior cones are much larger than interior cones and measure up to 1.25 inches (3.17 cm). Cones are larger in the upper hemisphere compared to the lower hemisphere and cone shells consisting of clay size material are thicker than interior shells. Thinning of cone shells toward the exterior is common. Cone shells often exhibit regularly repeating annular/clay rings on the peripheral of the cone shells.

Exterior Lenticular Bands. Lenticular bands are not common in the exterior cones, but smaller cones of exterior regions display more lenticular banding than large cones. As mentioned in the macroscopic descriptions four variations of cone in cone concretions were described, where the first three types exhibited external conal structures and the fourth did not. The first two exhibited clear boundaries between core and crust (interior and exterior) and the third showed a homogeneous nature. This third type exhibits smaller exterior cones with prominent lenticular banding. This likely represents concretion formation spanning one length of time and not multiple times of growth. Concretions with clear separation of interior and exterior regions exhibit pronounced lenticular banding in the transition zone (outward surface of the interior) supporting this assumption.

Exterior Lower Hemisphere Variations. For those concretions that do not exhibit visible cone in cone structures in the lower hemispheres; two alternatives include a lower granular crust or shale laminations, neither are common.

Four cone in cone concretions have granular crust. The crusts exhibit features similar to interior textures with a few differences. The crust has prominent lenticular bands although cones are harder to discern. There is porosity within the granular crust and an overall scorched appearance. The boundary between the lower crust and interior is abrupt in color alone, but not in size or orientation of cones or lenticular bands (Fig. 21).

There is also noticeable iron staining in this area, all of these factors likely indicates a change in sediment horizons during formation.

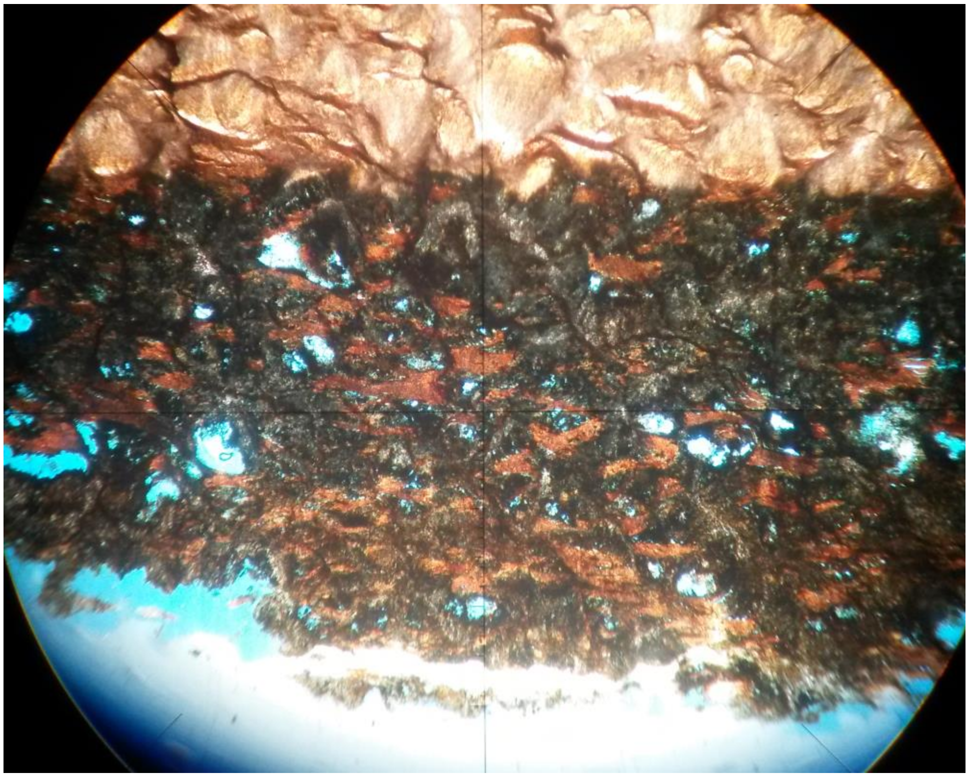

Figure 21. Granular crust of a lower hemisphere and the abrupt boundary between exterior and interior. (40x). Concretion 2A.

Laminated shale on the lower hemisphere was seen on 3 of the 31 concretions (Fig. 22). No visible cone structures or lenticular bands are noted within these laminated areas. Burrows are a common feature as well as mineralogical differences of the shale laminations giving a varve like appearance although they are not. These concretions are more convoluted compared to other concretions. Internal and external cones, lenticular banding, and cone shells are not well defined. This likely indicates bioturbation disrupted precipitation processes that produce carbonate concretions.

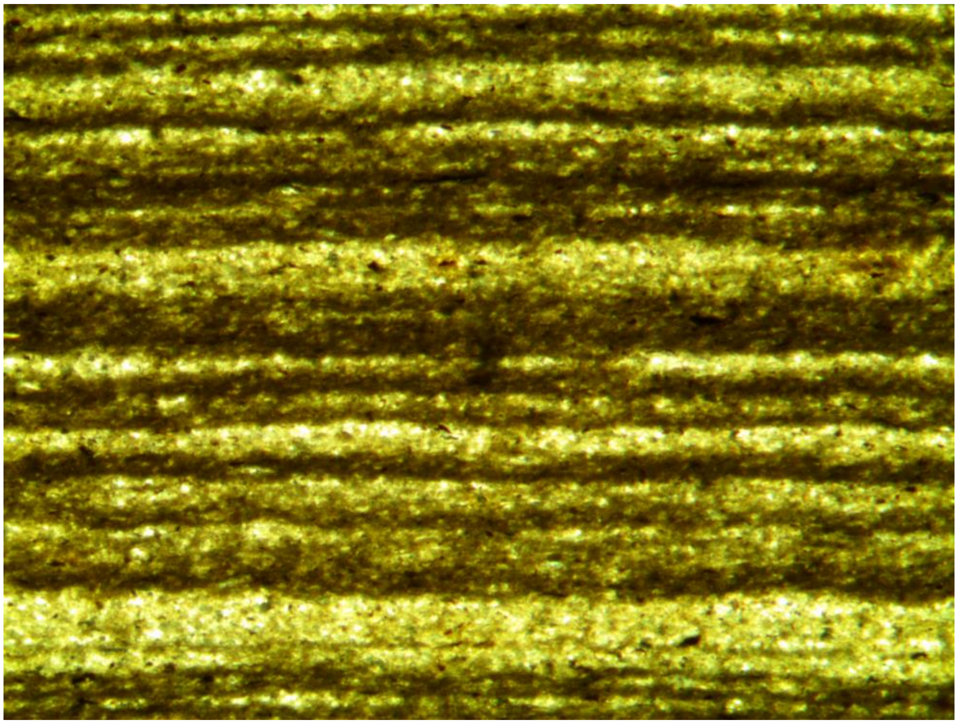

Figure 22. Shale laminations of lower hemisphere where microgranular precipitates are organized into layers between shale layers. (50x). Concretion 1A.

Source of Carbonate

The Ouachita Trough created by rifting of the Precordillera created a marine basin generally considered to be deep quiet waters, but no actual depth has been un-disputably proven. To be considered deep, a depth of 500 meters as the upper limit on the upper continental slope and below the influence of storms affecting the bottom sediment has been suggested by Hesse and Schacht (2011). The Stanley Group is thick, rapidly deposited siliceous marine sediment containing organic constituents in a reducing environment within a poorly circulated possibly deep basin (Johnson 1968). Johnson (1968) also concluded that very little to no reworking of sediments was observed in the hundreds to thousands of beds they observed. Over 10,000 feet (3000m) of compacted and lithified rock accumulated within 5 million years (Shaulis et al. 2012), but this does not include the thickness of the sediment and compaction ratios, something that will not be covered here. Another aspect that seems to be missing in descriptions of the Stanley Group is early diagenesis and the influence of microbial activity and oxidation of organic matter and soft bodied organisms within sediment horizons during sediment accumulation.

For the last 50 years deep sea and ocean drilling programs which penetrate sediments to ever increasing depths have given insights into the processes that are occurring to deep sea sediments at relatively shallow geological burial depths. Using this data, inferred early diagenetic processes occurring to the Stanley Group sediments as they were being buried will be contributory in the determination of where calcium carbonate to form carbonate cone in cone concretions originated.

Sediments and/or soil harbor much of the world’s genetic diversity and the interface between rock, air, water, and living organisms creates zones of sediment horizons also known as soil horizons in terrestrial environments. Deep sea drilling projects have concluded that numerous bacterial reactive zones are present before lithification and organic matter is the main driver of early diagenesis in these hemipelagic deep-sea sediments (Hesse and Schacht 2011). Bacteria utilize the organic matter that is deposited and at least five different oxidant-specific populations of bacteria follow one another during burial in the order of decreasing energy efficiency of their metabolic reactions (Froelich et al., 1979). The established vertical sequence of organic matter decomposition zones begin with the oxidation zone and with increasing depth evolves into a nitrate reduction zone, sulphate reduction zone, carbonate reduction zone, and methane generation zone (Fig. 23). Below the methane generation zone, thermocatalytic decarboxylation zones may be present if temperatures exceed 75° C where bacterial activity possibly ceases (Claypool and Kaplan, 1974).

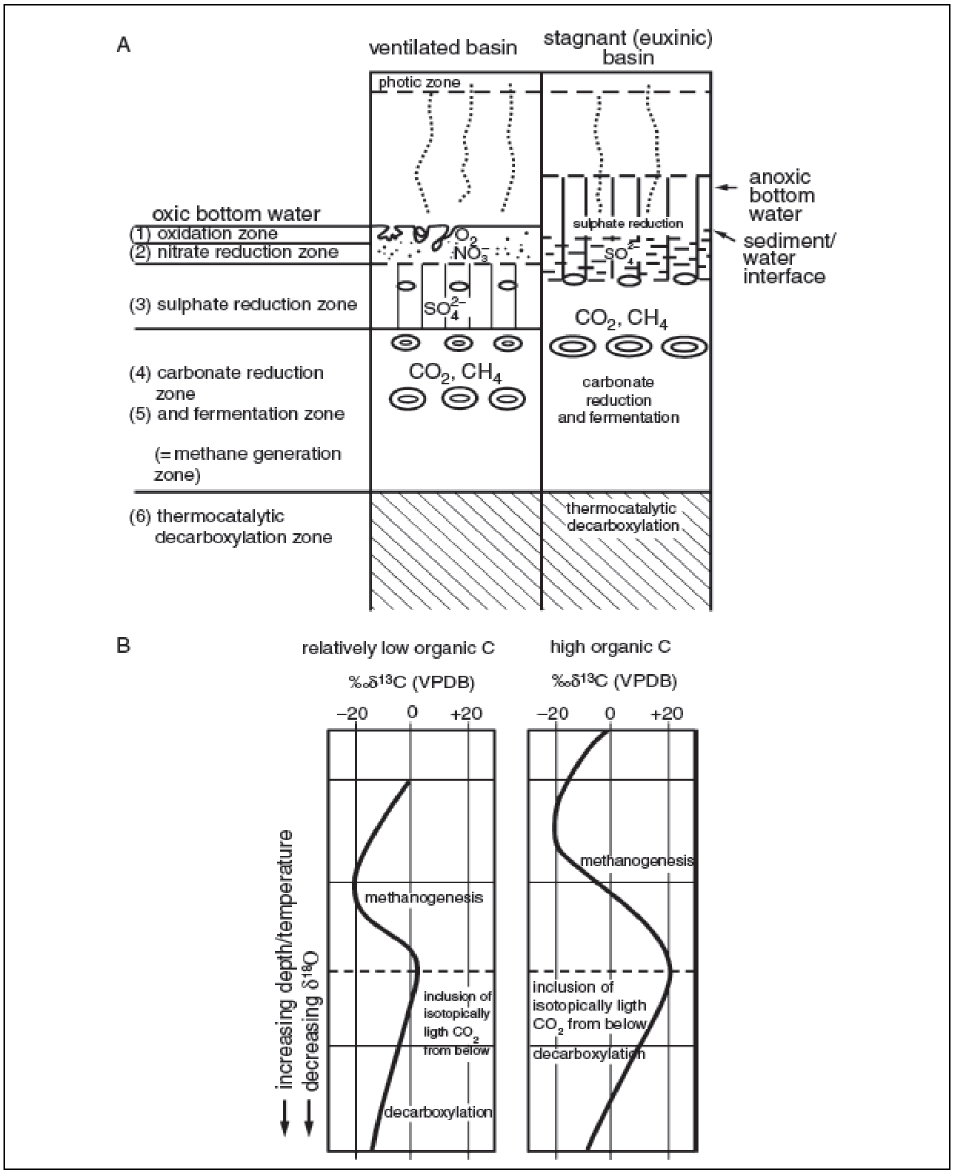

Figure 23. Stages of organic-matter oxidation in anoxic sediments in ventilated (or intermediate sedimentation-rate) basins and stagnant (or high sedimentation-rate) basins (redrafted from Hesse et al., 2004). (A) In stagnant basins the organic-matter decomposition zones are raised to shallower burial depths and zones (1)-(3) occur above the sediment/water interface compared with well-aerated basins (modified from Claypool and Kaplan, 1974). (B) Schematic δ^{13} C profiles for dissolved carbonate in the two types of basins (modified from Mozely and Burns, 1993)

For calcium carbonate to precipitate in a deep trough where biogenic carbonate is not directly deposited onto the ocean floor, the only source for carbonate would be production within sediment horizons, horizons may not be continuous/planar but focal depending on organic matter and rates of deposition. Curtis et al. 1972; Irwin 1980; Hudson 1978; Pearson 1979; Coleman and Raiswell 1981; Gauthier 1982 and others utilized stable carbon isotopes and determined that most carbonate concretions were derived from microbiological oxidation of organic matter through sediment horizons such as sulphate reduction and methanogenesis. Canfield and Raiswell 1991 and Raiswell 1997 performed modelling studies that indicated porewaters from the sulphate reduction and early methanogenic zones are supersaturated with $CaCO_3$. Continued addition of methanogenic CO_2 along with production of carboxylic acids has the capacity to produce undersaturation with the ability to dissolve carbonate. Thus for the formation of carbonate concretions to be produced and not dissolved a balance somewhere in the transition zone of these horizons and a hiatus in deposition would be needed. Hesse and Schacht 2011 described the production of authigenic carbonate precipitation due to methane oxidation and the increased alkalinity, especially when the pH is maintained by reactions such as Fe reduction. Therefore the sulphate/methane interface region above hydrate zones would be the preferred site of authigenic carbonate precipitation (Hesse and Schacht 2011).

Modern analogs of cone in cone structures have not been identified through deep sea drilling programs but this does not indicate that the processes are absent, rather that early growth stages are not readily distinguishable from the surrounding sediments (Kopef et al. 1995). These early diagenetic processes are masked by lack of lithification and are peds (a unit of soil/sediment structure such as an aggregate, crumb, prism, or granule) awaiting further cementation/diagenesis to form the hardened structures seen in the rock record. Sediment horizons in modern seas allow visualization of particular layers in the rock record where cone in cone structures are seen in some beds and not others. This is the case within the study area of the Stanley Group, where cone in cone structures are prevalent within particular shale beds. Some other factors that should be considered is the type and/or size of organic matter undergoing chemical processes, the type of transport system in place to include closed or open systems, types of diffusions like ionic and fluid movement and the patterns emplaced, and constituent pore water chemistry.

Literature citing the precipitation of carbonates is bountiful and complex and this particular model (which may be over simplified) is only one interpreted by the author, respectively. It would be wise to not directly state that Stanley Group cone in cone concretions are formed by this process alone, and due to the variability of cone in cone concretions found in the Stanley Group, more than one model of formation may apply, and multiple models may apply to a single concretion. It is not the intent of this thesis to examine all the possibilities of carbonate precipitation in siliceous sediments, although a thorough review was performed; researchers should perform their own investigations and decide which are plausible for their studies. Additional research of carbonate concretions formed by the oxidation and reduction of organic matter and how it relates to the precipitation of carbonates and other minerals, continual concretionary growth, and diagenesis of cone in cone concretions in marine sediments would be insightful.

Mineralogy and Diagenesis

One way to organize the types of mineral present within these concretions is to describe those with similar interior and exterior cone precipitates and to proceed to those that reveal more variation due to diagenesis. Mineral accumulation begins with the precipitation of carbonates migrating laterally away from and eventually enclosing an organic/clay like matter as seen in the non-visible cone in cone concretions. Original carbonate growth could begin either at cone apexes or the cone bases. Although cone orientation is random near the core center, continued diffusion of carbonates away from the core center creates a pattern of flow so that orientation of cone bases become distinctly facing outward. This indicates a length of time of continual movement outward of minerals and/or fluid.

Homogenous Interior and Exterior Carbonate Precipitates

The original precipitate or crystal variety may not be represented but the least altered mineral form is microgranular calcite within the cones. Microgranular calcite can be seen throughout interior and exterior cones. These concretions show the least amount of mineral variation and the smallest exterior cones. They also contain lineations within the cones that are parallel with cone shells. Clay like material is also very prominent and usually concentrated within the cone bases as a light inter-matrix particulate film. This particular attribute indicates that cone growth is from apex to base pushing clay out of the way during cone growth. Corresponding thin sections include 3A, 4AE, and 4AM.

Variable Carbonate Precipitates

These concretions exhibited microgranular calcite within the interior cones and twin lamellae calcite in the exterior cones. Although these typically had homogenous interior and exteriors with no clear boundary, these concretions had larger exterior cone structures. Annular rings are prevalent in conjunction with the larger twin lamellae cones. These also contained both types of clay lineations within cone structures. Exterior cones mostly had parallel lineations, whereas interior cones developed perpendicular lineations to cone shells. Clay material within cone bases as a light inter-matrix particulate film is still observable. This stage represents early dissolution of calcite from the interior and its migration outward. Corresponding thin sections include 2A and 4BE.

Mixed Siliceous and Calcitic Precipitates

These types of concretions start to demonstrate the complex diagenetic histories that carbonate concretions undergo throughout time. They exhibit either a chertification and/or quartz clast precipitation from the core center and it partial migration outward. One thin section contains a 1.5cm layer of silt sized quartz clast with pyrite cubes and rutile inside the clast in the core center. A clay matrix surrounds these quartz grains. Outside of this silty core center, but still within the interior, cherty cones are identified along with a 2 cm burrow. Clay lineations are perpendicular to cone shells. Lenticular bands are present throughout the interior but become rare near the boundary of the interior and exterior. A siliceous precipitation is continuous throughout the interior. Silicification of cones near the boundary of the exterior and interior are common while the outermost exterior cones are twinned lamellae calcite. The exterior cones have annular rings and migration of clay inward. Stylolites are common. Silicification began after the carbonate concretion formed then dissolved the carbonate from the inside out. Siliceous rich fluid migrating inward also allowed the clay to migrate inward. As carbonate minerals were dissolved and pushed outward, re-precipitation followed. This can be the origin of cone structures that appear to have grown into the surrounding shale. Corresponding thin sections include 1HB and 1RM.

The silicification of these Stanley Group cone in cone concretions marks a point in time where orogenic events, compaction, and/or fluid migration imposes its greatest diagenetic alteration of these concretions. Silicified concretions contained the greatest variation in color, hardness, and mineral constituents. It is also a likely starting point where Fe precipitation other heavy metals contained in the invading fluids could alter the cone shells resulting in external hematitic cone shells.

Siliceous Precipitates

The majority of concretions collected are classified as siliceous cone in cone concretions with no remaining carbonate precipitates. Microscopic cones of the interior are completely siliceous and most without clay lineations within the cones. The siliceous precipitate is chert. The large external cones exhibit complete or partial solidification of the surrounding shale. One concretion exhibits quartz veins traversing the entire thickness. Silicified concretions exhibit the strongest differential of core and crust. Annular rings are prominent as is migrating clays. Stylolites are seen transecting boundaries of cones mostly within the exterior. Corresponding thin sections include 1AM, 1BM, 1DT and 1DM.

CONCLUSION

The Stanley Group of Southeastern Oklahoma contains a wide variety of cone in cone concretions. Six locations in the study area near Smithville, Oklahoma revealed numerous cone in cone concretions within shale beds. Most outcrops of shale were identified along Eagle Fork and Mountain Fork Rivers north of Broken Bow Lake, Oklahoma.

Cone in cone concretions are best identified by their visible cone structures on the exterior, but not all concretions exhibit these features externally. Those that have external cone structures are classified by similarities and differences in the upper and lower external crust and boundaries between interiors and exteriors. Three groups were identified; visible cone structures on upper and lower exteriors, visible cone structure on upper exterior only with variable lower exteriors, and those with a homogeneous interior/exterior with no clear separation. A fourth type did not exhibit external cones.

Microscopic evaluations revealed that all four types mostly contained micrometer size cones in the interior. Other features that were recognized include cone shells, lenticular bands, and lineations within cones of the interior and exterior regions. Orientation of cones and their relationship to lenticular bands indicate at least lateral diffusion of ions capable of precipitating minerals away from an organic/clay rich sulfur reducing horizon. Cone axes are perpendicular to horizontal bedding planes but precipitation could originate either from cone bases or apexes.

Mineral precipitation, dissolution and re-precipitation divided the concretions into four distinct classes; homogeneous carbonate precipitates, variable carbonate precipitates, siliceous and calcitic precipitates, and completely silicified concretions. Microgranular calcite is recognized as the least altered carbonate mineral precipitate within microscopic and macroscopic cones. As exterior cones increase in size, twin lamellae calcite predominates as the next diagenetic step forming the external conal structures. Concretions containing siliceous and/or cherty cones always exhibited dissolution of carbonate cones from the interior first with precipitation of silica outward from the core center. Concretions with siliceous cones exhibited the largest exterior cones whether they were completely silicified or retained twinned lamellae calcite in external cones. Completely siliceous concretions demonstrated the greatest amount of incorporation of surrounding shale into the external cones. Because these carbonate concretions were formed by diffusion currents and/or fluid movement, they became distinctly different than the surrounding shale, and after significant cementation, migration of fluids both inward and outward allowed late diagenetic events to be recorded within the concretionary boundaries. Inward movement of fluids most likely followed cone shells and lenticular bands. The greatest amount of fluid pressure would be located in the core center where siliceous precipitation begins.

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VITA

Kyle Ayres was born in 1980 and grew up in Nacogdoches, TX. He graduated from Nacogdoches High School in 1998 and attended Stephen F. Austin State University where he received his Bachelors of Biology in 2004. For 10 years Kyle was a Histotechnologist for Nacogdoches Memorial Hospital serving as lead tech for the Pathology Department. In 2012 he returned to SFASU to achieve a Master's in geology with the plan of graduating in May 2016.

APPENDIX

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 1A "Type Concretion"

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Cone in cone concretion. 10.5 x 8 x 1.5 inch. Disc shaped or "cow pattie" in appearance, not ovoid. Single layer of cones on upper surface, upper surface has scaley appearance. Layered crust on bottom, likely altered shale. Cone structures measure 7/8"in height. Cone shells appear nearly extinct. Cone fillers are dominant.

Thin Section Microscopic Description:

Microscopic examination reveals horizontal bands of clay/shale and original but replaced carbonate layers at the bottom of the concretion. No reaction to dilute HCl was noted due silica precipitation overprinting the original carbonate. Above the layering is a distinct dark colored boundary, likely clay clast and or organic rich deposit. Cone in cone structures are noted above this boundary to the top crust. Cone shells no longer retain any carbonate minerals. An overall silica overprinting of the entire concretion is appreciated. Cone shells are nearly extinct in the upper crust surface.

Interpretation:

This is a cone in cone concretion with shale layers attached to the bottom. All calcite has been dissolved, and there is minimal cone shells present. Clay fraction was minimal due to bioturbation resulting in a more homogeneous carbonate cementation precipitation process. The cone bases all point to the top crust, indicating a preferential flow of carbonate fluid in one direction during cone formation. Banded lower hemisphere was due to horizontal precipitation during shallow burial. Cow pattie appearance is due to a lack of cone shells thus minimal clay interference in external surface.

Comments:

Upper crust effervescence: No
Inner core effervescence: No
Lower crust effervescence: No

Degree of Alteration: Medium to high

Pictures:

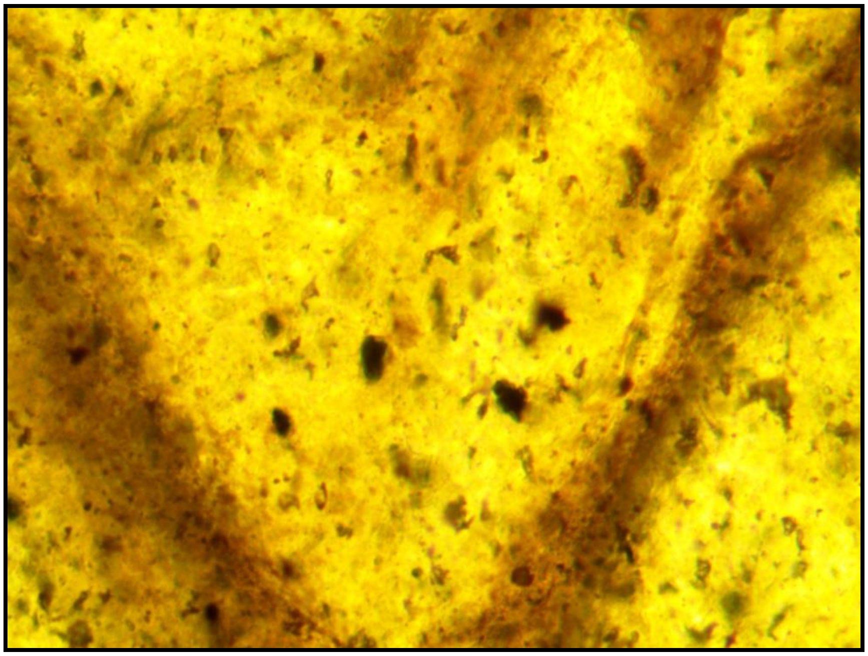
Top Crust; scaley "cow pattie" appearance. Scale in inches

Top Crust. Scale in inches.

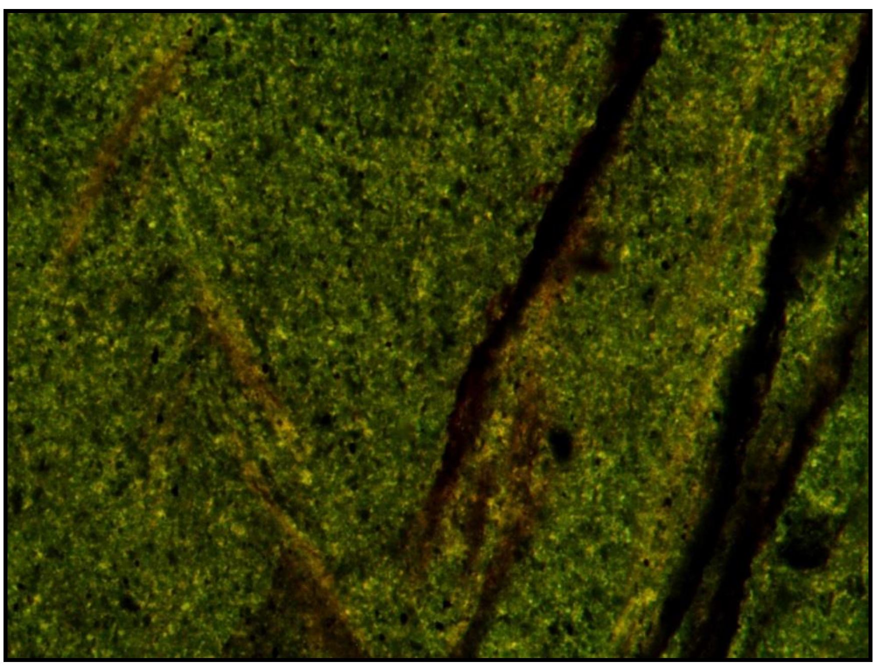
Bottom Surface, no cone in cone structures, shale layering. Scale in inches.

Side View. Scale in inches.

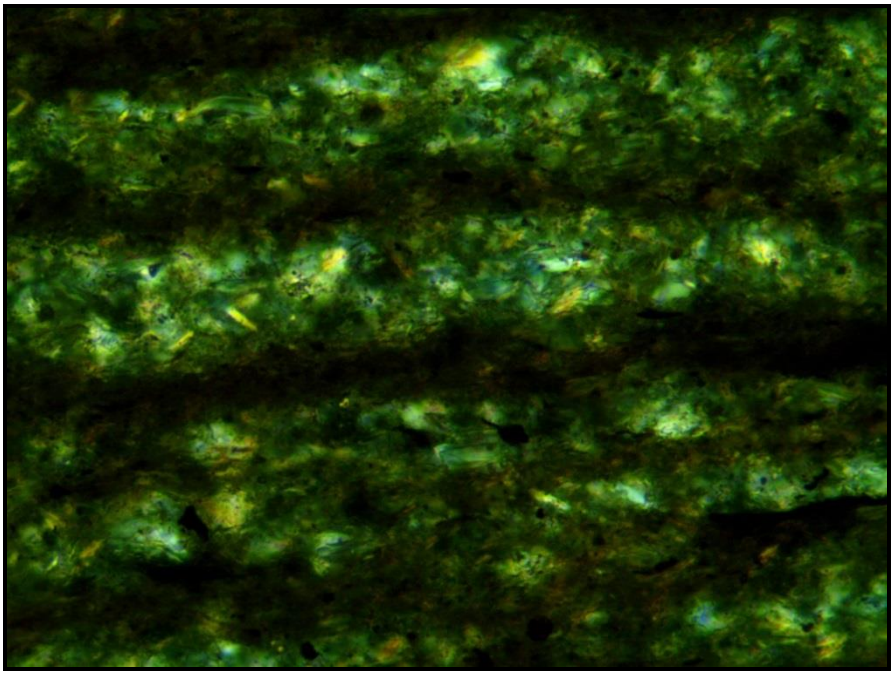

Cross Section View. Cone in Cone structures only on top, shale crust on bottom.

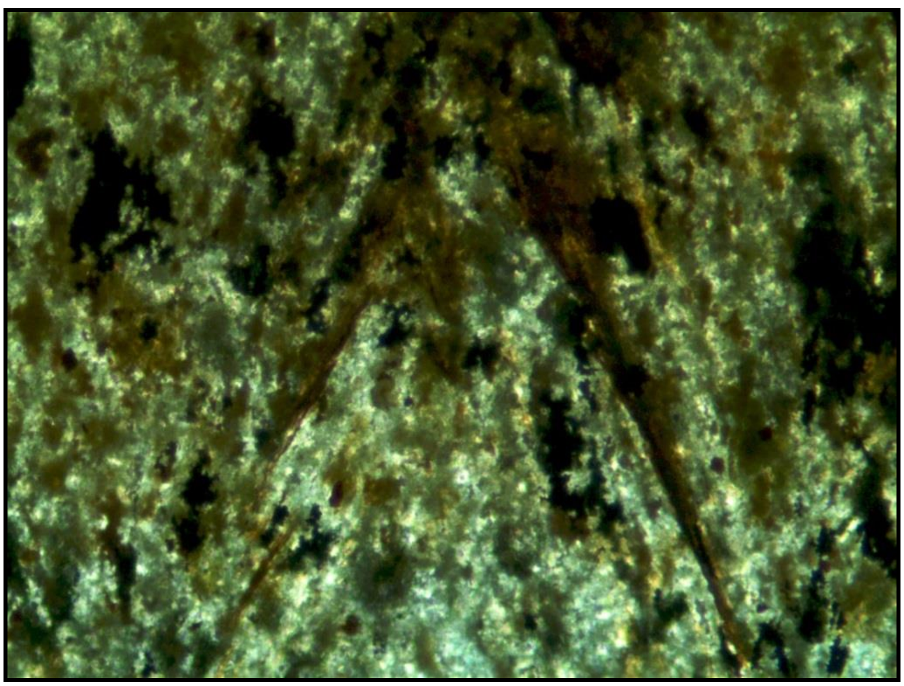


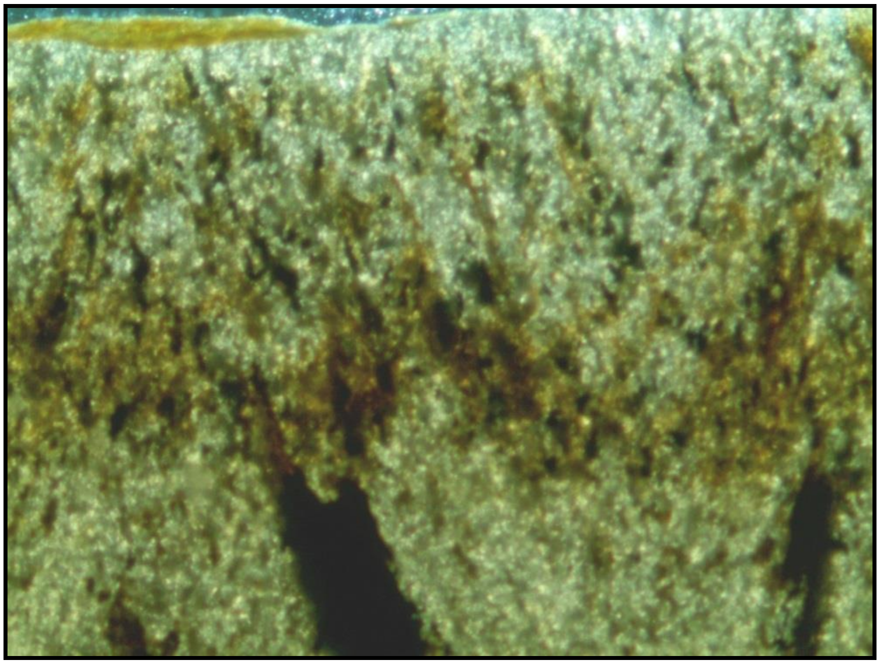
Normal light: Bottom of picture is of a cone apex with dark colored cone shell and light colored siliceous cone with particulates. (100x).



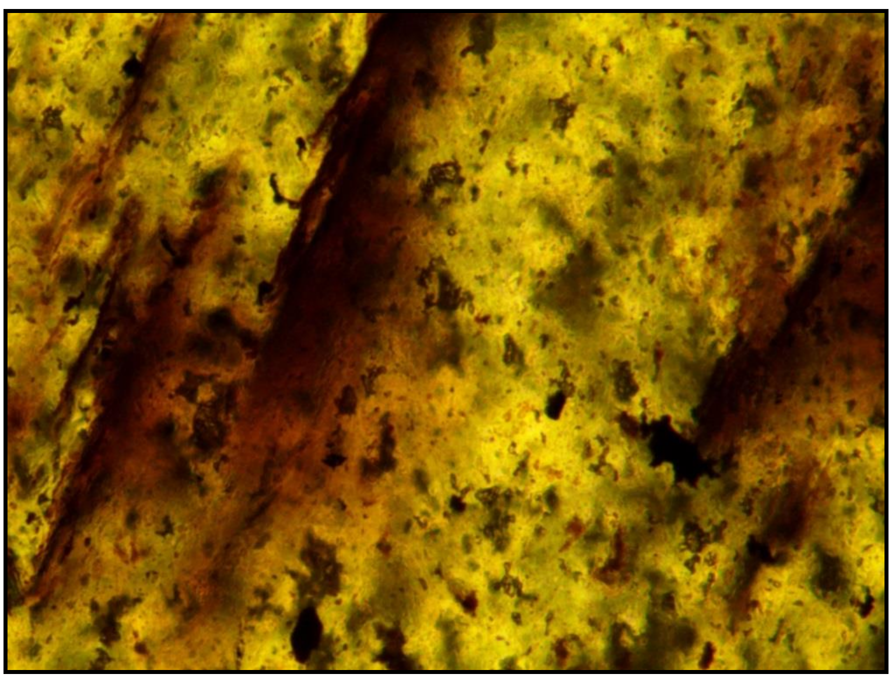
Cross Polarization of thin section exhibiting dark cone shells and siliceous cones. (50x).


Possible remnant carbonate layered with clay bands (50x).

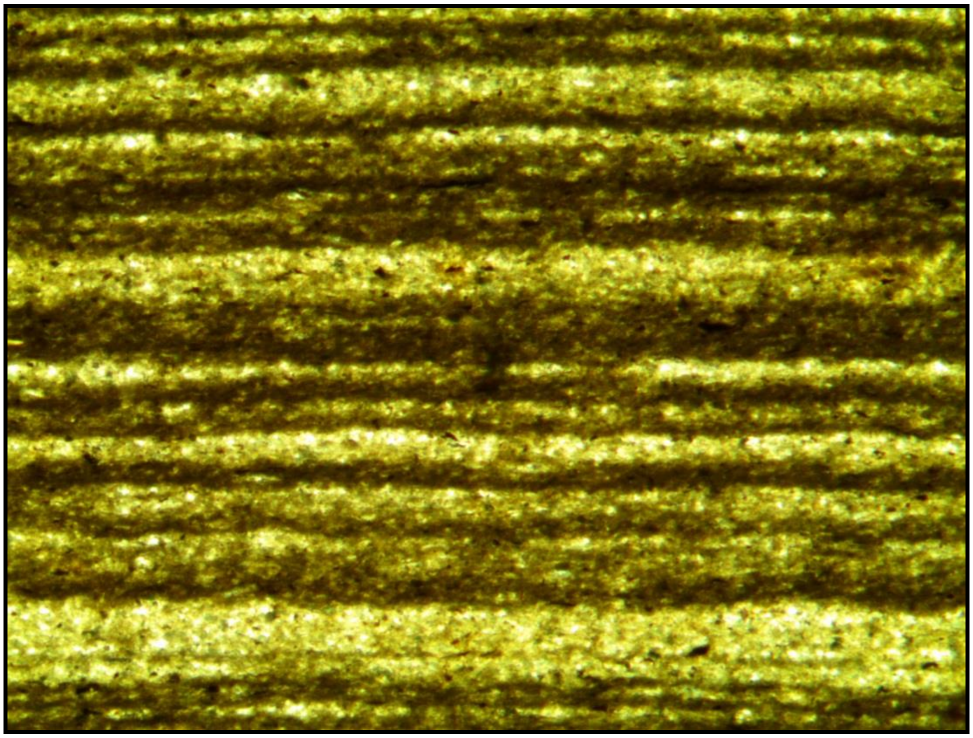

Cross Polarization of cones in thin section (50x).

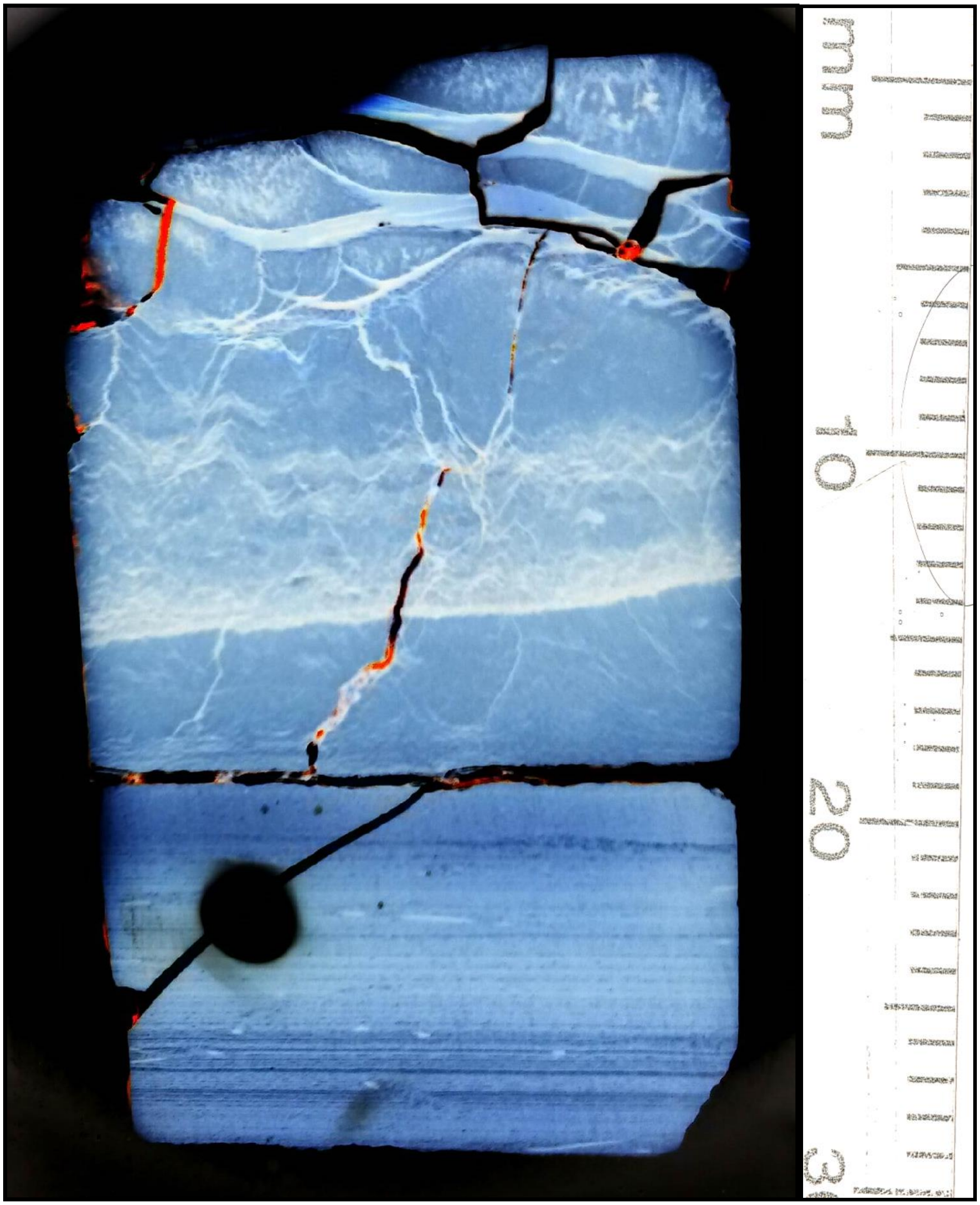


Cross Polarization: Top crust of concretion with incomplete/overprinting/obliteration of cones and cone shells (50x).

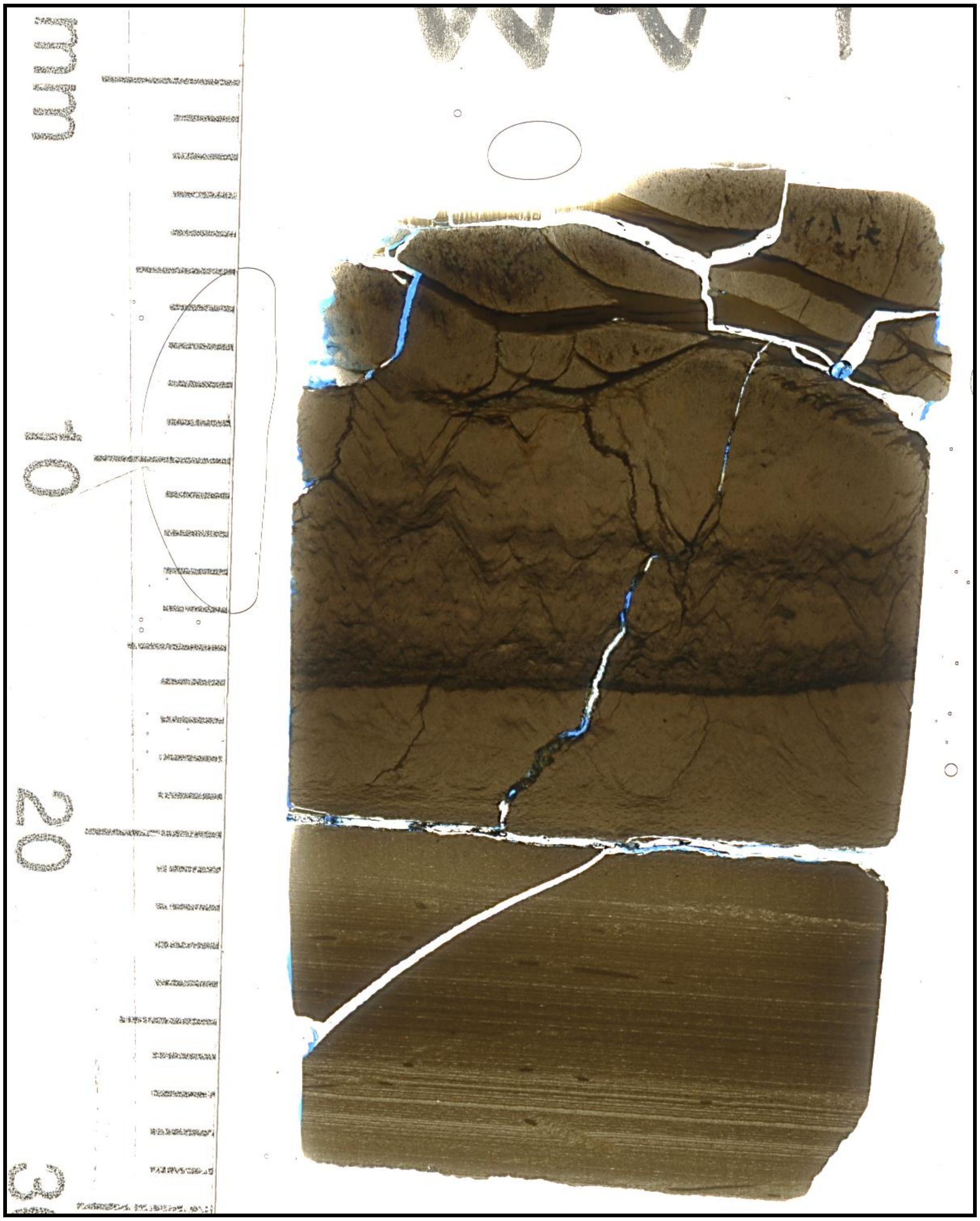


Chert, particulates, and cone shells (100x).


Banding of clay and carbonate layers in bottom of concretion (50x).



Reverse light image of thin section: bands or layers at the bottom and nearly invisible cone structures at the top. 2"x3" inch slide.



Light image of thin section. Bands seen at the bottom. Cones and cone shells are difficult to identify at this magnification. Burrows seen in banded bottom region.

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 1B

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Partially broken concentric cone in cone concretion with outer core completely solidified with clay filler material that exhibits no extruding conal structure and is smooth. Below 1mm of surface a rough and brittle cone like structures are seen which is highly permeable. It measures 11 x 4 x 2 inches. Cone in cone structures are present in both upper and lower crusts measuring up to ½ inch, with clear graduation of thickness toward the center, and thinner toward the edges. Surfaces are smooth except where weathered. Solid shale like core that is dividing the crust and core. Core measures up to 1 inch. Apparent hydrothermal quartz veins cross cutting concretion. Appears very silicified

Thin Section Microscopic Description:

Thin section examination reveals cone in cone concretion with a core and crusts. The core is divided into two zones: a light and dark zone. The dark zone consist of more clay like material whereas the lighter zone lacks the quantity. Although cones within the core can have bases and apexes pointing in the same direction, the overall structure shows that each zone of the core contains cones with their bases pointing to the crust which it is connected too. Millimeter to centimeter cones are seen in the crust. Hydrothermal quartz veins are seen, with quartz crystallization, the longest axis of the grain perpendicular to the quartz vein. Cherty precipitation is evident through cross polarization. Calcite is not seen. Cone shells appear to be a clay fraction with some evidence of iron oxide precipitation.

Interpretation:

This is a cone in cone concretion with hydrothermal conduits or veins infiltrating through the concretion. The lack of carbonates delineates this concretion to have been subjected to intense pressure and temperature and secondary siliceous precipitation. Inner core cones bases mainly point to their respective hemisphere exterior.

Comments:

Upper crust effervescence: No
Inner core effervescence: No

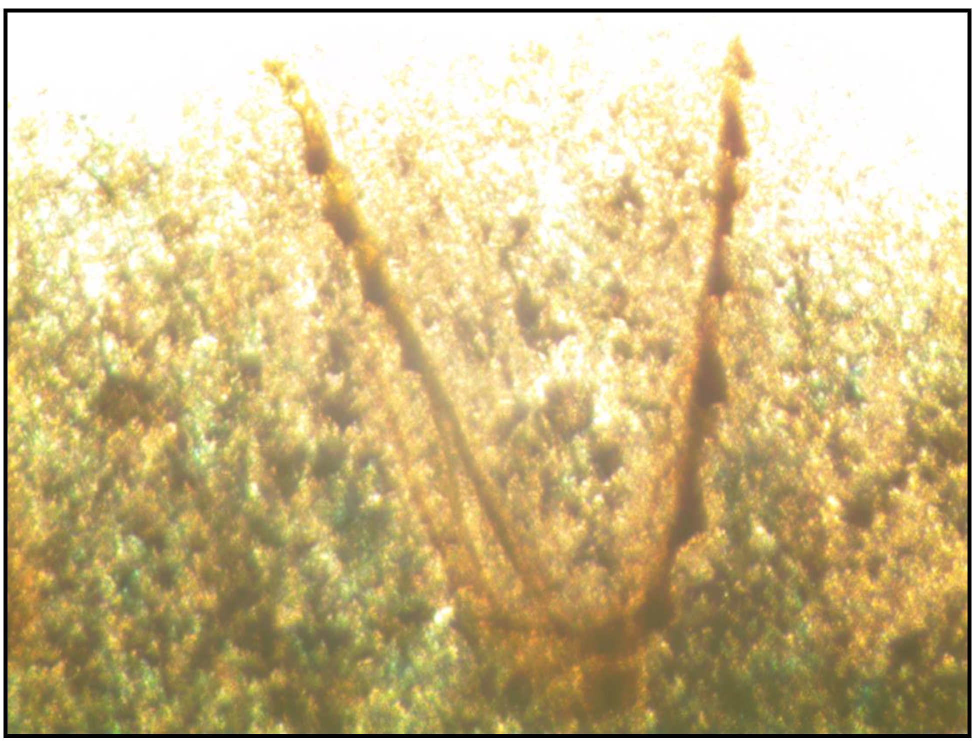
Lower crust effervescence: No
Degree of Alteration: High
Lack of remnant carbonate

Photographs:

Side View. Scale in inches.

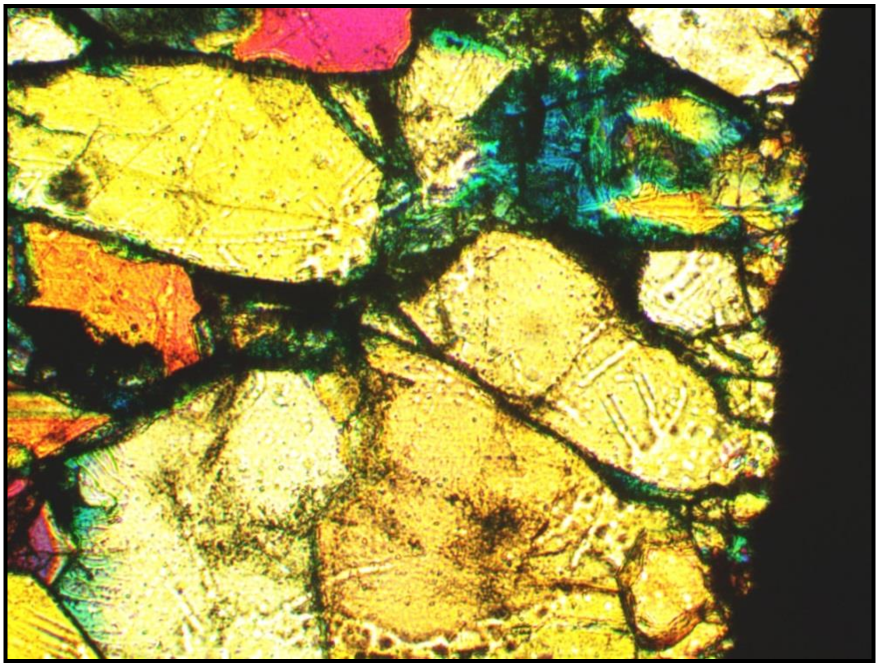
Top Surface; inverted cones on surface. Scale in inches.

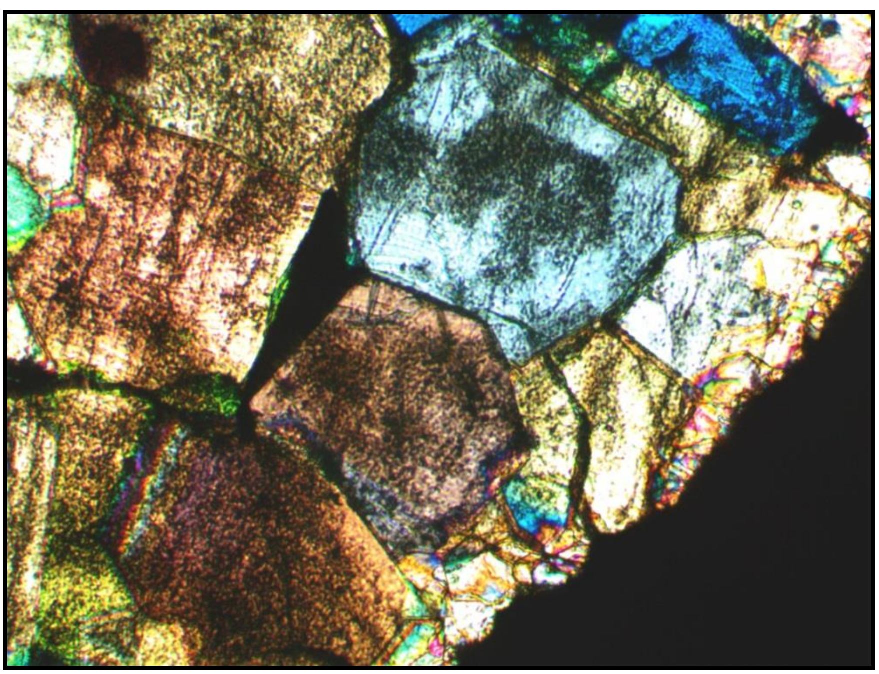
Side view exhibiting hydrothermal quartz veins cross cutting

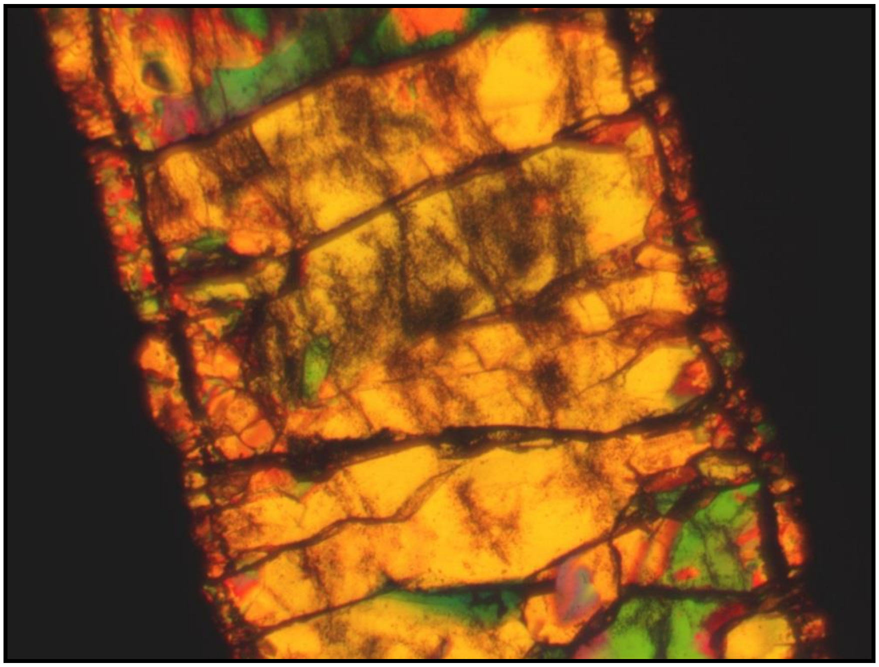


Top crust: cone shell with clay filler, possible siliceous precipitation (50x)

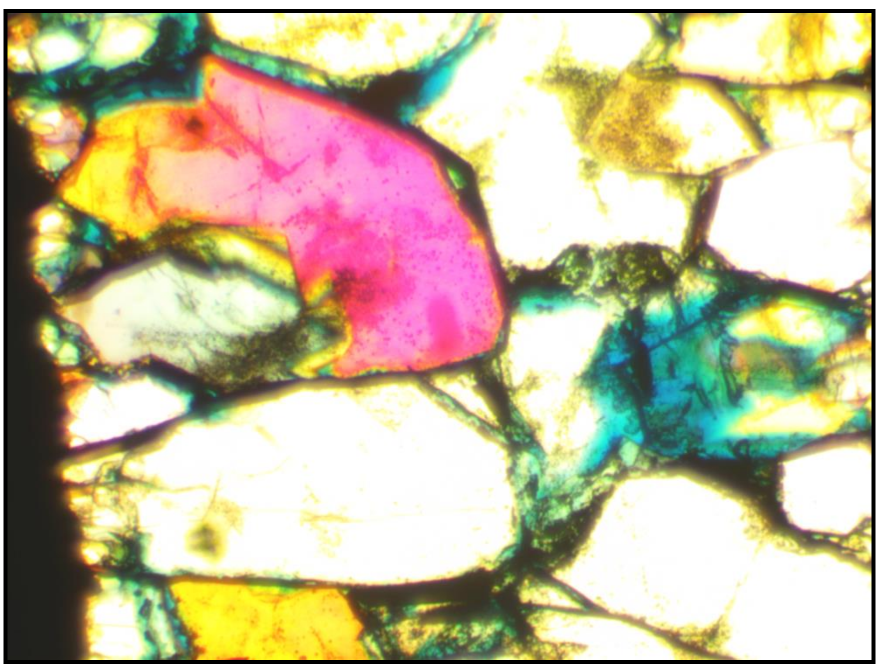
Thin section 2"x3" slide photo; prominent boundary between outer crust and inner core


Hydrothermal quartz vein deposit. (100x)

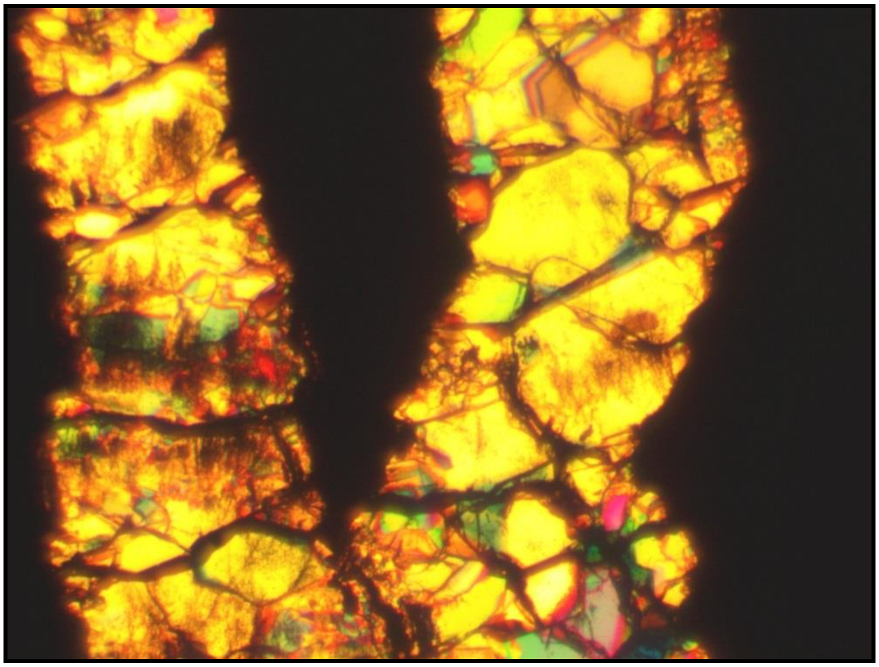

Hydrothermal quartz vein deposit. (50x)

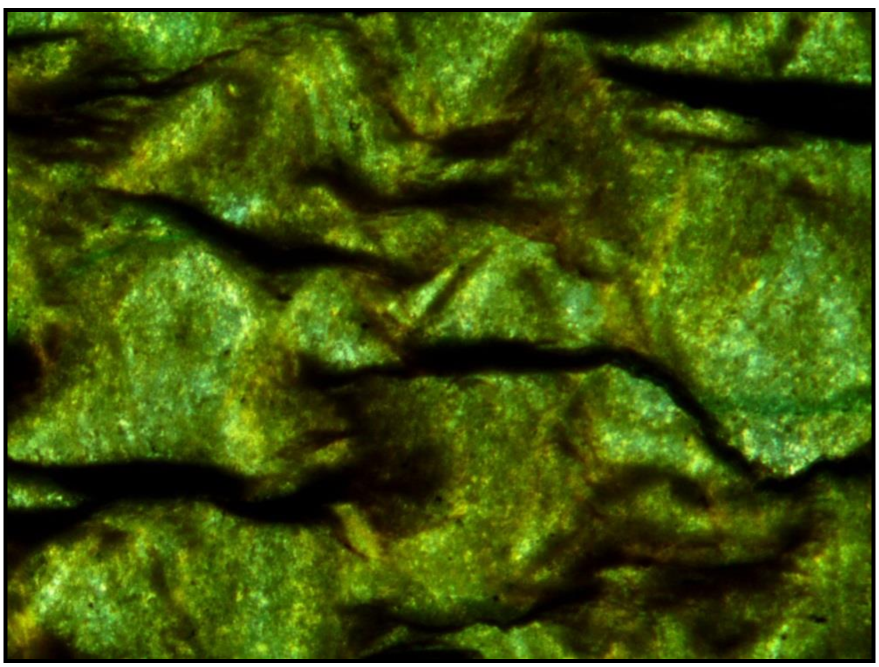


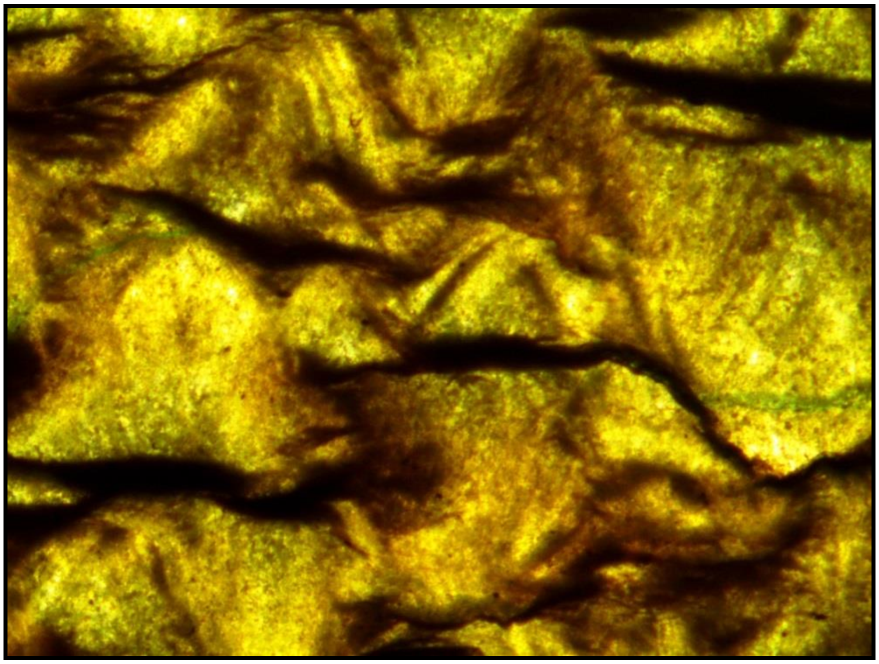
Hydrothermal quart with quartz growth perpendicular to pressure. (50x)



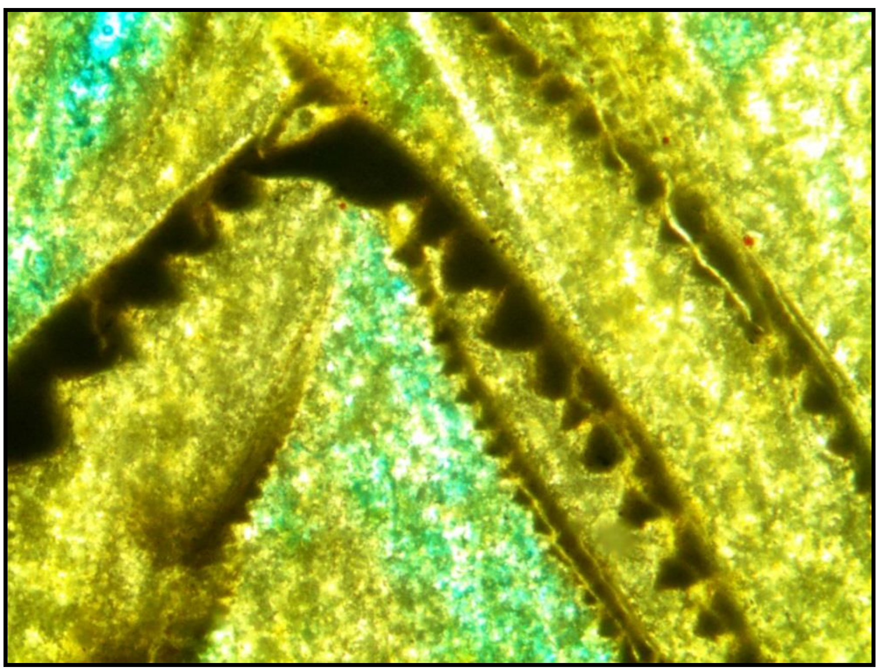
Hydrothermal quartz growth. (100x)


Hydrothermal quartz vein. (50x)

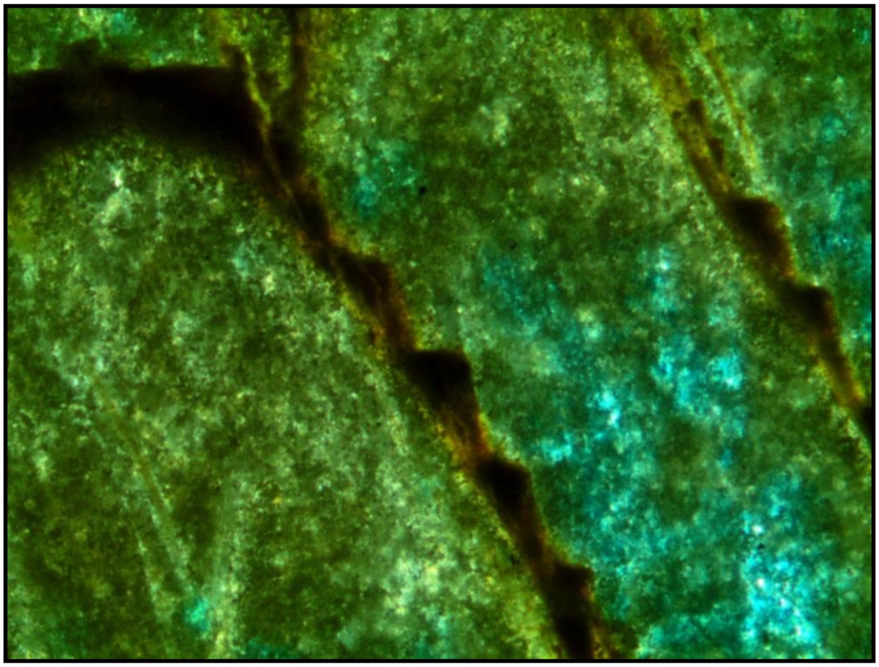

Cross polars: opposite facing cones in lighter core zone. Chert mineralization (100x)



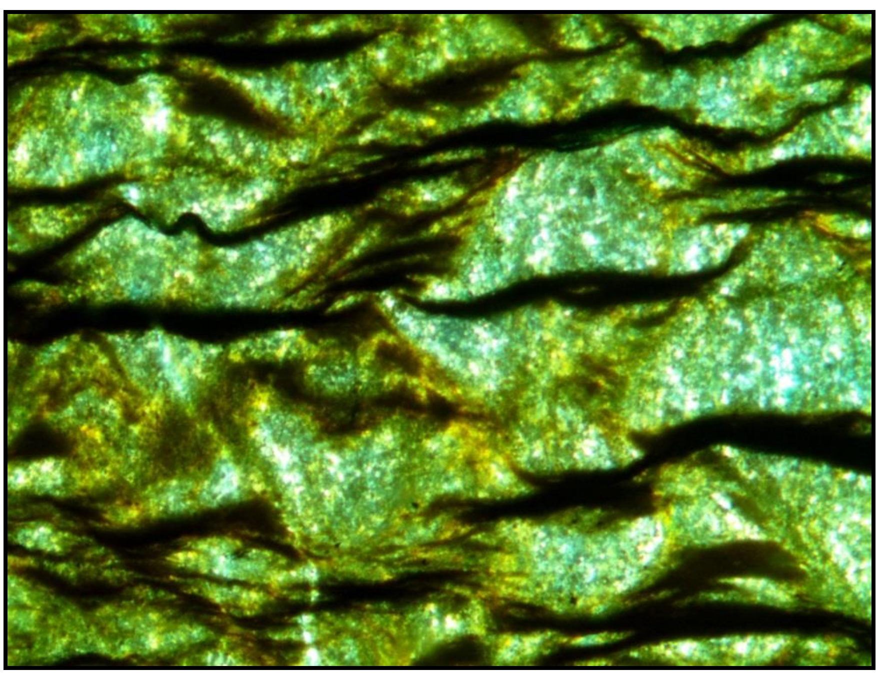
Regular light: same as above photo. Opposite facing cones (100x)



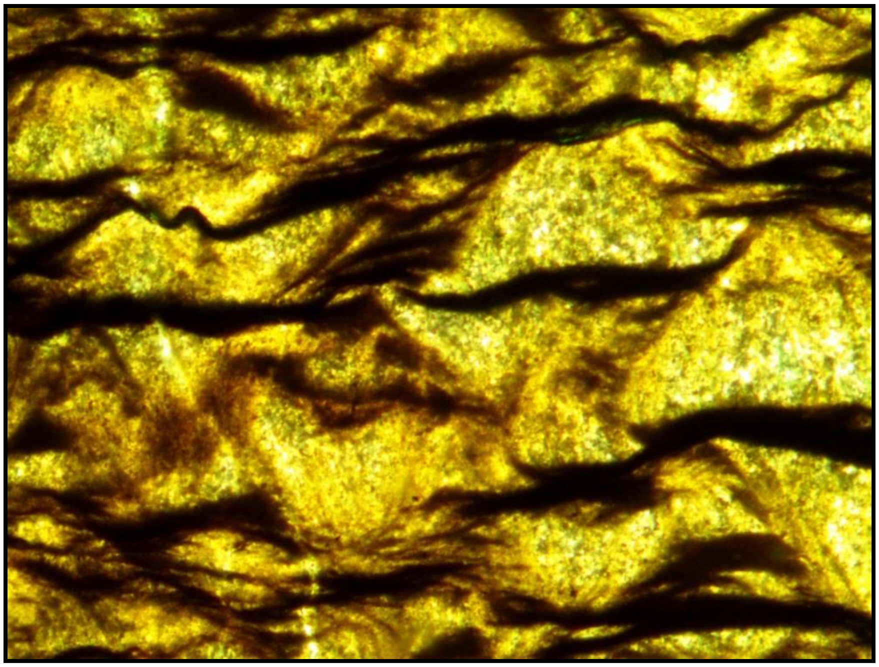
Regular light: annular rings on outside of cone shell (40x)



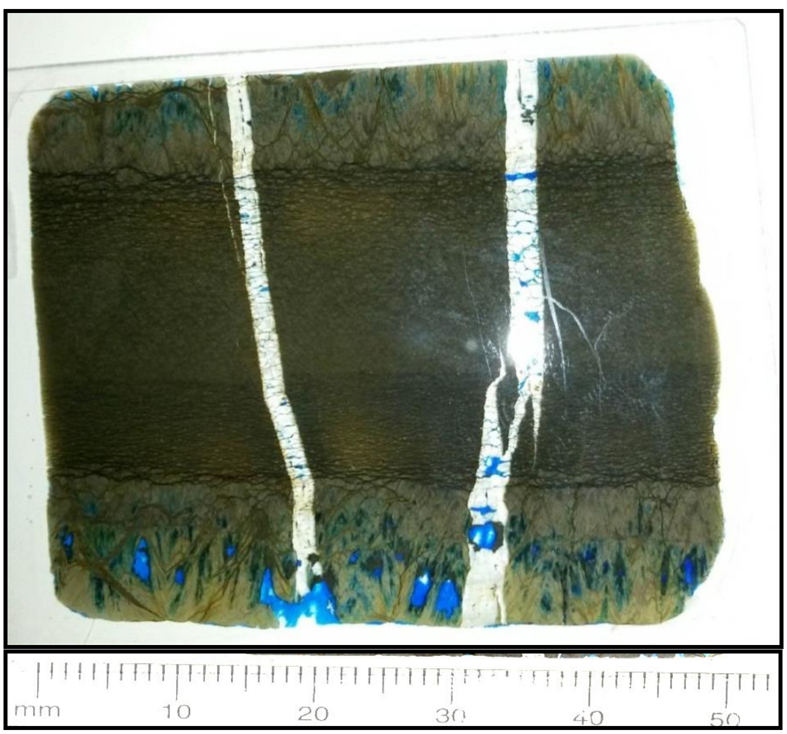
Cross polars: annular rings on outside of cone shell. (100x)



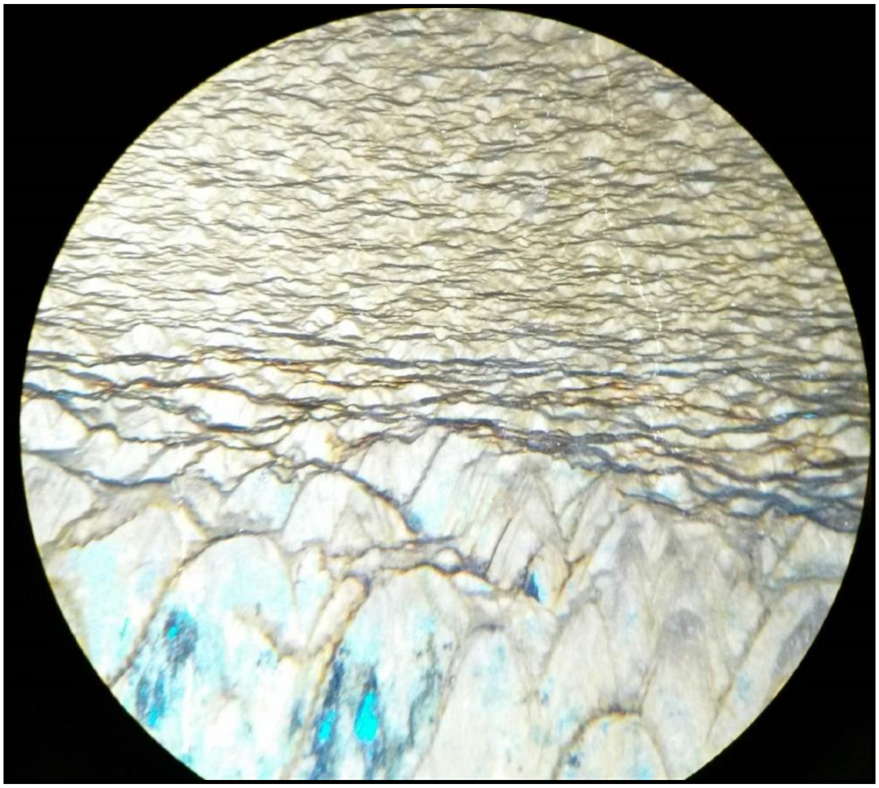
Cross Polars: Darker side of core. Opposite facing cones (100x)



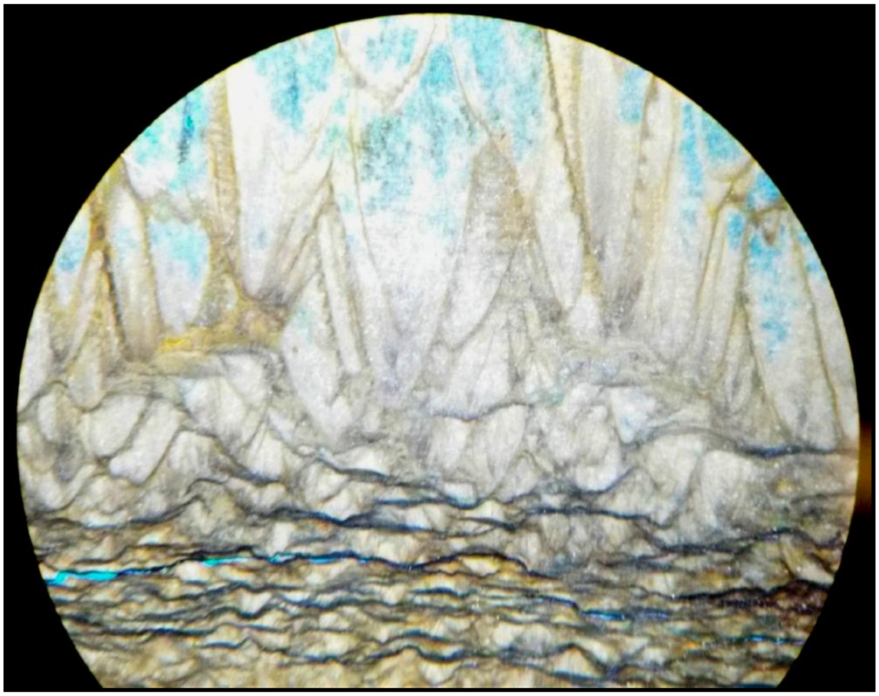
Regular light: Same as above photo (100x)



Thin section gross photo: exhibiting light/dark core with large conal crust



Zone between crust and core. Cone in cone structures are present in both. Lenticular banding prominent in transition zone. (40x)


Large cones are seen in the crust (40x)

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 1C

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:
½ of a cone in cone concretion with outer core exhibiting cone in cone structures with a solid inner core matrix. Dimensions 12 x 9 x 3.5 inches. Partial scales on surface. No cone shells visible on un-weathered surface. Clay cone fillers are either smooth or scaley on surface. Variable thicknesses of cone structures 1/4 to 1 inch. Slight layering of cone structures into beds nearing edge of concretion.

Thin Section Microscopic Description:
NA

Interpretation:
This is a large cone in cone concretion with a typical core and crust with core material containing small cones while the larger cones are seen in the crust. Carbonates have been removed and replaced. Clay fillers are dominant features on the surface giving a scaley appearance. A slight alteration by hydrothermal fluids and the precipitation of a trace metal might be expected due to slight untypical color variation. The concretion represents a moderate to high degree of diagenesis.

Comments:
Upper crust effervescence: No
Inner core effervescence: No
Lower crust effervescence: No
Degree of Alteration: Moderate
Lack of remnant carbonate

Pictures:

Side View. Scale in inches.

Top Surface. Scale in inches.

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 1D

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Partially broken concentric ellipsoid concretion with cone in cone structures on upper and lower surface. Solid inner core matrix. Dimensions 12 x 6 x 2.25 inches. Crustal cone in cone structures measure 1/32 to 3/8 inch. Top crust has the thickest cone structures. Slight bluish green color is in contrast to the usual darkish gray brown color. Cone shells are not prevalent on the surface.

Thin Section Microscopic Description:

Thin sections obtained: 1DT=1D Top and 1DB=1D Bottom

Thin section examination reveals a cone in cone concretion with an inner core and both an upper and lower crust. Upper crust contains large cone in cones while the bottom crust is less than 2-3mm in thickness. This concretion is relatively thick with no residual carbonate remaining. Complete replacement of the cones by siliceous forming process. Cone shells are present but thinner near the crust. The concretion is denser than others.

Interpretation:

This is a cone in cone concretion with a relatively thick core and a nearly extinct lower crust. Upper crust contains larger cones. There is a high diagenetic process indicated by the loss of calcite and precipitation by chert. Possible hydrothermal trace elements also deposited. The main fluid gradient would be directed toward the upper crust. The thick core is due an initial large carbonate precipitation within a clay fraction forming lenticular bands and cone shells.

Comments:

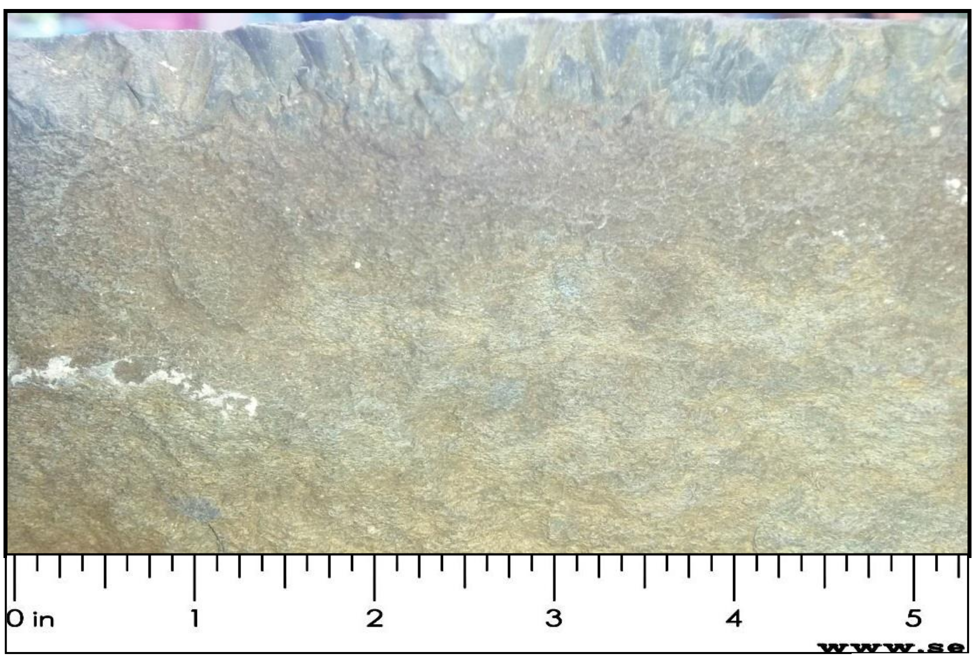
Upper crust effervescence: No
Inner core effervescence: No
Lower crust effervescence: No
Degree of Alteration: High

Pictures:

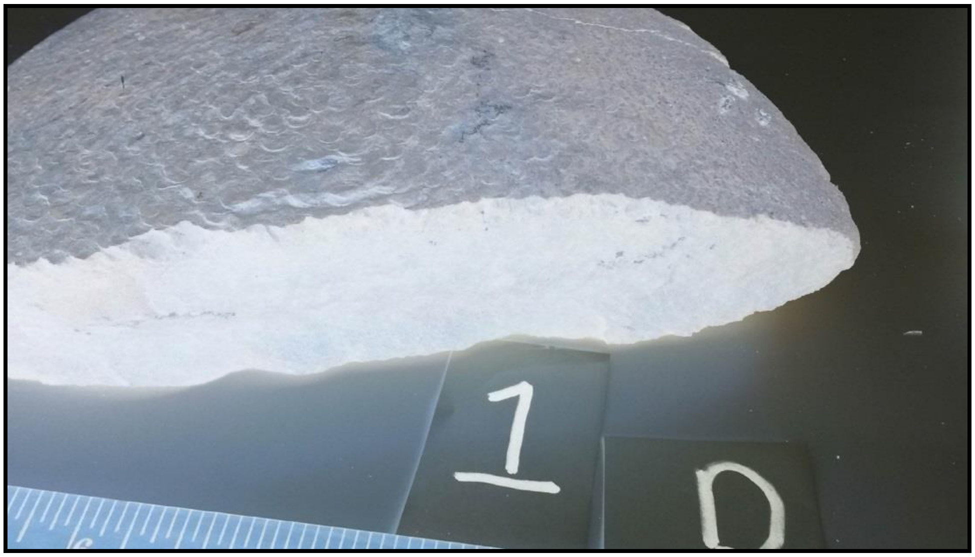
Side view with upper crust on top, concretion has already been sectioned. Scale in inches.

Top view of upper crust. Scale in inches.

Lower crust view, note the bluish coloration. Scale in inches.



Side view showing top crust and core.

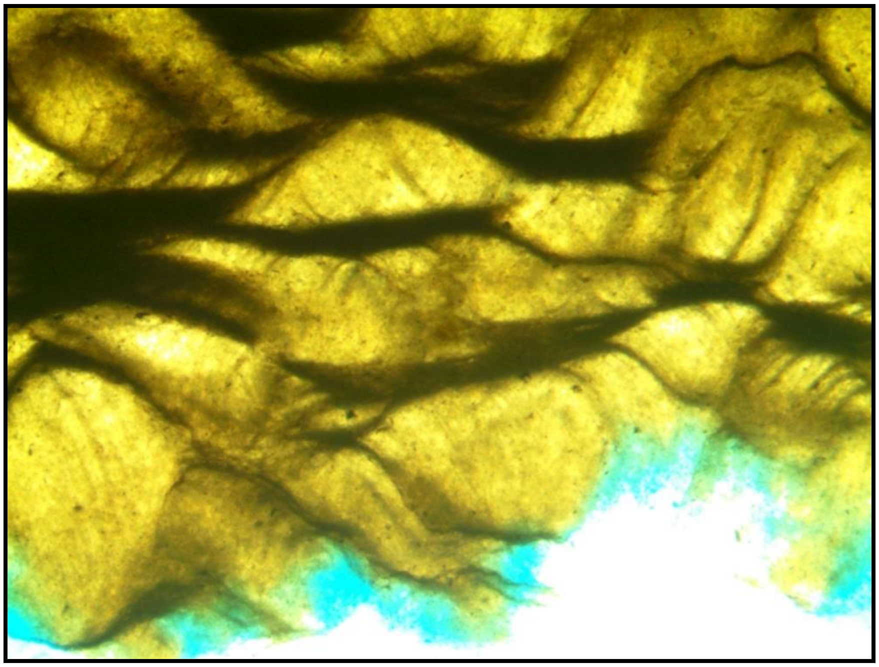


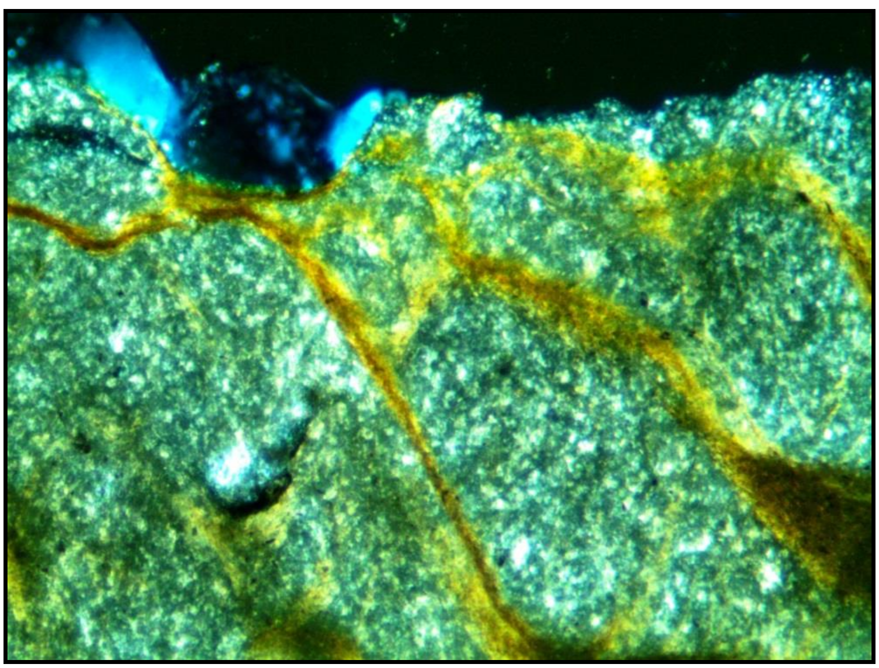
Reverse light image showing scaley top crust. Scale in inches.

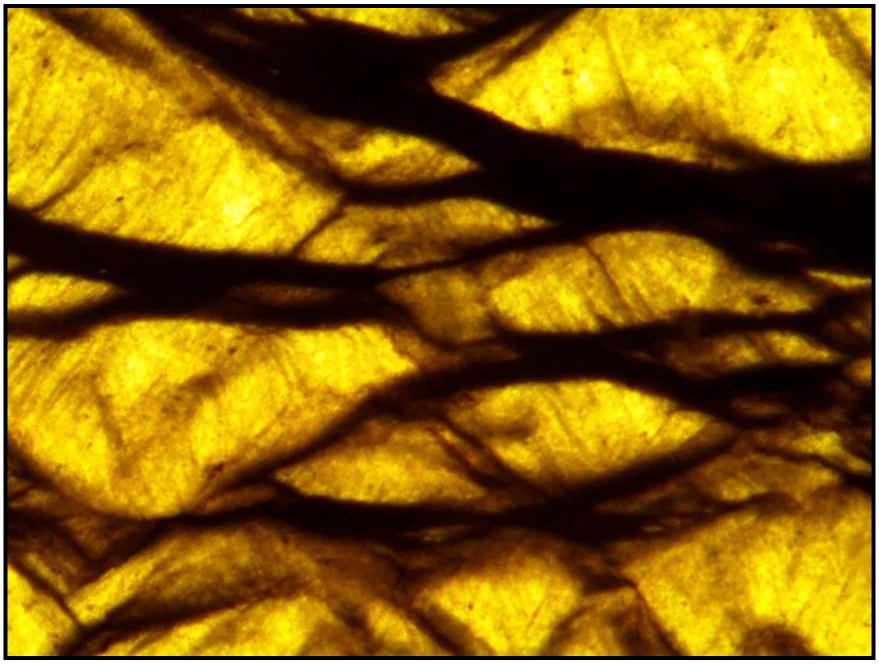
Top view. Scale in inches.

Thin section gross photo. Sample 1D top of concretion. Top of concretion or upper crust is at top. Cone in cone structures seen throughout. Large cones only seen on the upper crust.

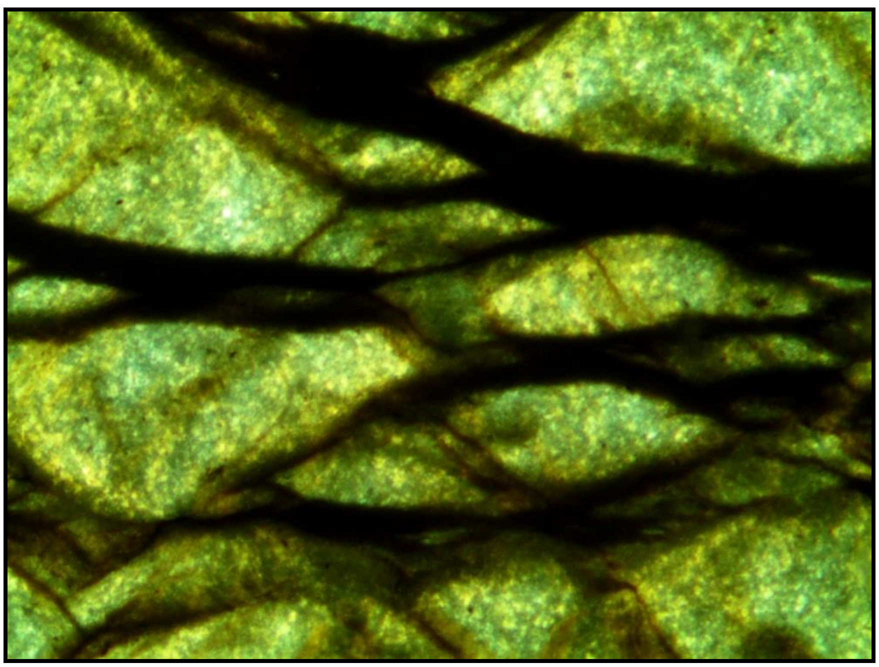
Thin section 1"x2" inch photo. Sample 1D bottom of concretion. Bottom of concretion or lower crust is at the bottom. Cone in cone structures seen throughout. Middle of concretion or core center at top.


Bottom of lower crust boundary. (40x)

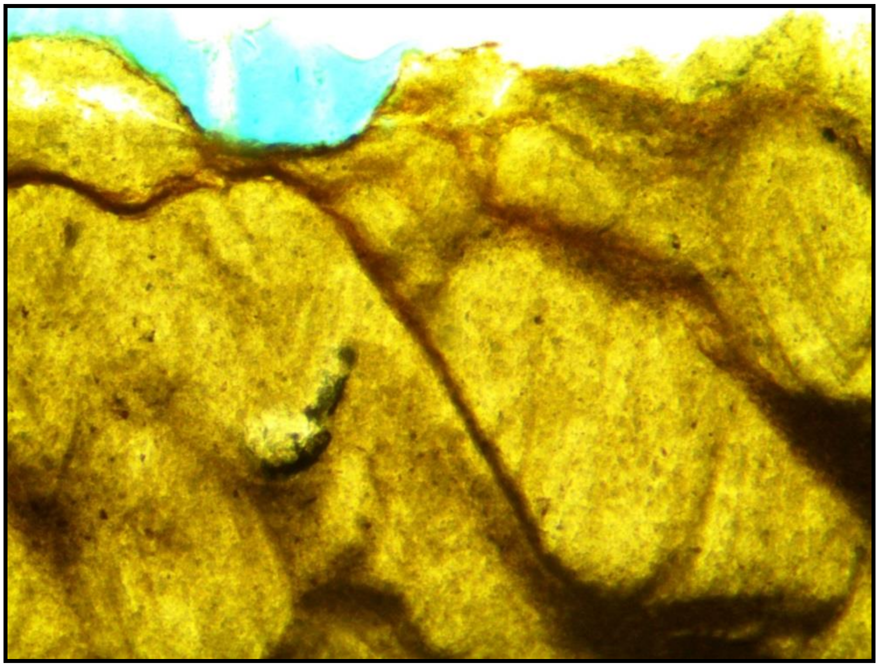

Slight hematitic cone shell replacement remaining of original shells. (40x)

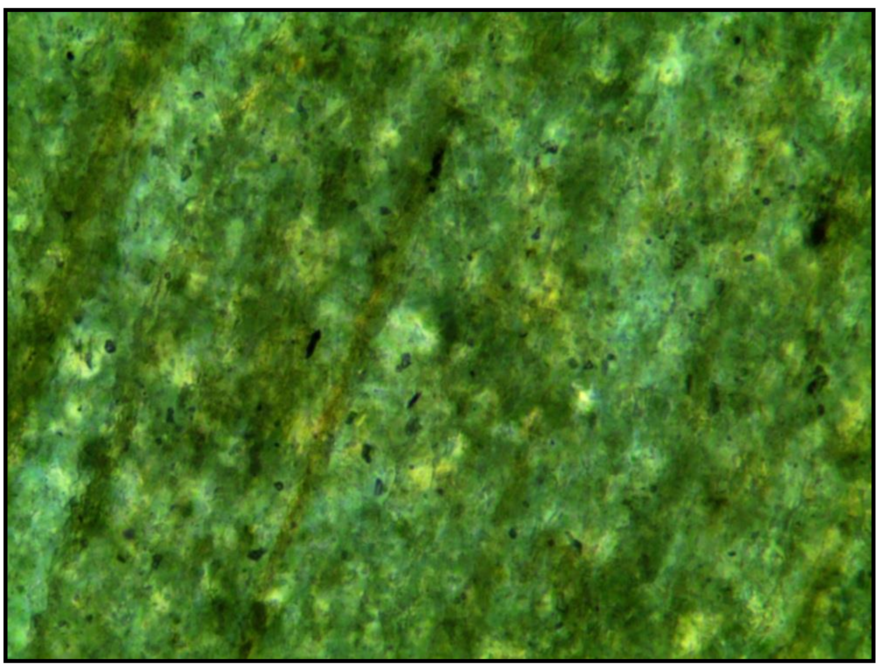


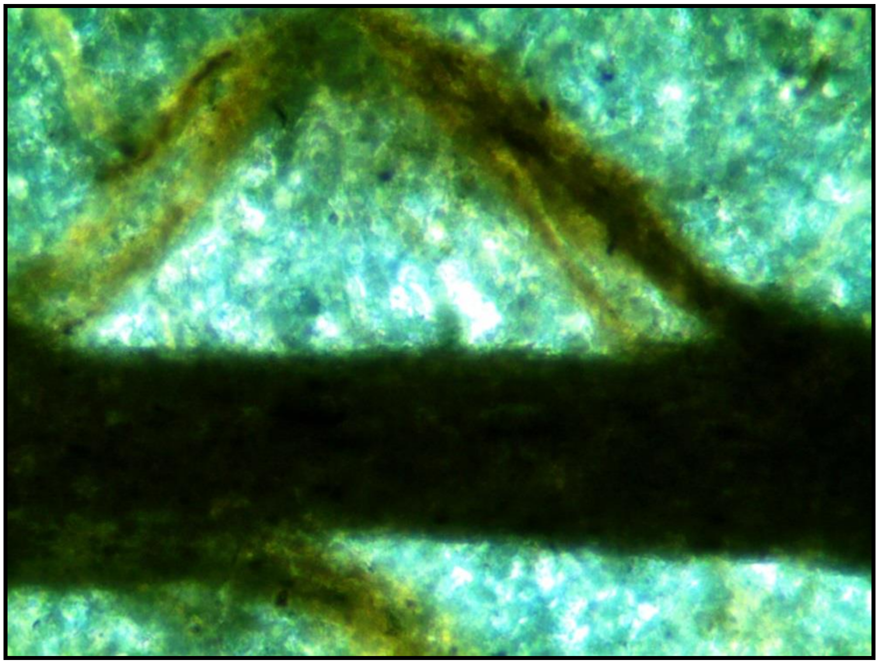
Lenticular bands of clay material throughout section. (100x)



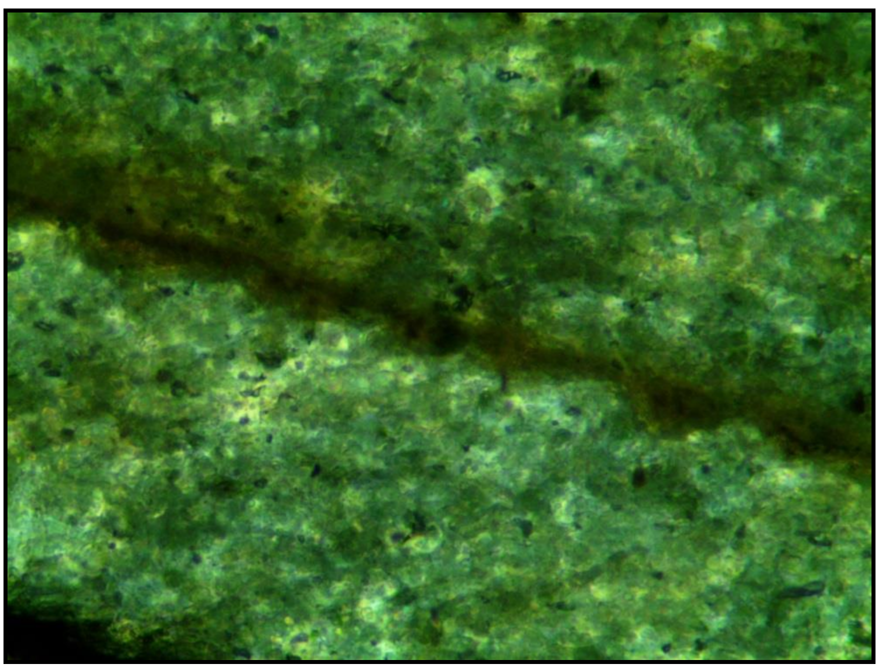
Cross polar of above photo. (100x)


Light microscopy of large cones on upper crust, with embedded particulate (40x)

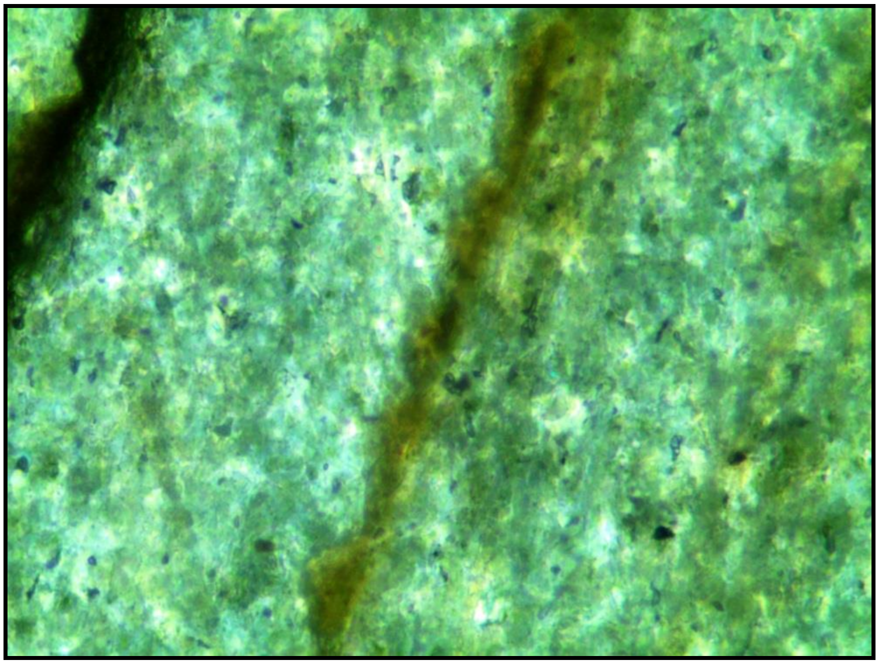

(200x) cross polars of upper crust cones.



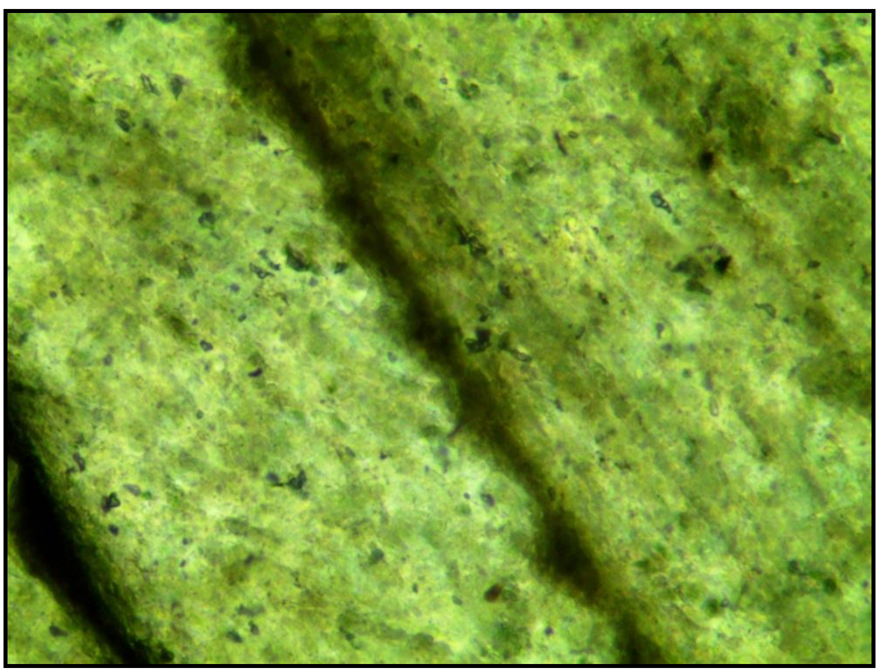
(400x) of cone radiating along a lenticular clay band



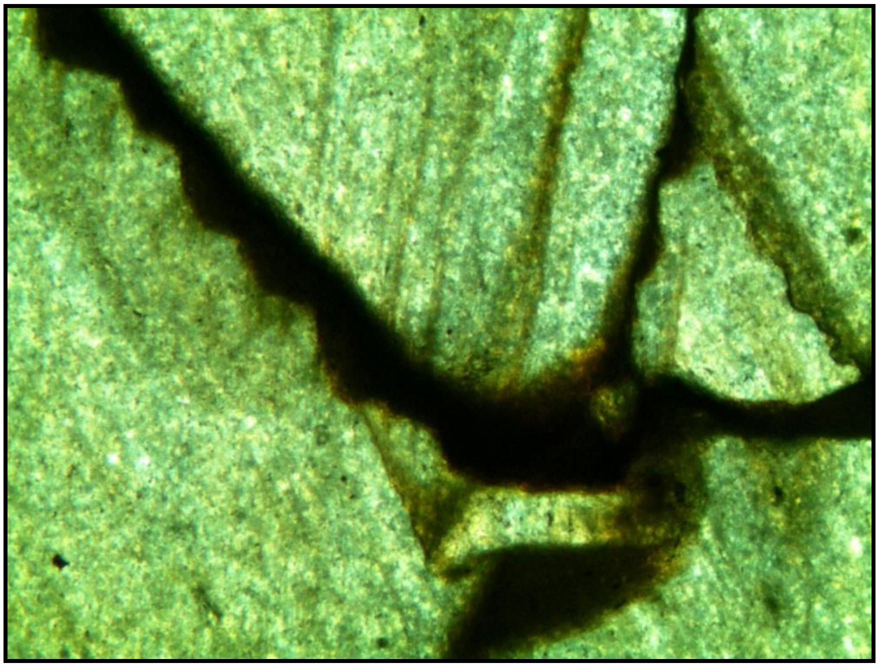
Cross polars 200x of annular rings



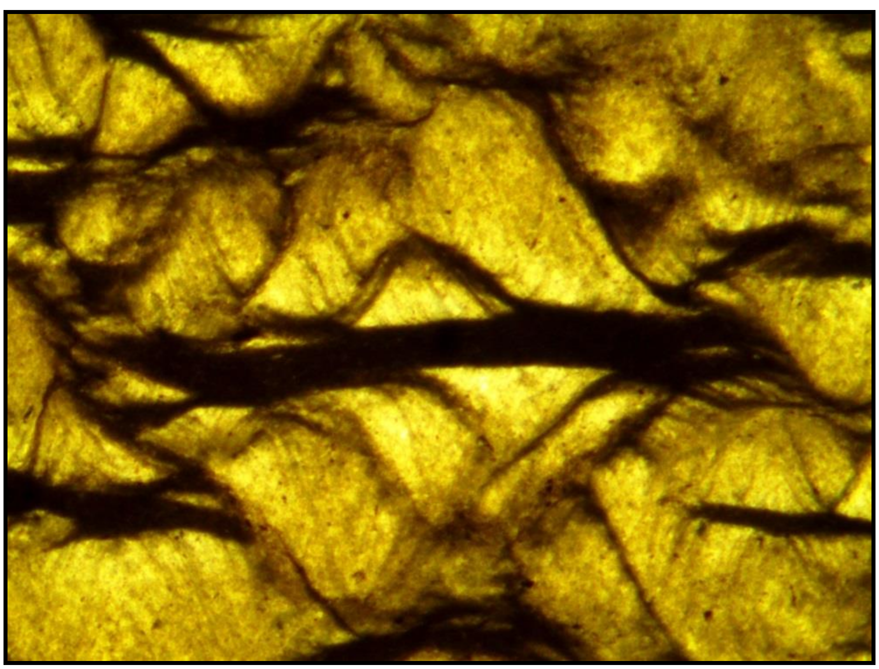
Cross polars 200x of annular rings, rotated of above photo



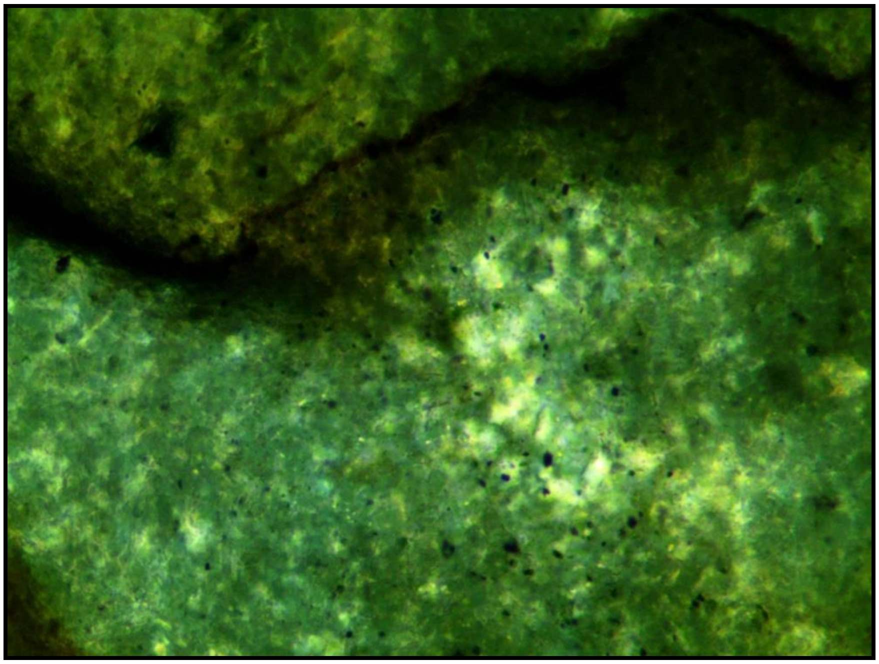
Cross polars 200x of annular rings on cone shell, rotated of above photo



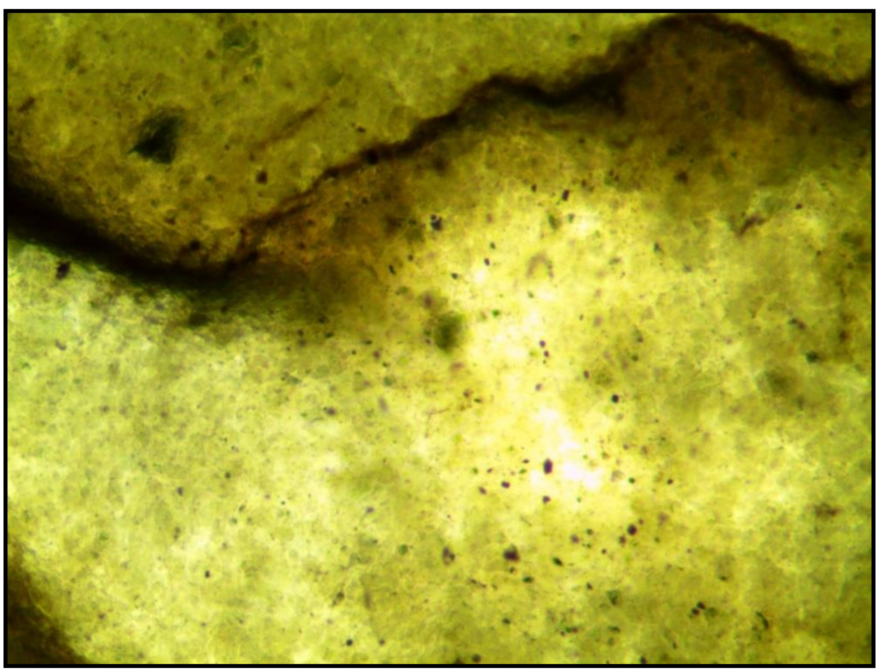
Apex of large upper crust cone shell and annular rings (100x)



Opposing cones along clay lenticular band (100x)



(200x) cross polars of particulates in cherty matrix



(200x) light microscopy of particulates in matrix, same as above photo.

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 1E

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Ellipsoid cone in cone concretion. Only a small sample was removed due to size and emplacement of concretion within the shale. Sample measures 6 x 2 x 5 inches. Obvious cone shells and clay fillers with an uneven surface are located on top and bottom crust. Cone shells appear to be hematitic or metallic, brittle, and well defined. Dimensions of crustal conal structures are 1 inch with individual cones reaching 1 inch also. Core matrix measures approximately 3 inches. No clear boundary seen between crust and core.

Thin Section Microscopic Description:

NA

Interpretation:

This is a large cone in cone concretion with low to moderate diagenetic alterations. Carbonate is present throughout the concretion. Alteration of the clay or shale fraction into a cherty process is not seen. Hydrothermal alterations are also not seen. Hematitic replacement of the cone shells is present, indicating some diagenesis after initial formation. The carbonate source was substantial for this size of concretion.

Comments:

Upper crust effervescence: Yes, readily
Inner core effervescence: Yes, readily
Lower crust effervescence: Yes, readily
Degree of Alteration: Mild

Pictures:

Removing sample from larger concretion embedded into shale

Top view of uneven crust with cone shells and fillers. Scale in inches.

Complete cross section of concretion. Scale in inches.

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 1F

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:
Partial concretion with cone in cone exterior and core. Dimensions are 14.5 x 6 x 3 inches. Surface appears weathered but "hematitic" brittle cone shells cover the surface. Bottom surface lacks clay fillers whereas the top retains moderate amounts of clay fillers. Crust measures no more than ½ inch on either side. Core matrix is porous with very similar features as the crust possibly exhibiting micro cone structures. Rare bluish color is noted on edges and in the lower core matrix, possibly indicating hydrothermal fluid migration.

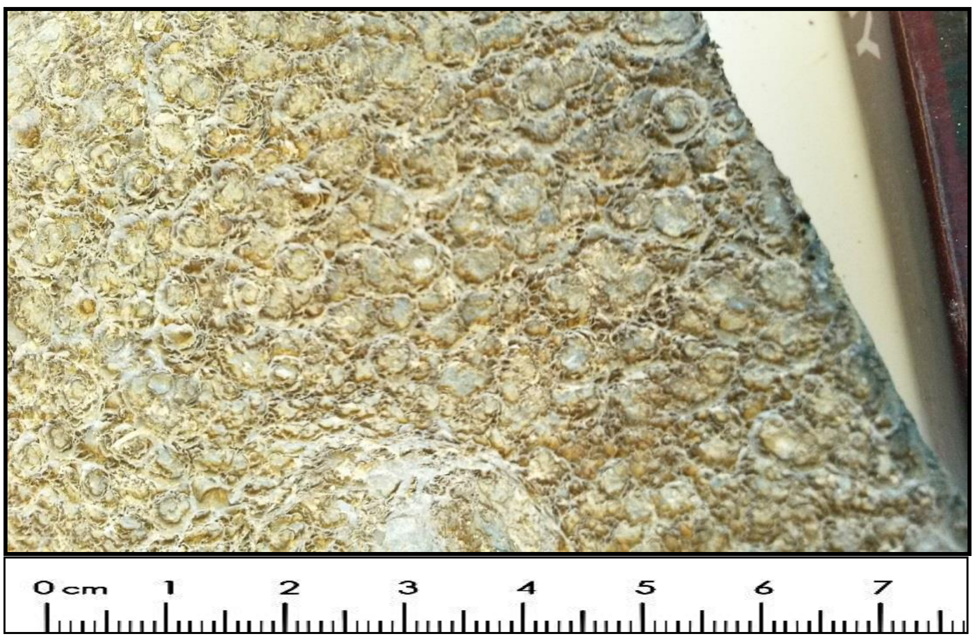
Thin Section Microscopic Description:
Na

Interpretation:
This is a cone in cone concretion with silica slowly replacing the calcite from the inside out (core to crust). Cone shells have mostly been replaced with a hematitic mineral on the crustal surface.

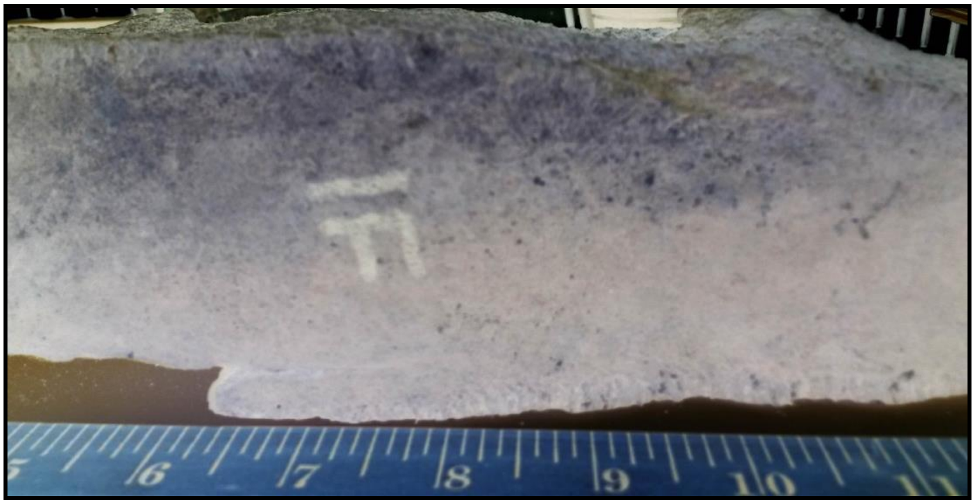
Comments:
Upper crust effervescence: Yes, readily
Inner core effervescence: slight, mainly on edges
Lower crust effervescence: Yes, readily
Degree of Alteration: mild to moderate with possible hydrothermal influence.

Pictures:

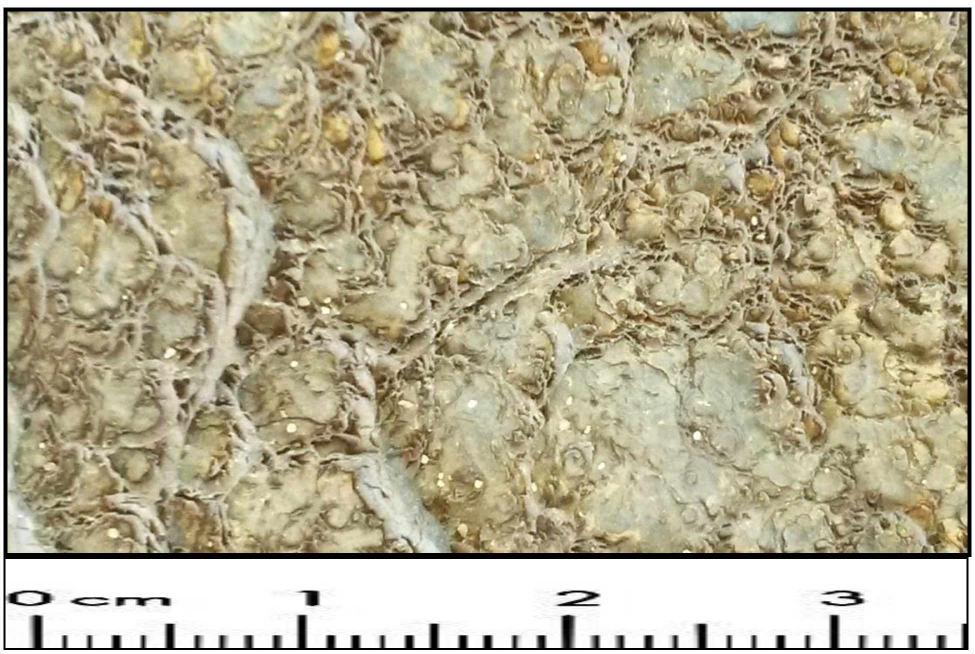
Top view showing cone shells and clay cone fillers clearly distinguishable; cone shells growing into clay layers. Scale in inches.



Close up view of upper crust. Scale in centimeters



Side view; reverse lighting. Scale in inches.



Close up view of crust.

Cone in Cone Description

Specimen #: 1G

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Small fragment of larger concretion **same as 1E.**
Ellipsoid cone in cone concretion. Only a small sample was removed due to size and emplacement of concretion within the shale. Sample measures 6 x 2 x 5 inches. Obvious cone shells and clay fillers with an uneven surface are located on top and bottom crust. Cone shells appear to be hematitic or metallic, brittle, and well defined. Clay fillers are molded within these cone shells. Dimensions of crustal conal structures are 1 inch. Core matrix measures approximately 3 inches.

Thin Section Microscopic Description:

Na

Interpretation:

See specimen #1E

Comments:

Upper crust effervescence: Yes, readily
Inner core effervescence: Yes, readily
Lower crust effervescence: Yes, readily
Degree of Alteration: Mild

Pictures:

Side View. Scale in inches.


Side View. Scale in inches

Cone in Cone Description

Specimen #: 1H

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Gross Description:

Complete cone in cone concretion with conal structures on exterior surface/crust. Dimensions 7.5 x 6 x 2 inches. Crust and inner core present, no clear boundary. External crustal cones are thickest toward the top and at one end cones appear to be warped or slanted. Bottom crust is $<$ .25 inches. Top crust measures 0.25 to 0.75 inches. Inner core contains a separate cone in cone like concretion measuring 0.37 inches from the bottom. Maximum cross section of this inner concretion measures 2.5 x 0.5 inches. Cone shells on exterior are thickened clay like and less hematitic.

Thin Section Microscopic Description:

Thin section examination reveals conal structures throughout with an additional 2nd inner core or lens of organic matter. This second inner core is a planar feature with no reaction to HCl, possibly containing increased iron. Directly extending from this 2nd inner core are larger cones than seen in the remaining core. Microcrystalline quartz or chert precipitation is present in the cone fillers. Annular rings are present in cone shells. The lower crust is much more defined, containing a solidified crust of less altered shale or clay.

Interpretation:

This is a cone in cone concretion with a 2nd inner core within the core. A crust is seen on both top and bottom. Cone shells have been altered closer to the crust as the carbonate was removed and replaced. Cone shells are hematitic. The clay fillers in the crustal zone have absorbed the carbonate released from the cone shells, but have not been altered any further. Within the core the cones within the cone shells are microgranular quartz. Numerous lenticular clay bands are present with some exhibiting lineations. The lenticular bands are possibly the result of migration of clay in the direction of fluid movement.

Comments:

Upper crust effervescence: Clay fillers effervesce while the cone shells do not

Inner core effervescence: Central most core does not effervesce, but the inner concretion readily effervesce especially cone structures.
Lower crust effervescence: Clay fillers effervesce while cone shells do not
Degree of Alteration: Mild to moderate

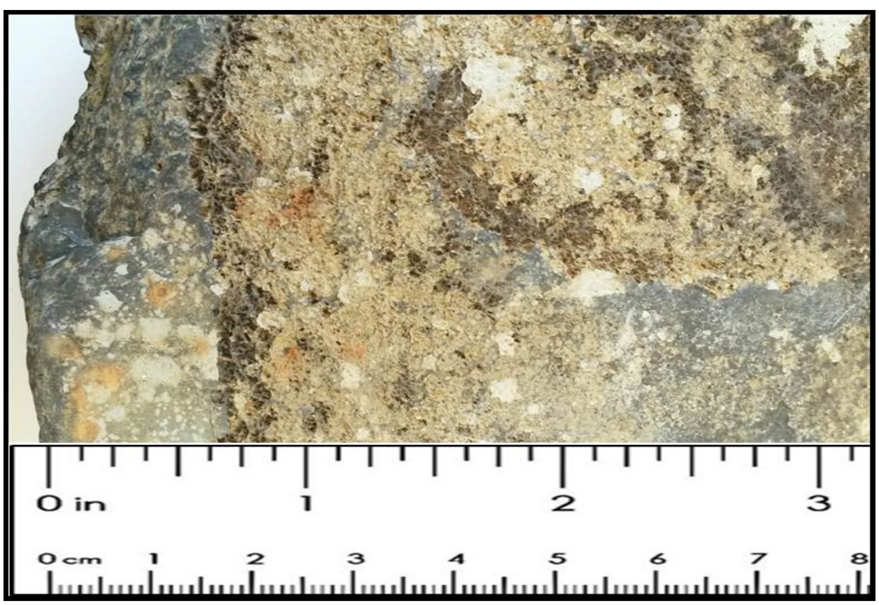
Pictures:

Top view. Scale in inches

Close up of cone shells and clay fillers.

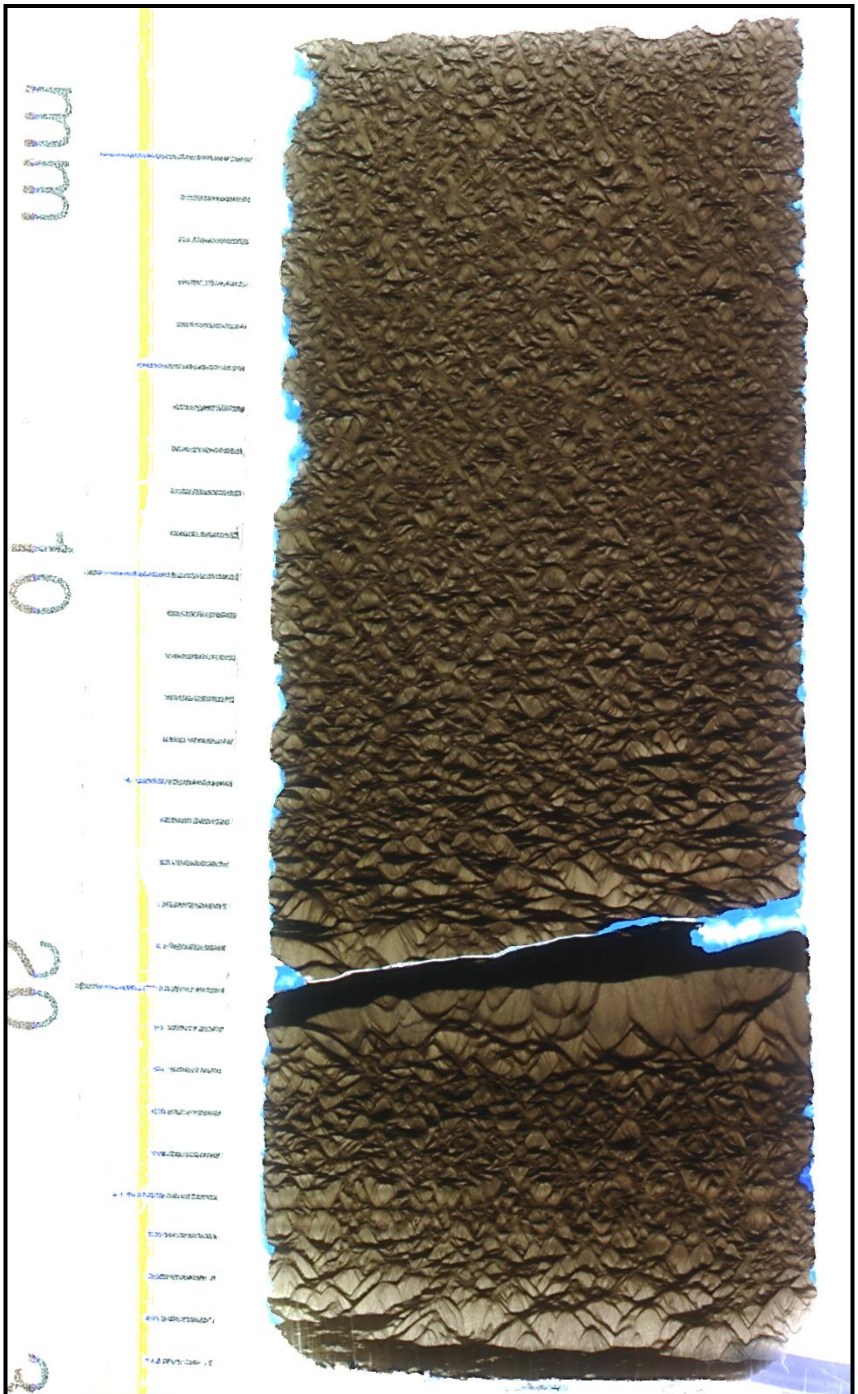
Close up of cone shells and clay fillers.

Bottom view. Scale in inches

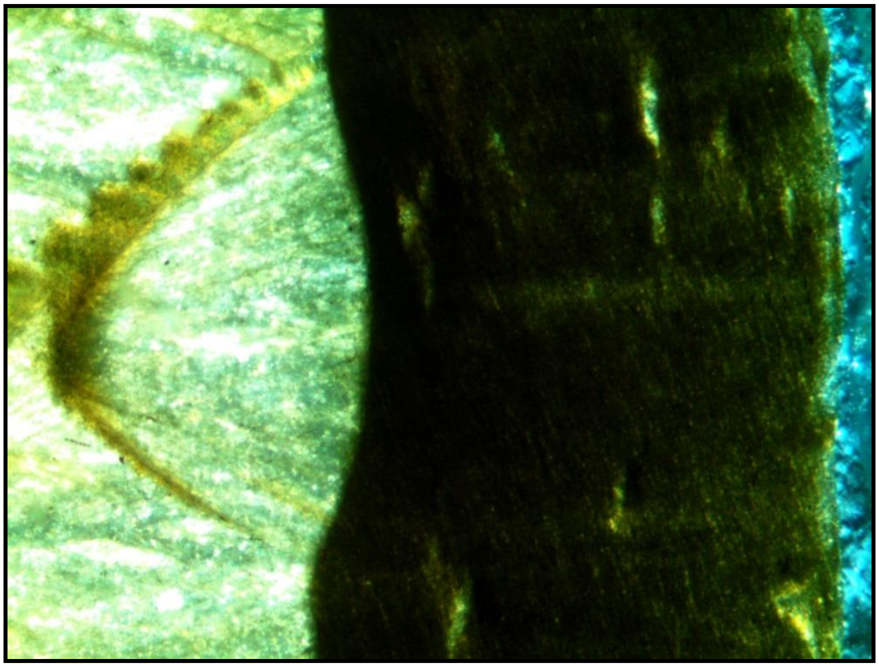


Bottom view of crust, shows weathering and minute cone shells

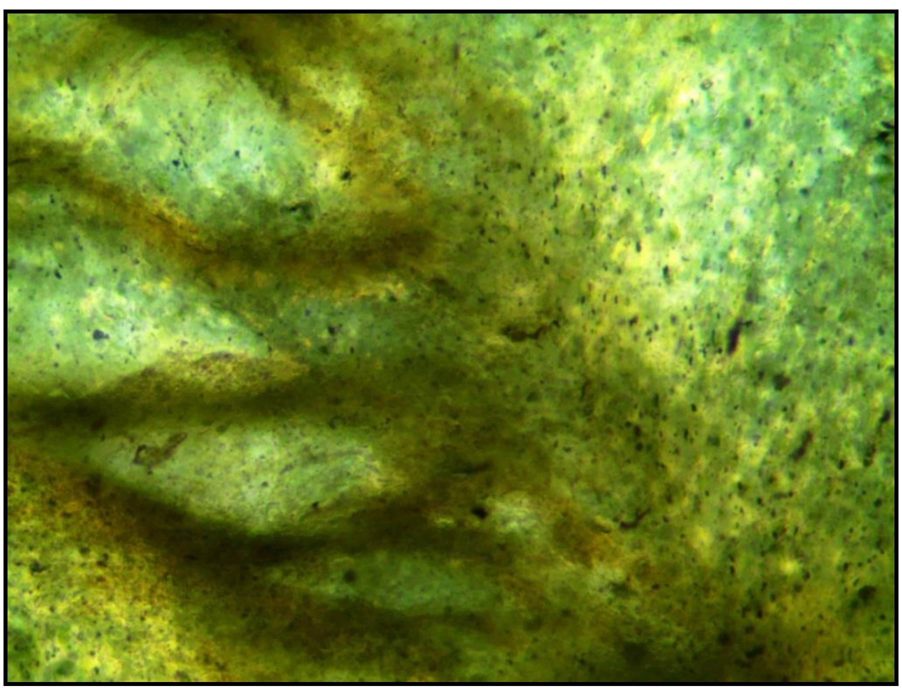
Side view after cross sectioning, shows second cone in cone formation within the core, spots are HCl discoloration, note slanted cones near the right edge. Scale in inches



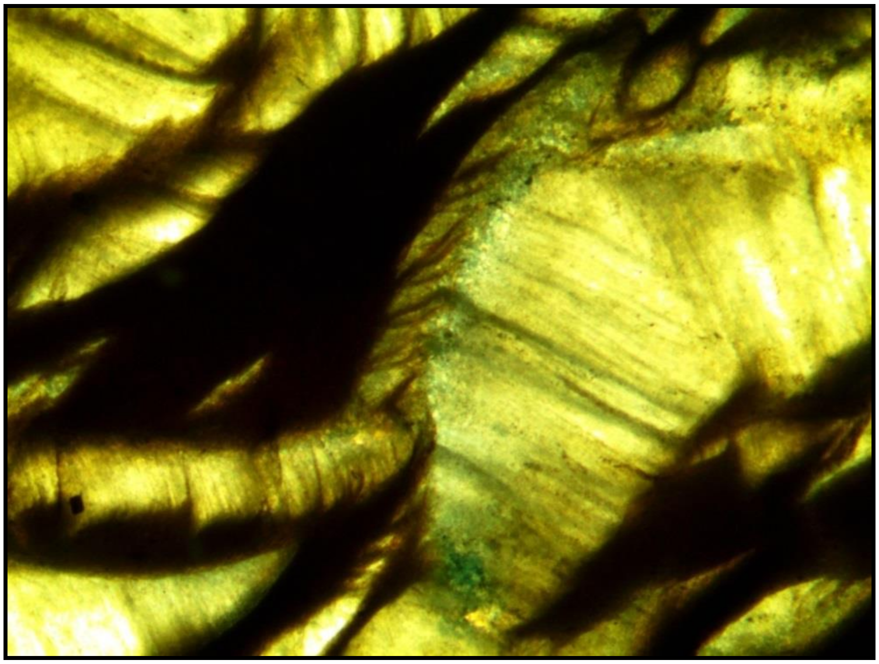
Photograph of thin section 1”x2”. Bottom crust of concretion is on bottom with 2nd inner core seen as a dark line above. Inner core seen on the top.



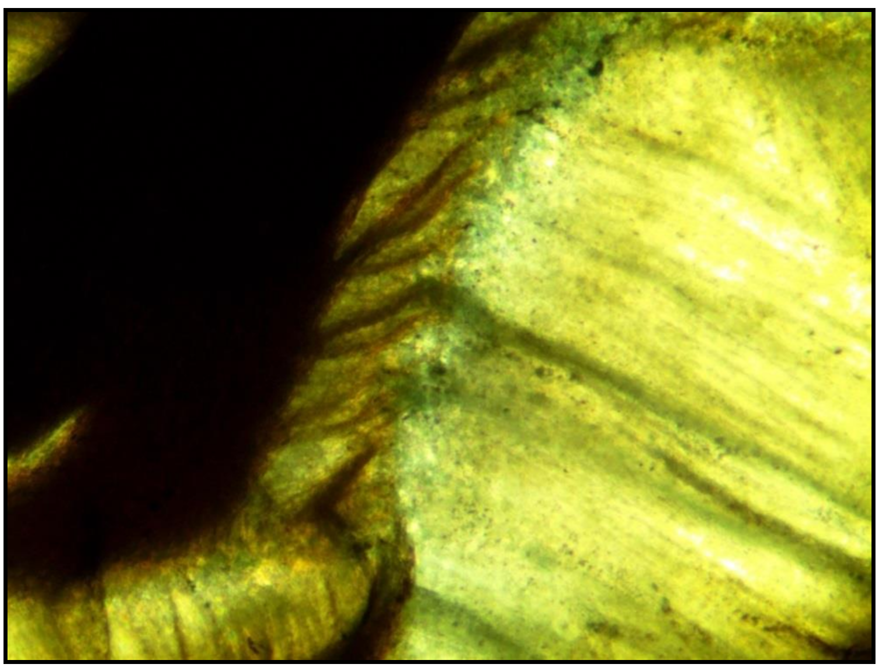
Lower crust on right with a bounding shale layer possibly high in iron. Annular rings present in exterior cone shell (100x)



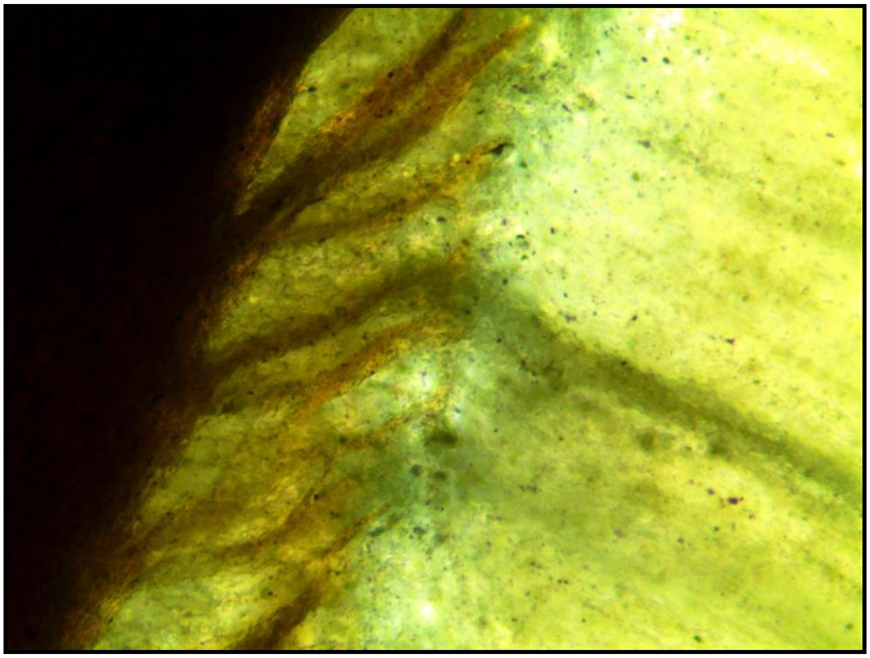
Chert and clay particulates (100x)

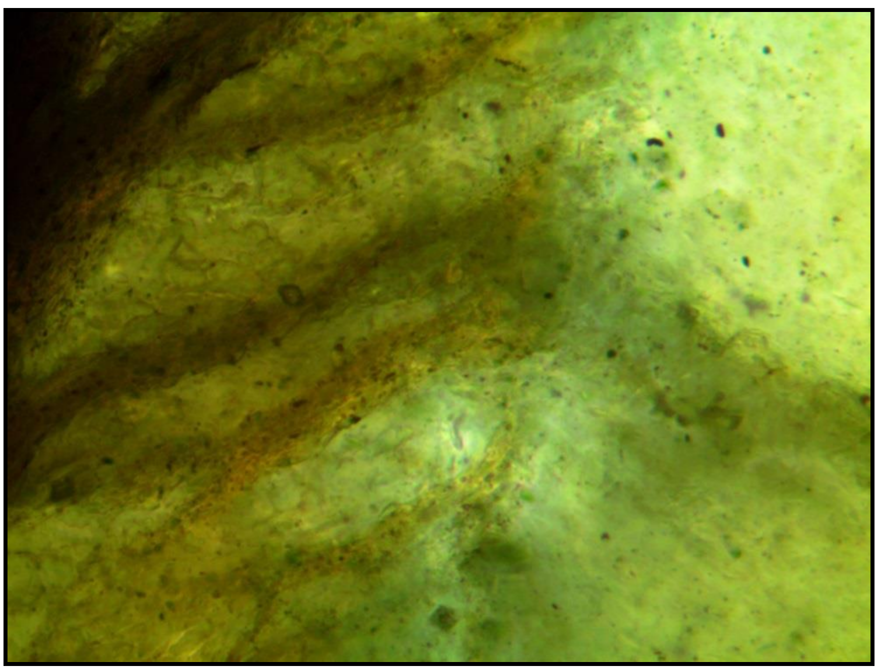


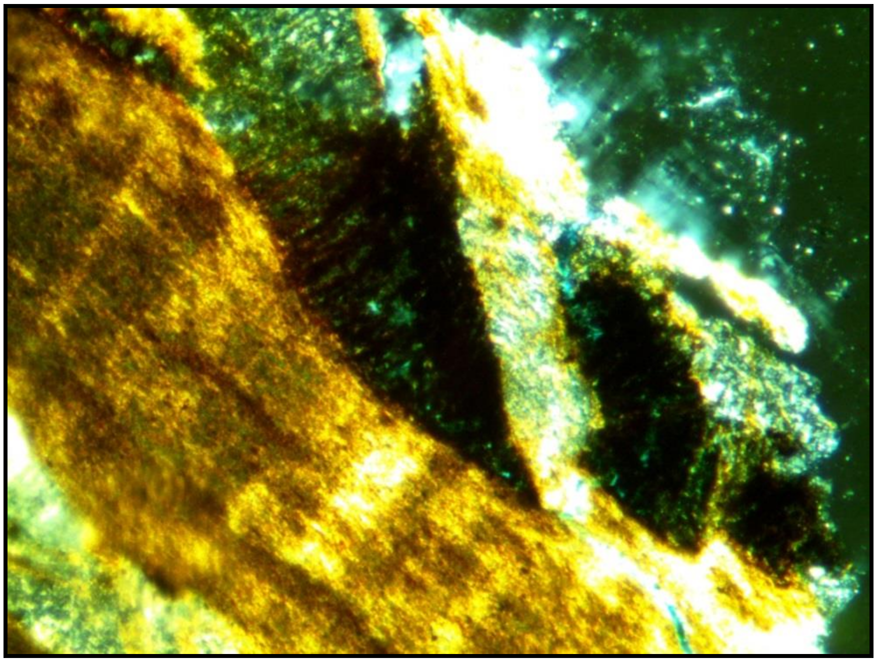
Clay lenticular band with lineations. Cross polars 50x

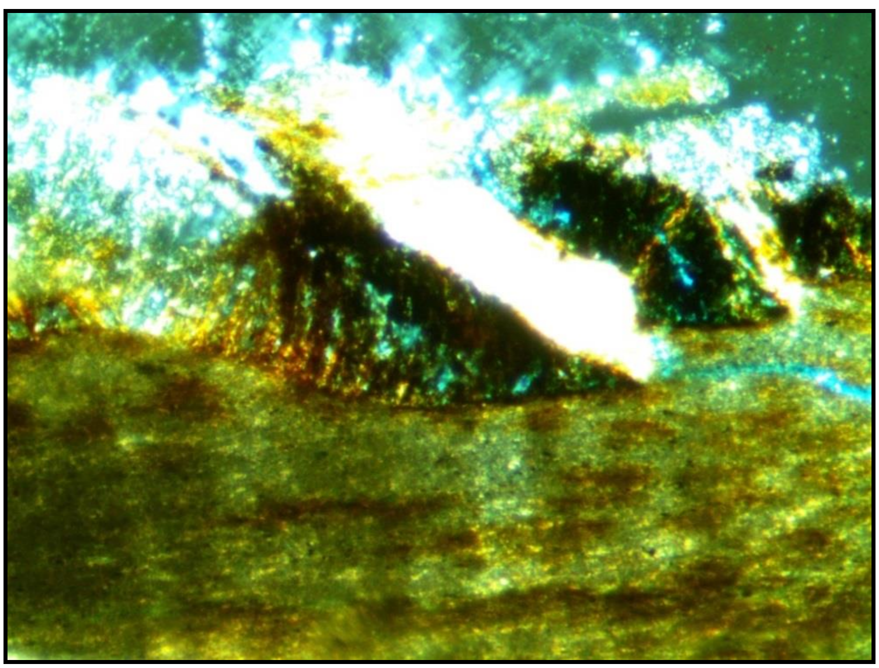


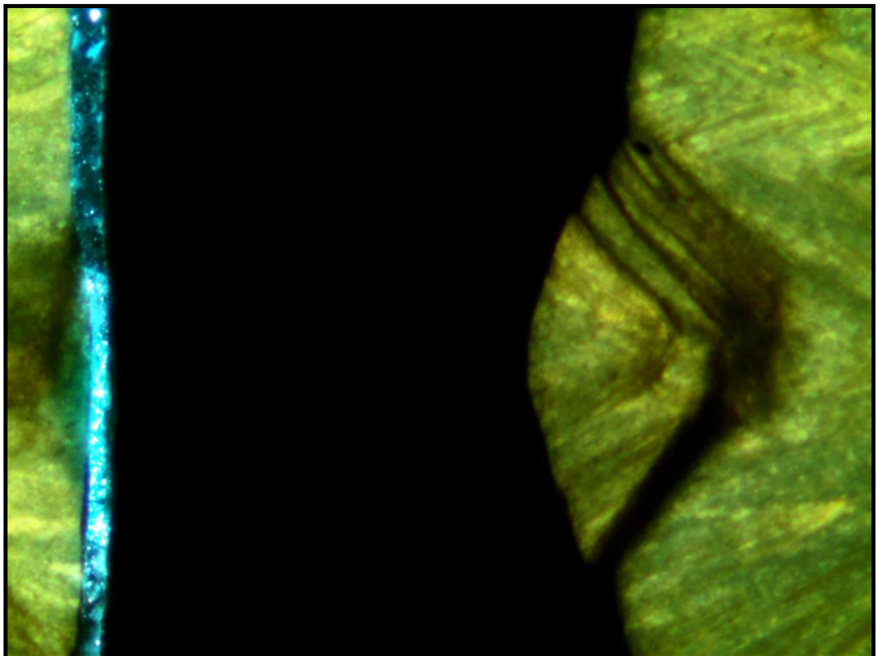
Same as above photo. Cross polars 100x

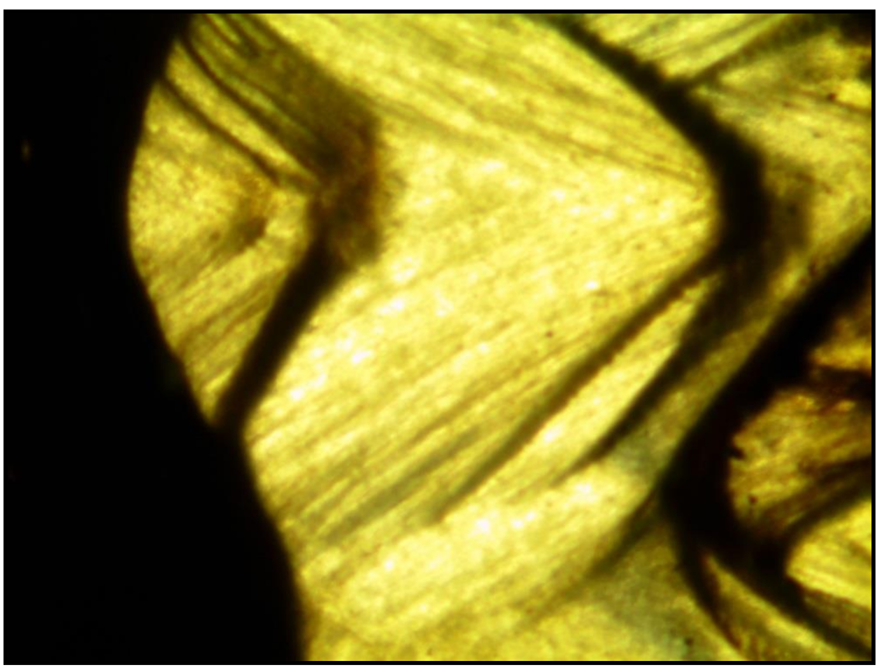

Same as above photo. Cross polars 200x


Same as above photo. Cross polars 400x


Lower crust shown on top left to bottom middle. Partial chert precipitation within inner shale lower crust with hematite present. Cross polars, (200x).


Same photo as above rotated. Cross polars, (200x).


2nd inner core with cone shell. Cross polars. (100x).


Same photo as above with plane polarized light. (100x).

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 1I

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Smooth ovoid concretion, no visible cone in cone structures on surface, measures 5 x 4.5 x 2.5 inches. First observation appears to be a core only, but after cross sectioning a partially encompassing granular like crust is visible. Dark linear/planar lens in the center. Light area inter-fingering into surrounding dark core area which is partially encompassed by crust.

Thin Section Microscopic Description:

Thin section examination reveals the outer core with few well defined cones although they are more prominent away from the edges toward the center axis of the concretion. Clay lenticular bands are common. Microgranular quartz is present. The dark shale core reveals a clay faction with numerous clast including quartz and silica spicules. The linear dark central lens is surrounded by a lighter color halo which contains some cone in cone structures. The lighter color is due to precipitation of a mineral which radiates from the dark lens. Lenticular bands become well defined near the dark central lens . Some clast are noted within this lighter inter-fingering region.

Interpretation:

This sample was an unexpected type of cone in cone concretion. Cone structures are noted near the central portion within the lighter zone and on the outer crust, while the main dark shale core is void of cones and lenticular bands. One possible explanation is that the carbonate source was small and originated from the central dark lens, the precipitation of the mineral forces clay clast out of the way producing lenticular bands. The carbonate that precipitated was dissolved by an early chert forming process and was able to precipitate on the outer edges. Which would suggest this concretion is an early forming cone in cone concretion that never reached maturity. Microgranular quartz replacement is present.

Comments:

Upper crust effervescence: No
Inner core effervescence: No

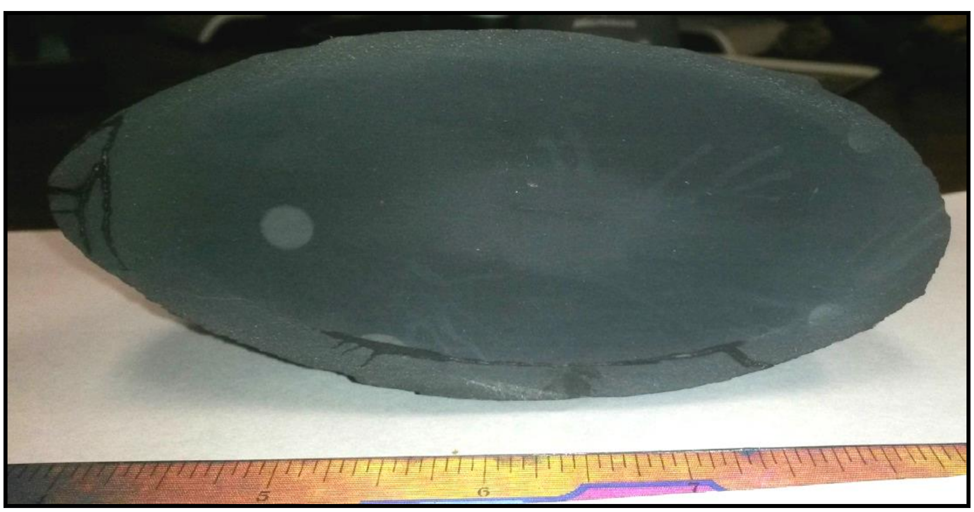
Lower crust effervescence: No
Degree of Alteration: Moderate

Pictures:


Close up view of crust with no visible cone structures

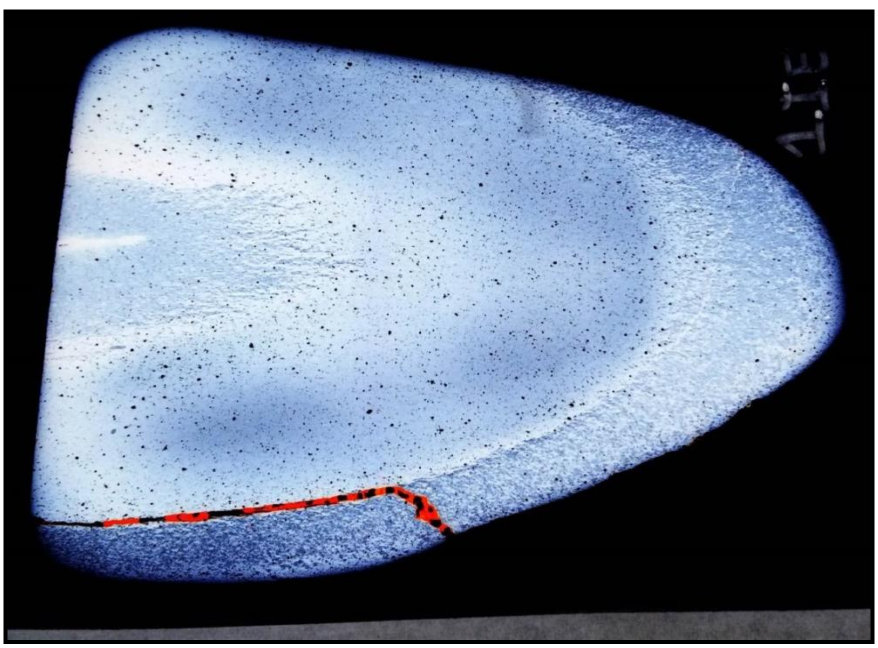
Side view of smooth crust. Scale in inches

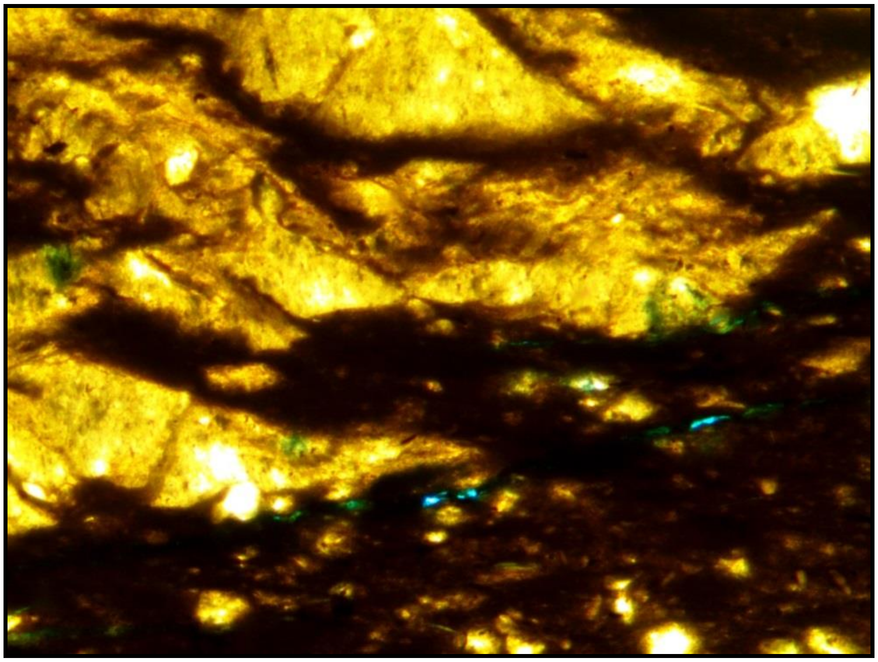
Top view of crust. Scale in inches.



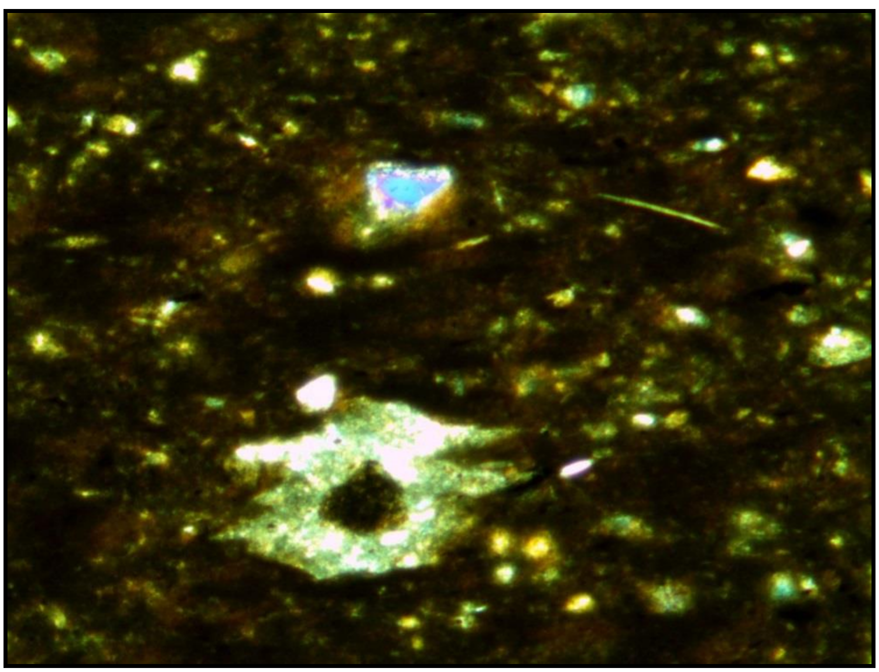
Cross section view shows crust and core with inner light core center with dark linear lends. Color splotches are HCl discoloration. Scale in inches.


Gross photo of thin section 2”x3” slide

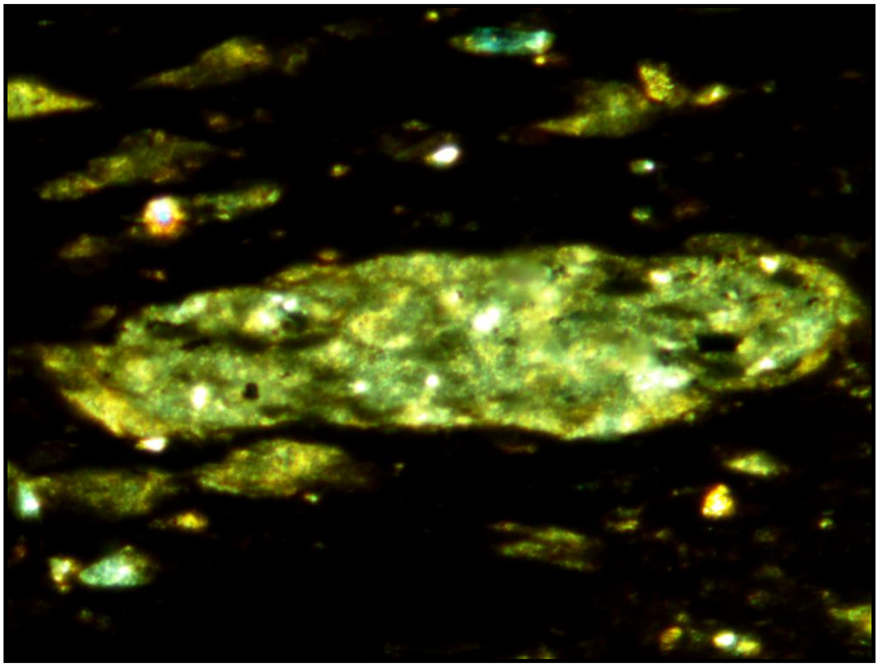

Gross photo of thin section 2”x3” slide. Reverse lighting



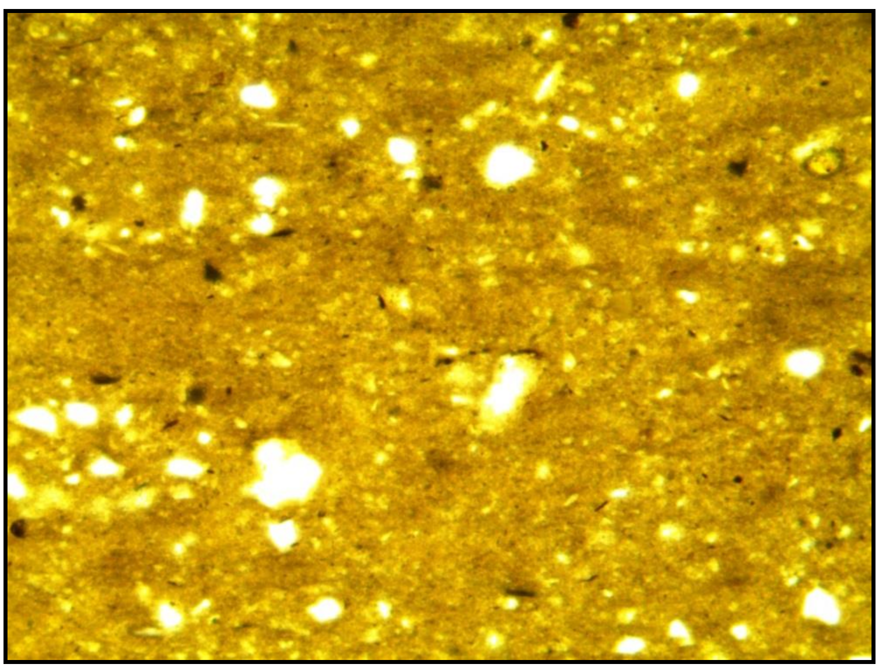
This section shows the boundary of the outer smooth crust that contains some cones and the inner dark shale core on the bottom. (100x)



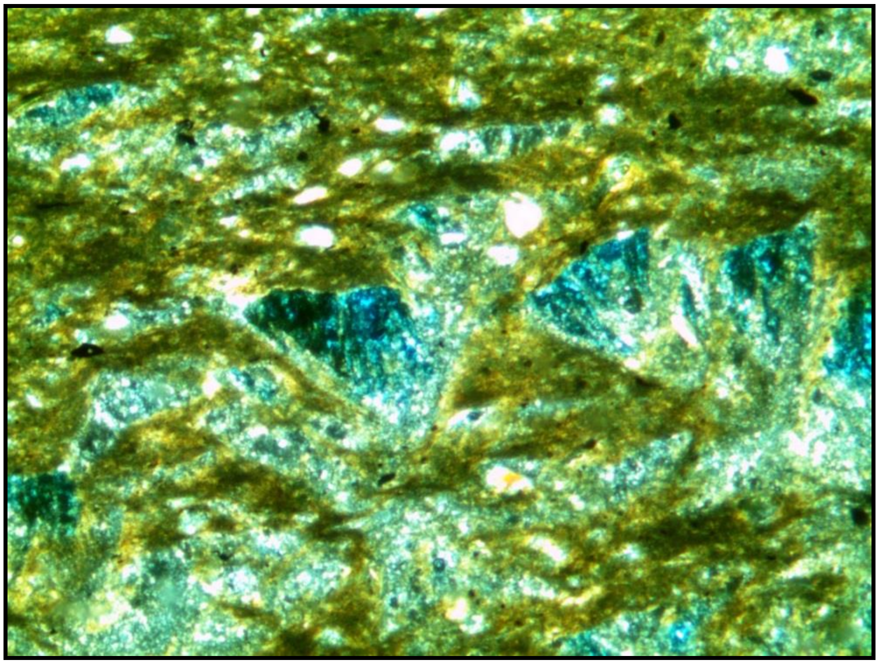
Microgranular quartz and spicules in the dark shale core, other clast are noted. Cross polars (40x)



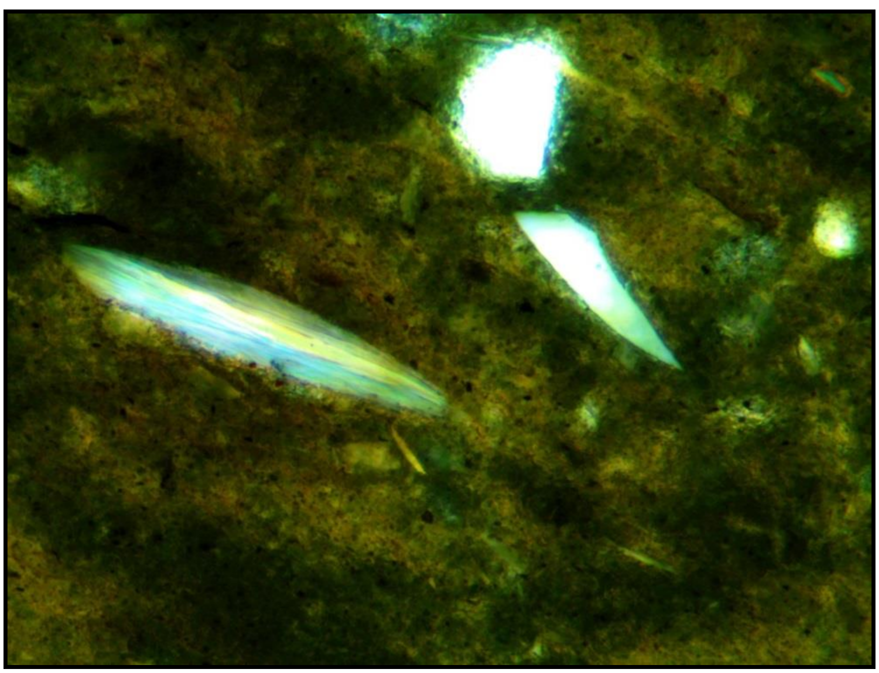
Cherty nodule in dark shale core cross polars (100x)



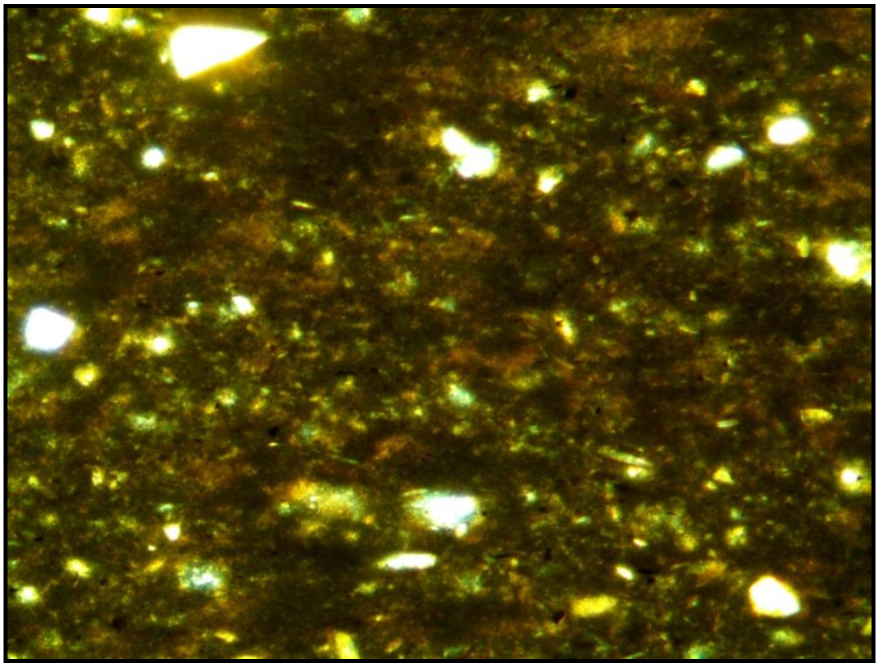
Dark shale core normal polarized light. Numerous quartz clast are seen (50x)

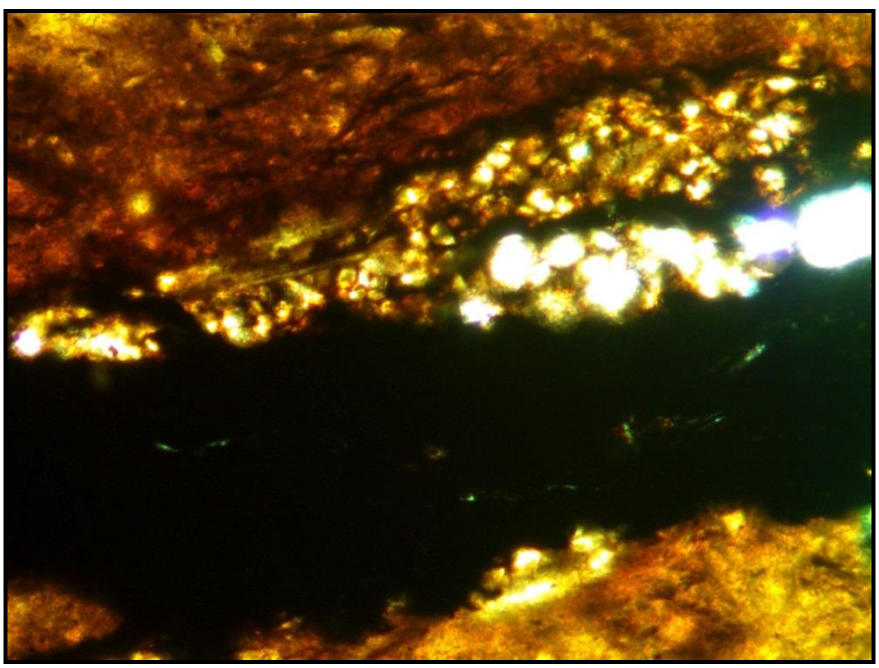


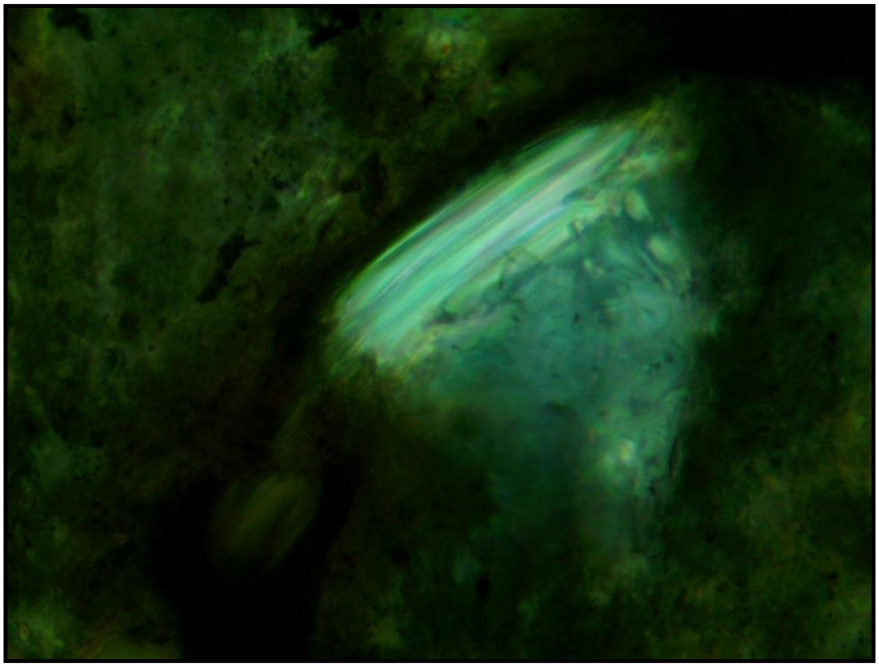
Cones seen in crust with blue epoxy noted. Cone bases pointing to exterior/crust. 50x cross polars

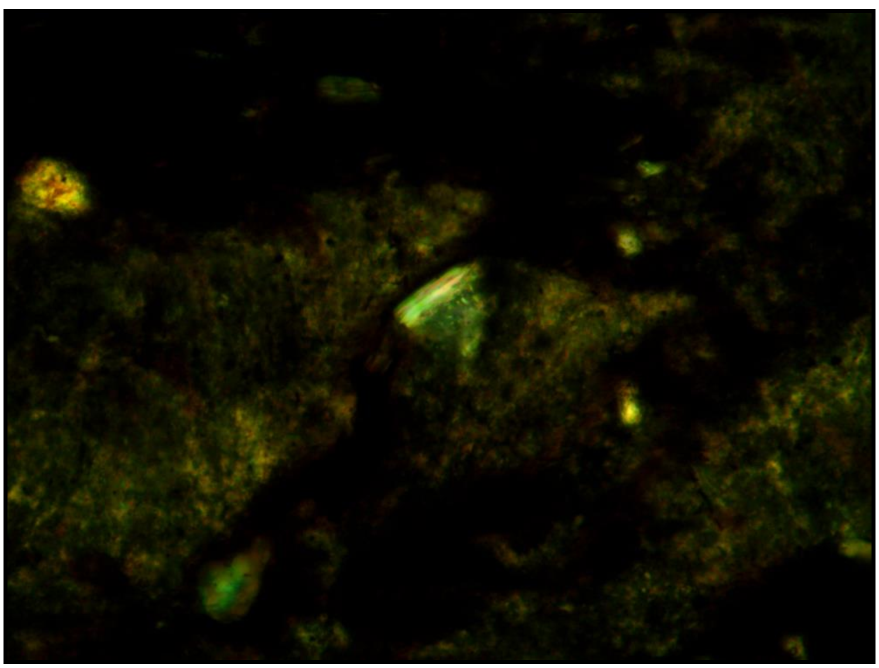


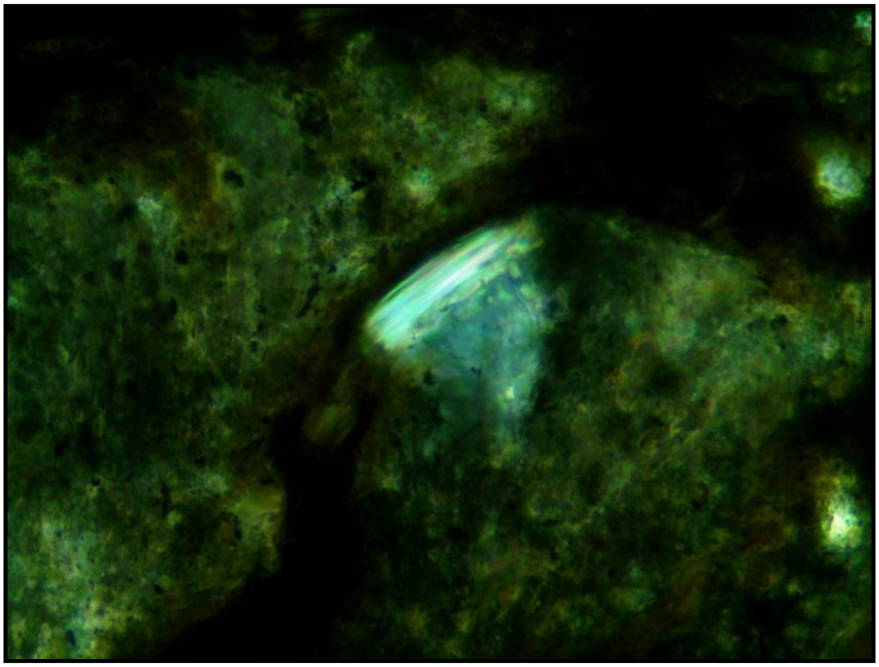
Variable clasts noted in dark shale core 100x cross polarization.


Numerous clast in dark shale core 50x, cross polarization

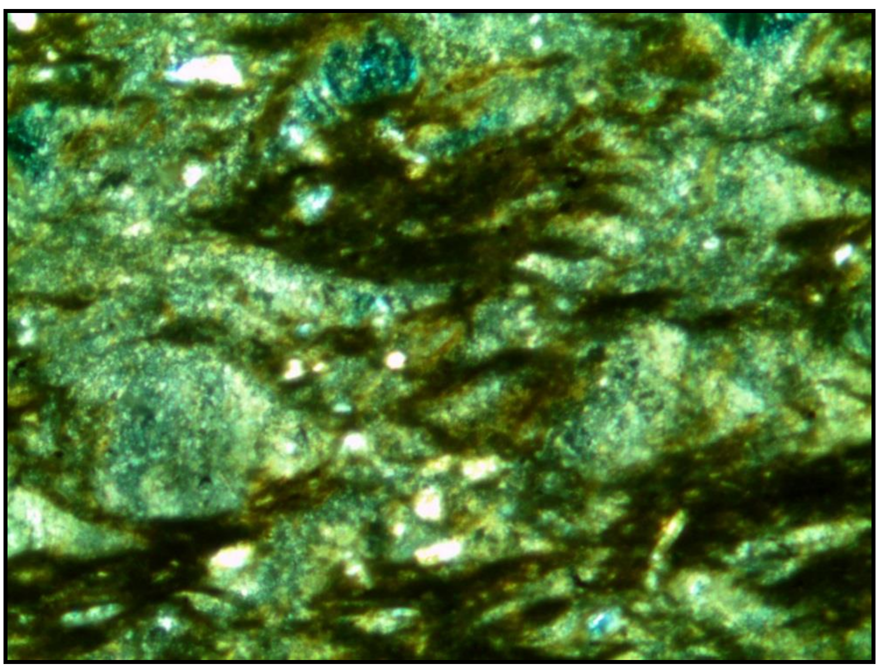

Central dark planar lends, possible organic matter, plane polarized.


400x, cross polarization

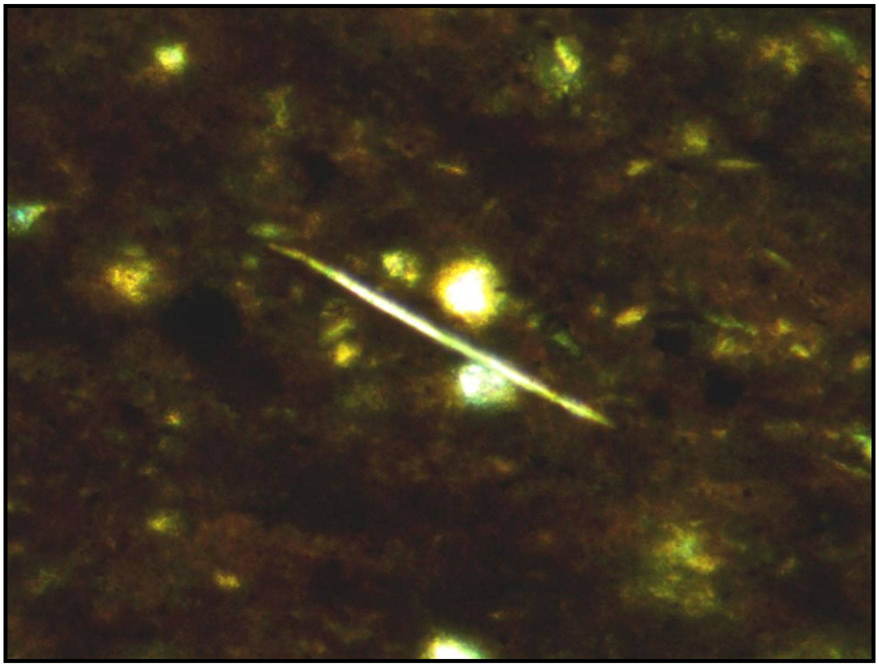

Same photo as above 100x



Same photo as above 200x



Outer crust containing lenticular bands with microgranular quartz and clast, cross polarization 50x


Siliceous spicule in dark shale core. 100x, plane polarized light

Cone in Cone Description

Specimen #: 1J

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Same concretion as 1E and 1G.
Another piece from hammered out large concretion. Much larger cone in cone structures. Crustal cones measure up to 1.75 inches. Crustal surface is very atypical compared to other types; this may be a weathering process. Cones appear to be tilted or slanted at crust surface, in one direction.

Thin Section Microscopic Description:

Na

Interpretation:

See sample 1E

Comments:

Upper crust effervescence: Yes, readily
Inner core effervescence: Yes, readily
Lower crust effervescence: Yes, readily
Degree of Alteration: Mild

Pictures:

Cross section view showing large slanted cones. Scale in inches

Side view. Scale in inches.

Top view exhibiting non-conformal surface crust. Scale in inches.

Cone in Cone Description

Specimen #: 1K

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Partial cone in cone concretion, elliptical with formation of small cone structures sparsely on surface, may be a byproduct of weathering, cone shells are mostly hematitic with rare clay fillers, most of which are possibly secondary infilling of sediment. One side is extensively covered in crustal cone shells while the other is sparsely covered. Crustal cone shells measure at most 0.25 inches. Core material is granular and possibly contain microscopic cone structures.

Thin Section Microscopic Description:

Na

Interpretation:

This is a cone in cone concretion. It contains a core and crust. Lack of effervescence of the core would suggest all carbonates have been altered by microgranular quartz. The outer crust on the other hand still retains some carbonate while the cone shells may be hematatitc.

Comments:

Upper crust effervescence: No
Inner core effervescence: No
Lower crust effervescence: very slight in some crustal cone shells
Crust underneath large exterior cones: Yes, readily.
Degree of Alteration: moderate to well

Pictures:

Top view with numerous cone shells. Scale in inches.

Bottom view, rare cone structures. Scale in inches

Close up of cone shells. Scale in inches.

Granular core. Scale in inches.

Cone in Cone Description

Specimen #: 1L

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Gross Description:

Partial cone in cone concretion. Crustal cones are mainly on top side with a scaley appearance. Cone shells are slightly noticeable, with cone fillers being the most distinct feature. Top crustal cone structures measure at max 0.5 inches. Core is very thick with a lighter color than most other concretions. Numerous light colored variations or halos within the core. Very rare cones on bottom.

Thin Section Microscopic Description:

Na

Interpretation:

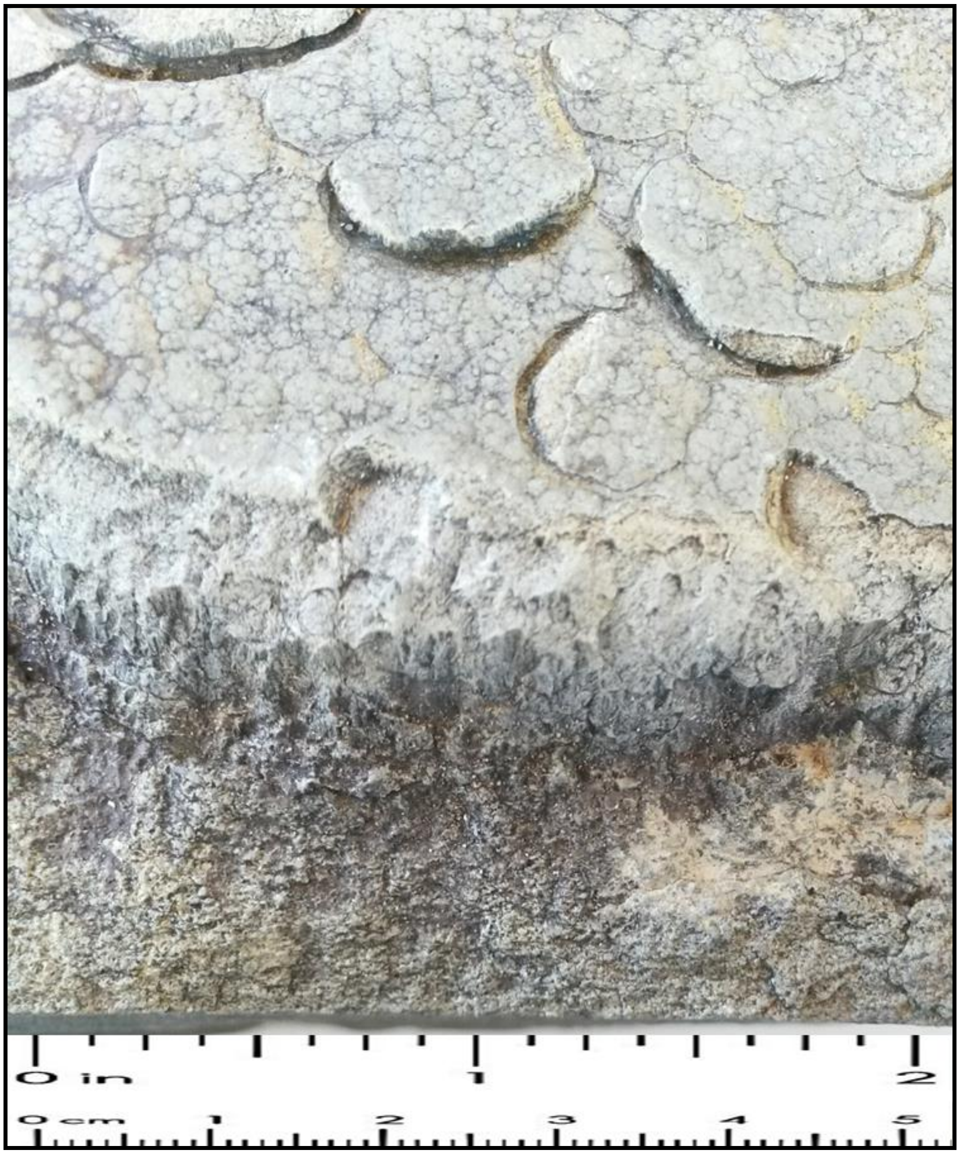
This is an elliptical cone in cone concretion. An inner core and exterior crust is present. Cone shells in the crust are not clearly evident, although the cone fillers are quiet prominent and give definition to the cone in cone structures. There is a clear boundary between the crust and core. The lighter color of this sample gives rise to the possibility of siliceous alterations or secondary migration inward. The crustal cone structures are mostly limited to the top of the sample indicating initial fluid movement upward or in one direction. The lack of carbonate is striking due to the less than cherty or siliceous appearance of the sample, which might help indicate hydrothermal processes.

Comments:

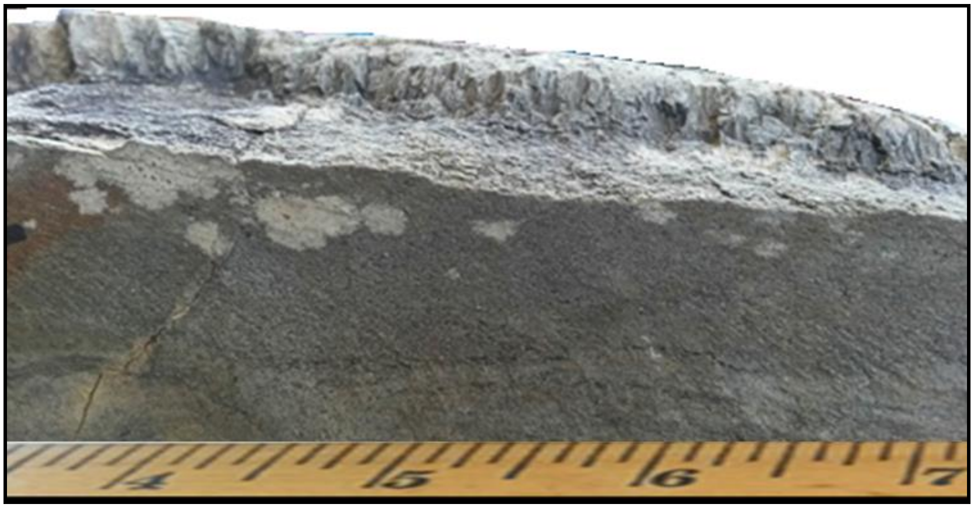
Upper crust effervescence: No
Inner core effervescence: No
Lower crust effervescence: No
Degree of Alteration: Moderate to high

Pictures:

Top view show crustal cone structures. Scale in inches.



Close up view of top crustal cone in cone structures, scaley appearance



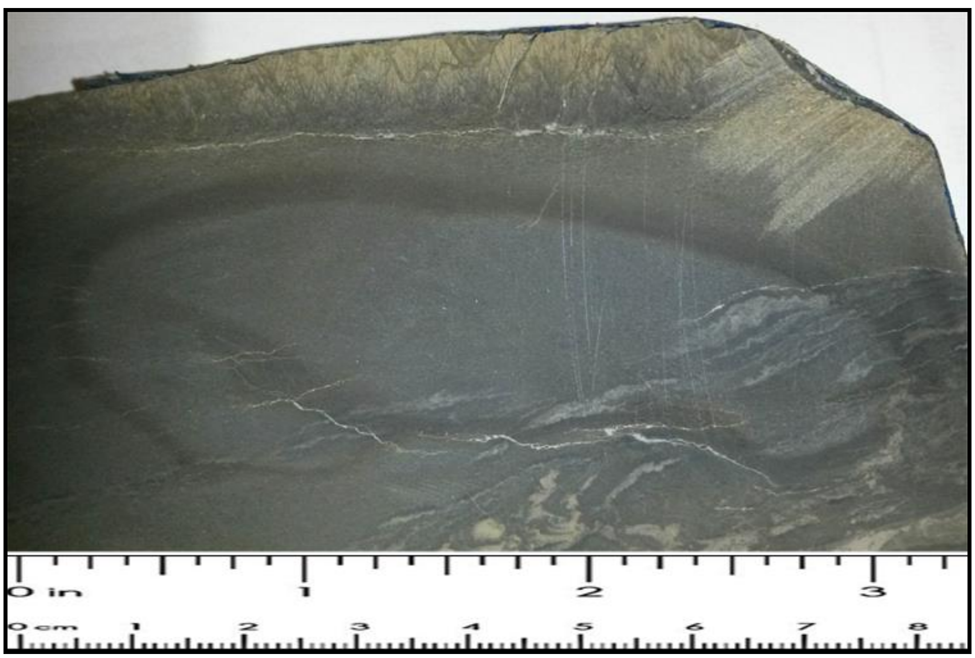
Side view of top crust and core. scale in inches.

Cross section view showing lighter color variation of core. Scale in inches.

Bottom view. Scale in inches.


Cross sectional view showing cones at the top and lighter core area with halos present. Scale in inches.

Cross sectional view showing lighter core area with halos present and lighter migrating clay size clast. Scale in inches



Cross sectional view showing cones at the top and lighter core area with halos present.

Cone in Cone Description

Specimen #: 1M

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Gross Description:

Weathered portion of a much larger cone in cone concretion. Crustal cones on both top and bottom. Surface appears to have been severely weathered, clay fillers are rare on one side and present on the other. Clay fillers are more altered with slight overriding of cone shells planeing off or encapsulating the clay filler. This might be early scaley formation of crust or due to movement of the shale during orogenic deformation. Slightly thicker cone shells with hematitic and fibrous appearance are seen compared to other concretions. Cones measure 1mm to 0.75 inches. Crust appears blackened or almost burnt. Dimensions are 9 x 3 x 3.5 inches.

Thin Section Microscopic Description:

Na

Interpretation:

This is a cone in cone concretion. The lack of carbonate on the interior core demonstrates the migration of the carbonates from the central core region, which also means that cones in the core contain no carbonate which would leave the clay faction or hematitic cone shells within the core. The lack of reactivity with the crustal cone shells indicates they are hematitic. The cone fillers contain carbonate which indicates migration of the carbonate from the interior to cone fillers; this might also indicate the transference of minerals between the two separate structures and the mineralogical differences between them. The scaley shale almost encapsulating the crustal region is lacking carbonate indicating this is the end point for carbonate precipitation for this sample.

This concretion has a cooked or baked appearance to it. This might indicate a high temperature environment the concretion was subjected to.

Comments:

Upper crust cone shells effervescence: No
Upper crust cone fillers effervescence: Yes, readily
Upper crust scaly shale layer effervescence: No

Inner core effervescence: No
Lower crust cone shells effervescence: No
Lower crust cone fillers effervescence: Yes, readily
No lower crust scaly shale layer.
Degree of Alteration: Mild

Pictures:

Top and side view; scaley top crust. Scale in inches.

Top view, cone shells, cone fillers, and partial shale scaly layer. Scale in inches.

Top view: shows shale scaley layer partially encapsulating the concretion, cone shells, and cone fillers. Scale in inches.

Close up of above picture. Scale in inches

Close up view of cone shells. Scale in inches.

Cross section view showing granular core. Scale in inches.

Cone in Cone Description

Specimen #: 1N

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:
Numerous pencil shales. No concretions seen in this outcrop

Thin Section Microscopic Description:
Na

Interpretation:
Not a cone in cone concretion, pencil shales found near concretions in other shale beds. No further interpretation or analysis will be performed

Comments:
Upper crust effervescence: no
Inner core effervescence: no
Lower crust effervescence: no
Degree of Alteration: Na

Pictures:
None

Cone in Cone Description

Specimen #: 1O

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Not a cone in cone concretion.

Stanley shale with turbitic or irregular surface planes. Slight fissility or bedding, micaceous clast/growths, soapy like texture.

Thin Section Microscopic Description:

Na

Interpretation:

Not a cone in cone concretion, turbitic shale found near concretions. Soapy feel with some microscopic reflected minerals present. Also slight layering or fissility seen. No further interpretation or analysis will be performed.

Comments:

Upper crust effervescence: No
Inner core effervescence: No
Lower crust effervescence: No

Pictures:

Gross photo of surrounding shale. Scale in inches


Gross photo of surrounding shale. Scale in inches.

Cone in Cone Description

Specimen #: 1P

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Most likely not a cone in cone concretion

Float that has numerous separating planes throughout with scaley like structures that need to be further investigated/ cut. A long planar fracture is seen through long axis of rock with no visible cone in cone structures, but a scaley pattern is seen in this fracture. Dimensions 10 x 6 x 3 inches.

Thin Section Microscopic Description:

Na

Interpretation:

Further studies needed for this sample. Scaley inner core along fracture along with some banding seen on edge, which has same appearance as some of the inner cores seen in cone in cone concretions, possibly related.

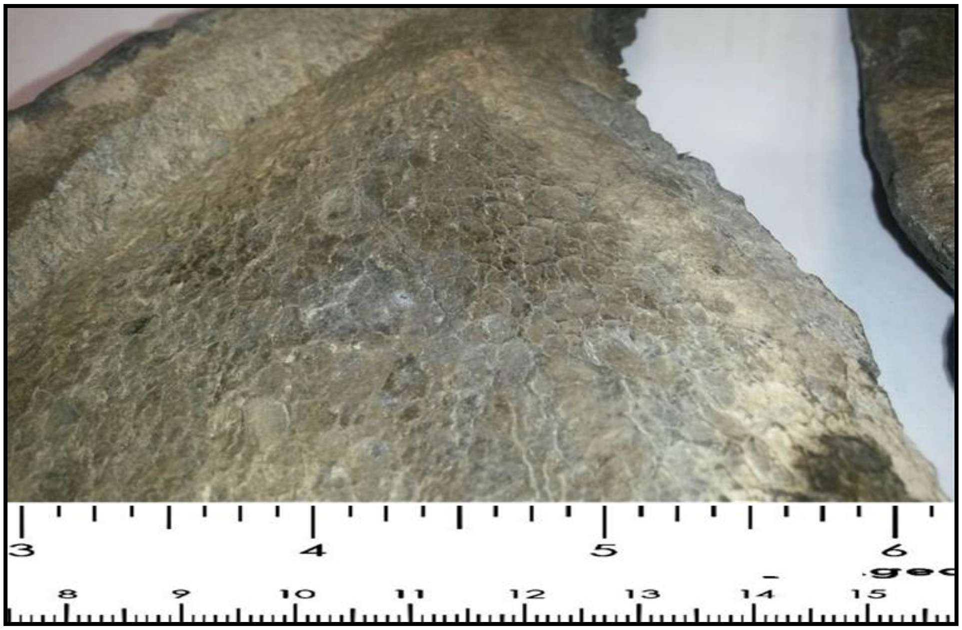
Comments:

Upper crust effervescence: No
Inner core effervescence: No
Lower crust effervescence: No
Degree of Alteration: NA

Pictures:

Top view of rock. Scale in inches.

Side view showing planes or beds. Scale in inches.



Scaley appearance found along fracture dividing two of the layers

Top view looking down at the two fractured pieces that fit on top of each other with scaley appearance.

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 1Q

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Large cone in cone concretion with only half present. Extreme weathering has occurred. Both top and bottom crust present with cone structures. A core is also present. Dimensions are 18 x 7 x 4.5 inches.

Thin Section Microscopic Description:

Na

Interpretation:

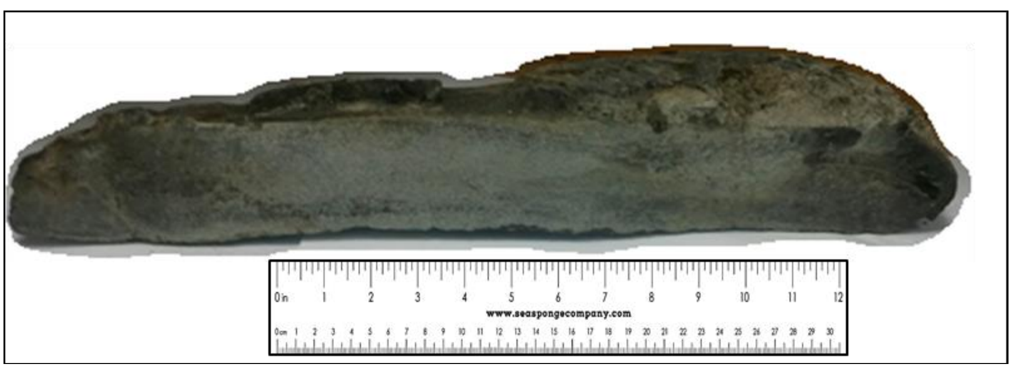
This is a large cone in cone concretion with a clear core and crust. Cone structures are seen on the crust where they have not been weathered. It is interpreted to have been altered from the core out to the crust with the only remaining carbonate found in the clay fillers. No further interpretations will be given for this sample.

Comments:

Upper crust effervescence: very slight
Inner core effervescence: No
Lower crust effervescence: No
Degree of Alteration: Moderate

Pictures:

Top view with irregular conal shapes, high degree of weathering



Cross section view showing crust and core

Cone in Cone Description

Specimen #: 1R

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County, OK
34.451196 N, 94.662260 W

Gross Description:

Mid-section of a medium size cone in cone concretion. Top and bottom crust with a core clearly seen. Crust appears shaley, slumpy, and slick with no visible cone structures discernable until cross sectioned where they are apparent. Core has a silt layer approximately 0.25 inch thick running the length of concretion. Top crust cone structures measure approx. 0.5 inches whereas the bottom crust measures 0.3 inches. Core measures 1.25 inches total. Lighter grayish blue color noted, also specks of a goldish metallic mineral present possibly indicating hydrothermal or sulfide mineralization.

Thin Section Microscopic Description:

Thin section examination reveals a very unique cone in cone concretion. The outer crust contains shale. Just beneath the shale, conal structures made of twinned lamellae calcite are prevalent. The calcite is protruding into the shale of the outer crust. The core is divided into two regions; inner most core and outer core. The inner most core contains a thin 0.25 to 0.5 inch layer of silt size quartz grains with rutilated quartz grains and a most peculiar quartz grain that appears to have a pyrite cube within the quartz. The outer core which measures 0.5 to 0.75 inches contains microscopic cones and lenticular bands of clay. The outer core demonstrates cone structures with a gradual change in mineralogy. The cone structures closest to the quartz inner core exhibit microgranular quartz with lenticular bands of clay while the outer core closest to the exterior is microgranular calcite. The inner crust contains cones of twin lamellae calcite with cone shells of clay.

Interpretation:

This is a cone in cone concretion showing three stages of evolution in cone growth and diagenesis. Carbonate precipitation of cones are the first crystallization process affecting the deposit. Carbonates migrate/push clay particles during crystallization. If fibrous calcite is the original precipitate then it alters into microgranular calcite. At some point the twinned lamellae calcite cones are formed by the dissolution of calcite. The next stage is chertification of the microgranular calcite. In this instance, it could be the result of hydrothermal influences and or silica rich fluids. This concretion is unusual because of the silty rich quartz grains of the inner core which may have been originally a carbonate precipitate. Possibly three precipitations are observed. The key idea to these concretions is that a halo effect is seen which seems to start in the core and migrates outward. This would suggest a water pressure disparity between the core and the outer crustal regions and surrounding shale due to infrastructure in the core area. These saturated carbonate focal deposits within a clay faction would be surrounded by fluids at a later time that had enough pressure to infiltrate the concretions along cone shells and lenticular bands. When those fluids reached the interior core where the greatest pressure would accumulate first, dissolution of the carbonate and precipitation of silica would begin. This pattern would operate with an inside to out dissolution and precipitation. The amount of either 3 processes depends on time, amount of carbonate, and the rate of dissolution and recrystallization of each of these diagenic steps.

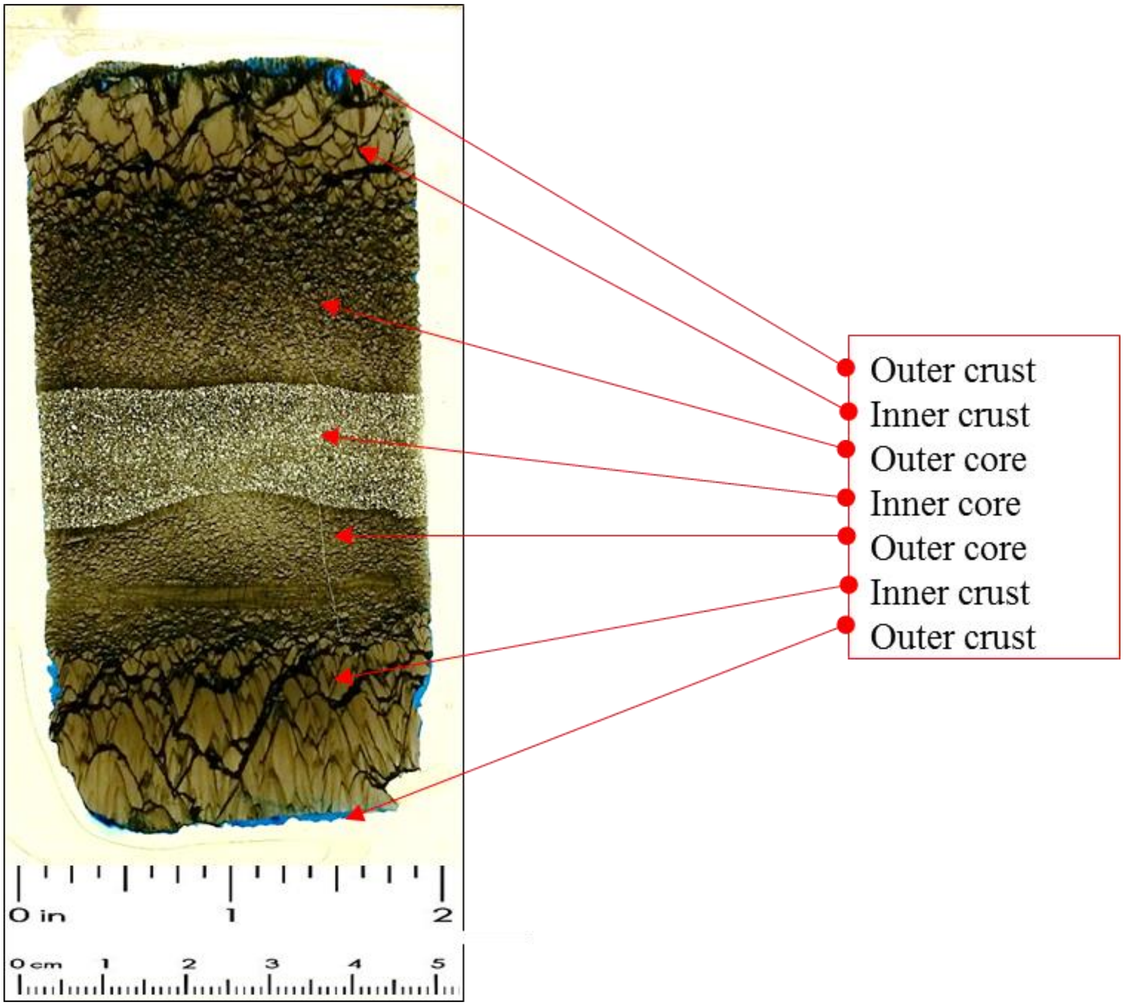
Comments:

Upper crust effervescence: yes, delayed
Cone structures of the inner crust applied in cross section: Yes, Readily
Inner core effervescence: No
Outer core effervescence: No
Lower crust effervescence: Yes, delayed
Degree of Alteration: moderate

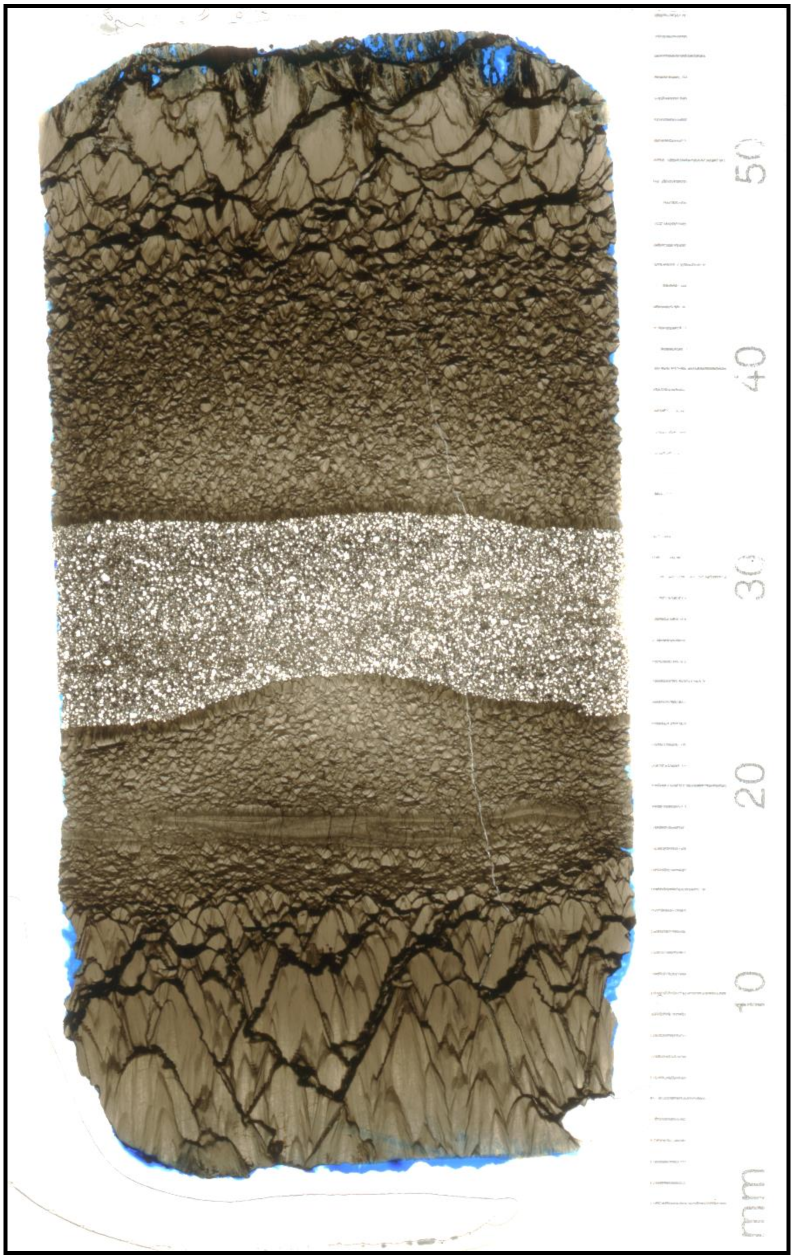
Pictures:

Top view, no visible conal structures. Scale in inches

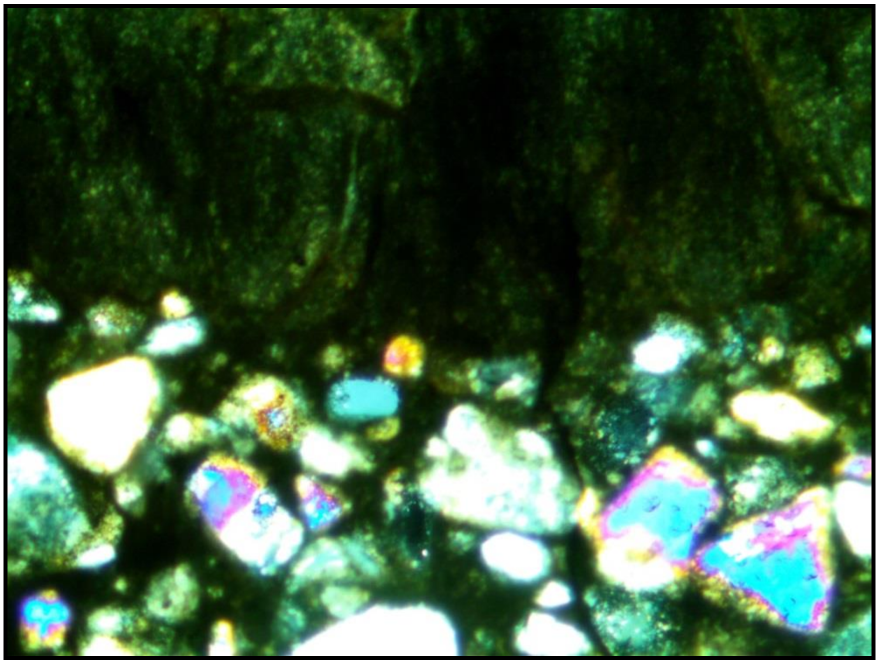
Cross section view showing crust and core, and conal structures. Scale in inches.



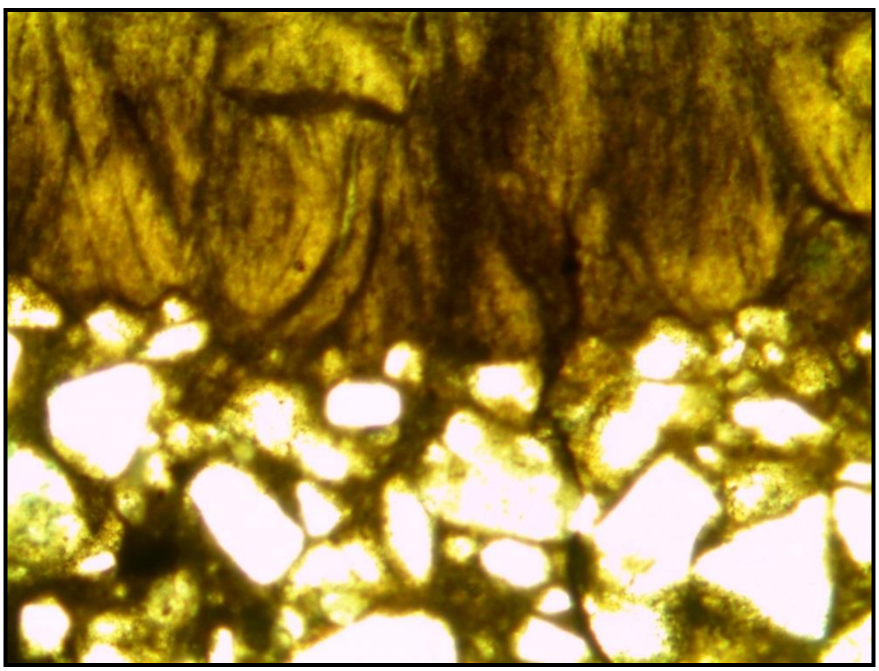
Gross photo of thin section 2"x3" slide.



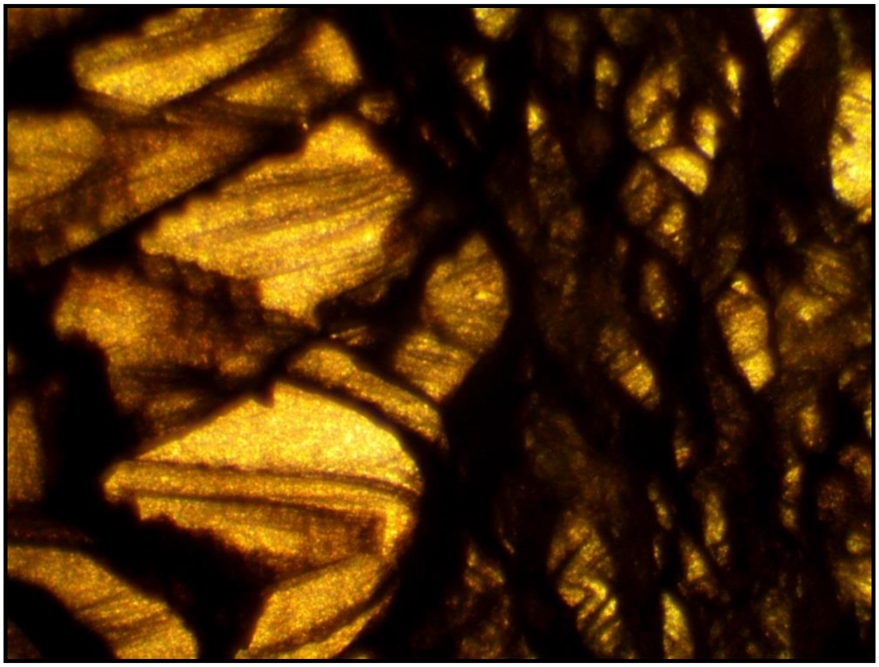
Photograph of thin section slide with burrow present in outer core.



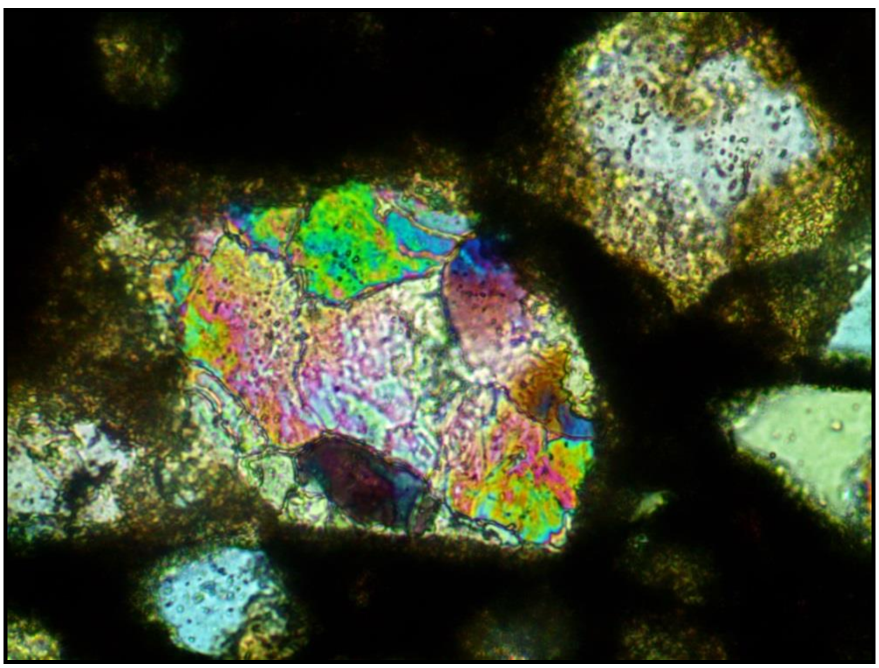
Boundary between inner core and outer core. Cross Polars (50x)



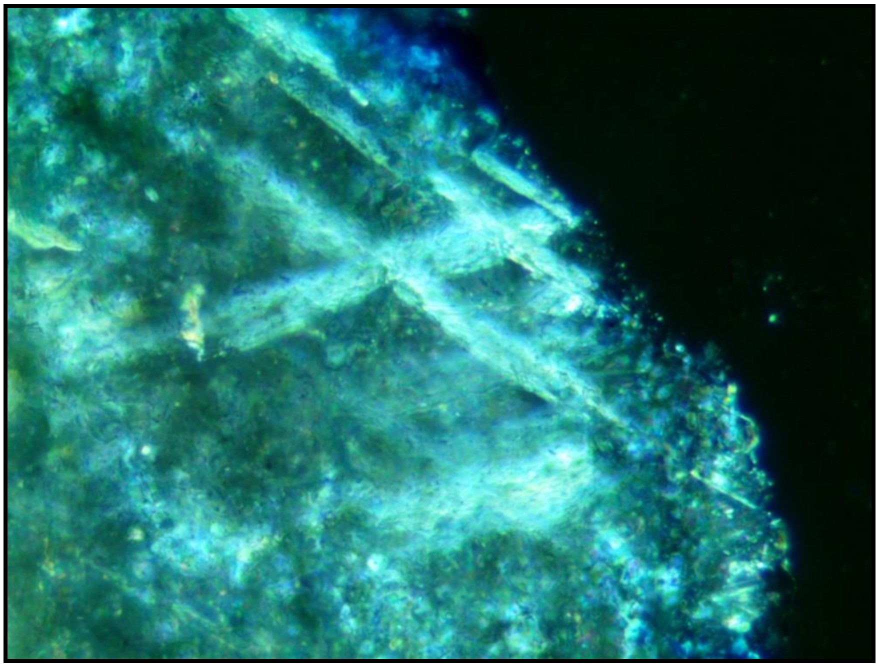
Boundary between inner core and outer core. Normal polarization (50x)



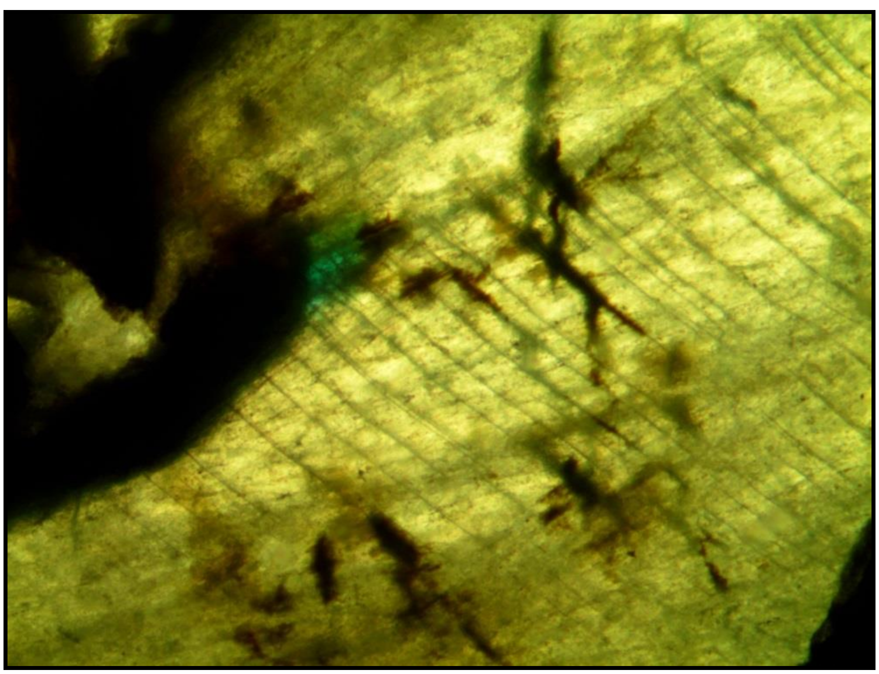
Boundary between inner crust and outer core (right) with prominent lenticular bands (50X)



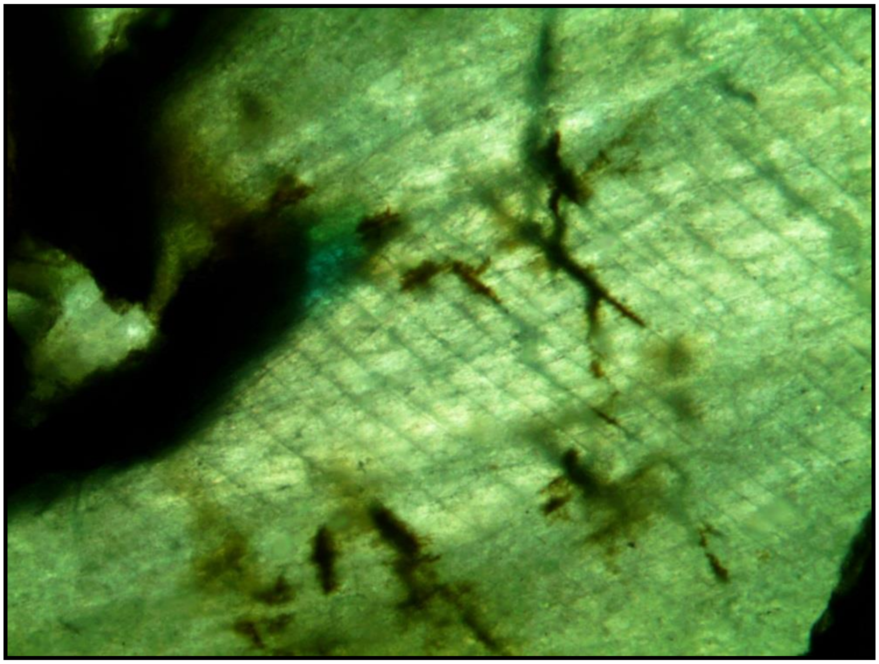
Possibly hydrothermally altered quartz in inner core that replaced the carbonate precipitate (100x)

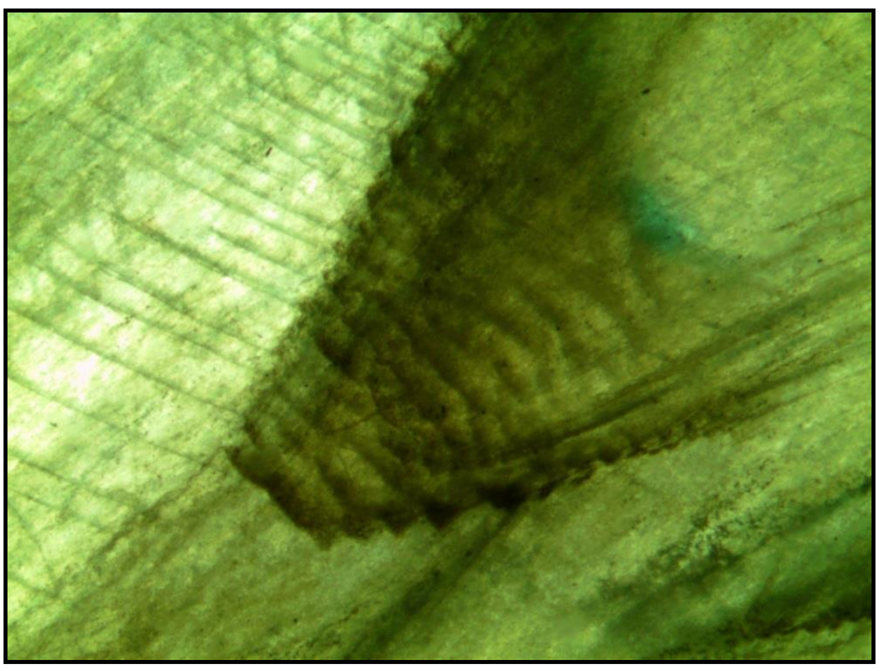


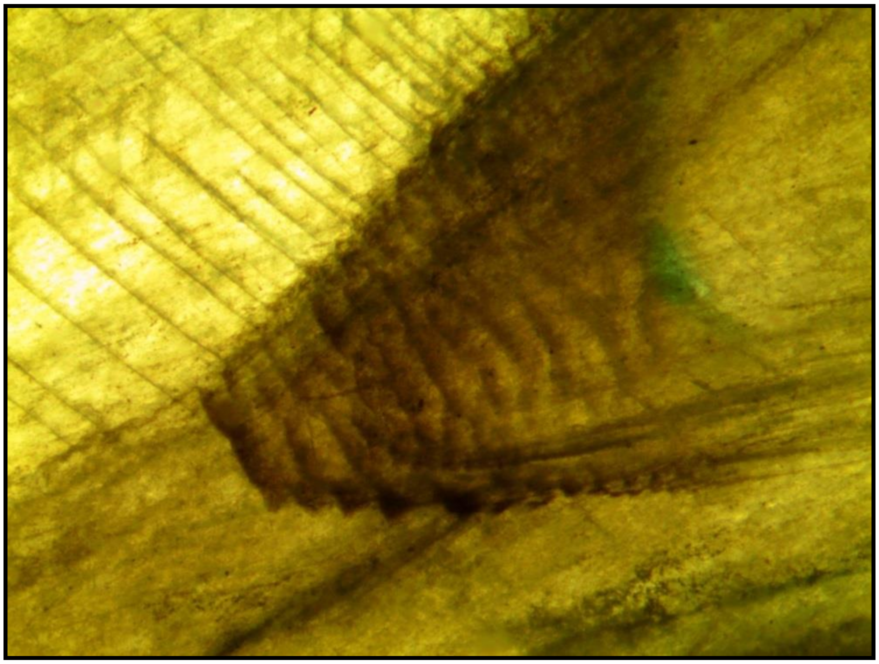
Calcite in inner crust. Cross polarization (50X)

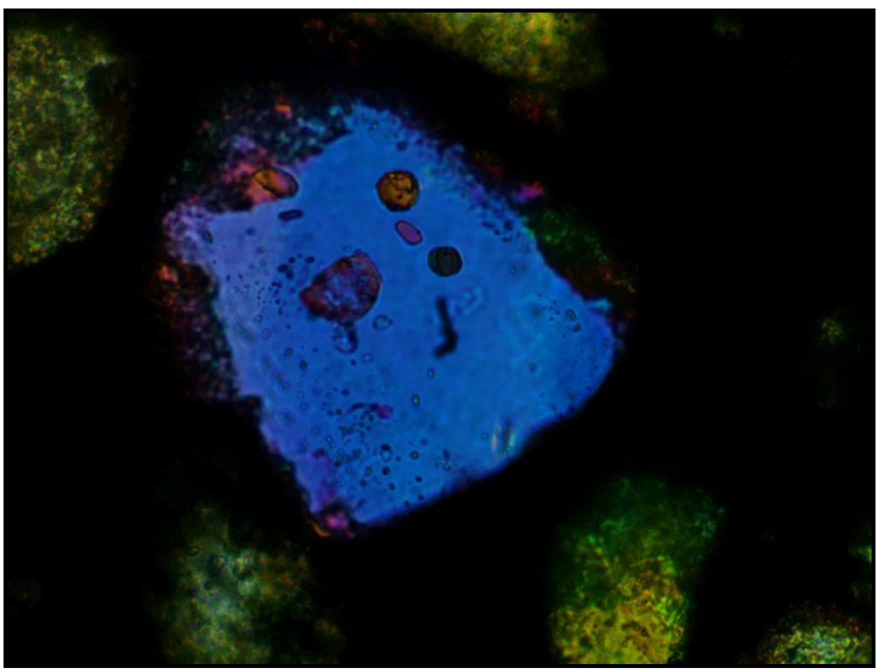


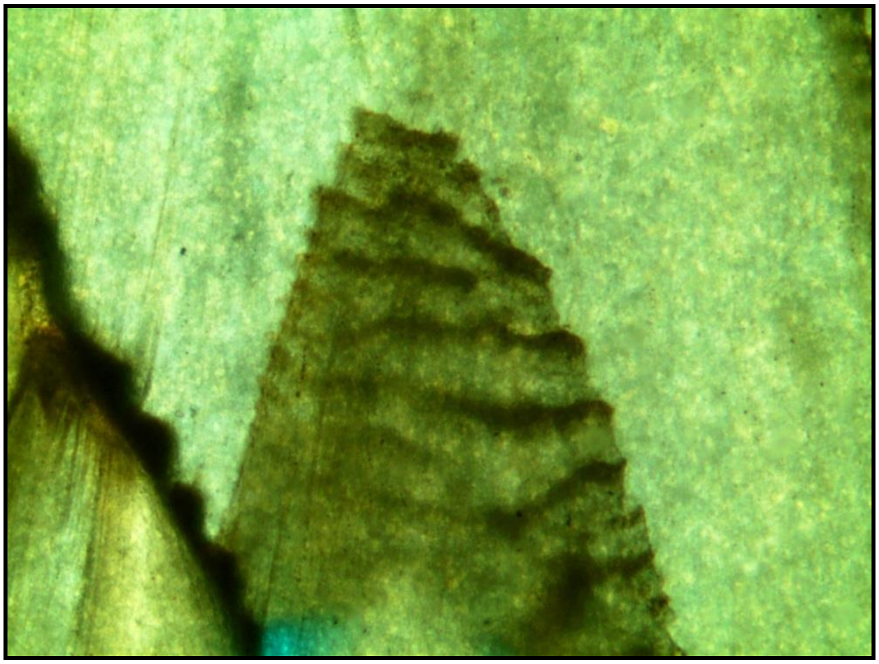
Inner crust with clay migration within the cone, normal polarization (50x)

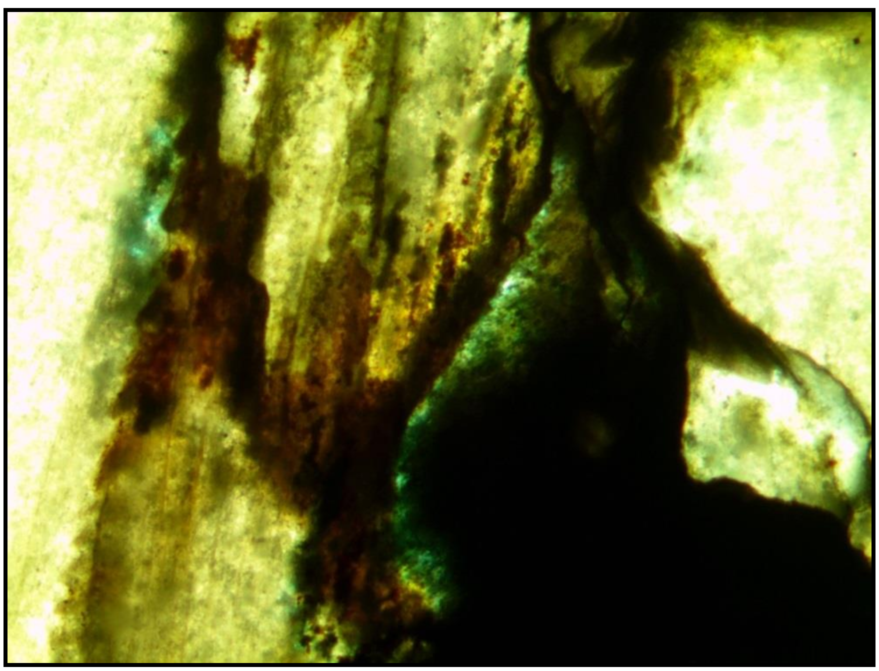

Inner crust with clay migration, cross polars

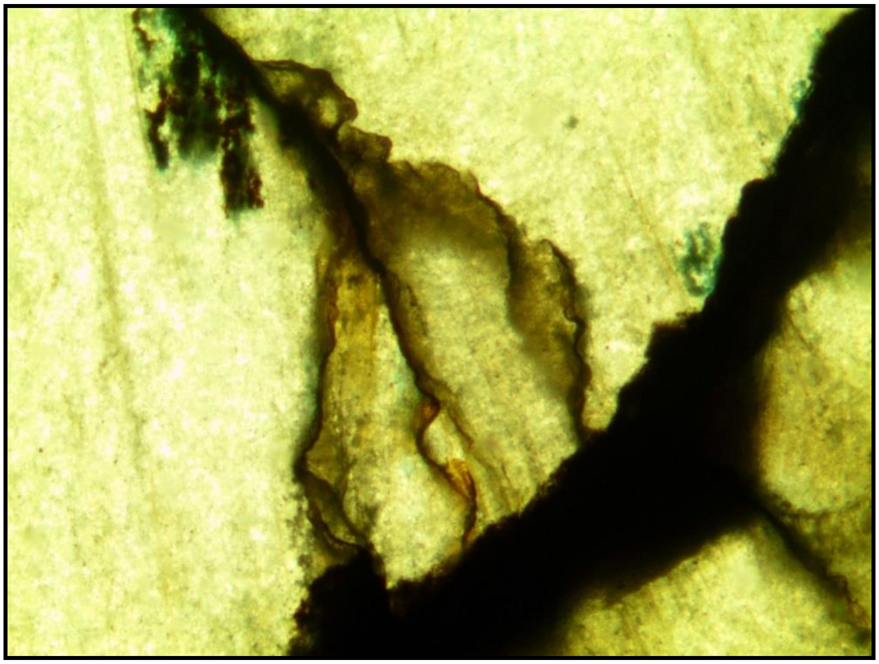

Migrating clay possibly forming cone shell within calcite in outer crust, cross polars (50x)

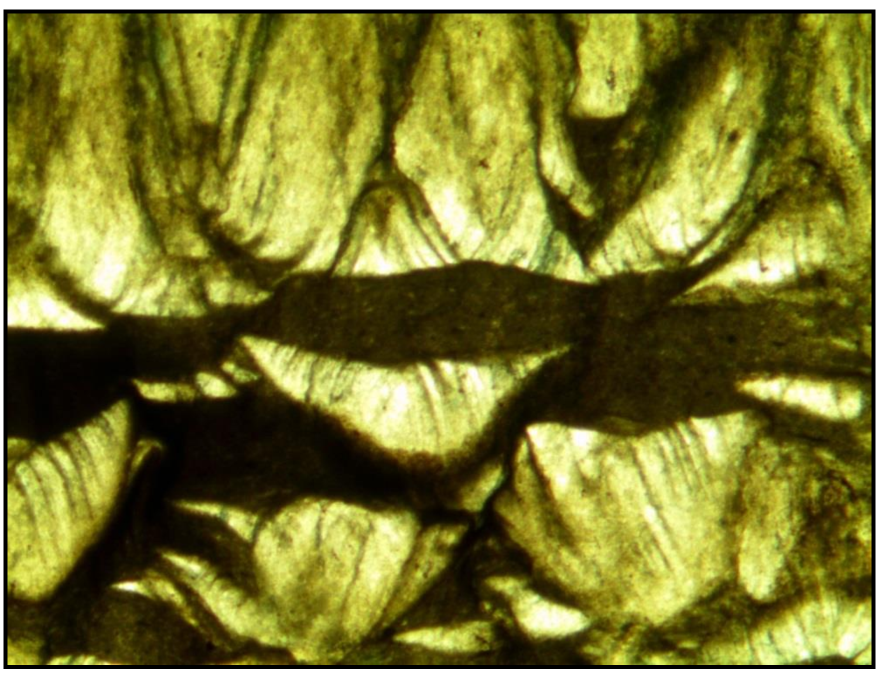

Migrating clay possibly forming cone shell within calcite in outer crust, normal polarization (50x)

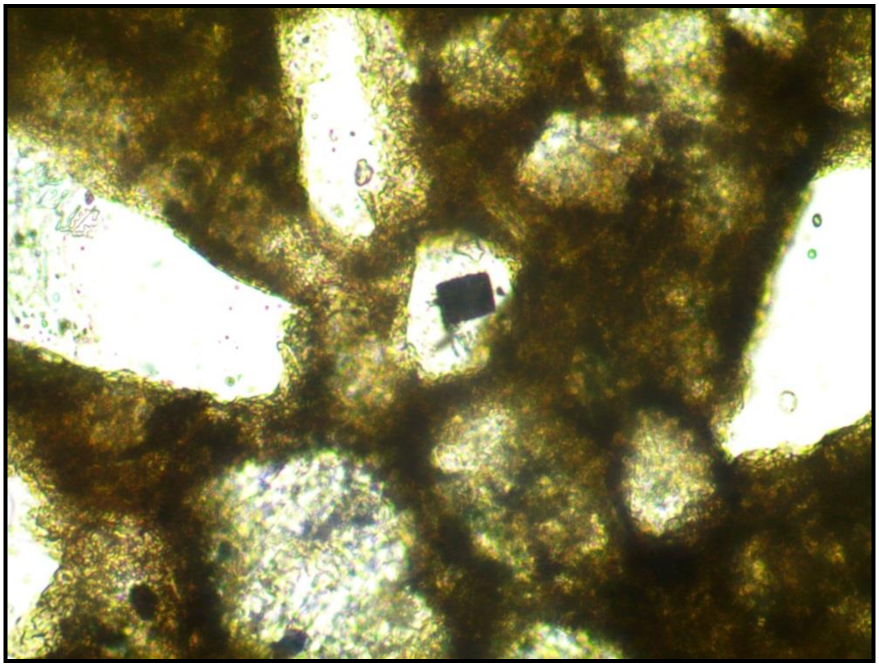

Quartz grain with inclusions (100x)


Outward migrating clay (50x)

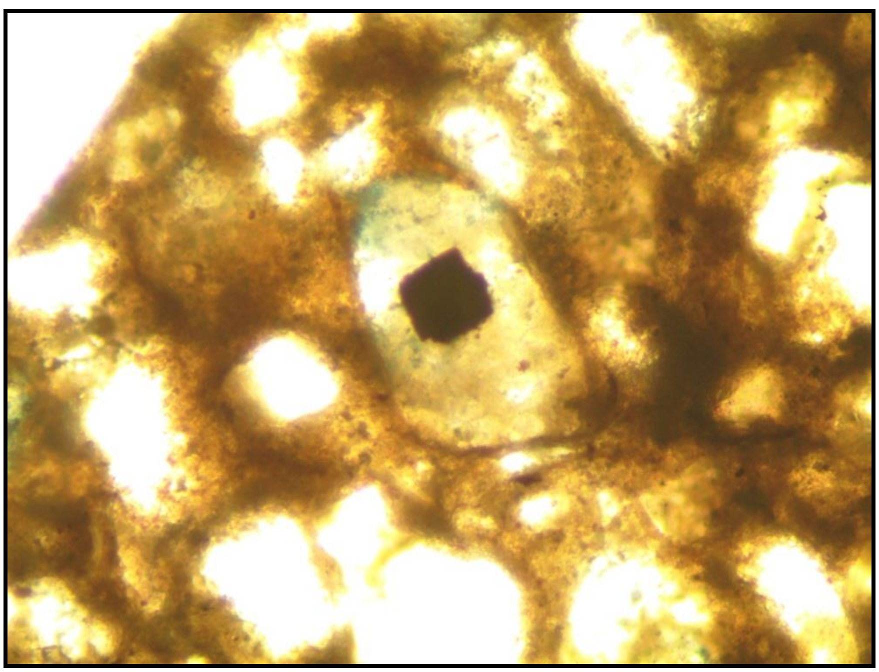

Migration of clay in outer crust (50x)


Migration of clay possibly inward toward core, late diagenetic alteration, possible stylolite (50x)

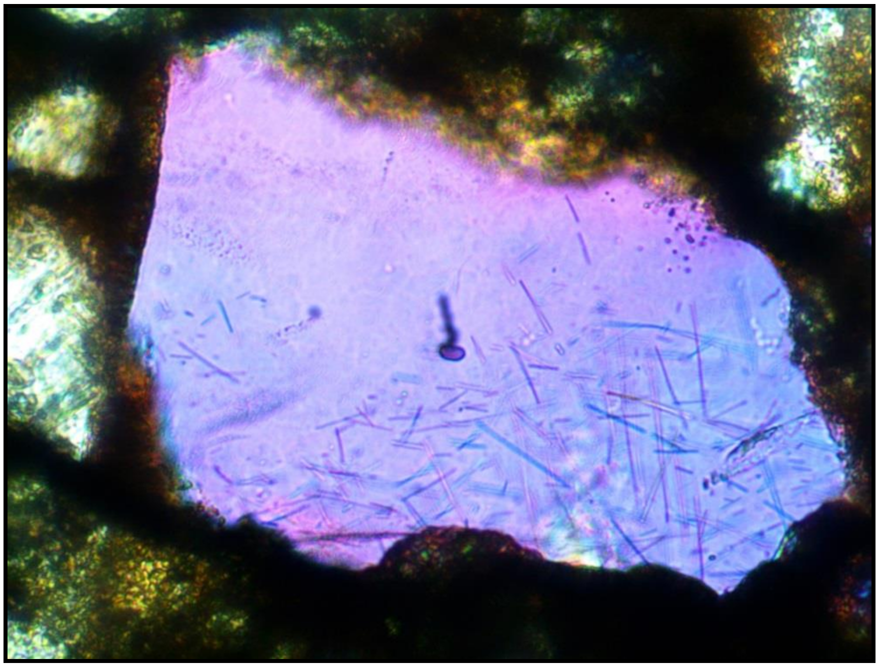

Opposite facing cones along a lenticular band from outer core. (50x)

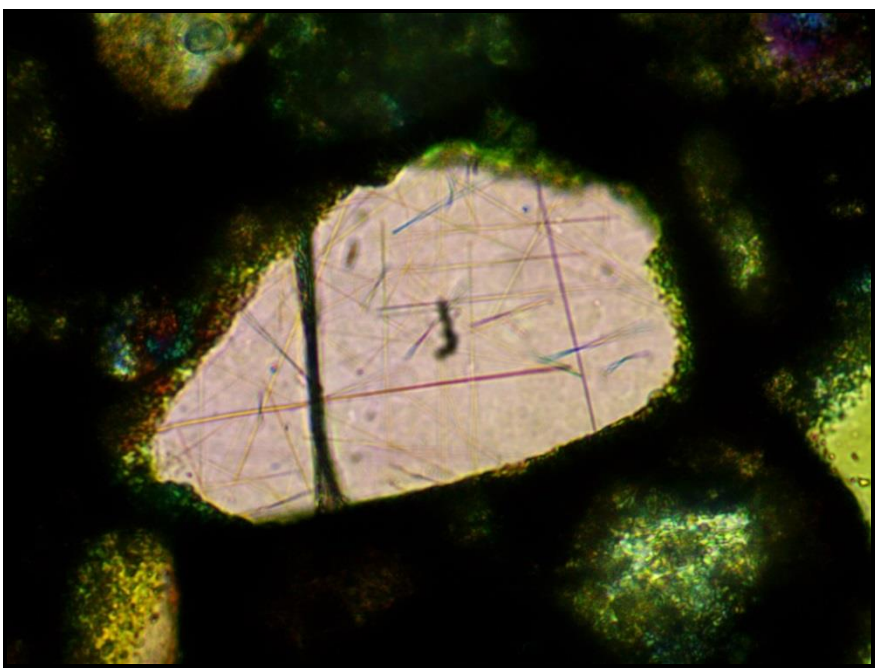


Possible pyrite inside quartz grain in inner core (100x)



Possible pyrite inside quartz grain in inner core (200x)


Rutilated quartz grain in inner core (100x)


Rutilated quartz grain in inner core (100x)

Cone in Cone Description

Specimen #: 2A

Location: McCurtain County, OK
Smithville, OK 74957
34°26'21.2"N 94°38'05.0"W

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Gross Description:

Small weathered cone in cone concretion with crustal cones on top only and a finer crustal material on bottom and partial sides. Hematitic cone shells appear less resistant to weathering as opposed to the more solidified clay fillers. Dimensions 6.5 x 3.5 x 1.75 inches. Cones range up to 0.5 inches.

Thin Section Microscopic Description:

An inner core is present with microscopic cones, cone shells and lenticular banding. Inner cones are carbonaceous although exact crystal type is hard to tell due to clay film infiltrates within cones. Lineations are not well defined. Lower crust is granular with obvious lenticular bands; cones are harder to differentiate and are microscopic at best. Hematitic staining is noted along with a cooked appearance of the lower crust. Porosity is present. Lower crust cones are microgranular calcite, possibly. Upper crust contains large grossly visible cones with cone shells containing annular rings and stylolites. Lineations are present inside cones and arranged at 45 degrees to cone shells. Also clay particulates are abundant in the cones. Cone mineralogy is mixed with twin lamellae calcite and some other unidentified form that almost appears fibrous.

Interpretation:

Carbonate is mainly disguised by clay films, cone shells are well formed and so are lenticular bands. Precipitation of dissolved carbonate formed the twinned lamellae calcite seen in the large upper crust cones. A change or position in sediment horizons likely altered the bottom of the concretion.

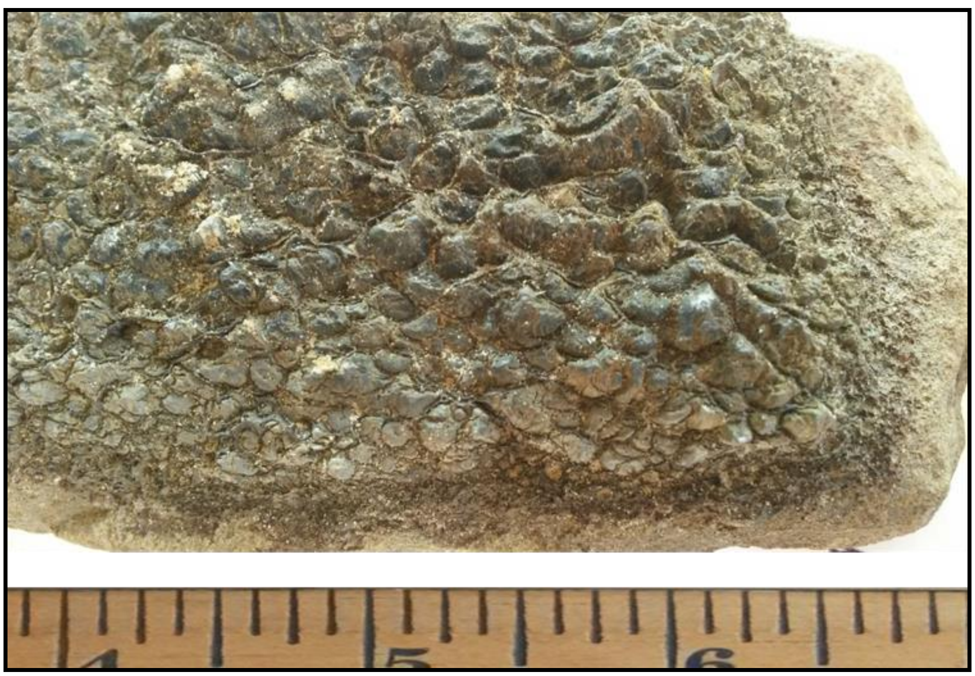
Comments:

Upper crust effervescence: Yes readily
Inner core effervescence: Yes readily
Lower crust effervescence: Yes readily
Degree of Alteration: Low

One direction of fluid pressure more prominent.

Pictures:

Bottom crust. Scale in inches.

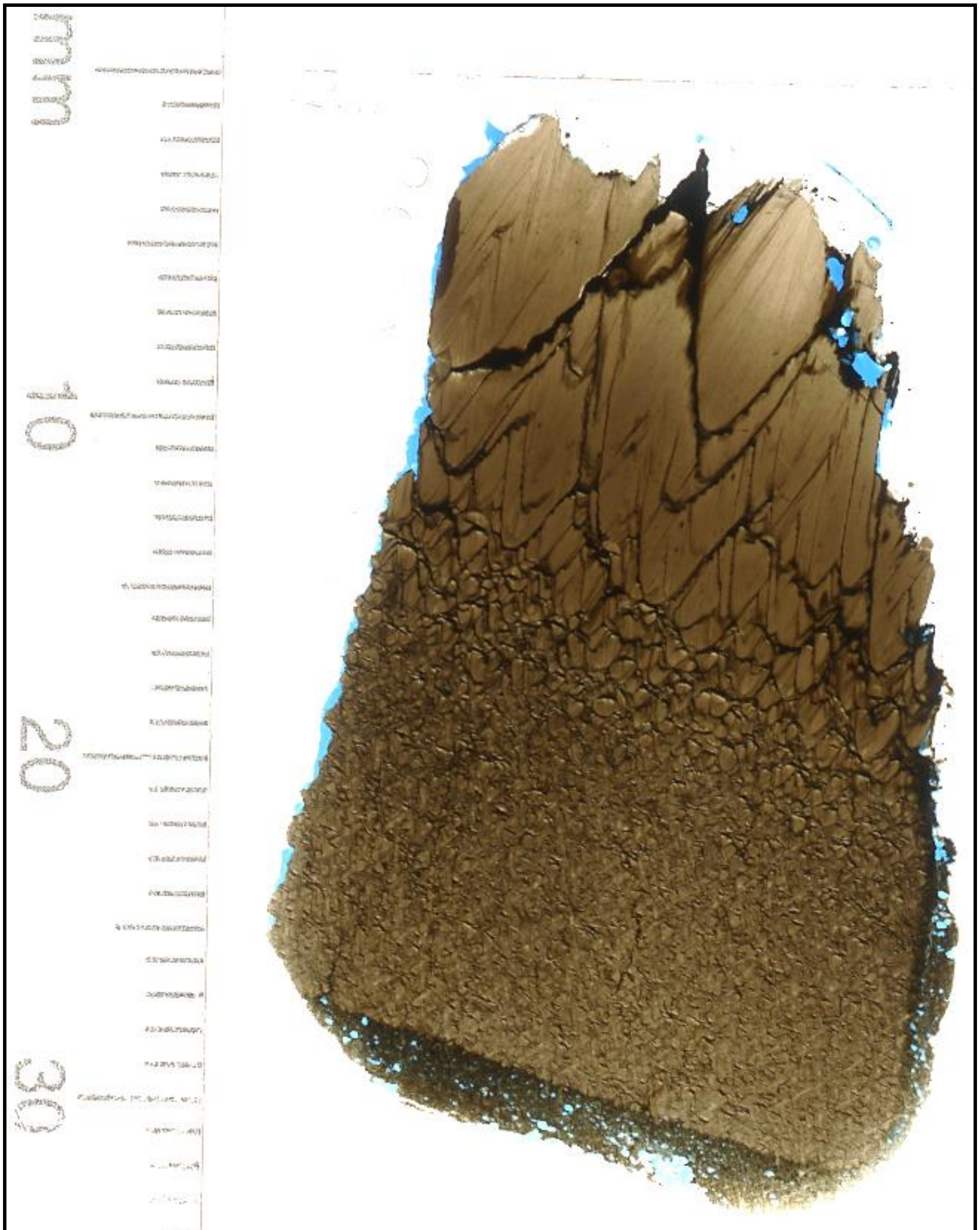


Close up view of top crustal cones. Scale in inches

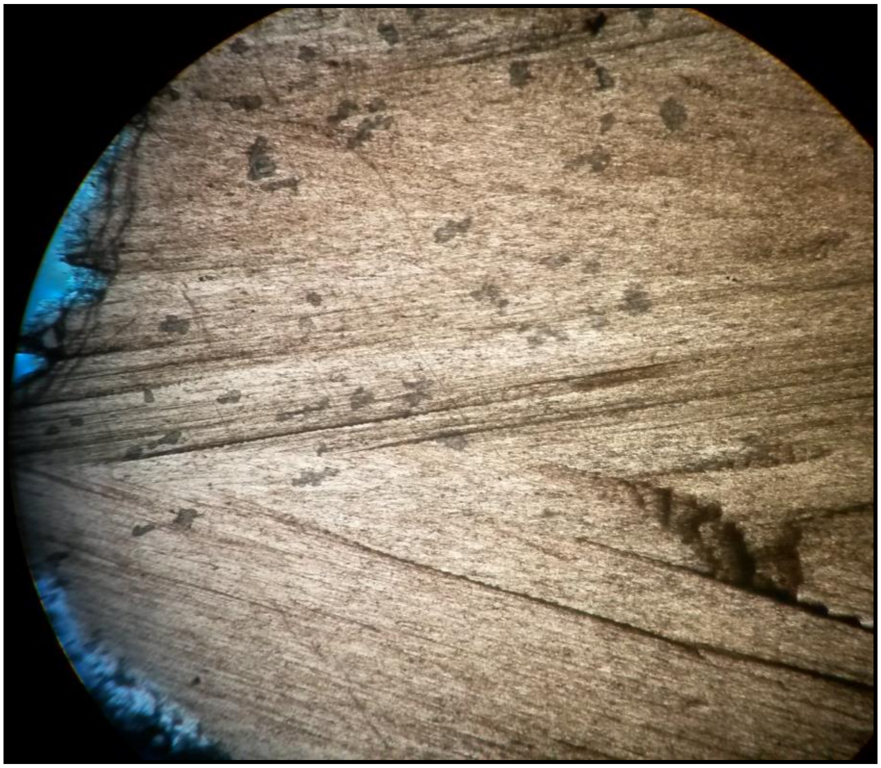
Side view of concretion showing top and bottom crust with core.
Clay fillers appear more resistant. Scale in inches.

Top crust. Scale in inches.

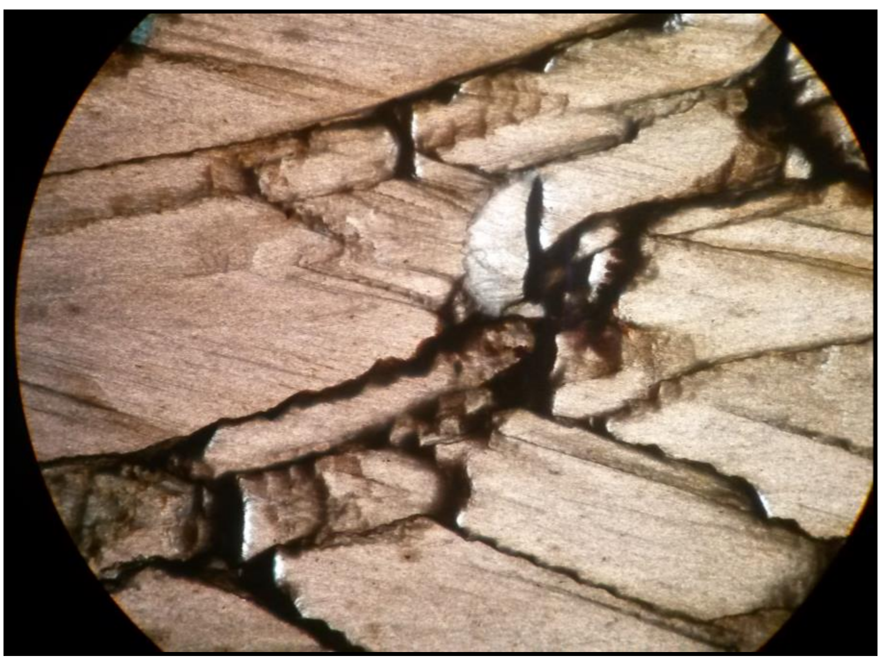
Cross section view showing upper and lower crustal differences and core. Epoxy is present on the top crust. Scale in inches.



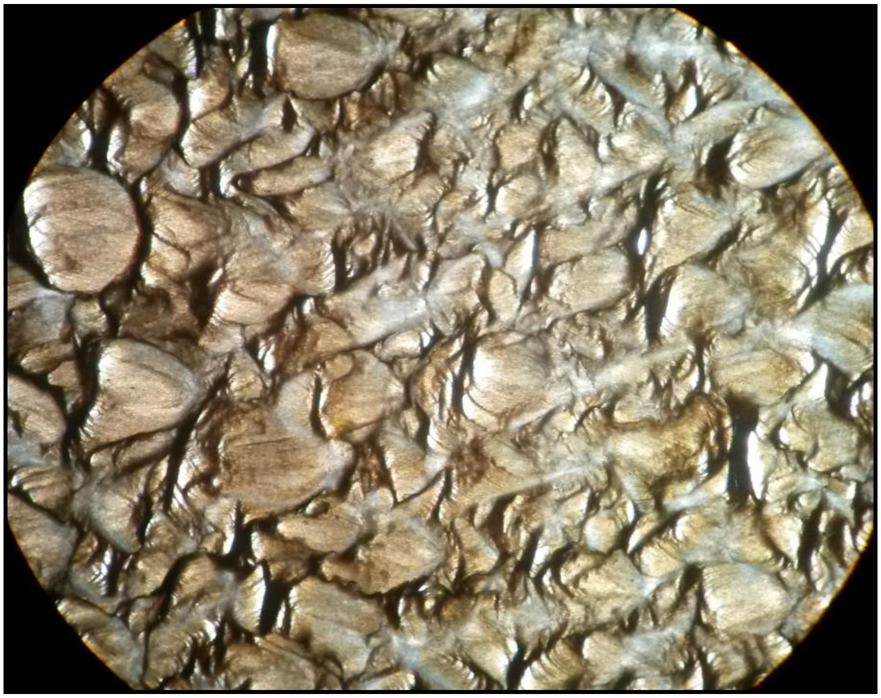
Thin section photograph of slide 1”x2”, upper crust seen at top with granular crust seen on the bottom and partial right side.



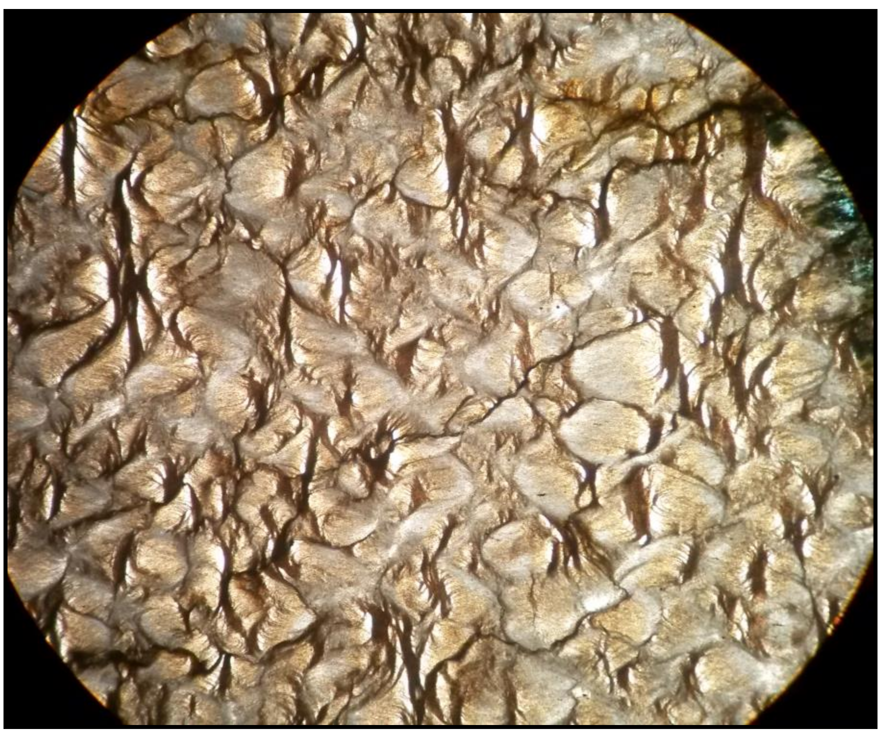
External crustal cone with linear clay features and particulates inside cone . (40x)



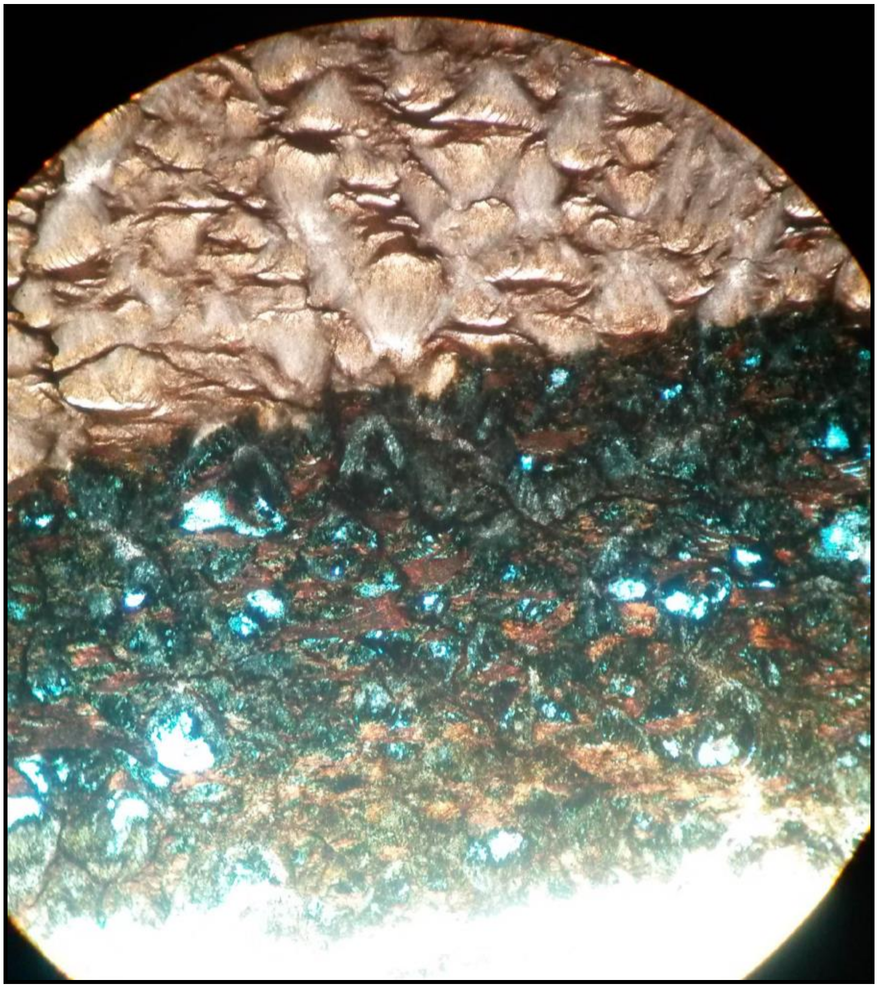
Cone shells, stylolites, annular rings, and carbonate cones in exterior crust (40x)



Microscopic interior core cones with lineations and cone shells, (40x)



Microscopic interior core cones with lineations and cone shells, (40x)


Granular lower crust boundary with lower interior core. (40x)

Cone in Cone Description

Specimen #: 2B

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County
Smithville, OK 74957
34°26'21.2"N 94°38'05.0"W

Gross Description:

Partial concretion with nearly the entire width in one direction present. Both top and bottom crust with exterior cones present, a core is noted with a semi-apparent boundary. Top crust contains hematitic cone shells with weathered or nearly absent clay fillers. Core appears to have less alteration or fluid movement. Dimension 10 x 3 x 2 inches, external cones are at most 0.25 inches.

Thin Section Microscopic Description:

Na

Interpretation:

None given

Comments:

Upper crust effervescence:
- Clay fillers: yes readily
- Hematitic cone shells: No

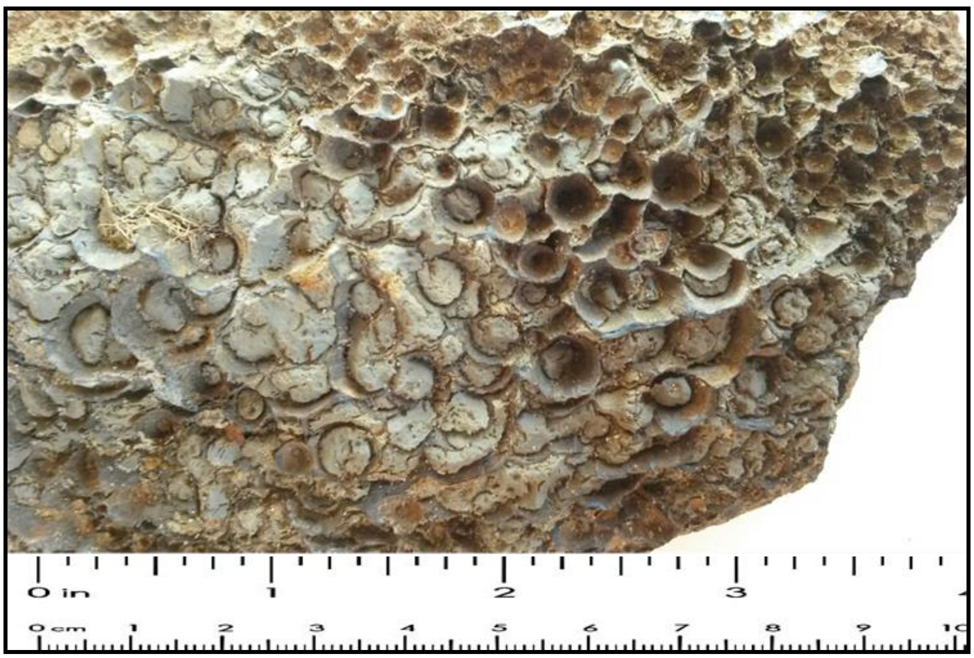
Inner core effervescence: No
Lower crust effervescence: yes, differential is most likely just clay fillers.
Degree of Alteration: moderate because of inner cone carbonate removal

Pictures:

Top view with conal crust. Scale in inches.

Bottom view with limited cone in cone structures. Scale in inches.

Bottom view. Scale in inches.



Close up view of top crust.

Cone in Cone Description

Specimen #: 2C

Location: McCurtain County
Smithville, OK 74957
34°26'21.2"N 94°38'05.0"W

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Gross Description:
Partial weathered ovoidal concretion with some smooth shale surfaces. Some surfaces contain cone in cone structures on crust. At least 6 layers of some alternating brown black and grayish brown bands running through center. A pentagonal stem is present in center and parallel with long axis of concretion

Thin Section Microscopic Description:
Na

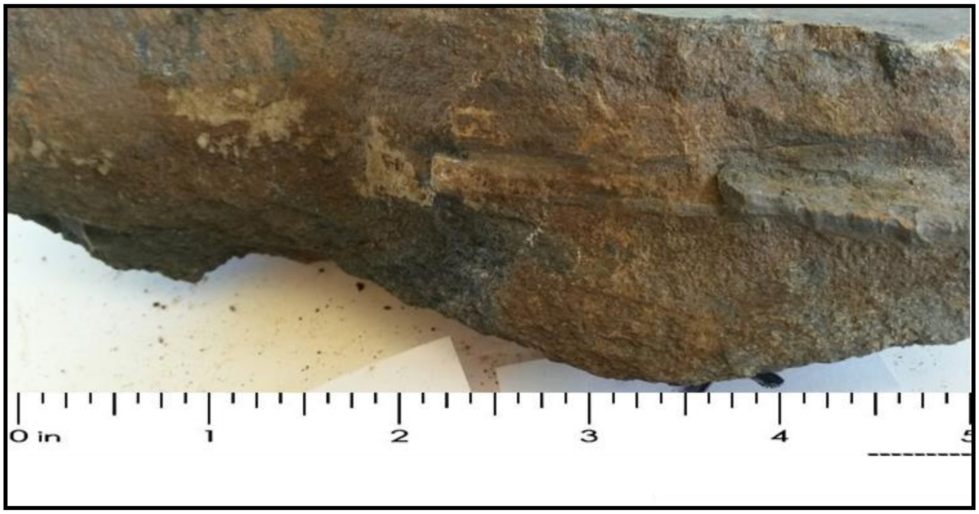
Interpretation:
None given

Comments:
Upper crust effervescence: Yes, readily
Inner core effervescence: Yes, readily
Pentagonal stem: Yes, readily
Lower crust effervescence: Yes, readily
Degree of Alteration: Low

Pictures:

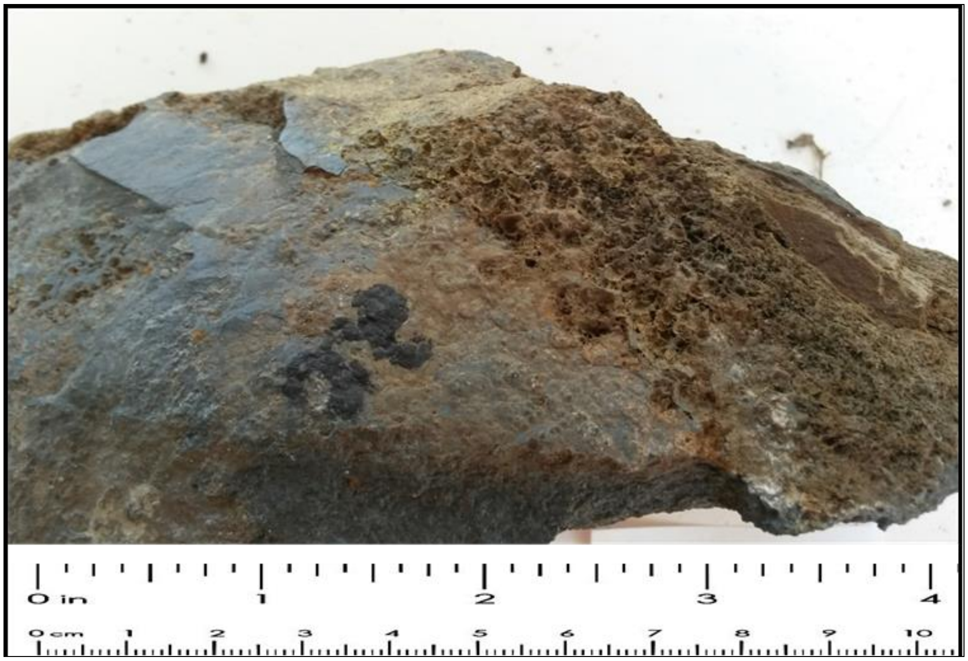
Top View; few conal structures. Scale in inches.

Banding or layers present; side view



Pentagonal stem in center of side view.

Cross section view, shows bedding.



Top surface with cone structures.

Cone in Cone Description

Specimen #: 2D

Location: McCurtain County
Smithville, OK 74957
34°26'21.2"N 94°38'05.0"W

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Gross Description:
Semi complete cone in cone concretion. Conal structures on both sides with the dominant cones on top crust. Core is present. Crustal cones do not cover the entire width of the crust but are more focused on the center of the concretion. This concretion seems to be slanted and /or twisted and not concentric. Crust contains hematitic cone shells with light green to tan clay fillers. Some cone shells seem to be forming long curved ridges present on both sides indicating a major conduit for fluid flow. Fluid pattern must have been slightly tilted or the bedding was irregular or an early soft sediment deforamtion. Some of the bottom and side crust exhibit small external cone structures.

Thin Section Microscopic Description:
Na

Interpretation:
None given

Comments:
Upper crust effervescence: clay fillers yes, shells very little
Inner core effervescence: Yes, readily
Lower crust effervescence: Yes, readily
Degree of Alteration: Low to moderate

Pictures:

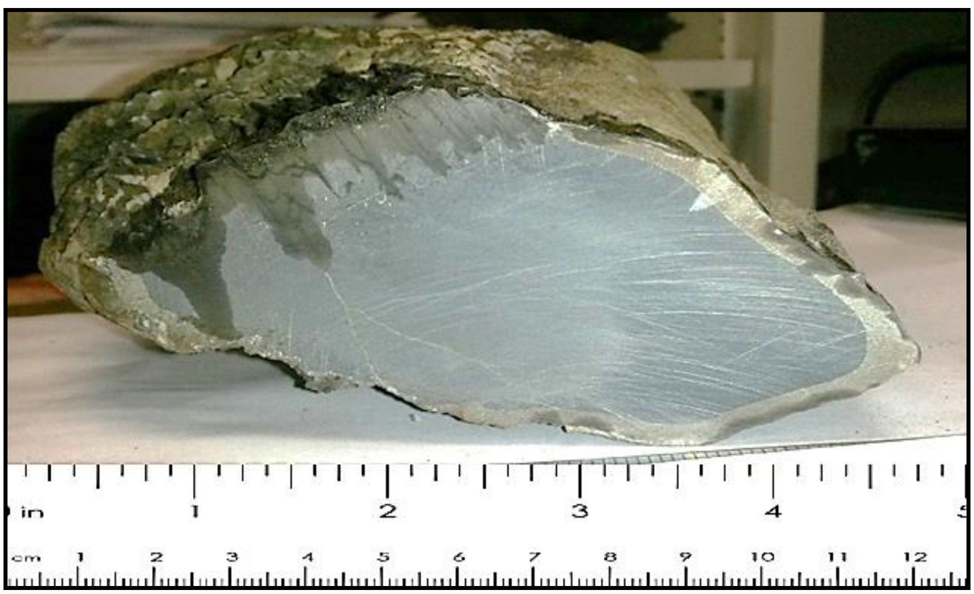

Top view showing conal structures and long curved ridges. Scale in inches.


Bottom view. Scale in inches.


Bottom view. Scale in inches.


Side view showing core and top crust. Scale in inches.

Top view. Scale in inches.



Cross section view showing wedge shaped bottom and side crust. Epoxy infiltration permeated through cone shells and fillers indicating pathways for fluid movement both inward and outward. Scale in inches and centimeters.

Cone in Cone Description

Specimen #: 2E

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County
Smithville, OK 74957
34°26'21.2"N 94°38'05.0"W

Gross Description:

Partial of a hammered out cone in cone concretion. At least 3 layers or bands of visible conal structures. Cone structures are seen on the top and bottom crust and also near the center of the core. Core is non-conformal, it consist of light tan vuggy material which is not uniform in placement. Scaley ridges are noticed in the central core area but with a shale like appearance. Conal structures are highly variable. Cone shells are hematitic or shale like which easily erodes. Clay filler are also highly variable. Core color ranges from tannish to a greenish clay material. Exterior cones are more altered and less resistant to erosion than some cone shells. The overall appearance of the concretion is abnormal. Cones are seen perpendicular and parallel to long axis of concretion. Usual concretion has cone apexes pointing toward the center of the core, where this one is much more variable.

Thin Section Microscopic Description:

Na

Interpretation:

This concretion likely was moved or slumped during early cementation creating the variable cone structure orientations and concretion type. Differential sediment accumulation also could be indicated.

Comments:

Upper crust effervescence: Yes, readily
Inner core effervescence: Yes, readily
Lower crust effervescence: Yes, readily
Degree of Alteration: low

Pictures:

Side view showing light colored core with vuggy appearance, and multiple layers of visible cone structures. Scale in inches.

Side view of top crust and with scaley shale like layer below conal structures. Scale in inches.

Side view showing multiple cone layers and variable core. Scale in inches.


Side view.

Cone in Cone Description

Specimen #: 2F

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County
Smithville, OK 74957
34°26'21.2"N 94°38'05.0"W

Gross Description:

Small broken weathered cone in cone concretion, with cones only visible on upper surface which are very small. Side and bottom crusts are most likely microscopic cones forming a porous layer. A core is present with definable boundaries. Cone shells on upper crust appear to be both shale and hematitic. Clay fillers are present but unknown composition, as they could be river sediment lodged into cone shells or incorporated clay from surrounding shale deposits.

Thin Section Microscopic Description:

Na

Interpretation:

None given

Comments:

Upper crust effervescence: Yes, readily
Inner core effervescence: Yes, readily
Lower crust effervescence: Yes, readily
Degree of Alteration: Low

Pictures:

Top view. Scale in inches.


Side view showing core

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 3A

Location: McCurtain County, OK
34°25'59.4"N 94°39'43.2"W

Gross Description:

Complete cone in cone concretion, ellipsoidal, with a thin crust on top and bottom and a central core. The bottom crust is not as defined and lacks well developed cones with shale layers possibly attached; the upper surface is composed of at least half its surface area in fully developed cones. Cone shells are tannish brown and fined grained. Clay fillers are dark gray and appear infiltrated by a secondary cementation process. A lamination process, shale like, covers cone structures on the bottom, encapsulating this area and restricting fluid movement across this boundary. There is no clear boundary between crust and core and core color extends into the exterior extruding cone shells and fillers. This concretion likely represents early fluid differential in shales due to "carbonate source" and the amount of fluid held in this sediment ("ped"). This in return causing fluid movement into undersaturated areas of the surrounding shale under non-normal pressures or when those pressures that exceed the internal pressures of the ped. The oversaturated shale/ped diverts all migrating fluids in a spherical pattern around the central source area. This process produces geometrical 3d polygons on the basis of confining beds, proximity to source areas of carbonates, and/or movement along fault beds or planes.

Thin Section Microscopic Description:

The outer crust and interior are homogeneous with only a thin shale like lenticular band composing the exterior crust. Microscopic cones are abundant in the homogeneous texture areas as well as lenticular bands and lineations. Clay lineations within the cones are parallel with cone shells near the crust while the core center contains more perpendicular lineations to the cone shells. Clay particulates and a clay film are prominent in the cone apex areas. Cones are mineralogically carbonate although a distinction of twin lamellae, microgranular calcite, or other is not evident. The bottom crust does not exhibit large cone structures and with a single layer of cones at most having their bases pointing outward towards the bottom. Most cone bases point toward the top crust.

Interpretation:

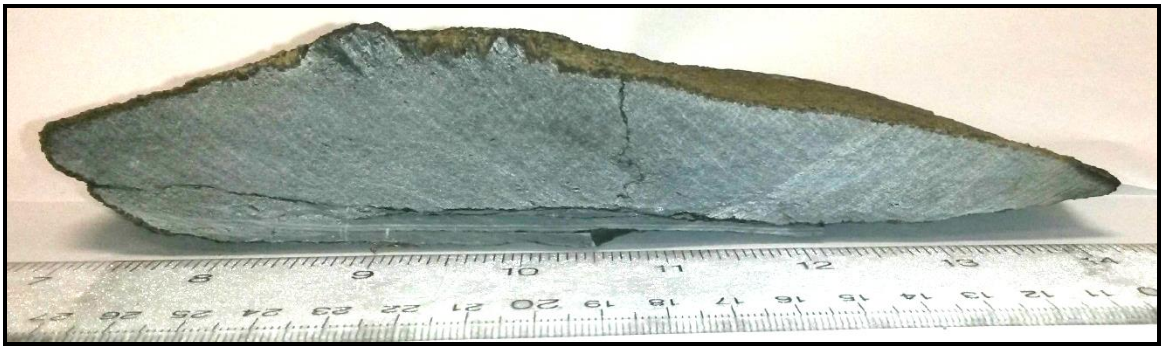
This appears to be a single event creating this concretion due to less than developed exterior cones. The change in clay lineation orientation is problematic but may indicate mild influx and dissolution of interior cones. The shale layers on the bottom are not demonstrated in thin section, but could indicate bioturbation and a better mixing of carbonate rich pore waters

Comments:

Upper crust effervescence: yes
Inner core effervescence: yes
Lower crust effervescence: yes
Degree of Alteration: Low

Pictures:

Top view before cross sectioning.



Cross section view showing an encompassing core to edge of crust. Scale in inches.

Cross section. Scale in inches.

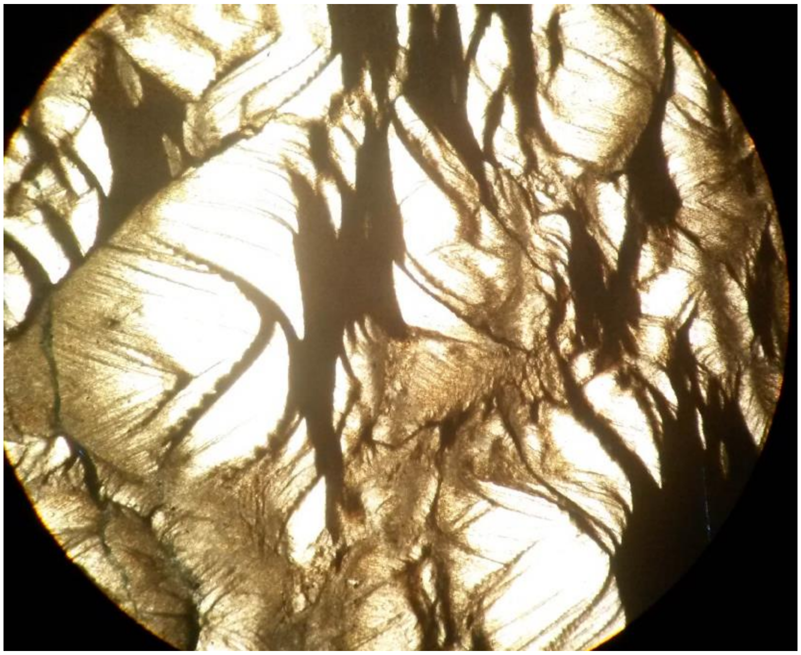
Cross section with bounding shale layer along the bottom. Scale in inches.


Bottom view of cross section: Shale layer with microscopic cone structures just above. Scale in inches.

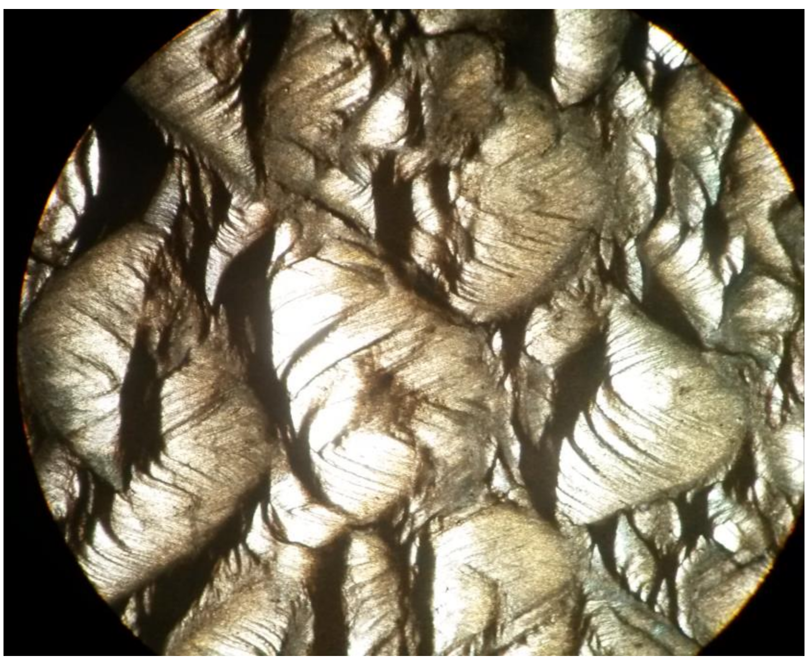
Top view of cone shells and fillers. Scale in inches.

Thin section photograph of slide, upper crust seen on left with bottom crust seen on right side. Thin section billet is from the center of concretion.


Upper shale crust with underlying slightly larger cones than interior cones (40x)



Interior cones, lineations, lenticular bands and annular rings (40x)



Interior cones, lineations, lenticular bands and annular rings (40x)

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 3B

Location: McCurtain
34°25'59.4"N 94°39'43.2"W

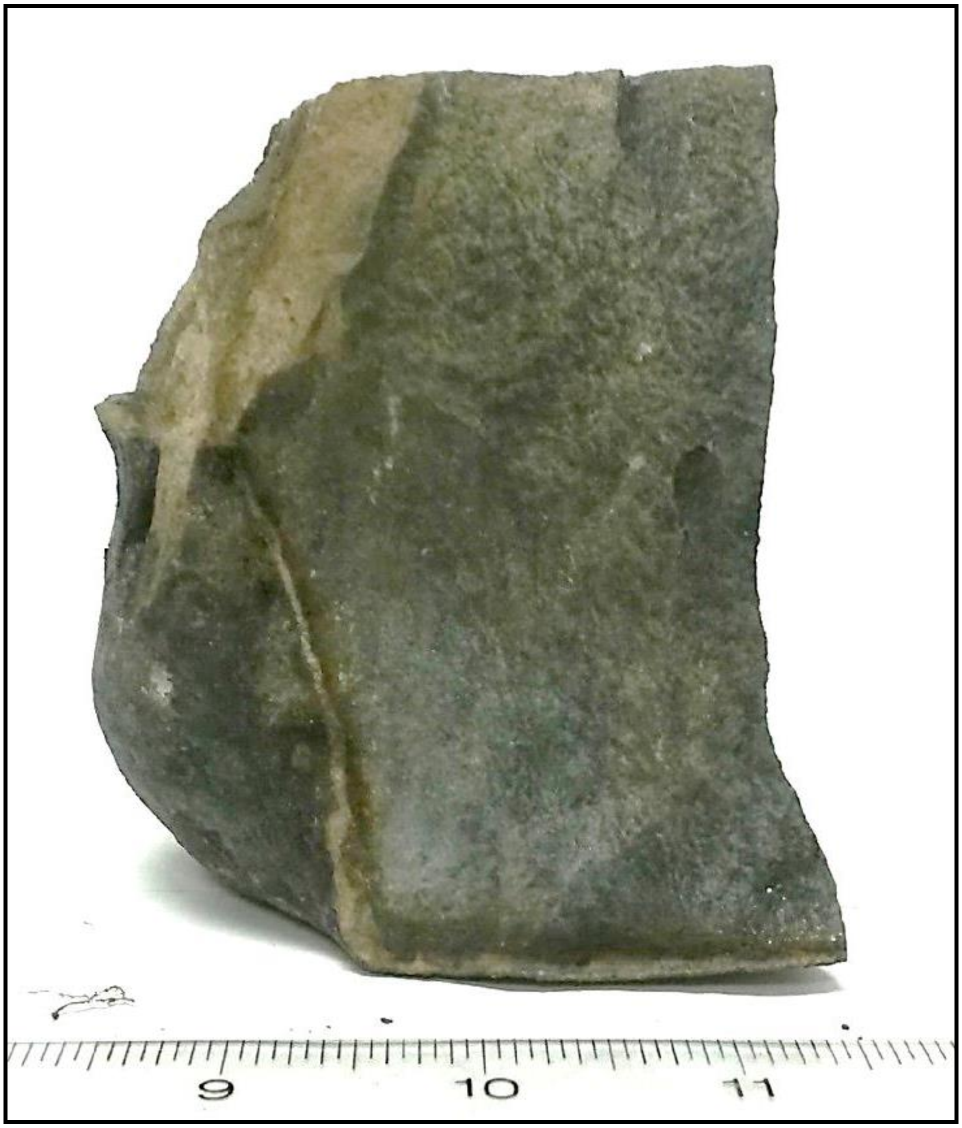
Gross Description:
A piece of nodule or concretion, no visible cone in cone, but it does have a crust along the bottom and sides. Crust is banded with possibly an iron cement with a shale/slate like core giving the specimen a halo effect.
Dimensions are 3.25 x 4 x 3 inches. No further work will be done on this one.

Microscopic evaluation:
Na

Interpretation:
None given

Comments:
Upper crust effervescence: no
Inner core effervescence: no
Lower crust effervescence: no
Degree of Alteration: none given

Pictures:



Side view. Scale in inches.

Cone in Cone Description

Specimen #: 3C

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County, OK
34°25'59.4"N 94°39'43.2"W

Gross Description:

Not a concretion, Stanley shale sample, found near sample 3A. Dimensions 4.5 x 2.5 x .75 inches. On the exterior or bedding plane, a few extruding shapes appear to be fossils, possibly bryozoans. The interior effervesces readily while the exterior does not. The interior has whitish aphanitic texture with a light gray matrix.

Interpretation:

None given

Comments:

Carbonate present; read gross description.

Pictures:


Bottom view? Scale in inches.

Side view showing carbonate rich shale in the core center. Scale in inches.

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 4A

Location: McCurtain County, OK
34°25'14.6"N 94°40'05.2"W

Gross Description:

Small fragment of a much larger flat elliptical cone in cone concretion with crust and core. Cone shells on crust are small with the core extending to the edge of crust which measures 1 mm. There is a small amount of iron or manganese staining on the bottom crust along with a white crusty patchwork layer. Core is gun metal gray and slightly granular. Exterior cone shells and fillers are almost indistinguishable.

Thin Section Microscopic Description:

The outer crust and interior are homogeneous with only a thin shale like lenticular band composing the exterior crust. Microscopic cones are abundant in the homogeneous texture areas as well as lenticular bands and lineations. Clay lineations within the cones are parallel with cone shells near the crust while the core center contains more perpendicular lineations to the cone shells. Clay particulates and a clay film are prominent in the cone apex areas. Cones are mineralogically carbonate although a distinction of twin lamellae and microgranular calcite is not evident. The bottom crust does not exhibit large cone structures and with a single layer of cones at most having their bases pointing outward towards the bottom.

Interpretation:

This appears to be a single event creating this concretion due to less than developed exterior cones. The change in clay lineation orientation is problematic but may indicate mild influx and dissolution of interior cones.

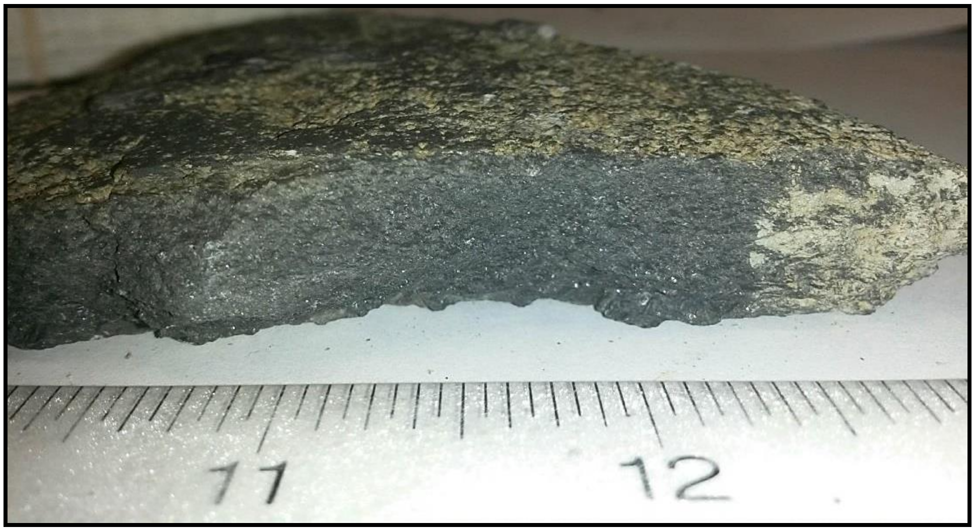
Comments:

Upper crust effervescence: yes
Inner core effervescence: yes
Lower crust effervescence: yes
Degree of Alteration: low

Pictures:

Top view. Scale in inches.

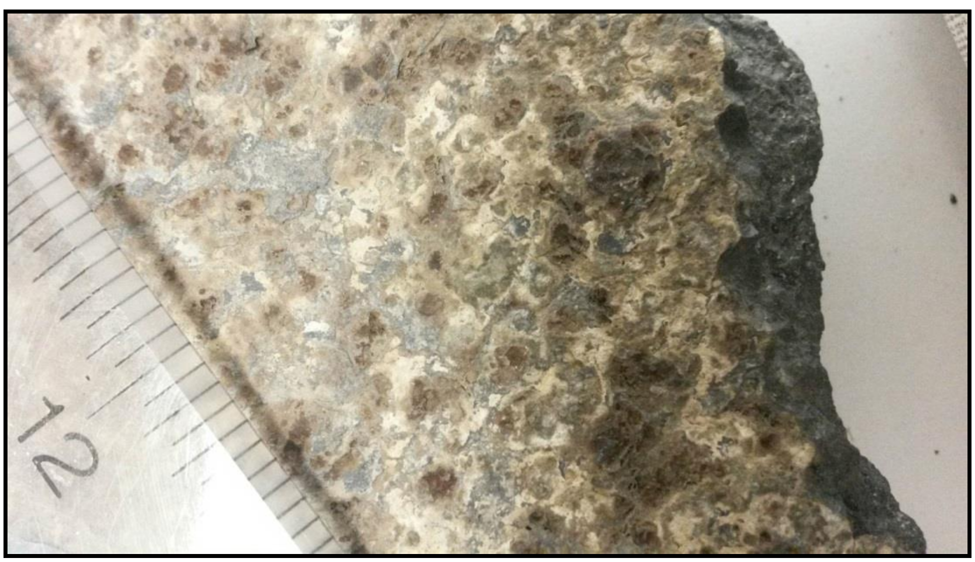
Top view. Scale in inches.



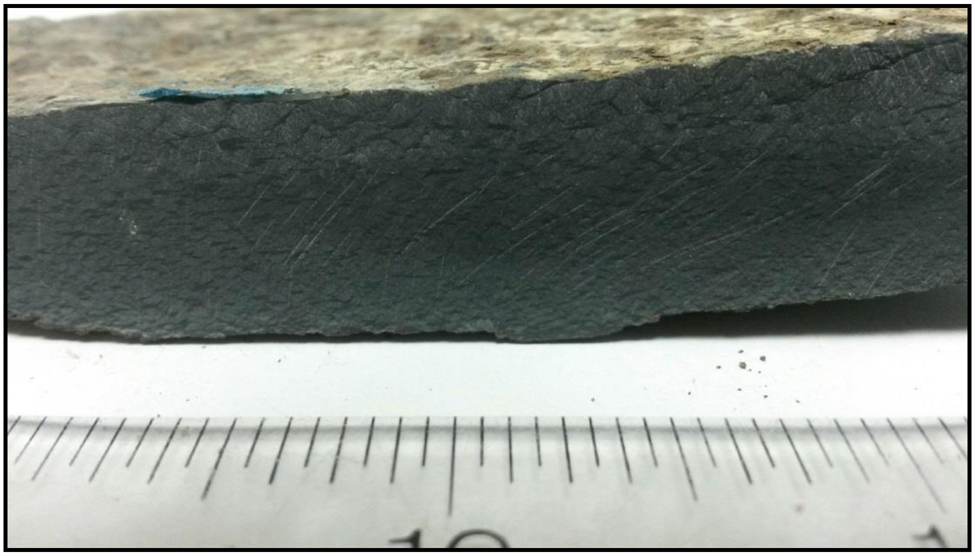
Side view. Scale in inches.

Cross section view. Scale in inches.

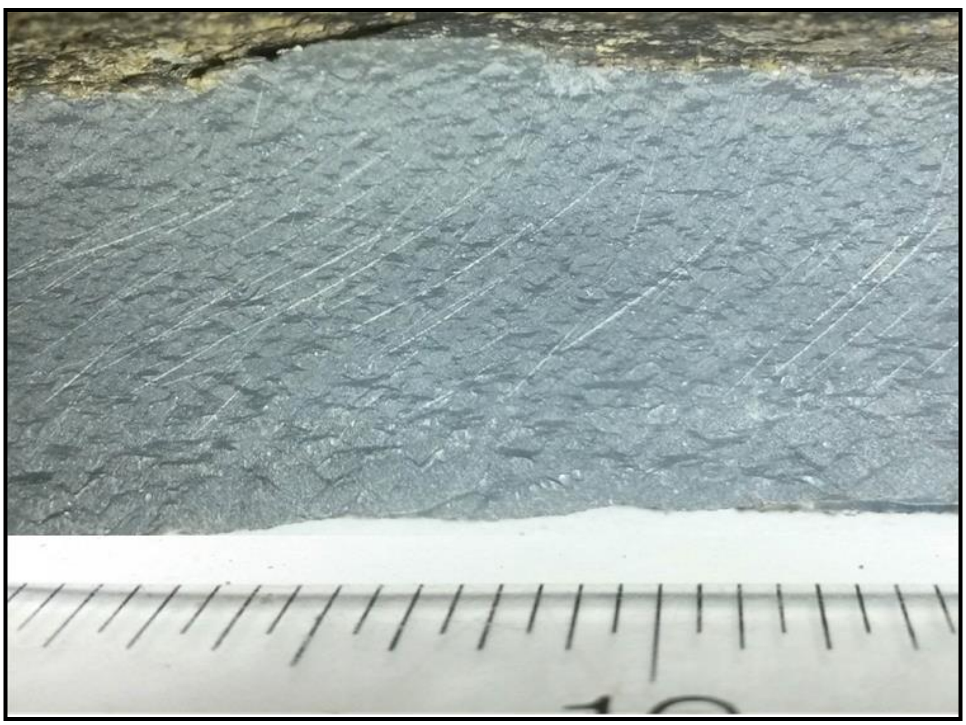
Bottom view exhibiting white crusty material and iron staining. Scale in inches.



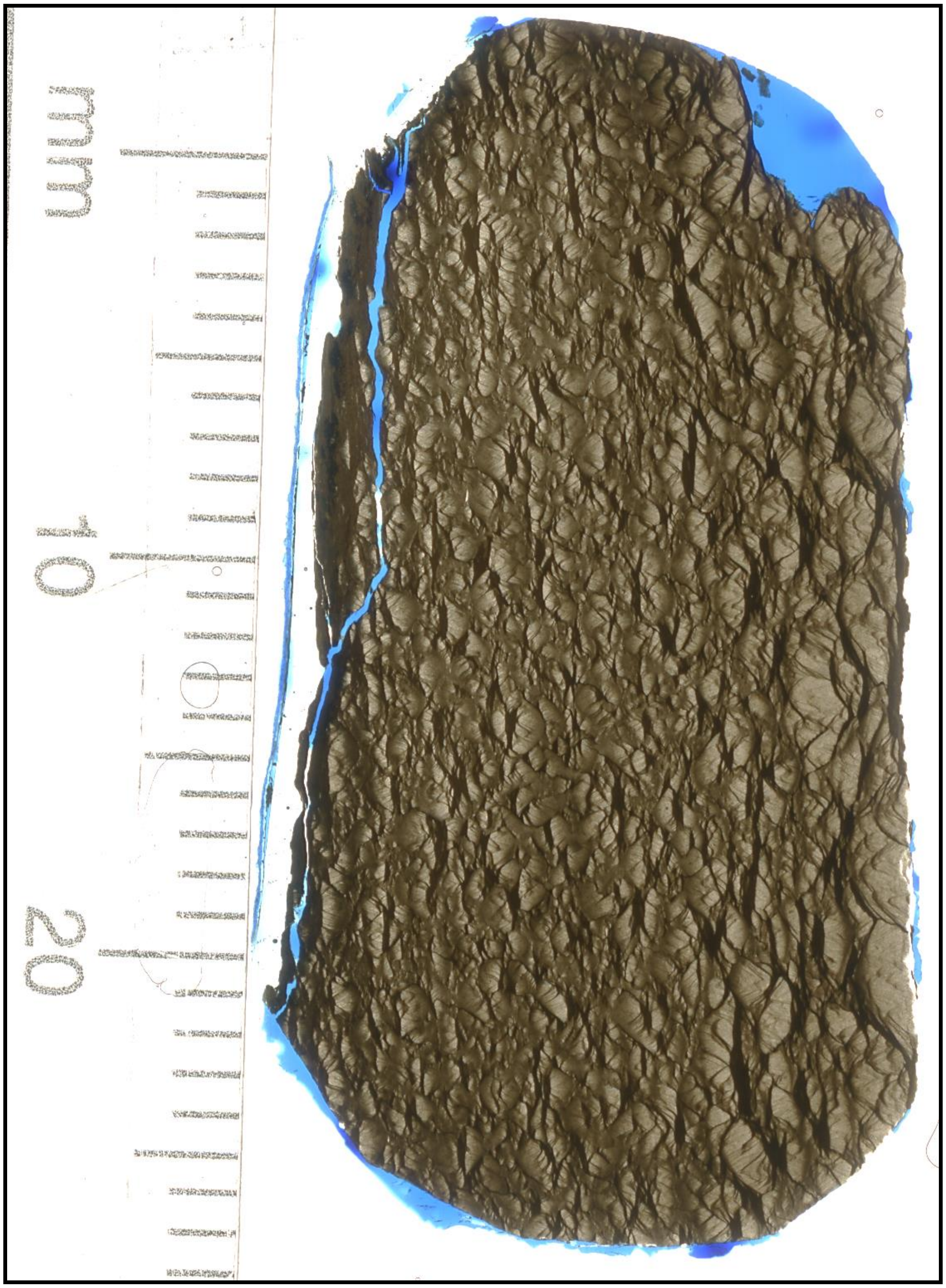
Close up of bottom view. Scale in inches.



Side view showing larger cones with no clear boundary with core. Scale in inches.

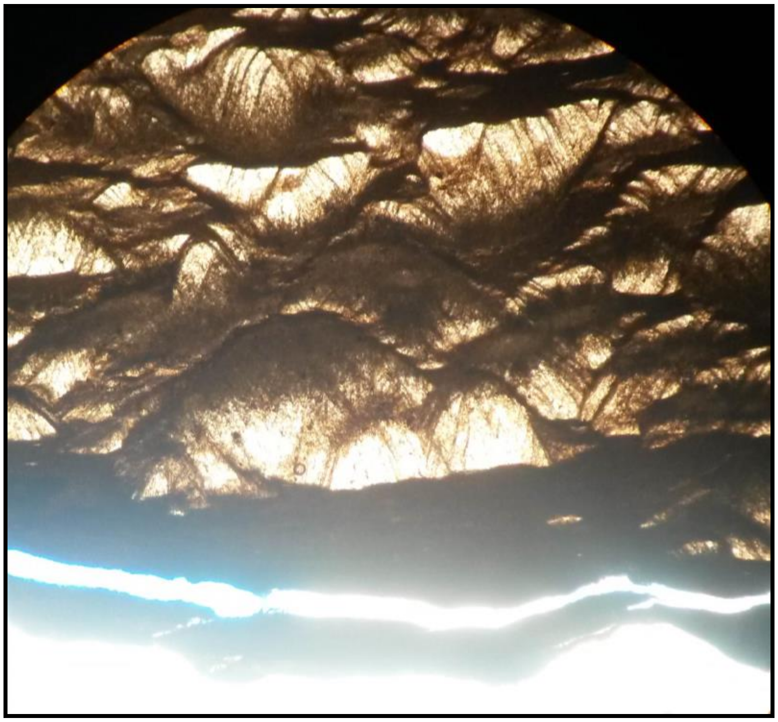


Side view showing homogeneous interior with lenticular bands as dark areas. Scale in inches



Thin section photograph of slide 1”x2”, upper crust seen on right with bottom crust on left side. Thin section billet taken from tapered edge of concretion. 4AE

Thin section photograph of slide 1"x2", upper crust seen on left with bottom crust on right side.Thin section billet taken from middle of concretion. 4AM


Bottom shale outer crust and single layer of cone bases pointing toward it. (40x)


Interior cones, lenticular bands, and cone shells. (40x)

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 4B

Location: McCurtain County, OK
34°25'14.6"N 94°40'05.2"W

Gross Description:
Partial cone in cone concretion with cones visible on both top and bottom surfaces. Crust is thin less than 2mm. Cone shells are slightly hematitic with partial dark gray clay fillers. Core is homogeneous and composes the entire thickness minus the 1-2 mm crust. A noticeable dark gray lenticular pattern is seen amongst the gray shale like matrix.

Thin Section Microscopic Description:
The outer crust and interior are homogeneous with only a thin shale like lenticular band composing the exterior crust. Microscopic cones are abundant in the homogeneous texture areas as well as lenticular bands and lineations. Clay lineations within the cones are parallel with cone shells near the crust while the core center contains more perpendicular lineations to the cone shells. Clay particulates and a clay film are prominent in the cone apex areas. Cones are mineralogically carbonate in the interior while the exterior larger cones contain some twin lamellae.

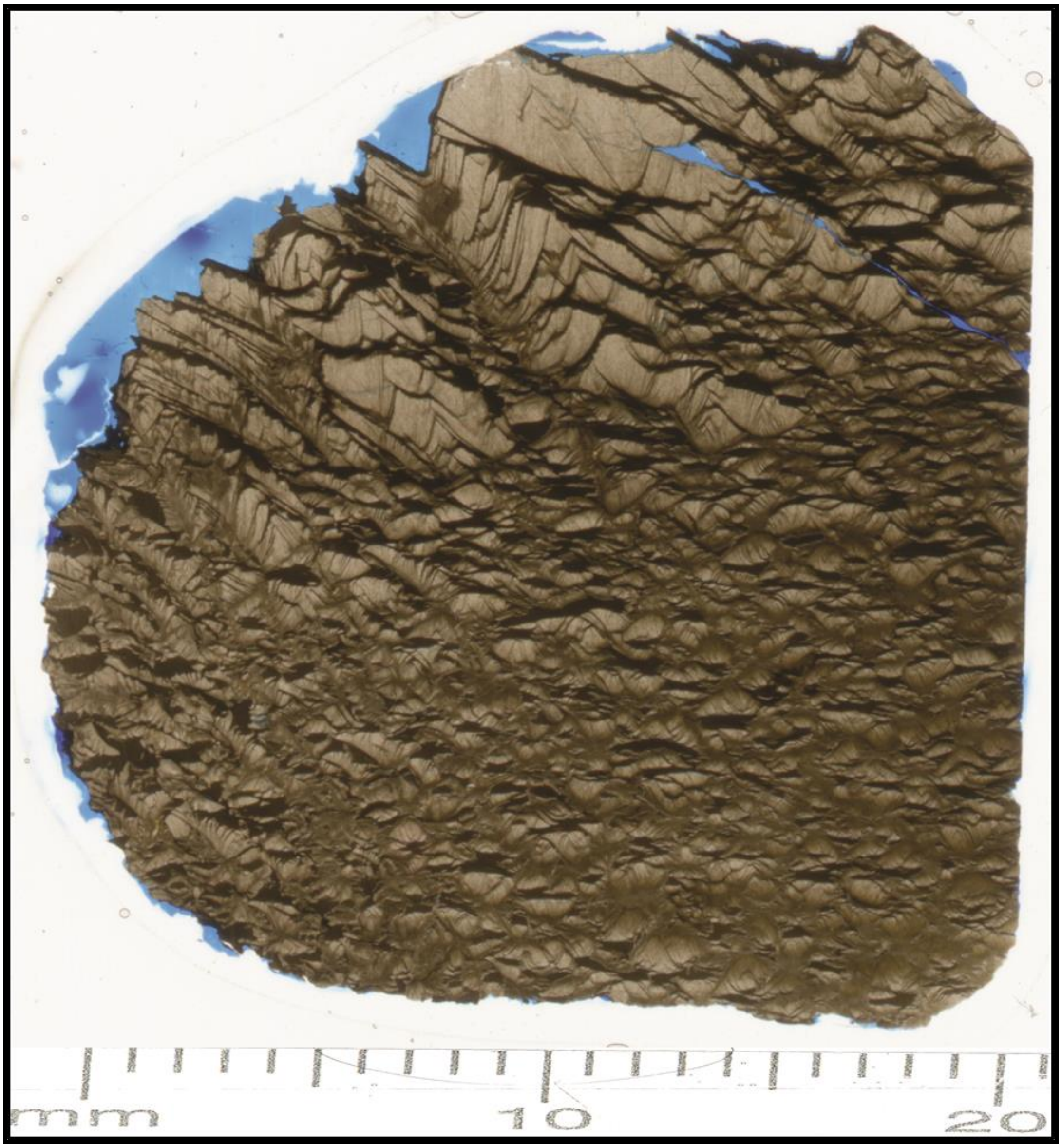
Interpretation:
The presence of twinned lamellae and larger cones on the upper surface indicates some dissolution of the carbonate and re-precipitation as the larger cones. Stylolites may be present.

Comments:
Upper crust effervescence: Slight
Inner core effervescence: yes
Lower crust effervescence: slight
Degree of Alteration: low to moderate, weathering may have reduced crustal carbonate

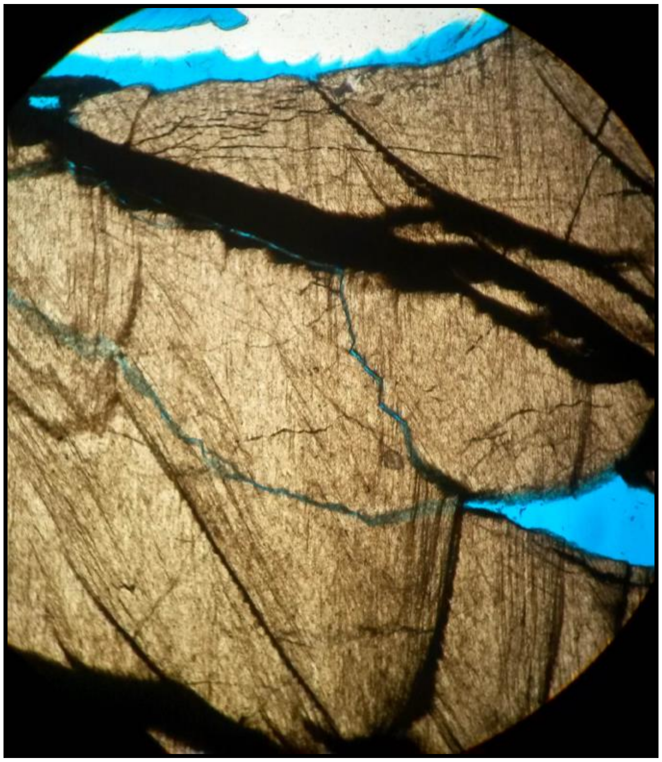
Pictures:

Top view showing well developed conal structures. Scale in inches.

Cross section view showing core and thin crust. Scale in inches.

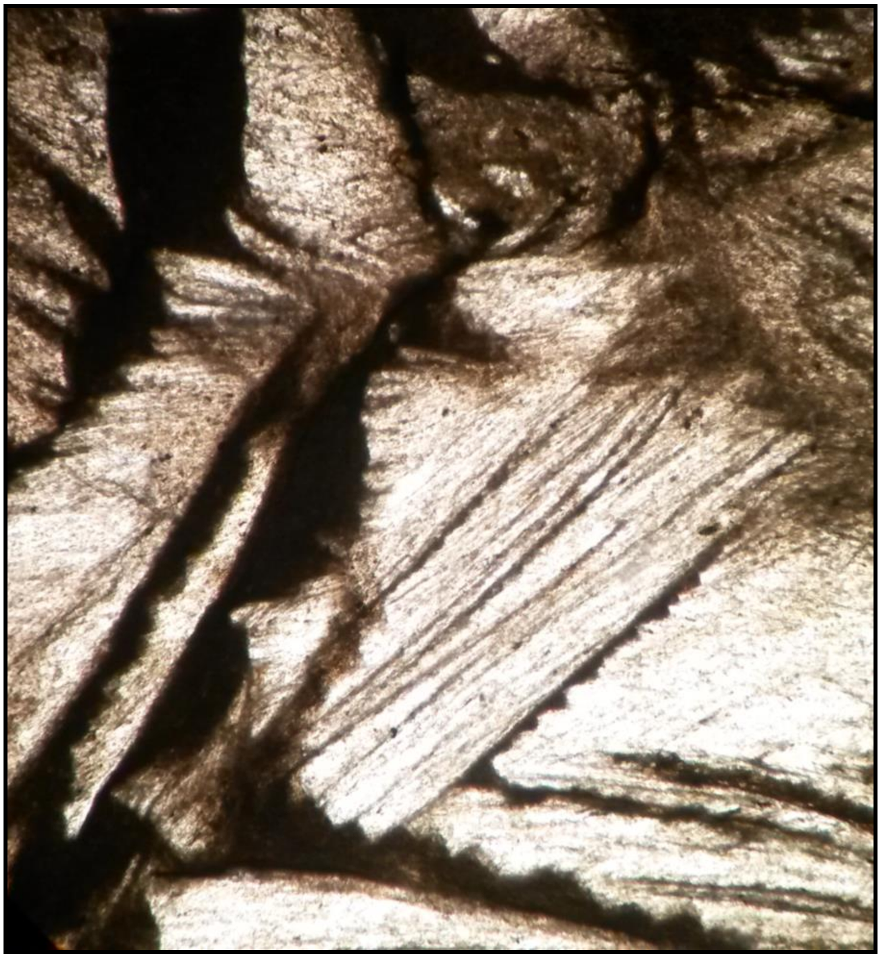


Thin section slide photograph 1”x2”; lower crust on bottom, upper crust on top. This is from the tapered edge of concretion.



Exterior cone and cone shells with annular rings, twinned lamellae calcite (40x)

Interior cones, lineations, lenticular bands. (40x)



Interior core area with peculiar striping corresponding with annular rings in bottom middle region of microphotograph. (100x). This area is near the edge where cone structure is more random, cone axes are not always vertical.

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 5A

Location: McCurtain County, OK
34°31'44.7"N 94°41'18.1"W

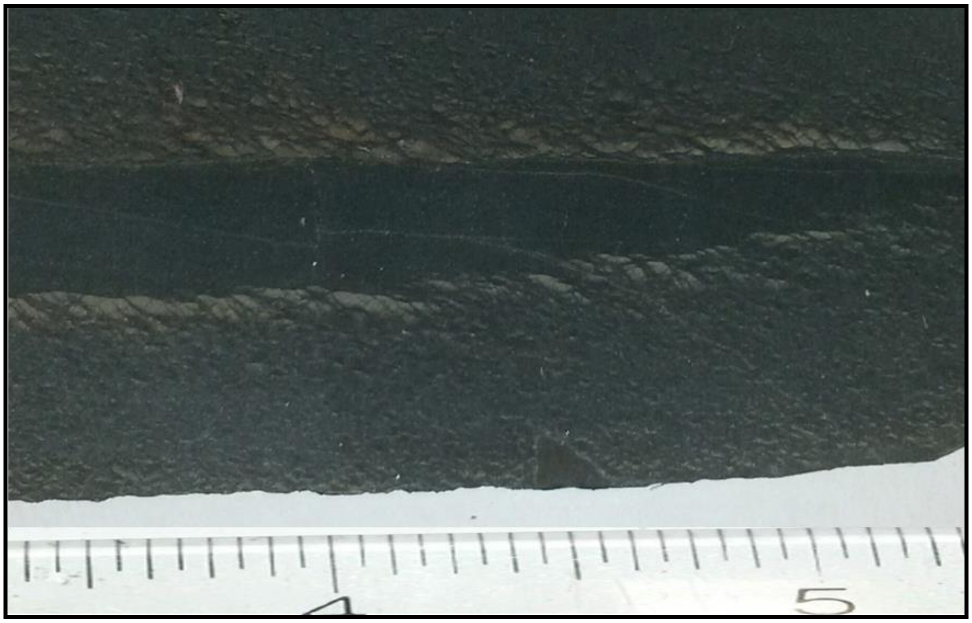
Gross Description:
An ellipsoid concretion with smooth outer surface. No conal structures present on exterior. There is a crust with a core noticeable because of the exfoliating nature of shale crust. Crust appears to be shale with slight fissility. Dimensions 8 x 6 x 2.4 inches. After cross sectioning the concretion, 2 elliptical bands become apparent within the interior. Both bands have cone in cone structure surrounding a dark gray shale like core with clear separation of boundaries. One band is of greater thickness and stretches the entire length of the concretion. Dimensions of larger band 0.75 x 5.8 inches, smaller is 0.25 x 4 inches. The planes separating these conal structures and the core have a scaley texture. Cones bases point inward toward the dark lenses which is stark contrast to all other concretions.

Thin Section Microscopic Description:
Na

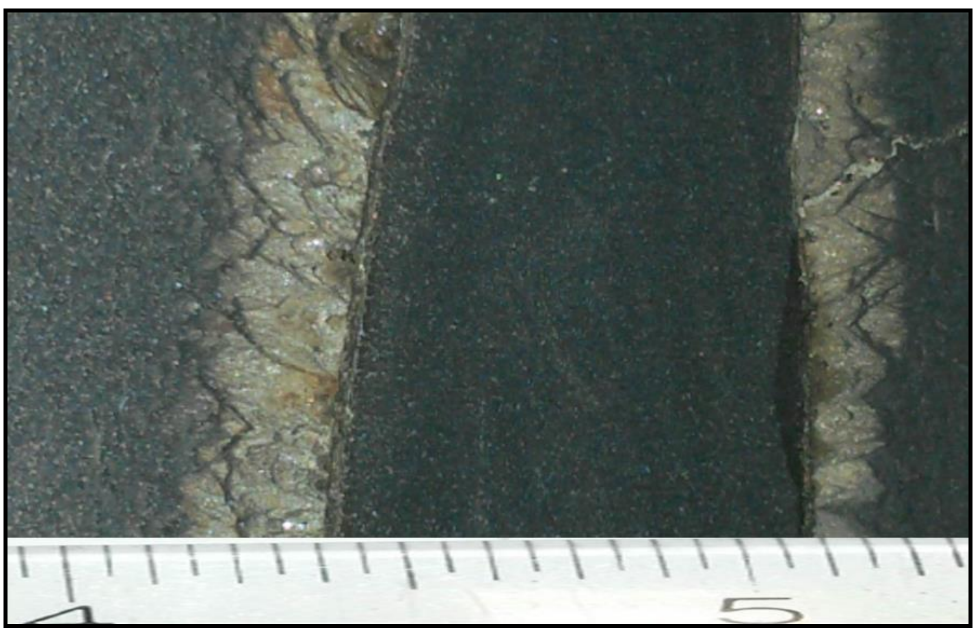
Interpretation:
Na

Comments:
Upper crust effervescence: No
Inner core effervescence: No
Large cone structures in cores non-iron stained: No
Large cone structures in cores iron stained: Slight
Lower crust effervescence: No
Degree of Alteration: Moderate to High

Pictures:



Thin band of cone in cones around dark inner “inner” core lens. Scale in inches.



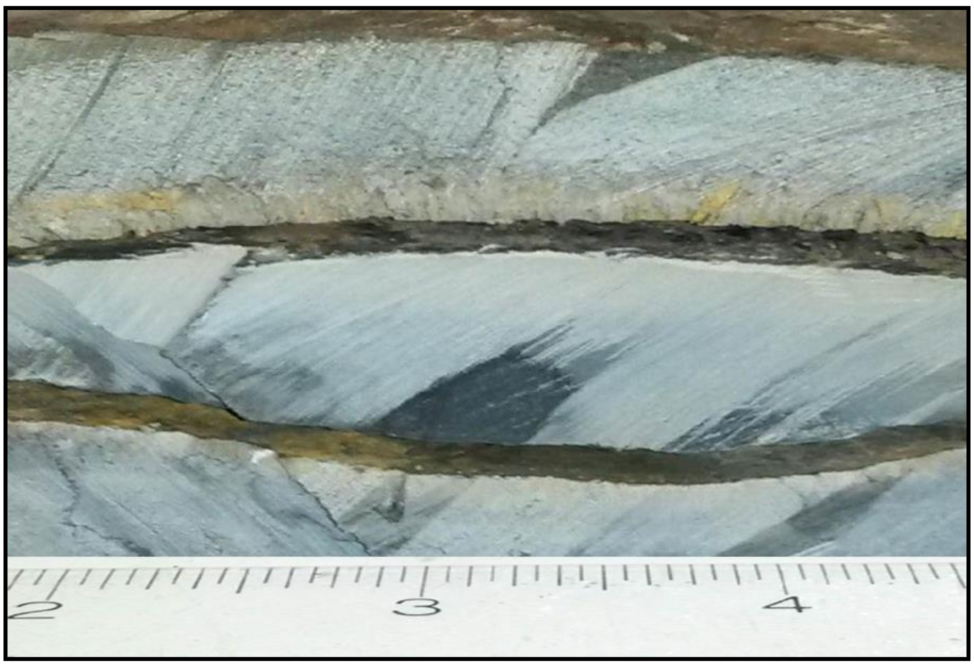
Cross section view of larger band containing cone in cone structure. Scale in inches.

Cones from larger band. Scale in inches.

Cross section of smooth concretion showing two bands of cone in cones structures, slight epoxy infiltration in smaller band. Scale in inches.

Top view of concretion after cross sectioning, notice the smooth outer shale surface.
Scale in inches.

Cross section view of concretion. Concretion split along boundaries of conal structures. Scale in inches.



Close up view of boundaries of larger band. Scale in inches.

Scaley appearance of bounding surfaces. Scale in inches.

Scaley appearance of bounding surfaces. Scale in inches.

Scaley appearance of bounding surfaces. Scale in inches.

Iron staining on bounding surface near the cone structures with iron staining. Scale in inches.

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 5B

Location: McCurtain County, OK
34°31'44.7"N 94°41'18.1"W

Gross Description:

Fragment of a larger concretion with possible cone in cone structures on both sides. Crust and core appear homogeneous. Clast or grains appear porous and /or cooked. Dimensions measure 7 x 5.5 x 2 inches. The crust has a speckled pattern with yellowish tan specks in a gray matrix which is shale in appearance with slight effervescence. The inner core region also contain speckles and effervesces readily.

Thin Section Microscopic Description:

Na

Interpretation:

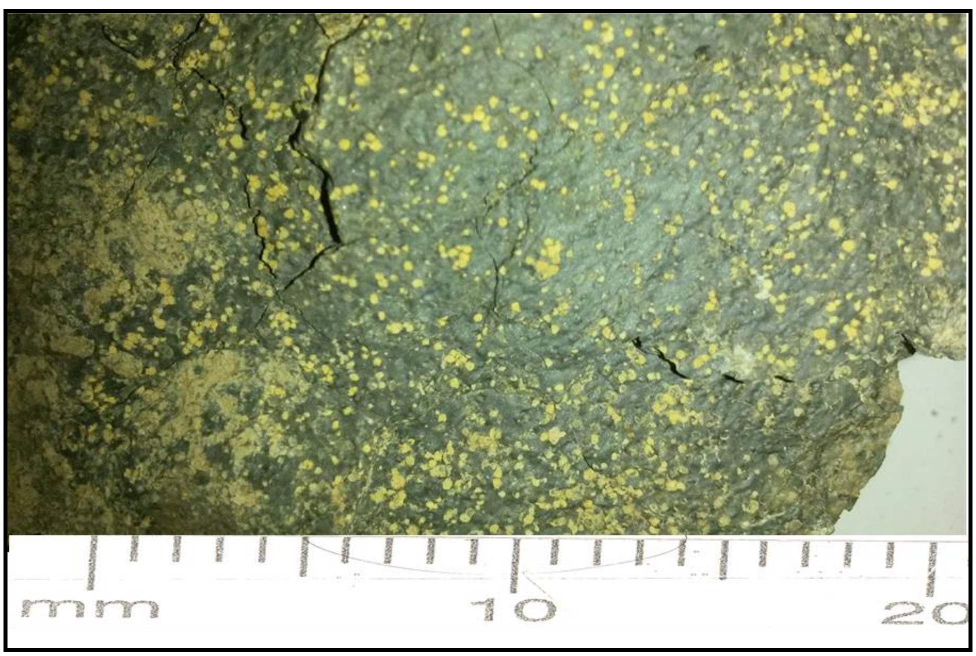
None Given

Comments:

Upper crust effervescence: yes
Inner core effervescence: yes
Lower crust effervescence: yes
Degree of Alteration: very low, sediment material may have been different.

Pictures:

Top and side view. Scale in centimeters.



Yellow specks in crust and core.

Cone in Cone Description

Specimen #: 5D

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Location: McCurtain County, OK
34°31'44.7"N 94°41'18.1"W

Gross Description:

Not a cone in cone concretion
"Ayres Interlacy clay horn"
Horned type concretion without cone in cones. Tannish gray black with prevalent layering up the "horn". Bottom of horn concaves upward. Dimensions 3 inches tall with 3.25 inch diameter. After sectioning the horned concretion through the longest axis an admixture of banded and twisted clay layers were present. Further studies should be initiated on this unusual concretion. These concretions were found with their layering in sync with the bedding of the shale, the concave portion being the base or bottom.

Interpretation:

This concretion is a ball and pillow like structure which contained a carbonate shell that migrated with the "ball" structure and due to highly variable pore waters carrying clay sized particulates encapsulated the carbonate instead of removing the carbonate. This would essentially be a dead end for fluid migration. Orogenic events and heating might be the cause of morphological shell feature disintegration of the ghost shell. The intertwining or inter-lacing gives this concretion a very unique perspective of fluid migration, thus this concretion is formally named the "Ayres Interlacy Clay Horn".

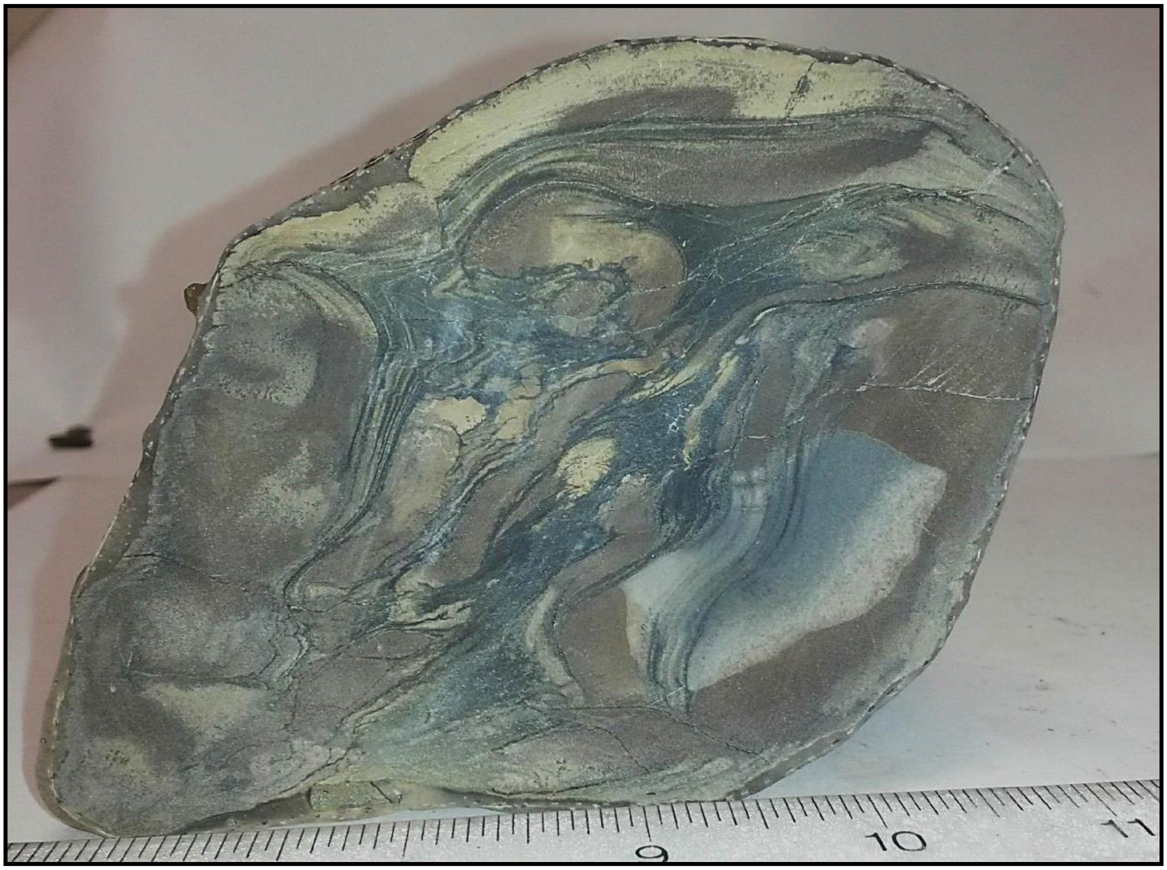
Comments:

Outer surface effervescence: No
All inner structures excluding large white ghost fossil effervescence: No
Large white ghost fossil: Yes, Readily

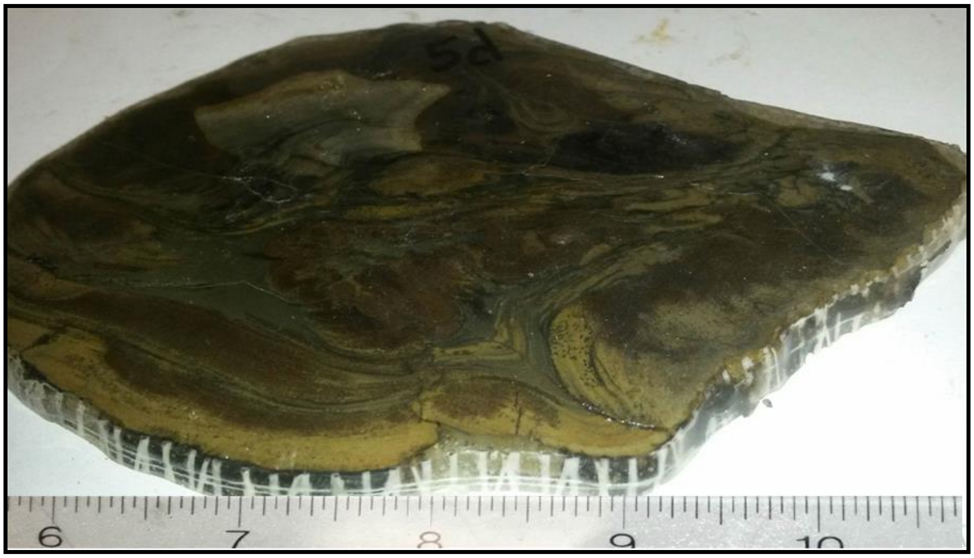
Pictures:

Top view of horned concretion with layering slightly evident in picture. Sample has been epoxied and ready to cross section.


Side view of concretion. Layering is mildly apparent on exterior. Concave base is at bottom. Concretion was removed from layered shale in this position



Cross section view. Intermingling of the clays. Large white area to the right is the carbonate ghost fossil. The first example of an Ayres Interlacy Clay Horn. Scale is in inches.



Side view of cut concretion. Scale is in inches.

Reverse light image of interior. Scale is in inches.

Side view of cross section. Scale is inches.

Cone in Cone Description

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Specimen #: 6A

Location: McCurtain County, OK
34°31'23.2"N 94°45'41.6"W

Gross Description:

NOT A CONE IN CONE CONCRETION
"**Ayres Interlacy clay horn"**
A tannish gray brown horned concretion 3.25 inches in diameter and 2.25 inches tall/high. Exterior horizontal layering starting from the concave base. The concretion appears to be more sediment style clay with dark grayish shale attached. These were found in place and extending through the shale layers. The interior exhibits a light grayish form toward the top with halo features surrounding a light colored and non-reactive to HCl "ghost shell". There is an iron like halo around ghost shell. The remaining concretion contains swirls of clay. This process likely represents an end clay rich fluid movement in the subsurface after burial and during diagenesis. More detailed study is recommended.

Interpretation:

See concretion worksheet 5D

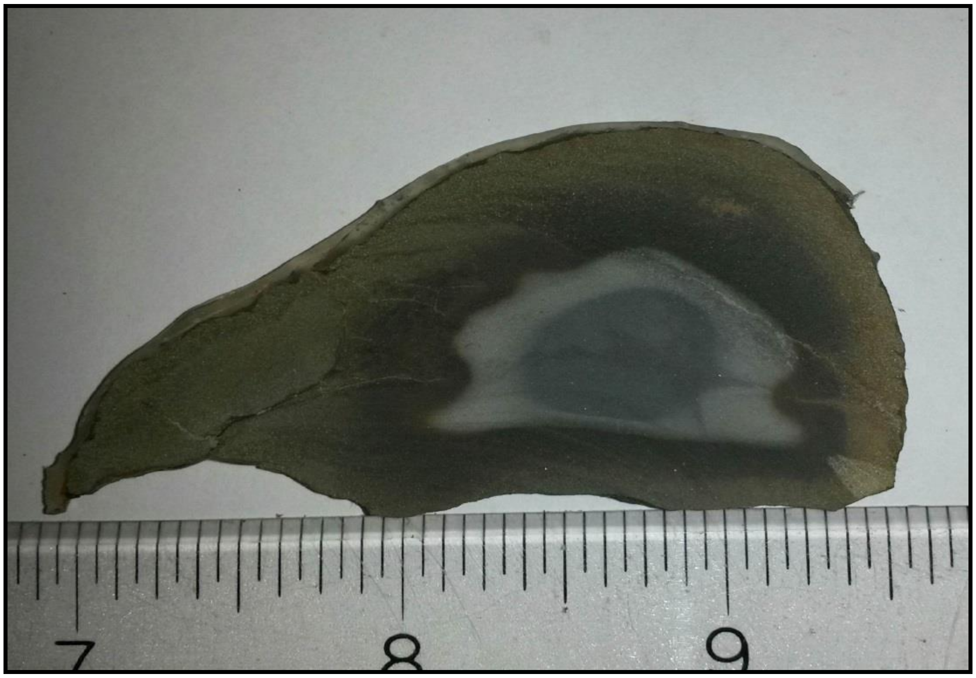
Comments:

Outer layer effervescence: Slight
Ghost shell effervescence: No
Remaining interior effervescence: No

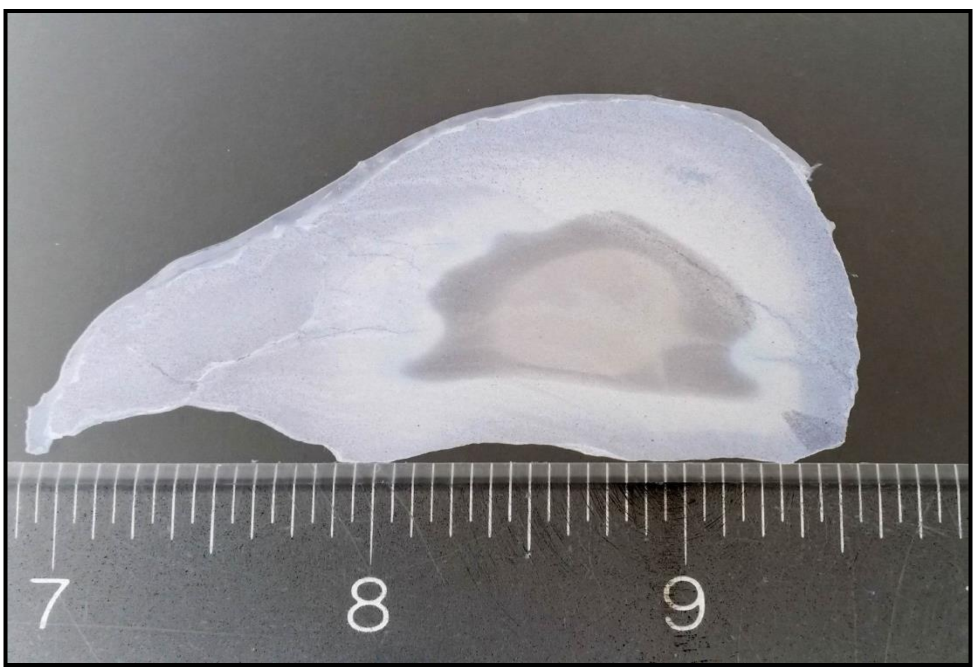
Pictures:

Side view of horned concretion with concave base toward the bottom and layering slightly seen. Scale is in inches.

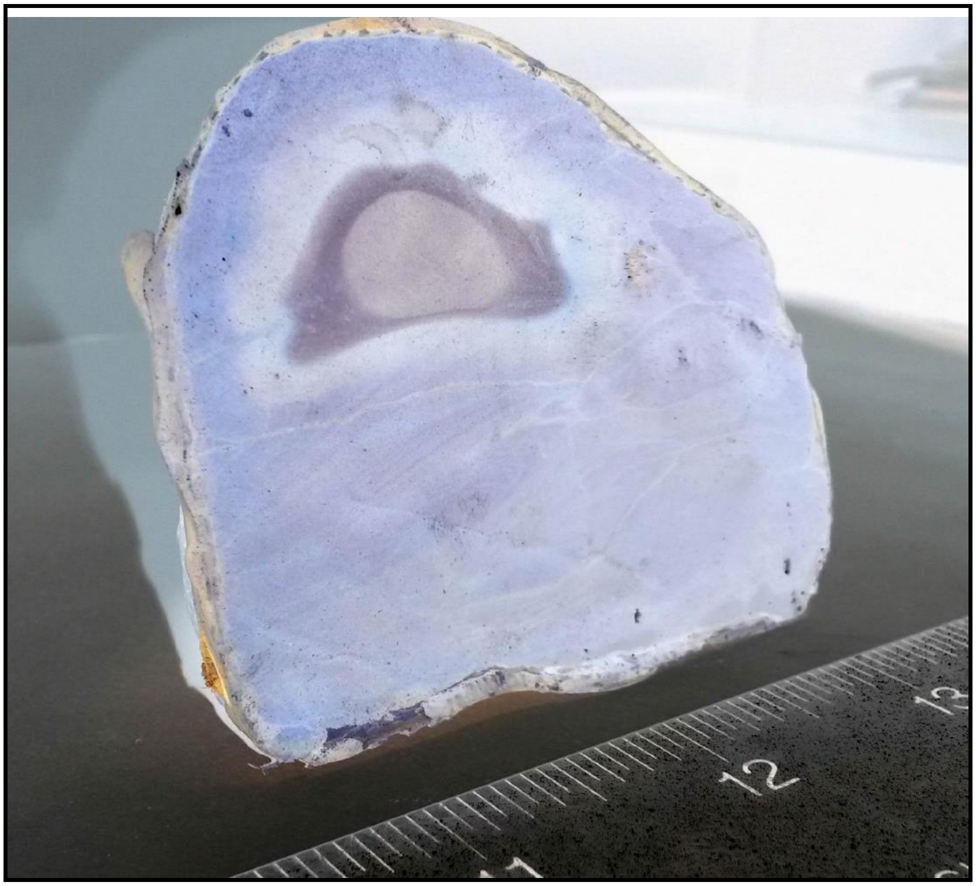
Inside view or cross section view with epoxy applied to the surface. The “ghost shell seen in the upper portion of the concretion, halo effects noted surrounding this light area. Swirling patterns of clay seen more toward the base. Scale is in inches.



Close up view of the “ghost shell”. Scale is inches.



Reverse light image of same above picture. Scale is inches.



Reverse light image of cross section of concretion. Scale is inches.

Cone in Cone Description

Specimen #: 6B

Location: McCurtain County, OK
°31'23.2"N 94°45'41.6"W

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Gross Description:

Shale composite concretion showing cone in cone structures on top and bottom. On the exterior there are multiple cones bands with cones pointing in opposite directions at these bands. The lower half has cones that are bent or tilted in one direction due to fluid flow or structural drag. There is a homogeneous nature about this shale concretion with no defining core or crust.

Thin Section Microscopic Description:

Na

Interpretation:

Carbonate precipitation was initiated at different time intervals or there were multiple carbonate sources. Slumping of the sediment altered the flow of carbonate minerals and started a new path giving the light color minerals tentacle like appearance. Lenticular banding or parted clay really defines the carbonate precipitates. There may have been preferential flow along bedding planes to account for the opposite facing cones in banded regions.

Comments:

Outer crust effervescence: yes
Inner core effervescence: yes
Slanted fibers effervescence: yes
Clay filler between slanted fibers effervescence: very slight
Degree of Alteration: low

Pictures:

Concretion sectioned into halves. Scale is in inches and centimeters.

Close up view of cone in cone structures which are not grossly evident in cross section. This is the opposite side of the concretion with the slanted carbonate cones. No striking cone structures are seen on the interior of this end. Scale is in inches.


Close up view of cone in cone structures. Scale is inches.

Cross section view with obvious slanted cones on one end with the small cone band in the middle. Visible exterior cones are on the left side without the fibrous “tentacle” precipitates. You would expect to see cone structures on the left side since they are present on the exterior. Scale is in inches.

Cone in Cone Description

Specimen #: 6C

Location: McCurtain County, OK
°31'23.2"N 94°45'41.6"W

Stephen F. Austin State University
Geology Department
Kyle Ayres
Fall 2015
Cone in cone concretions of the Stanley Group near Smithville, OK
Thesis: Cone in cone concretions of the Stanley Group in Southeastern Oklahoma

Gross Description:

Shale composite type concretion with cone in cone structures visible on the exterior. No visible distinction between the cone shells or clay fillers. Mineralization of the shale is present with pyrite and micaceous material. Three bands of cone in cone structures seen, one on either end and in the middle. The middle band expresses cones with bases in opposite direction.

Thin Section Microscopic Description:

Na

Interpretation:

None Given

Comments:

Outer crust effervescence: Yes, everywhere readily
Degree of Alteration: low

Pictures:

Side view of concretion. Scale is inches.

Top view of concretion. Scale is in inches.

Bottom half with only half of cones evident. Could be drag process during soft sediment deformation. Scale is in inches.

Top end with rare visible cones. Scale is inches.


Middle band of cone structures with opposite facing bases. Scale is inches.

Close up view of all 3 conal regions; top middle and bottom. Scale is inches.

Pyrite precipitating on outside of cone shell. Bottom half of concretion. Scale is inches.