Technical Report

Title: ***Petrography of DGR-1 and DGR-2 Core***

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DGR Site Characterization Document
Intera Engineering Project 06-219

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1 Introduction

Intera Engineering Ltd. has been contracted by Ontario Power Generation (OPG) to implement the Geoscientific Site Characterization Plan (GSCP) for the Bruce site located on Lake Huron, Ontario. The purpose of this site characterization work is to assess the suitability of the Bruce site to construct a Deep Geologic Repository (DGR) to store low-level and intermediate-level radioactive waste. The GSCP is described by Intera Engineering Ltd.,(2006).

As part of the GSCP, Intera Engineering Ltd. and Activation Laboratories ("ActLabs") of Ancaster, Ontario retained Dr. Eva Schandl of GeoConsult, Toronto to undertake petrographic testing of cores collected from boreholes DGR-1 and DGR-2. This Technical Report summarizes the results of the petrographic and electron microprobe analyses of DGR-1 and DGR-2 core samples to quantify the minerals present in the cores by optical microscopy and to identify geochemical properties of some of these minerals.

Work described in this Technical Report was completed with data generated from Test Plan TP-07-01 – Laboratory Testing of DGR-1 and DGR-2 Solid Core for Geochemistry & Mineralogy (Intera Engineering Ltd., 2007b), which was prepared following the general requirements of the DGR Project Quality Plan (Intera Engineering Ltd., 2007a).

2 Background

Core samples of 76 mm diameter were collected during diamond coring of boreholes DGR-1 and DGR-2 at the Bruce site from January until June, 2007. All core samples were vacuum sealed within nitrogen flushed polyethylene and aluminium foil/polyethylene bags following core retrieval and the general preservation and handling requirements of TP-06-10 (Intera Engineering Ltd., 2007c). Thirty four preserved core samples from boreholes DGR-1 and DGR-2 were shipped to ActLabs under chain of custody procedures (following procedure DGR P4).

The core samples were inspected by Actlabs and Dr. Schandl on receipt at Actlabs. If the cores were laminated with shale intervals in the case of carbonate rocks or were principally shale, then the shale was retained by Actlabs and analysed for clay-mineral identification. In this case, the thin sections for petrography were prepared from the bulk rock and results recorded by photomicrographs; consequently Dr. Schandl's report is biased towards the carbonate rocks rather than the shales.

In addition, Actlabs analyzed the whole rock by XRD to determine mineral concentrations. (i.e., TR-08-01, Intera Engineering Ltd, 2009a) and also undertook geochemical analysis of the cores that included measurement of 10 oxides and 50 trace elements and studied them by scanning electron microscopy and X-ray spectrometry (TR-08-02, Intera Engineering Ltd., 2009b).

Therefore, the objectives of this study were:

1. To describe the mineralogy and texture in the individual samples,
2. To identify halite, gypsum and anhydrite, where present,
3. To estimate the intergranular and/or interparticle porosity, and
4. To estimate, where possible, the percentage of clay minerals present.

It should be noted that these objectives do not include associating each thin section with a particular rock formation. These identities have been included by Intera Engineering Ltd..

3 Methods

3.1 Sample Preparation

Polished thin sections were prepared for microscopic study. As one of the objectives of the work was to determine the presence of halite, gypsum and anhydrite in the rocks, oil was used during thin section preparation, instead of water. This should have prevented the dissolution (and loss) of water-soluble minerals such as halite. Although mineral oil was used for preparation of the sections, the final polishing was done with ethylene glycol as the machine is sensitive to oil. As a result, gypsum and anhydrite were not lost, but halite was dissolved out of the rock, leaving just its imprint (chevron texture) on the thin section (only one sample contained halite). Thus, the composition of halite was obtained from the corresponding rock chip by electron microprobe.

3.2 Analytical Techniques

The polished thin sections were studied under transmitted and reflected lights, and an ETEC electron microprobe was used to analyze individual minerals and some of the fine-grained matrix of selected samples. The analyses were quantitative when possible, but semi-quantitative to qualitative when analyzing intergrowths of two or more minerals. Due to the small grains size, and the murky color of the minerals in the thin section, it was not possible to obtain single grain analysis from the clay minerals in the matrix.

4 Results

4.1 DGR-1: Devonian, Silurian and the Uppermost Ordovician Cores

4.1.1 Mineralogy

Petrographic descriptions for individual samples are shown in Table 1 together with sample number and formation identification based upon subsequent core logging. The most common minerals in the rocks are carbonates, clays (i.e., illite), and quartz. Although some samples are iron stained, e.g., the Cabot Head and Queenston Formations, the quantitative estimation of iron minerals is difficult as it rarely occurs in discrete grains. Table 2 presents the quantitative estimates of minerals identified in the DGR-1 cores.

The carbonates are mostly dolomite, and less commonly calcite. They occur as part of the matrix, as narrow bands in shales and as veins that cross-cut the rock fabric. Some of the carbonates partly replace fossil bits at the selvages (margins) and all fossils are calcareous. Dolomitic oolites occur in dolomite-rich matrix where the matrix contains several small interparticle pores.

Clay minerals are predominantly illite, as suggested by the composition of clay-rich domains in several of the samples (relatively low K_2O detected by microprobe analysis). Although individual grains could not be analyzed, and while there is significant variation in composition between samples – even between “dark” and “light” domains – the overall composition of the matrix would be consistent with illite.

Quartz occurs as minute detrital grains, as late veins that cross-cut and fragment some of the dark shales, and also as chert and fibrous chalcedony that form rims on carbonates.

Halite was identified only in one sample (DGR1-456.01, Queenston Formation), where it occurs as a relatively wide vein of 0.3 to 2.0 mm, that is intergrown with and partly replaced by carbonate. It also occurs in aggregate within up to 3 mm diameter domains, where they are partly replaced by fine-grained carbonate.

Table 1 Formation and Petrographic Description of DGR-1 Cores

Intera Sample ID	*Formation*	*Petrographic Description*
DGR1-049.06	Amherstburg	Fossiliferous packstone
DGR1-097.08	Bois Blanc	Fossiliferous packstone + chert
DGR1-130.03	Bass Islands	Fine grained dolostone
DGR1-156.63	Bass Islands	Oolitic dolostone
DGR1-231.49	Salina E Unit	Calcareous shale
DGR1-267.78	Salina B Unit	Calcareous shale
DGR1-322.19	Salina A-2 Unit	Anhydrite / gypsum
DGR1-361.76	Salina A-1 Unit	Calcareous shale
DGR1-399.85	Gasport	Fossiliferous packstone
DGR1-419.99	Cabot Head	Ferruginous shale
DGR1-446.25	Manitoulin	Dolomitic shale
DGR1-455.45	Queenston	Ferruginous, calcareous shale
DGR1-456.01	Queenston	Ferruginous, calcareous shale
DGR1-460.77	Queenston	Calcareous shale

Anhydrite and gypsum are more common than halite in the Devonian and Silurian cores studied. One sample (DGR1-322.19, Salina A2 Unit) consists of 85% anhydrite, 10% gypsum and 5% dolomite, where coarse-grained gypsum is replaced by the fibrous anhydrite. Gypsum also occurs as a wide vein (DGR1-231.49, Salina E Unit) that contains fragments of the dark, clay-rich wall rock. Both minerals occur (in lesser quantities) as small porphyroblasts in shales and gypsum also occurs as minute interstitial grains to laminae in shales.

4.1.2 Porosity

Due to the soft and friable nature of the rocks, it was not possible to determine whether “holes” and partings in the thin sections were the artefacts of sample preparation (grinding, plucking), or that they represent the intrinsic porosity in the rocks. Only in the oolitic dolostone in the Bass Islands Formation (DGR1-156.63) was intergranular porosity identified, and estimated at 0.5-1.0%.

4.1.3 Rock Types

Two distinct groups were identified within the 14 DGR-1 samples and are shown in Table 1: dolostones and shales. Sub-groups include fossiliferous packstones or dolostones, and anhydrite + gypsum.

Table 2 Visual Estimation of Mineral Percentages Present in DGR-1 Core Samples

Minerals	***DGR1-049.06***	***DGR1-097.08***	***DGR1-130.03***	***DGR1-156.63***	***DGR1-231.49***	***DGR1-267.78***	***DGR1-322.19***
Carbonates & Fossils	(f) 100	(f) 70	98	(oo)100	92	35	5
Quartz	x	30	2	x	2	5	
Illite / clays	x					60	
Glauconite							
Gypsum					6		10
Anhydrite	x						85
Halite							
Zircon			x			x	
Pyrite	x	x	x		x	x	
Fe(III)-oxides		x				x	
Minerals	***DGR1-361.76***	***DGR1-399.85***	***DGR1-419.99***	***DGR1-446.25***	***DGR1-455.45***	***DGR1-456.01***	***DGR1-460.77***
Carbonates & Fossils	N/A	(f) 90	10	39	N/A	80	75
Quartz		x	10	0.5		5	x
Illite / clays		10	80	60		x	20
Glauconite		x					
Gypsum				x		x	3
Anhydrite			x				2
Halite						10	
Zircon							
Pyrite		x		0.5			
Fe(III)-oxides				x		5	

N/A = cannot be resolved; (f) = fossiliferous; (oo) = oolitic; x = trace amount

4.2 DGR-2: Ordovician Shales and Limestones

4.2.1 Mineralogy

Petrographic descriptions for individual samples are shown in Table 3 together with sample number and formation identification based upon subsequent core logging. The cores include Ordovician cores as well as one Cambrian core. The most common minerals in the rocks are; carbonate (calcite and dolomite), clay minerals (mostly illite) and quartz. Pyrite (with or without chalcopyrite) occurs in most rocks, whereas other, less common minerals include anhydrite, celestite, glauconite, halite, oxyhydroxide/goethite, and chlorite. Table 4 presents the quantitative visual estimates of minerals identified in the DGR-2 cores.

The carbonate minerals in the rocks include calcite and dolomite. Anhedral aggregates that make up part of the matrix of the calcareous and fossiliferous shale are generally calcite, but also include porphyroblasts of euhedral dolomite. Some of the coarse-grained recrystallized aggregates interstitial to the fossil fragments are dolomite, but fine-grained calcite also occurs as replacement after the fossils (photos: DGR2-606.62a & b; Georgian Bay Formation.). Fine-grained, euhedral dolomite also occurs in aggregates in the limestones (photo: DGR2-687.47a; Cobourg Formation & DGR2-669.27a; Cobourg Formation.) where they contain interstitial, Fe-stained clays as cement.

Table 3 Formation and Petrographic Description of DGR-2 Cores

Intera Sample ID	*Formation*	*Petrographic Description*
DGR2-451.33	Queenston	Calcareous, fossiliferous shale
DGR2-482.45	Queenston	Fossiliferous limestone / shale
DGR2-508.93	Queenston	Ferruginous, calcareous shale
DGR2-535.56	Georgian Bay	Calcareous shale
DGR2-550.28	Georgian Bay	Calcareous shale
DGR2-570.73	Georgian Bay	Calcareous shale
DGR2-590.10	Georgian Bay	Calcareous shale
DGR2-606.62	Georgian Bay	Fossiliferous limestone + shale
DGR2-606.96	Georgian Bay	Fossiliferous limestone
DGR2-626.29	Blue Mountain	Shale
DGR2-644.49	Blue Mountain	Shale
DGR2-659.31	Collingwood Member, Cobourg	Fossiliferous limestone-mudstone
DGR2-669.27	Cobourg	Fossiliferous limestone - packstone
DGR2-677.93	Cobourg	Fossiliferous limestone - packstone
DGR2-687.47	Cobourg	Fossiliferous, ferruginous limestone
DGR2-695.51	Sherman Fall	Fossiliferous limestone
DGR2-704.87	Sherman Fall	Fossiliferous limestone
DGR2-745.97	Kirkfield	Fossiliferous shale - packstone
DGR2-816.85	Gull River	Dolomite
DGR2-844.95	Cambrian	Dolomite

The clay minerals are mostly illite. However, the bulk composition analyzed by electron microprobe demonstrates highly fluctuating totals, as well as K_2O, MgO and FeO concentrations - suggesting that illite is probably mixed with other clays. Because of Fe-staining in the clay-rich matrix, the individual minerals could not be positively identified. Further discussion of the clay mineralogy is presented in TR-08-01 (Intera Engineering Ltd., 2009a).

Quartz is ubiquitous in the Ordovician shale formations between DGR2-451.33 (Queenston Formation.) and DGR2-644.49m (Blue Mountain Formation.) depth, but it decreases in volume between DGR2-644m and DGR2-745m, i.e., from the Blue Mountain Formation shale down through the Middle Ordovician limestones to the Kirkfield Formation. Anhedral quartz generally occurs as part of the matrix, and also as small clasts within the shale.

Anhydrite and celestite ($SrSO_4$) occur as replacement of the carbonates at depths above the Blue Mountain Formation shale (DGR2-626.29m). Although a minor phase, some anhydrite is intercalated with fine-grained aggregates of tabular celestite (photo: DGR2-482.45d). Halite was identified only in one sample (DGR2-

606.96), i.e., in the Georgian Bay Formation. It occurs as a discontinuous vein of 0.01 – 0.05 mm width, leaving only its chevron-texture imprint on the glass (photo: DGR2-606.96b & d). As the halite could be analyzed only from the surface of the corresponding rock chip, the analyses are very poor and also include part of the matrix.

Table 4 Visual Estimation of Mineral Percentages Present in DGR-2 Core Samples

Minerals	***DGR2-451.33***	***DGR2-482.45***	***DGR2-508.93***	***DGR2-535.56***	***DGR2-550.28***	***DGR2-570.73***	***DGR2-590.1***	***DGR2-606.62***	***DGR2-606.96***	***DGR2-626.29***
Carbonates & (Fossils)	50 (15)	65 (25)	30 (x)	45	24.5	25	35	40 (35)	40 (35)	10
Quartz	x		5	20	20	10	10	x	x	5
Illite / clays	35	10	15	35	55	60	52	25	23	85
Sericite	x							x		
Chlorite					x	x				
Glauconite						x				
Anhydrite	x	x	x	x					1.5	
Celestite		x							x	
Halite									0.5	
Rutile	x				x	x				
Pyrite		x	x	x	x	2.5	1	x	x	x
Chalcopyrite		x		x	0.5	2.5	2			
Hematite-Fe(III) oxides			50							
Goethite-oxyhydroxide	x					x	x			
Minerals	***DGR2-644.49***	***DGR2-659.31***	***DGR2-669.27***	***DGR2-677.93***	***DGR2-687.47***	***DGR2-695.51***	***DGR2-704.87***	***DGR2-745.97***	***DGR2-816.85***	***DGR2-844.95***
Carbonates & (Fossils)	10	30 (50)	40 (40)	40 (33)	55 (25)	70 (20)	45 (30)	40 (30)	75	95
Quartz	5		x	xx	x	x	x*			4.5
Illite / clays	83	20	20	25	15	10	25	30	25	
Sericite										
Chlorite										
Glauconite										
Anhydrite										
Celestite										
Halite										
Rutile					x					
Pyrite	2	x	x	2	5	x	x	x	x	x
Chalcopyrite										
Hematite-Fe(III) oxides										
Goethite-oxyhydroxide										

x = trace amount; * = chalcedony

Sample DGR2-816.85 (Gull River Formation.) is made up of very fine-grained saddle dolomite and Fe-stained clay-rich domains such that parallel bands of iron-stained clays occur at 0.3 – 1.0 cm intervals throughout the entire core giving it a laminated appearance. Minor lamination in the rock is defined by parallel, Fe-rich veinlets.

Although nominally part of the Cambrian unit, sample DGR2-844.95 consists of relatively coarse-grained, anhedral, partly recrystallized carbonates with minor fine-grained quartz and feldspar clasts of sedimentary origin. Few grains of very fine-grained pyrite and marcasite are disseminated throughout the matrix and are interstitial to the carbonates. The carbonates show evidence of recrystallization and grain growth.

4.2.2 Porosity

Interparticle and intergranular pores are relatively rare in the carbonates, although a few were found in samples DGR2-669.27 (photos d & e; Cobourg Formation.) and DGR2-451.33 (photo d; Queenston Formation). In most cases, however, the carbonates contain interstitial clays as cement, or the carbonate grain boundaries have triple junction without pore space. Due to the friable nature of the rocks, some of the small veins and aggregates (of carbonate?) were scraped off the thin section – the latter of which may have contained interparticle pores. One of such "empty" veins is shown in photo DGR2-535.56a (Georgian Bay Formation.).

4.2.3 Veins

Veins are relatively rare in the rocks, and where present, they are often minute hairline-type that parallel the rock fabric, i.e., bedding plane fabric (cf. photo DGR2-550.28b; Georgian Bay Formation.). Some exceptions are, a relatively wide carbonate vein of ~ 0.3 mm width in a fossiliferous limestone / packstone (photo DGR2-669.27f; Cobourg Formation.), and a fragmented halite vein of 0.03 mm width (photo DGR2-606.96b & d; Georgian Bay Formation.). Pyrite veinlets also occur in some rocks - most notable is a pyrite vein of ~ 0.2 mm width in sample DGR2-695.51 (photo b; Sherman Fall Formation.) that cross-cuts the fossiliferous limestone.

4.2.4 Fossils

Most fossils are bryozoan fragments, crinoids, and brachiopods, whereas sample DGR2-669.27 (photo b) appears to contain fragments of trilobite. In the upper part of the stratigraphic section (DGR2-451.33 - DGR2-659.31m), fossiliferous shale is intercalated with fossil-free shale (Queenston Formation), whereas in the lower part of the section (DGR2-659.31 – DGR2-745.97m), fossiliferous limestones dominate (Cobourg Formation).

4.2.5 Rock Types

Four rock types were identified within the suite of 20 DGR-2 samples: (1) shale, (2) calcareous shale, with and without fossiliferous shale, (3) fossiliferous limestone and (4) dolomite. Some cores were a combination of the above. Table 3 summarizes the rock types identified in DGR-2 core samples.

5 Data Quality and Use

Tables 3 and 4 present the visually-estimated percentage of each mineral in the thin section for DGR-1 and DGR-2 respectively, however the percent estimation is very approximate due to the very fine-grained nature and the iron-staining of clay minerals and some of the matrix carbonates.

6 Conclusions

The two Devonian cores examined were classified as fossiliferous packstones, in which the rock grains support one another but the interparticle space contains 'mud' particles, and contain limestone, dolostone and chert. Minor amounts of anhydrite were detected in one Devonian core and pyrite was present in both cores.

The nine Silurian cores studied were predominantly dolostones and shales. The Silurian carbonate minerals were therefore principally dolomite and less commonly calcite; these occur as either part of the rock matrix, or as narrow bands in shales or as cross-cutting veins. All fossils were deemed to be composed of carbonate

minerals. The Silurian shales were predominantly composed of illite. The soluble minerals detected in the Silurian cores were anhydrite and gypsum, in particular the Salina A2 Unit where gypsum + anhydrite was 95% of the core sample. Pyrite was frequently detected in trace amounts.

Fourteen Upper Ordovician shales were examined – the Queenston (6), Georgian Bay (6) and Blue Mountain (2) Formations – and were determined to be principally composed of illite, quartz and carbonate minerals. The Blue Mountain Formation shales were over 80% illite and other clay minerals. The soluble minerals detected were minor or trace amounts of gypsum, anhydrite, celestite, and in one case within the uppermost Queenston Formation, halite (at 10%) in an in-filled fracture and in the adjacent rock matrix. Pyrite was frequently detected in trace amounts, often with chalcopyrite. Iron oxides were also present in the Queenston Formation.

Seven core samples of Middle Ordovician carbonate rocks were identified as limestones or fossiliferous packstones. The sample from the Collingwood Member of the Cobourg Formation was identified as a mixed limestone-mudstone due to the high illite content. No soluble minerals were detected; pyrite was ubiquitous as an accessory mineral.

7 References

Intera Engineering Ltd., 2009a. Technical Report: XRD Mineralogical Analysis of DGR-1 and DGR-2 Cores, TR-08-01, Revision 0, April 16, Ottawa..

Intera Engineering Ltd., 2009b. Technical Report: Lithogeochemistry, SEM & EDS Analysis of DGR-1 and DGR-2 Cores, TR-08-02, Revision 0, April 16, Ottawa.

Intera Engineering Ltd., 2007a. Project Quality Plan, DGR Site Characterization, Revision 3, January 17, Ottawa.

Intera Engineering Ltd., 2007b. Test Plan for Laboratory Testing of DGR-1 and DGR-2 Solid Core for Geochemistry and Mineralogy, TP-07-01, Revision 1, March 25, Ottawa.

Intera Engineering Ltd., 2007c. Test Plan for DGR-1 & DGR-2 Core Sampling and Distribution. TP-06-10, Revision 4, May 14, Ottawa.

Intera Engineering Ltd., 2006. Geoscientific Site Characterization Plan, OPG's Deep Geologic Repository for Low and Intermediate Level Waste, Report INTERA 05-220-1, OPG 00216-REP-03902-00002-R00, April, Ottawa.

APPENDIX A

DGR-1 Report, June 20, 2007 (DGR1-049.06 to DGR1-460.77)

NOTE

Ppl = plane polarized light

XN = crossed nicols

Refl. light = reflected light

Sample Number: DGR1-049.16 **Rock Type: Fossiliferous packstone**

Petrographic Description:

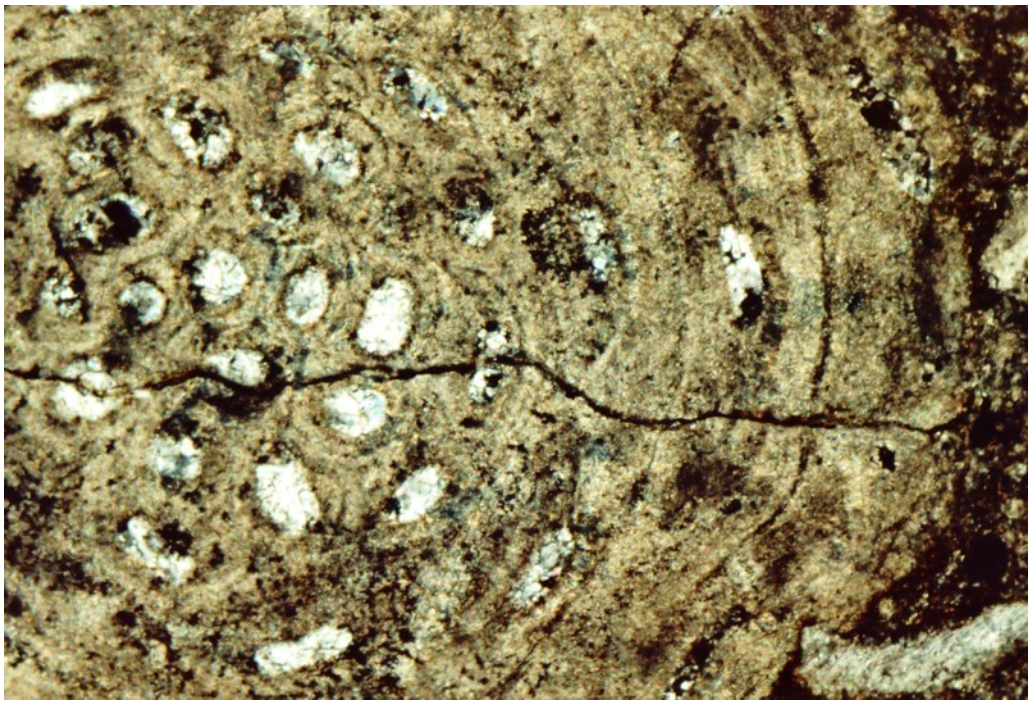
The rock consists predominantly of fossiliferous carbonates, recrystallized carbonates and void-filling carbonates of various grain size. Dissolution and replacement texture are common, as the earlier fossiliferous fragments are fragmented, partly dissolved, and some are flattened. Although most of the rock consists of carbonates, texturally, three different domains can be distinguished: 1. Three large calcified bryozoa (in fine matrix) with radially aligned zooecia replaced in center by coarse-grained calcite, 2. very fine-grained ferrous-calcareous “mud” interstitial to the fragmented calcified bryozoa, and 3. large calcified fragments of porous fossils (sponge?) and smaller fossil bits.

1. The large, recrystallized and calcified bryozoa that contains numerous, radially aligned zooecia connected by what appears to be replacement carbonate, and the differences in color suggests compositional differences between the replacement and the original carbonate. The center of each zooecia consists of recrystallized carbonate aggregates. They appear to be infilling a void or cavity, as the original walls are lined with fine-grained carbonates projecting to the center.

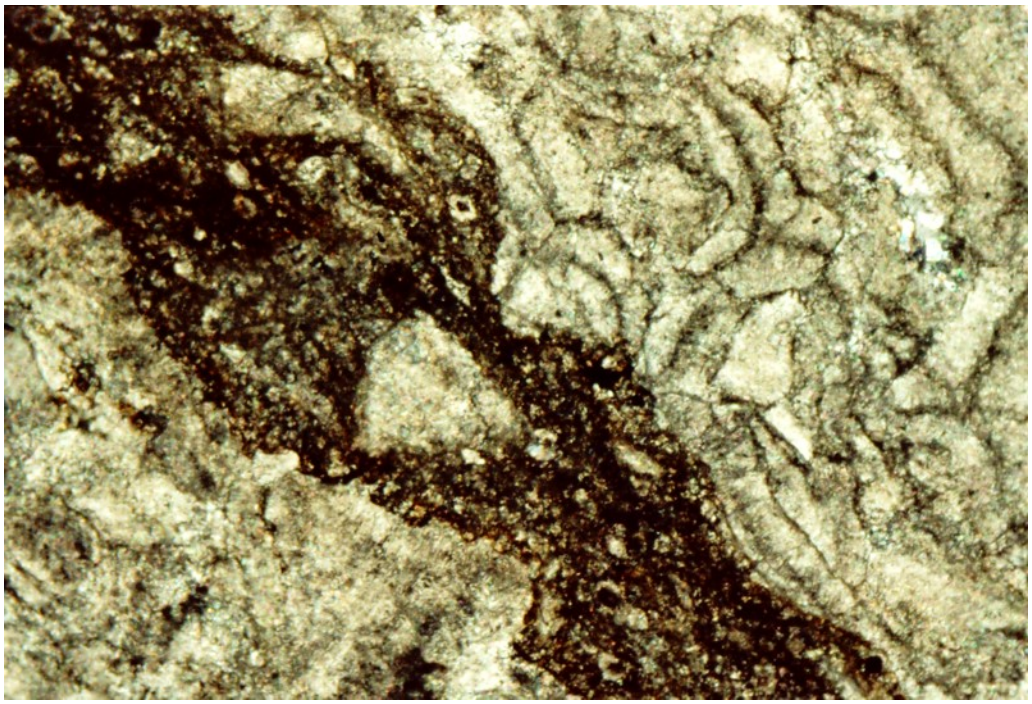
2. Fe-stained calcareous mud contains fossil bits, some of which appear to be ostracods, brachiopods (valves), and a few large porous fragments of sponge (?). The mud, interstitial to the more massive cemented, calcified fossils is, laminated and slightly deformed. Flattening is probably the result of compacting during deposition.

3. The fossils are partly recrystallized, and there are several types: a) porous spongy fragments, b) large flat concentrically zoned disks with fine-grained aggregates of carbonate inclusions in small vacuoles within the centre, and c) curved brachiopod (?) fragments.

The only accessory mineral found in the rock, is, fine-grained, anhedral pyrite. The small grains occur within the ferruginous mud that contain the fine-grained fossil bits.



DGR1-049.16a. Fossil fragment (bryozoa?). Small zooecia are filled by calcite (white). Width of photo: 2.3mm. XN.



DGR1-049.16b. Dark calcareous mud interstitial to fragmented fossil. Width of photo: 2.3mm. XN.

Sample Number: DGR1-097.08 **Rock Type: Fossiliferous packstone + chert**

Petrographic Description:

A fragmented and silicified calcareous and fossilifeorus packstone with cherty domains. Part of the rock consists of very fine-grained, featureless oxidized and fragmented dark shale intercalated with dark chert fragments, and the other part consists of fossiliferous packstone with fine-grained dolomite matrix. The fragmented dark shale is aphanitic and is cross-cut and fragmented by numerous very fine-grained quartz and chert veinlets. The fossiliferous domain consists predominantly of recrystallized, fine-grained dolomite with inclusions of relatively large fossil fragments (sponge, flattened bryozoa and fossil bits). The cherty domain is microcrystalline and contains numerous fine-grained, euhedral / subhedral dolomite porphyroblasts that over-grow the chert, as well as anhedral carbonate inclusions embedded in the chert. The fragment has undulatory contact with the dolomite-rich fragment, and is cross-cut by quartz veins.

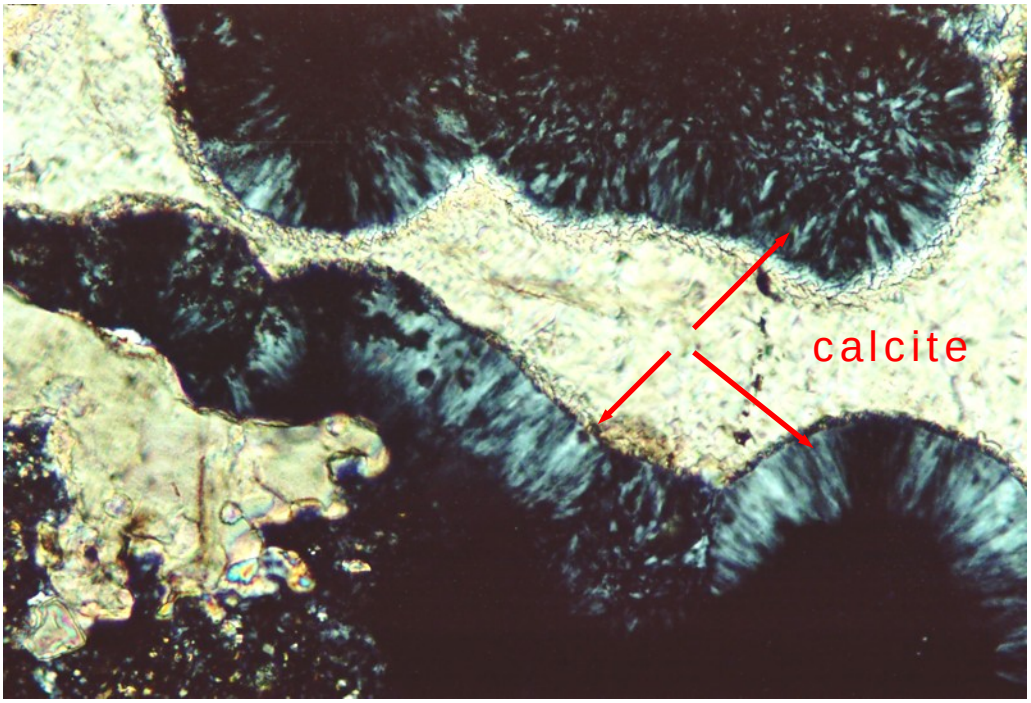
Large, anhedral carbonate occurs at the contact between the siliceous shale and the fossiliferous dolomite. The blocky carbonate is rimmed and partly replaced by radiating, fibrous chalcedony.

Pyrite is disseminated through the rock, and it mostly occurs as inclusions in the aphanitic matrix. Some are partly subrounded and some are angular.

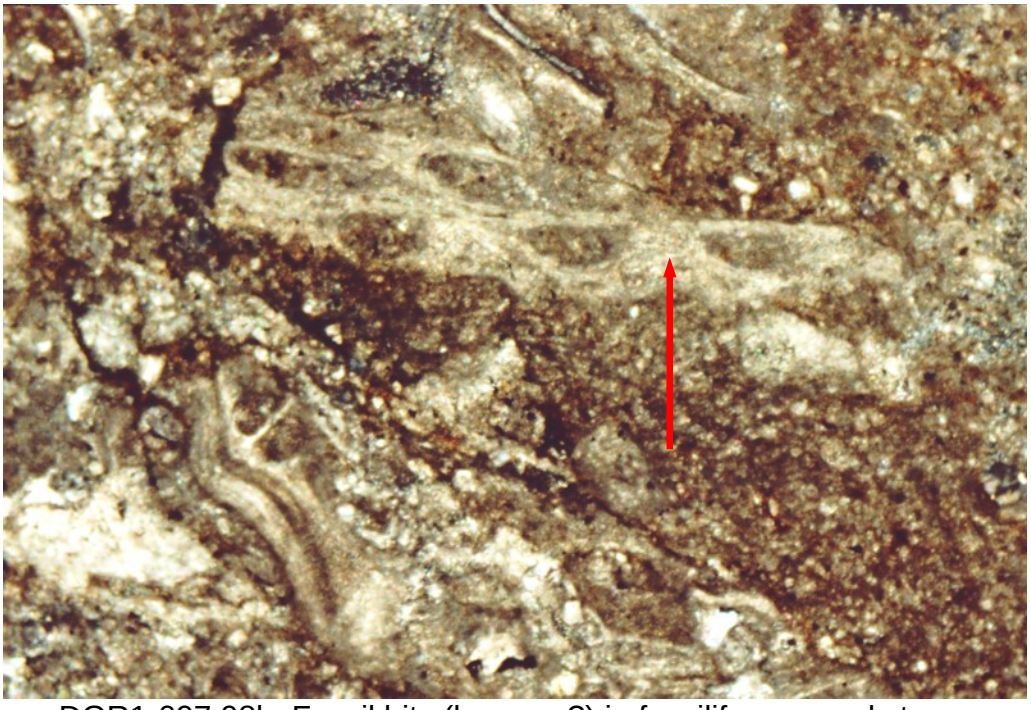
Detailed mineralogy

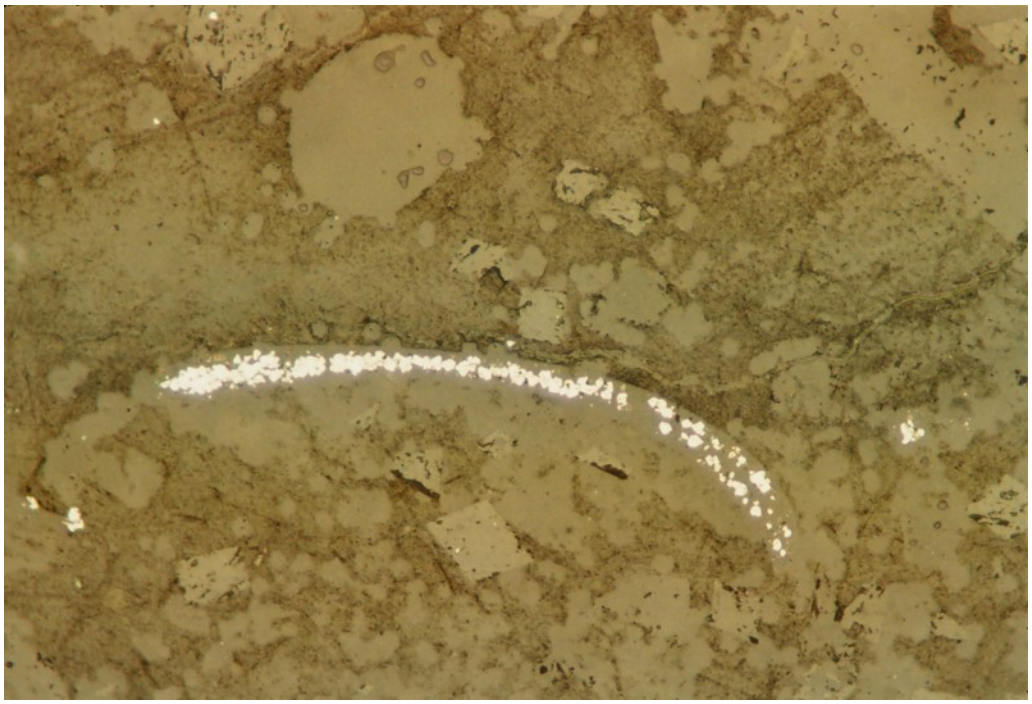
Mineral	%	Grain size(mm)	Comments
Carbonate	70	<0.2-2.5	Carbonate occurs as subhedral / euhedral rhombs within the cherty matrix. They are small porphyroblasts that over-grow the microcrystalline matrix. In the fossiliferous fragment, the fossil bits all consist of carbonate. Although most preserved the original shape of the fossil, some are partly recrystallized to fine-grained aggregates. Coarse-grained anhedral late carbonate occurs at the contact between fragments. They are rimmed and partly replaced by fibrous, chalcedony.
Quartz	30	Chert-0.3	Most quartz occur as amorphous chalcedony, they form veins that cross-cut the mudstone. The chert also makes up part of the matrix and chalcedony occurs as rims on recrystallized carbonates.

Accessory minerals: pyrite, hematite

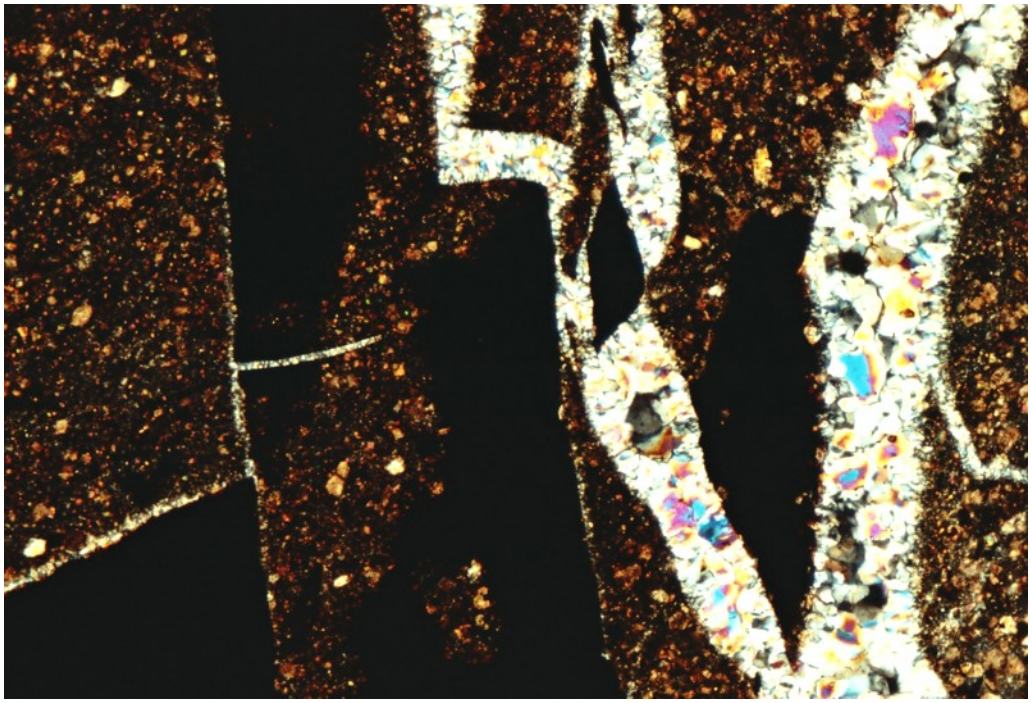


DGR1-097.08a. Fibrous chalcedony (arrows) rim calcite. Width of photo: 0.9mm. XN.


DGR1-097.08b. Fossil bits (bryozoa?) in fossiliferous packstone.
Width of photo: 2.3mm. XN.



DGR1-097.08c. Fine-grained pyrite (white) replaces fossil bits.
Width of photo: 0.45mm. Refl. light.



DGR1-097.08d. Ferruginous mudstone is fragmented by quartz veins.
Width of photo: 2.3mm. XN.

Sample Number: DGR1-130.03 **Rock Type: Aphanitic dolostone**

Petrographic Description:

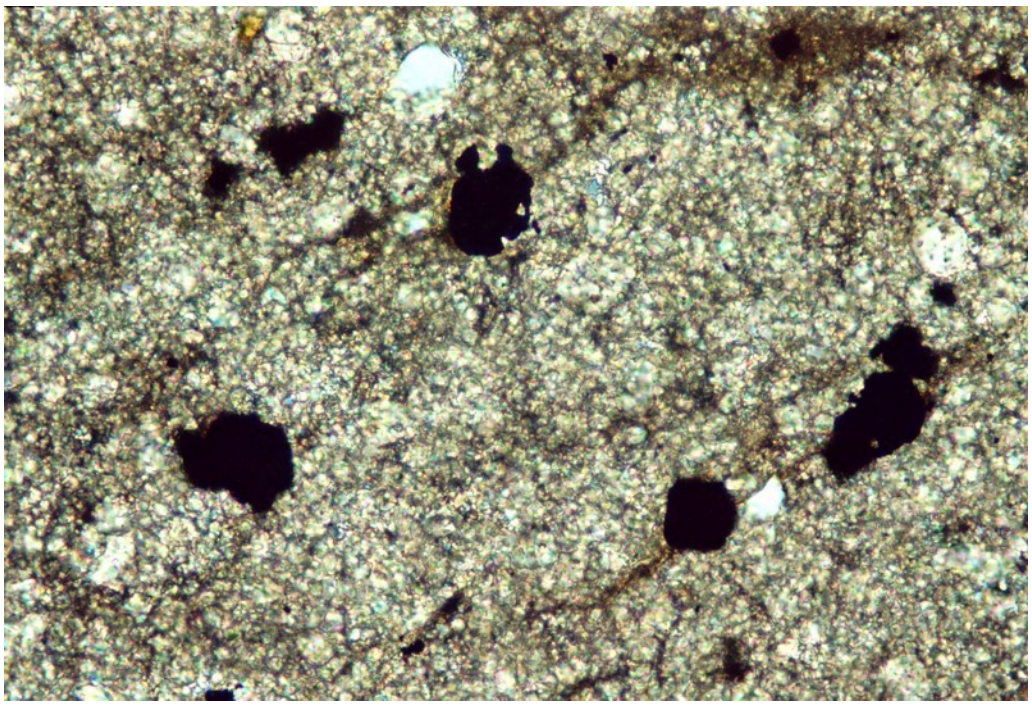
Microcrystalline, featureless, aphanitic dolostone. The rock consists of interlocking aggregates of microcrystalline carbonate, and a few small broken quartz fragments are included in the carbonate aggregates. The carbonates are more or less equigranular, with the exception of a few slightly larger carbonate rhombs (up to 0.3 mm). That the quartz clasts are detrital in origin and not chemical precipitates is apparent from the angular shape of most grains, and from the presence of fluid inclusions in some of the grains. Most quartz clasts have resorbed or sutured grain boundaries and are rimmed and partly replaced by very fine-grained carbonate.

Although the matrix carbonates form interlocking aggregates, there is textural evidence for the original presence of minute, rounded fossil fragments in the rock (resembling small oolites). There is also evidence for relict lamination in some of the domains.

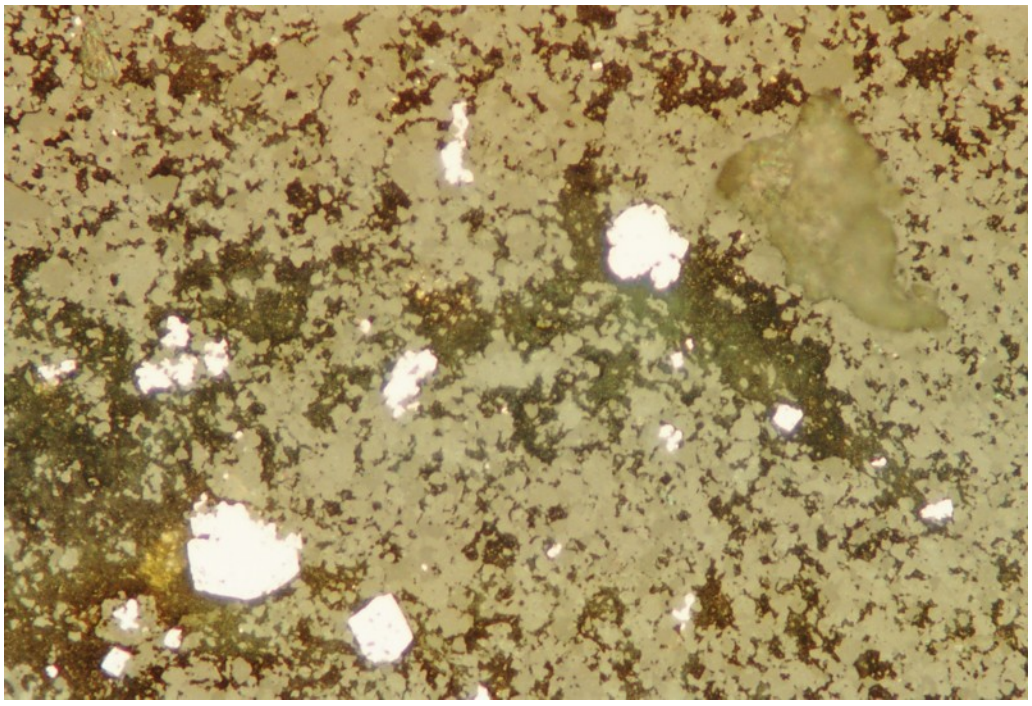
Carbonate makes up ca. 98% of the rock, and the rest consists of quartz clasts and pyrite. A small grain of zircon was identified in the carbonate matrix.

Fine-grained, anhedral and blocky pyrite are disseminated through the rock matrix and appear to be secondary. They are associated with some of the more Fe-stained domains and several of the grains occur in vein-like stringers. They either represent influx of Fe-rich fluid or it may be part of the relict laminae.

DGR1-130.03a. Featureless equigranular fine-grained dolostone.
Width of photo: 2.3mm. XN.



DGR1-130.03c. Fine-grained carbonate with pyrite (black). Width of photo: 0.9mm. XN.



DGR1-130.03b. As above, with reflected light.

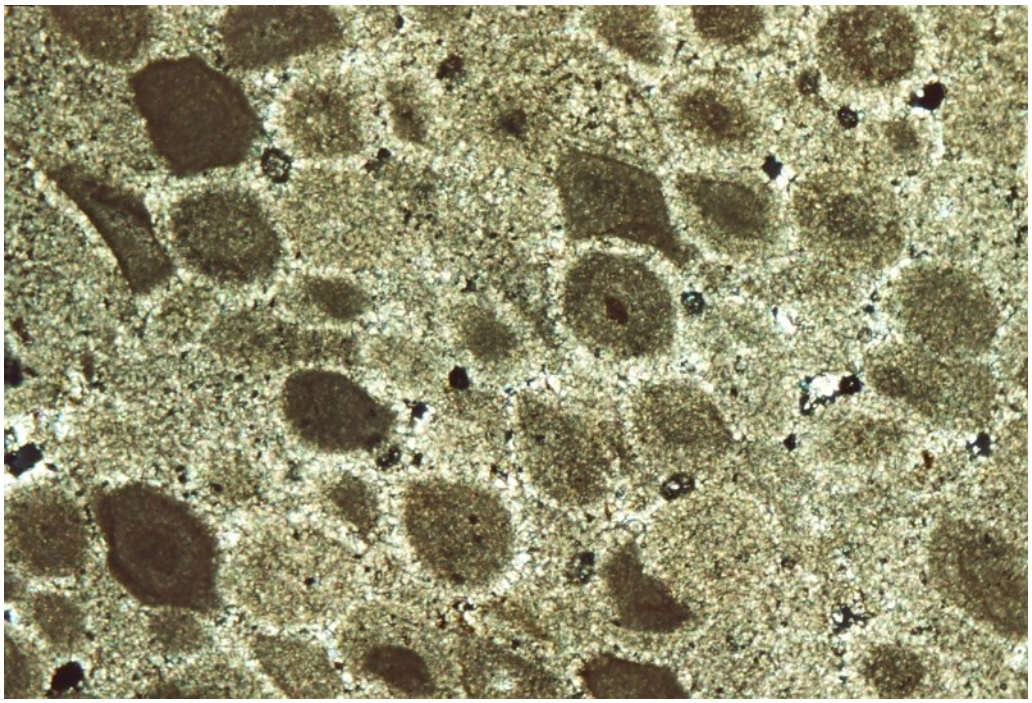
Sample Number: DGR1-156.63 **Rock Type: Oolitic dolostone**

Petrographic Description:

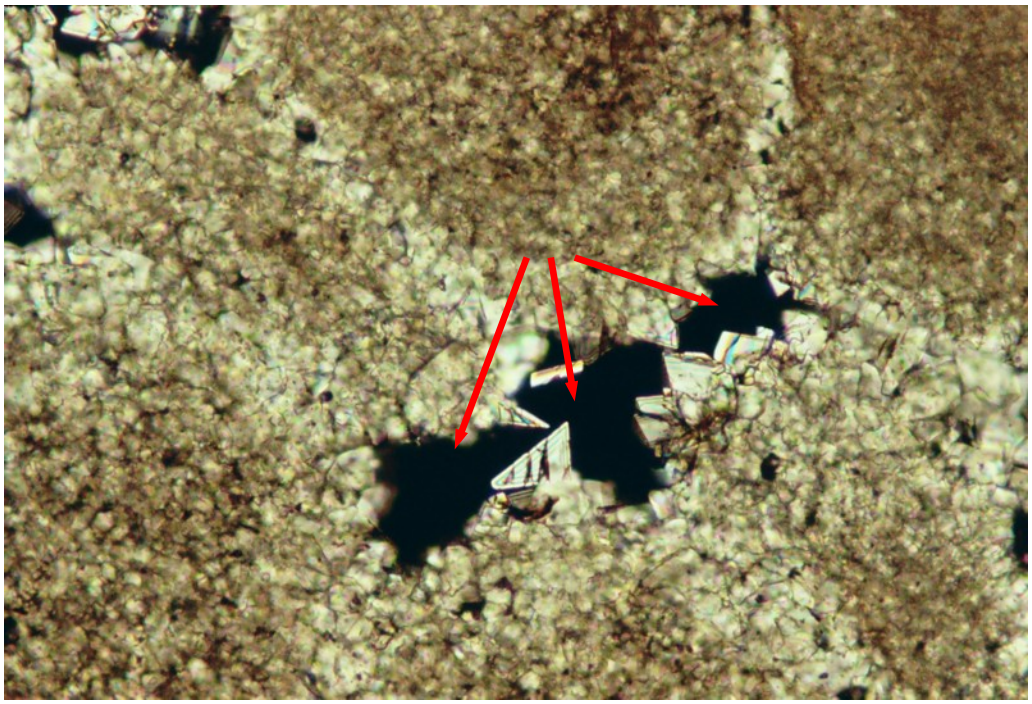
An oolitic dolostone. The rock is made up of small oval, sub-rounded oolites and sub-angular fragments set in a fine-grained matrix that consists of the same material - dolomite. Although most oolites do not have well defined internal structure, concentric structure is evident in some. The oolites are often rimmed by equigranular, fine-grained aggregates of dolomite. Other fragments have the shape of fossil bits, but they are completely replaced by fine-grained dolomite. Large, up to 4 mm long laminated rock fragments are included in the fine-grained matrix. They evidently represent broken sediment fragments.

The texture of the rock suggests replacement of earlier carbonates (calcite?) by fine-grained equigranular dolomite. The percent of small interparticle pores in the fine-grained interstitial matrix is difficult to evaluate, as some carbonates may have been merely ripped-out during sample preparation. However, as several of the holes contain aggregates of more coarse-grained dolomite than the matrix, and in some, the walls of the holes are lined with dolomite, the intergranular pore space may have developed during the replacement of calcite by dolomite.

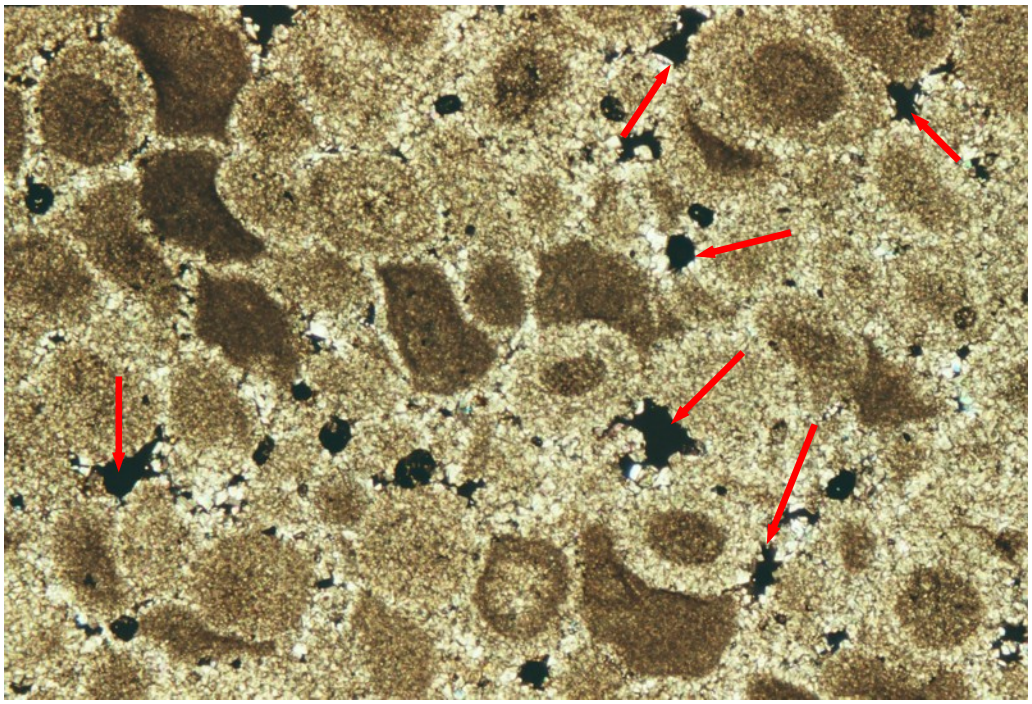
The rock consists of 100 % carbonate (mostly dolomite), and the intergranular pore space is estimated at ca. 0.5-1 %.



DGR1-156.63a. Oolites in fine-grained matrix of dolostone. Width of photo: 2.3mm. XN.



DGR1-156.63b. Interparticle pores interstitial to recrystallized cement between oolites. Width of photo: 0.9mm. XN.



DGR1-156.63c. Interparticle pores in oolitic dolostone. Width of photo: 2.3mm. XN.

```
ETEC                DGR1-156.63 DOLOMITIC OOLITE
ETEC                zaf cycles  4    bc drift=0.720
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.89  20.53   28.73  1.987
ETEC                MGO   0.51  12.61   20.91  2.013
ETEC                total       33.14   49.64   4

ETEC                DGR1-156.63 INTERSTITIAL DOLOMITE
ETEC                zaf cycles  4    bc drift=0.971
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.89  20.87   29.20  1.945
ETEC                MGO   0.51  13.37   22.17  2.055
ETEC                total       34.24   51.37   4
```

Sample Number: DGR1-231.49 **Rock Type: Calcareous shale**

Petrographic Description:

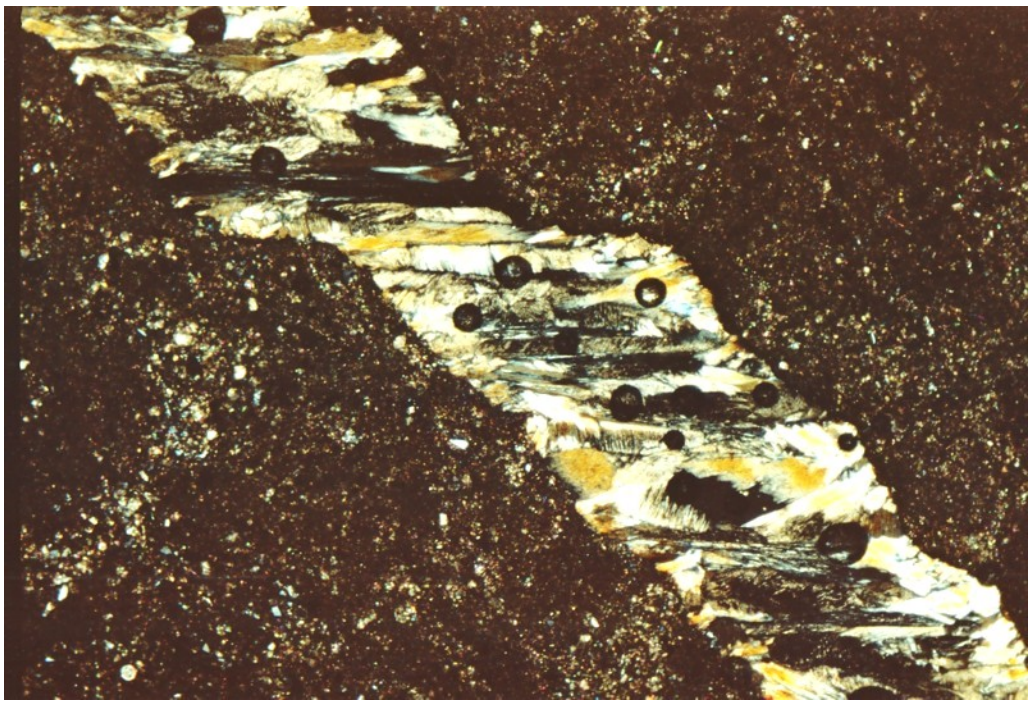
A featureless, fragmented and partly recrystallized calcareous shale. The dark, clayey shale is fragmented and the fragments "float" in a fine-grained dolomite-rich matrix. Aggregates of recrystallized fine-grained dolomite, and the fine-grained equigranular matrix contain small, angular quartz clasts.

Small gypsum veinlets parallel the rock fabric, and occur as cross-cutting veins normal to the rock fabric. The coarse-grained gypsum vein (some of which had been ground away during thin section preparation) consists of fibrous aggregates. The vein shows evidence of deformation. It parallels the relict sediment laminae and contains splayed off fragments from the dark brown, featureless shale. Gypsum also occurs in small veinlets that wrap-around the recrystallized carbonates. Very fine-grained needles of gypsum are interstitial to the recrystallized dolomite matrix

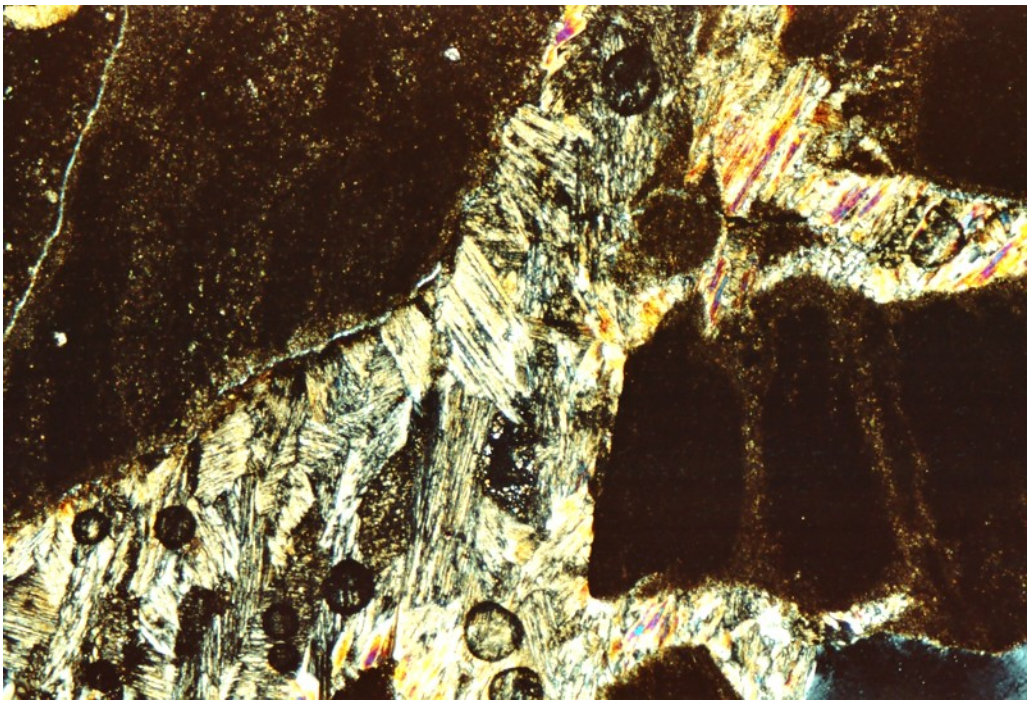
Numerous late carbonate veinlets cross-cut the rock fabric, they all post–dated the fragmentation of the rock.

Fine-grained quartz and very fine-grained pyrite are disseminated through the recrystallized carbonate-rich matrix, and also occur within the shale.

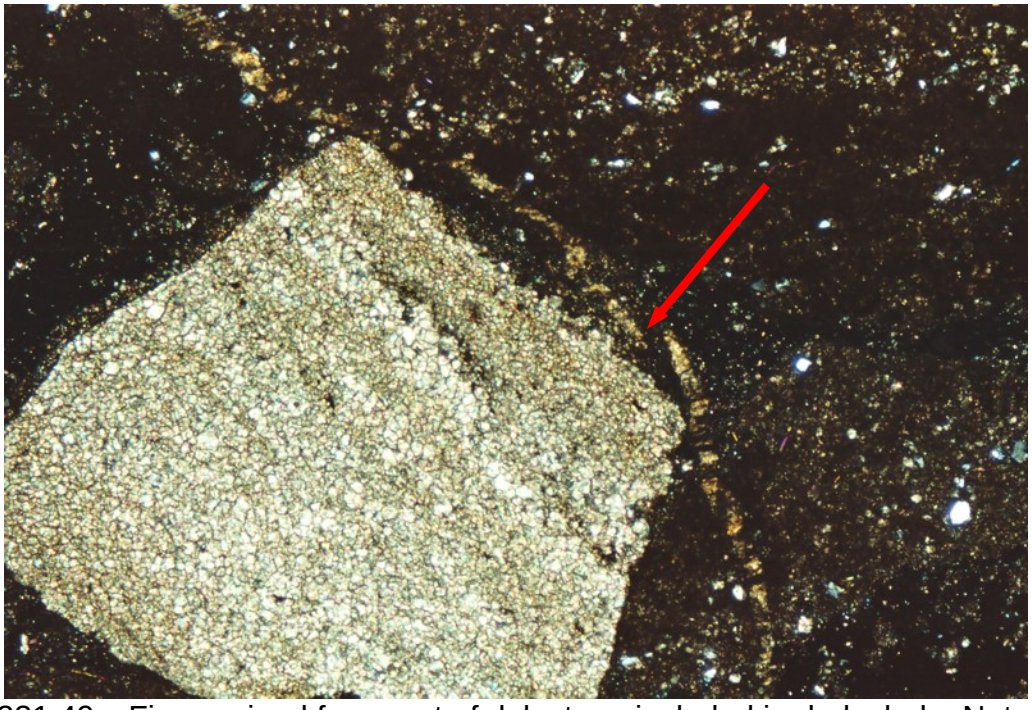
Mineral	**%**
Carbonate	92
Gypsum	6
Quartz	2
Pyrite	trace



DGR1-231.49a. Gypsum vein in calcareous shale. Width of photo: 2.3mm. XN.



DGR1-231.49b. Gypsum vein in dark shale. Width of photo: 2.3mm. XN.



DGR1-231.49c. Fine-grained fragment of dolostone included in dark shale. Note minute gypsum stringer in rock (arrow). Width of photo: 2.3mm. XN.

```
ETEC                DGR1-231.49 YELLOW GYPSUM VEIN
ETEC                zaf cycles  4    bc drift=1.036
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.86  23.81   33.31  1.072
ETEC                SO3   0.91  17.35   43.32  0.976
ETEC                F     0.10   0.00    0.00  0.000
ETEC                total       41.16   76.63   4

ETEC                DGR1-231.49 GYPSUM
ETEC                zaf cycles  4    bc drift=1.022
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.86  24.64   34.47  1.054
ETEC                SO3   0.91  18.37   45.88  0.982
ETEC                F     0.10   0.00    0.00  0.000
ETEC                total       43.01   80.35   4

ETEC                DGR1-231.49 DOLOMITE
ETEC                zaf cycles  4    bc drift=1.065
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.89  21.38   29.91  1.963
ETEC                MGO   0.51  13.46   22.32  2.037
ETEC                total       34.84   52.23   4

ETEC                DGR1-231.49 GYPSUM
ETEC                zaf cycles  4    bc drift=1.059
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.86  24.00   33.57  1.055
ETEC                SO3   0.91  17.87   44.62  0.982
ETEC                total       41.87   78.20   4
```

Sample Number: DGR1-267.78 **Rock Type: Calcareous shale**

Petrographic Description:

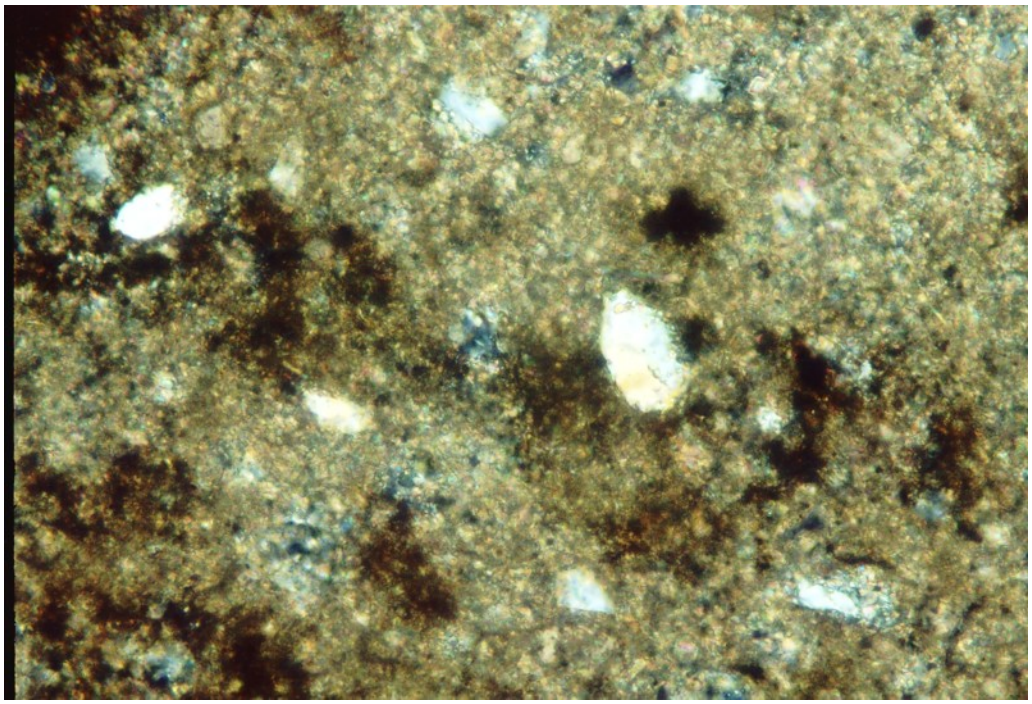
A featureless, more or less equigranular very fine-grained aphanitic rock. It consists of dark and light domains that correspond to higher and lower carbonate contents, respectively. Very fine-grained illite makes up approximately 2/3 of the thin section. Illite occurs in both, the light and dark matrix. Individual grains could not be properly analyzed (totals are too low) due to the miniscule grain size, but spot-checking the micaceous domains with electron microprobe demonstrates their approximate composition. Fine-grained quartz clasts and granular carbonate makes up the rest of the thin section. Quartz are small, detrital grains generally embedded in the matrix. Most are partly over-grown by fine-grained, dark dolomite. Equigranular, fine-grained carbonate is the second most abundant mineral in the rock and is intercalated with illite.

Very fine-grained pyrite is disseminated through the rock matrix. The anhedral grains mostly occur in the light domains.

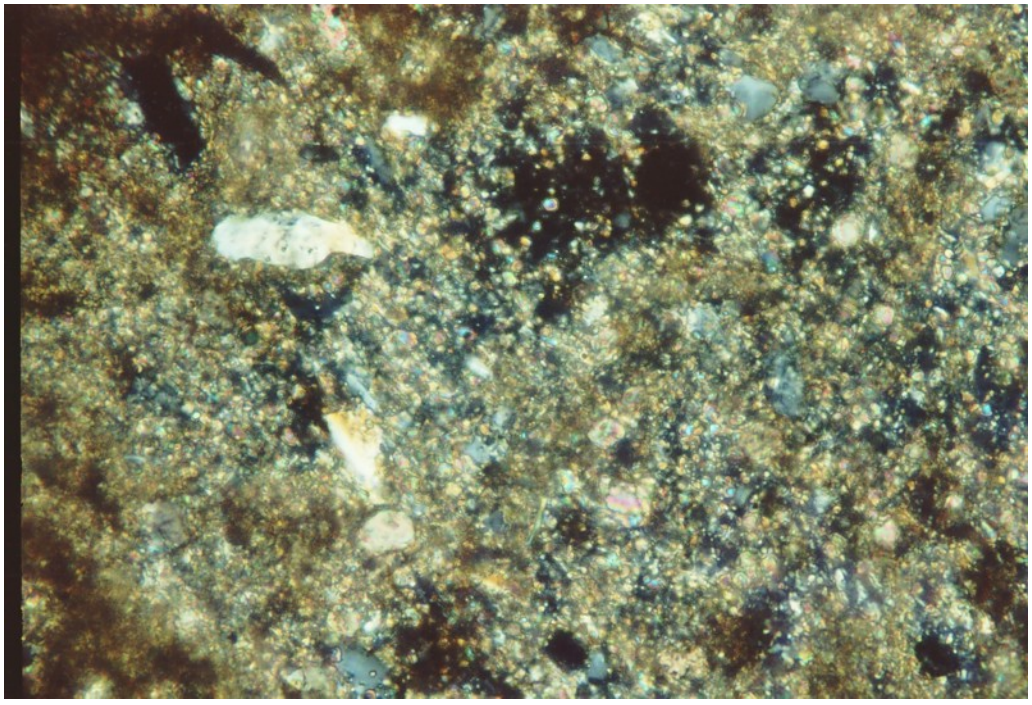
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Illite	60		Microcrystalline illite makes up much of the matrix in both, the dark and light domains. It occurs as a “mat” and is intercalated with quartz and the fine-grained carbonates. Their FeO and MgO contents are relatively high – but this may be due to the effect of including disseminated Fe-oxide and fine-grained dolomite in the analysis. The latter is suggested by the CaO content of the rock.
Carbonate	35	<0.2	Granular, fine-grained dolomite occurs in aggregates that partly replace some of the small quartz clasts. The anhedral grains are dark, poorly defined and lacking in cleavage.
Quartz	5	<0.2	Minute, sub-angular quartz are part of the matrix. Most are partly replaced by fine-grained carbonates.

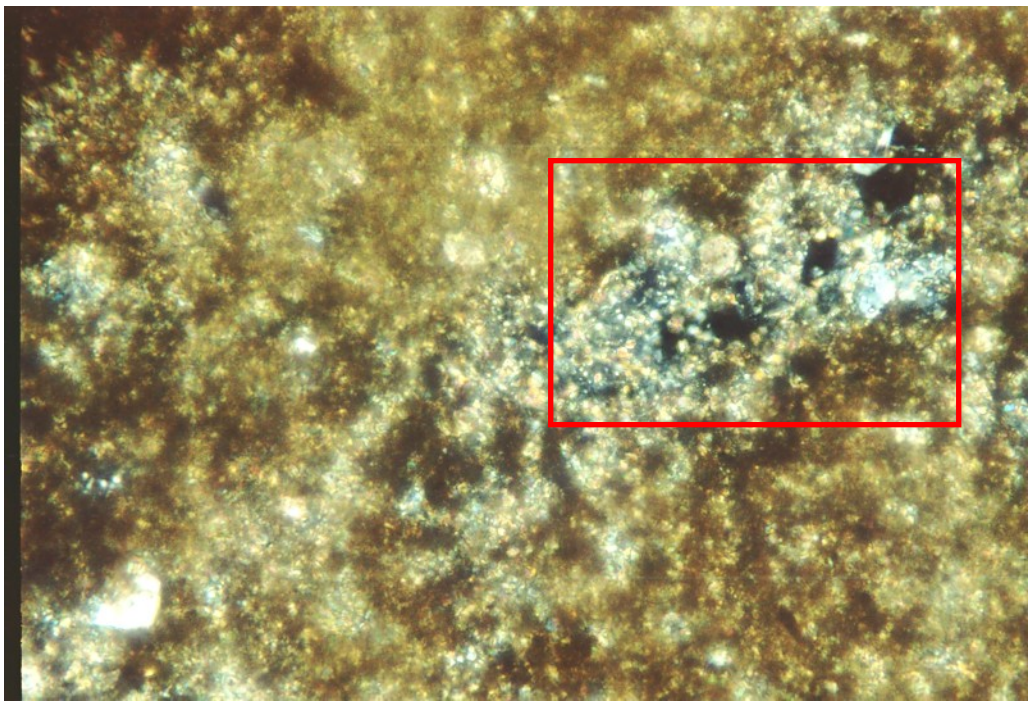
Accessory minerals: pyrite, hematite, zircon, oxyhydroxide



DGR1-267.78a. Illite-rich matrix with quartz clasts (white) in calcareous shale. Width of photo: 2.3mm. XN.



DGR1-267.78b. Similar to above.



DGR1-267.78c. Cherty domain in calcareous shale. Width of photo: 0.9mm.XN.

```
ETEC                DGR1-267.78 DARK AREA WITH MINUTE PYRITE
ETEC                zaf cycles  5    bc drift=0.926
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.69  12.86   27.51  0.695
ETEC                AL2O3 0.61   4.26    8.05  0.239
ETEC                MGO   0.48   2.62    4.34  0.163
ETEC                FEO   0.85  15.53   19.98  0.422
ETEC                SO3   0.77  11.40   28.46  0.539
ETEC                K2O   0.85   2.48    2.98  0.096
ETEC                total       49.14   91.33   4

ETEC                DGR1-267.78 DARK MATRIX
ETEC                zaf cycles  5    bc drift=1.037
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.68  20.68   44.24  1.241
ETEC                TIO2  0.84   0.92    1.54  0.033
ETEC                AL2O3 0.65   8.44   15.95  0.528
ETEC                MGO   0.55   4.79    7.95  0.332
ETEC                FEO   0.84   5.29    6.81  0.160
ETEC                CAO   0.84   1.81    2.53  0.076
ETEC                K2O   0.86   4.31    5.19  0.186
ETEC                NA2O  0.36   0.00    0.00  0.000
ETEC                total       46.25   84.21   4

ETEC                DGR1-267.78 LIGHT MATRIX
ETEC                zaf cycles  5    bc drift=1.062
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.68  16.46   35.21  1.230
ETEC                TIO2  0.84   0.23    0.38  0.010
ETEC                AL2O3 0.64   7.41   14.01  0.577
ETEC                MGO   0.53   3.83    6.36  0.331
ETEC                FEO   0.84   4.50    5.79  0.169
ETEC                CAO   0.84   1.03    1.45  0.054
ETEC                K2O   0.87   3.75    4.52  0.201
ETEC                NA2O  0.35   0.00    0.00  0.000
ETEC                total       37.22   67.71   4

ETEC                DGR1-267.78 DOLOMITE IN LIGHT MATIX
ETEC                zaf cycles  4    bc drift=1.068
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.68   2.14    4.57  0.282
ETEC                TIO2  0.81   0.00    0.00  0.000
ETEC                AL2O3 0.56   0.31    0.59  0.043
ETEC                MGO   0.51  11.09   18.38  1.688
ETEC                FEO   0.83   0.63    0.81  0.042
ETEC                CAO   0.89  17.53   24.52  1.619
ETEC                K2O   0.95   0.49    0.60  0.047
ETEC                NA2O  0.33   0.00    0.00  0.000
ETEC                total       32.19   49.47   4
```

```
ETEC                DGR1-267.78 DARK MATRIX
ETEC                zaf cycles  6    bc drift=1.063
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.66  22.92   49.04  1.227
ETEC                TIO2  0.83   0.23    0.39  0.007
ETEC                AL2O3 0.65  10.13   19.13  0.564
ETEC                FEO   0.84   5.96    7.67  0.160
ETEC                MGO   0.56   5.98    9.91  0.370
ETEC                CAO   0.83   2.23    3.12  0.084
ETEC                K2O   0.85   3.72    4.49  0.143
ETEC                NA2O  0.38   0.00    0.00  0.000
ETEC                total       51.17   93.74   4
```

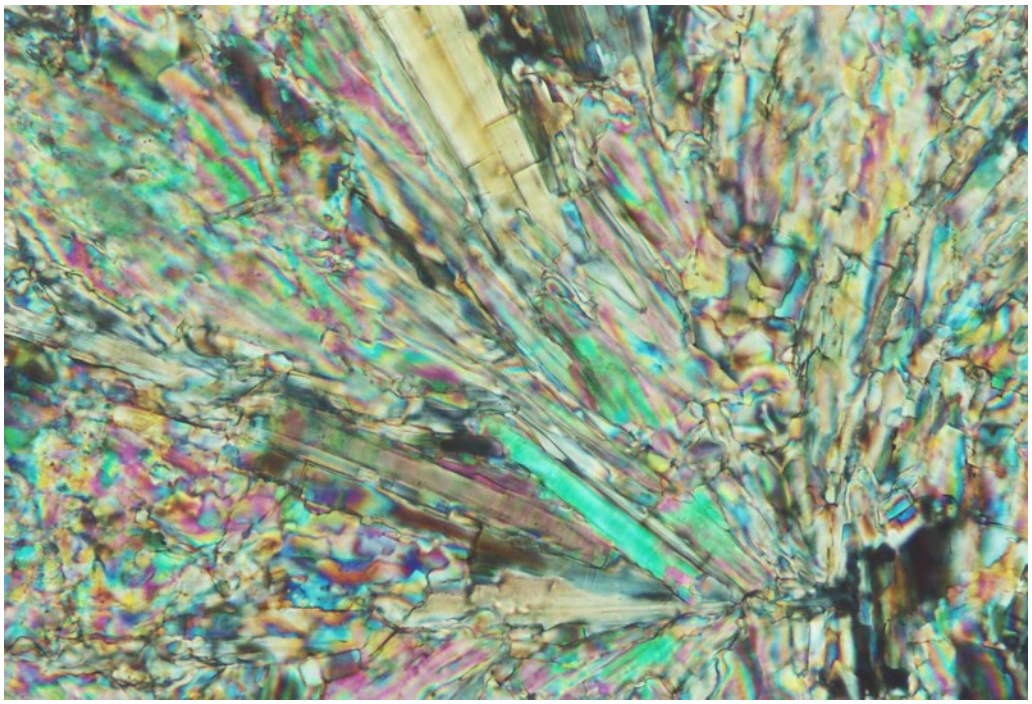
Sample Number: DGR1-322.19 **Rock Type: Anhydrite / gypsum rock**

Petrographic Description:

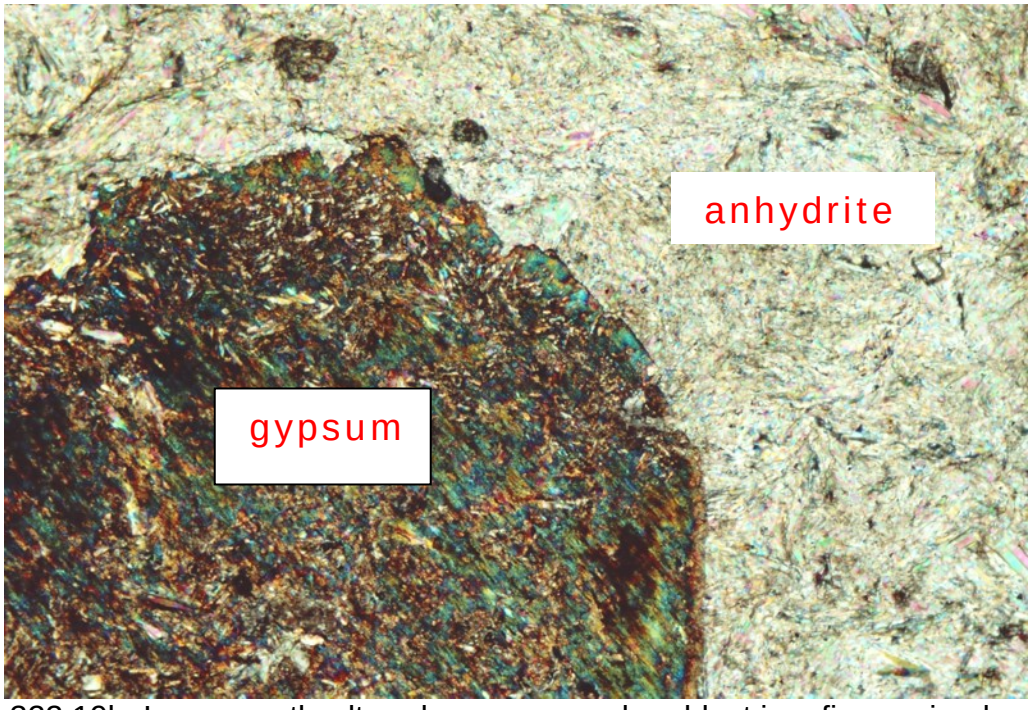
The rock has a very simple mineralogy. It consists predominantly of fibrous, radiating anhydrite, porphyroblasts of gypsum, and minor disseminated dolomite. The anhydrite is fine to medium-grained and crystallized at the expense of gypsum and the carbonates. All of the anhydrite are fibrous and form a mat or matrix to the gypsum and carbonate aggregates, and occur as inclusion in the gypsum (replacement). They have very high birefringence and superficially resemble talc. The large, up to 1 cm gypsum porphyroblasts are corroded and partly fragmented. The fractures are filled by the fine-grained anhydrite. Fine-grained carbonate is disseminated through the thin section, and just as gypsum, they are partly replaced by anhydrite.

Detailed mineralogy

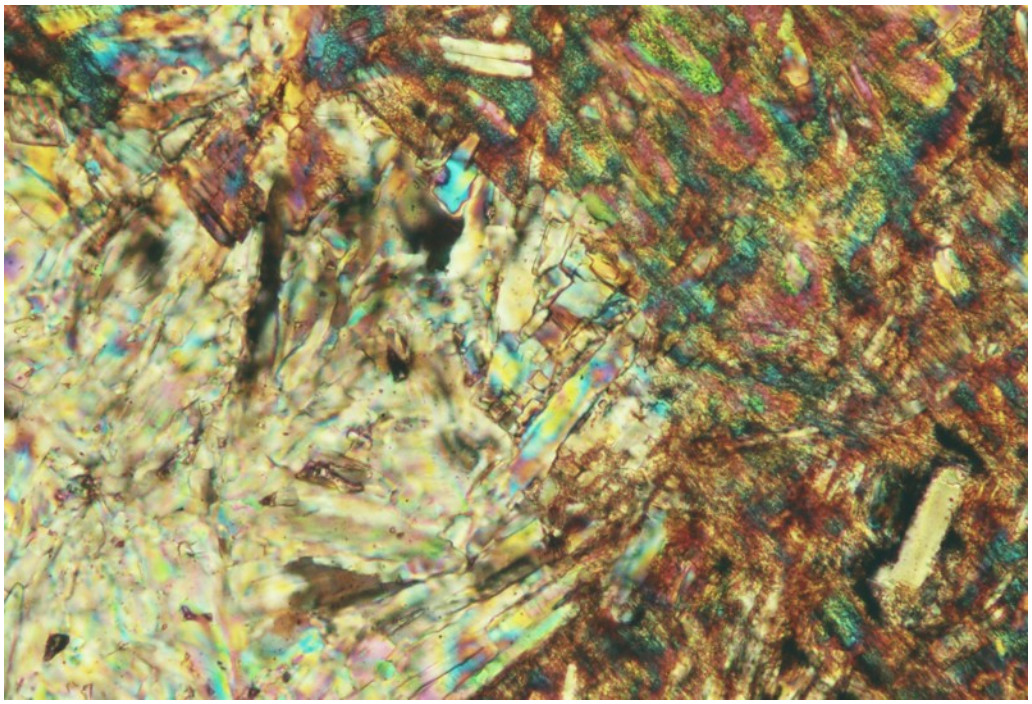
Mineral	%	Grain size(mm)	Comments
Anhydrite	85	<0.3-2.5	Fibrous anhydrite make up most of the matrix. It occurs mostly as radiating slender prisms and small laths that grew at the expense of gypsum porphyroblasts – and less commonly, after carbonates. Inclusions of anhydrite in the gypsum are replacement after the coarse-grained gypsum porphyroblasts.
Gypsum	10	2mm-1cm	Large porphyroblasts of subhedral gypsum are partly replaced by fibrous anhydrite. They occur as large, single grains, some of which are partly rimmed by fine-grained carbonates.
Carbonate	5	Av. 0.4	Most carbonates occur in aggregates disseminated through the anhydrite-rich matrix. The subhedral grains are partly replaced by fibrous anhydrite.



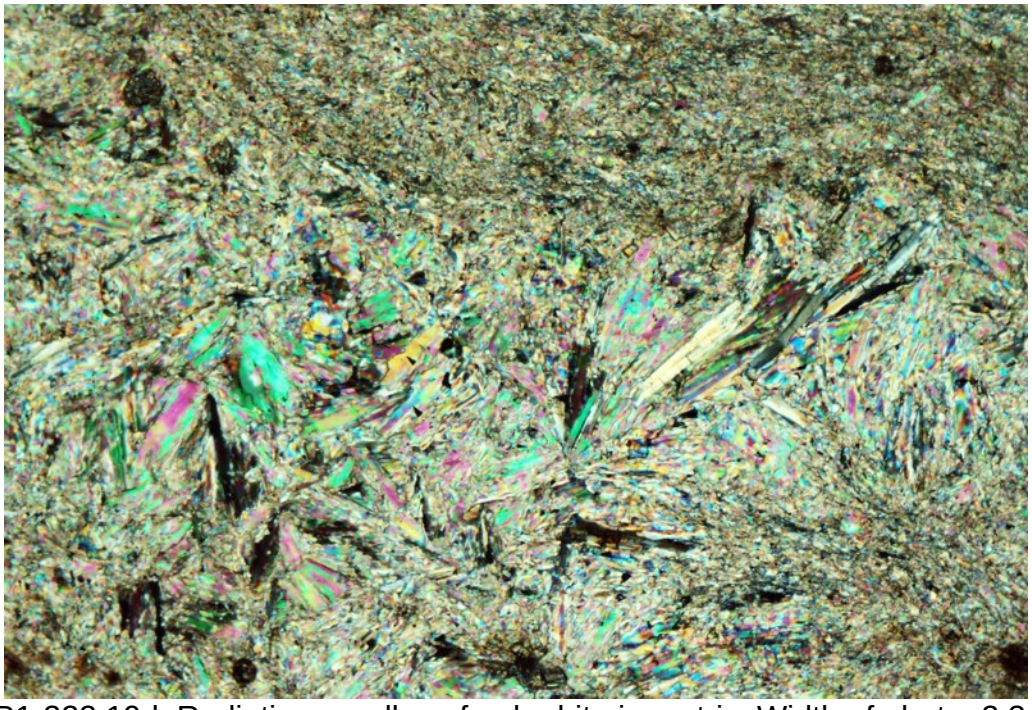
DGR1-322.19a. Radiating anhydrite . Width of photo: 0.9mm. XN.



DGR1-322.19b. Large, partly altered gypsum porphyroblast in a fine-grained matrix of anhydrite. Width of photo: 2.3mm. XN.



DGR1-322.19c. Anhydrite prisms replace the gypsum (dark) at the grain boundaries. Width of photo: 0.9mm. XN.



DGR1-322.19d. Radiating needles of anhydrite in matrix. Width of photo: 2.3mm.

```
ETEC                DGR1-322.19 FINE-GRAINED MATRIX ANHYDRITE
ETEC                zaf cycles  4    bc drift=0.961
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.86  28.39   39.73  1.050
ETEC                SO3   0.91  21.27   53.12  0.983
ETEC                total       49.67   92.85   4

ETEC                DGR1-322.19 GYPSUM PORPHYROBLAST
ETEC                zaf cycles  4    bc drift=1.013
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.86  24.19   33.84  1.039
ETEC                SO3   0.91  18.37   45.87  0.987
ETEC                total       42.56   79.72   4

ETEC                DGR1-322.19 FIBROUS ANHYDITE
ETEC                zaf cycles  4    bc drift=1.004
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.85  29.85   41.77  1.031
ETEC                SO3   0.91  22.92   57.23  0.990
ETEC                total       52.77   99.00   4
```

Sample Number: DGR1-361.76 **Rock Type: Calcareous shale**

Petrographic Description:

A laminated very fine-grained calcareous shale that consists of alternating light and dark bands. Both contain significant amount of carbonate (calcite) and illite. The very fine-grained calcite are intergrown with the illite, as suggested by the spot-check analysis of the dark bands. The totals are low due to the partial inclusion of calcite in the data, but the 2.56 wt% K2O in the analysis represents an illite fraction. As the grain size of most minerals is very small (<0.2mm), and the rock is stained dark brown, the individual minerals cannot be identified – with the exception of carbonates, quartz, pyrite, and some of the micas.

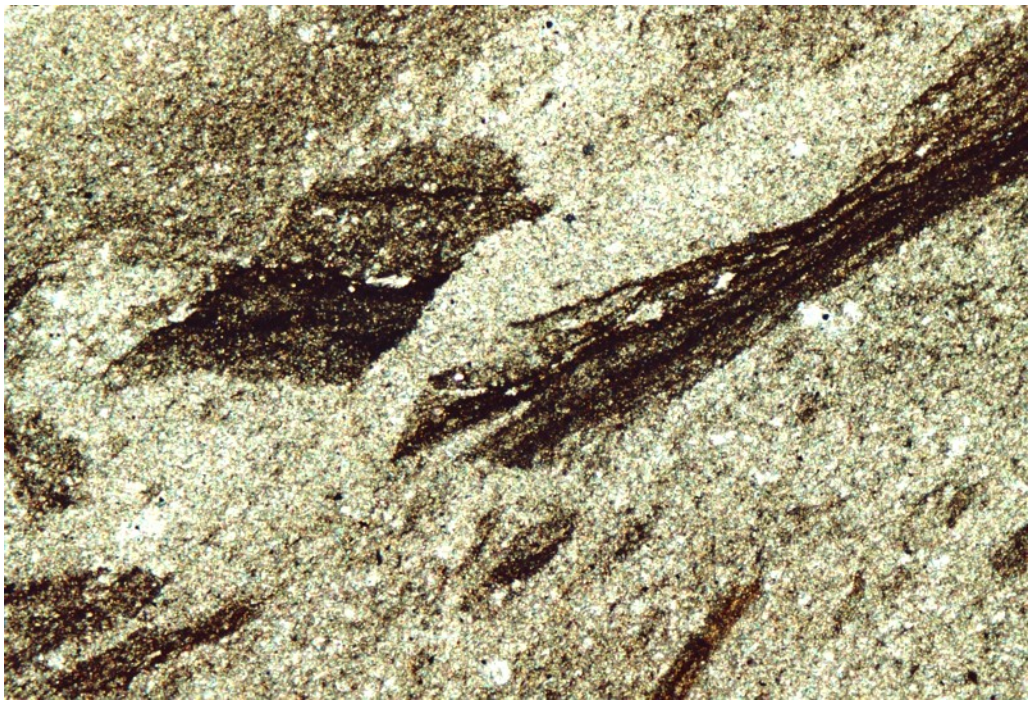
Clean, calcite-rich bands alternate with, and they are interstitial to the dark clay-rich bands. Some of the dark laminae are broken and the gaps are filled by fine-grained calcite. The calcite+illite-rich bands contain small fragments of the brown bands – which had been evidently cleaved off the dark shale/mudstone.

Pyrite is relatively common (compared to the other samples), and the small grains are disseminated throughout the rock. They are most abundant in the light-colored calcite+illite-rich bands. The anhedral grains form aggregates and the grain size is up to 0.3mm.

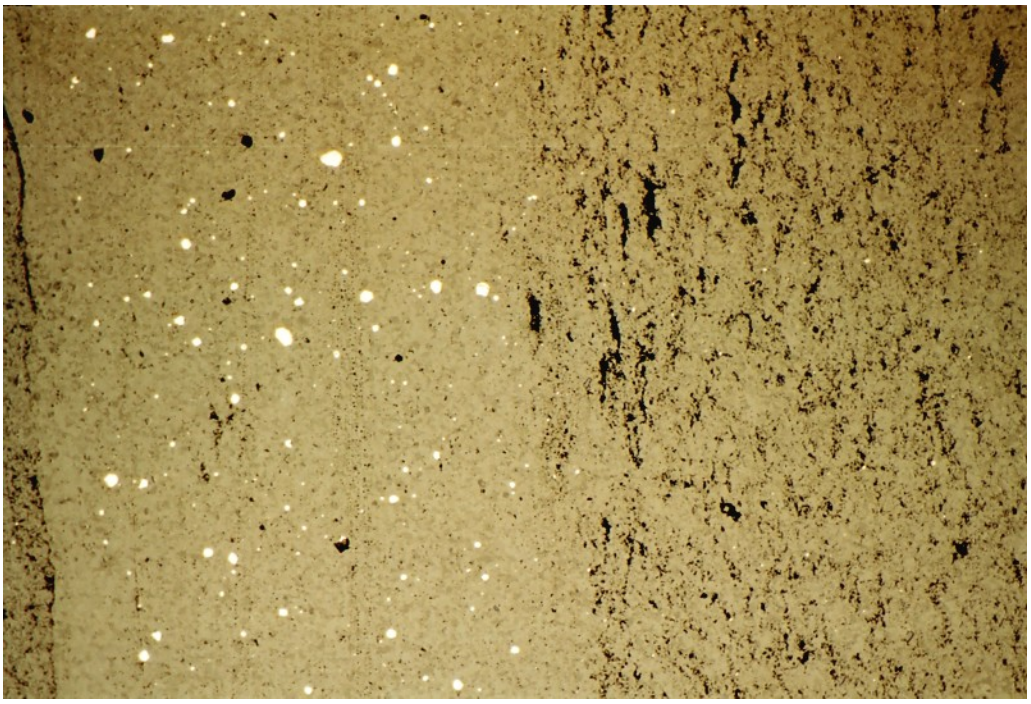
Reliable estimation of % minerals in the rock is not possible due to the small grain size of the individual bands. The major minerals present, however, are listed below in order of decreasing abundance:

Carbonate
Illite
Quartz
Pyrite

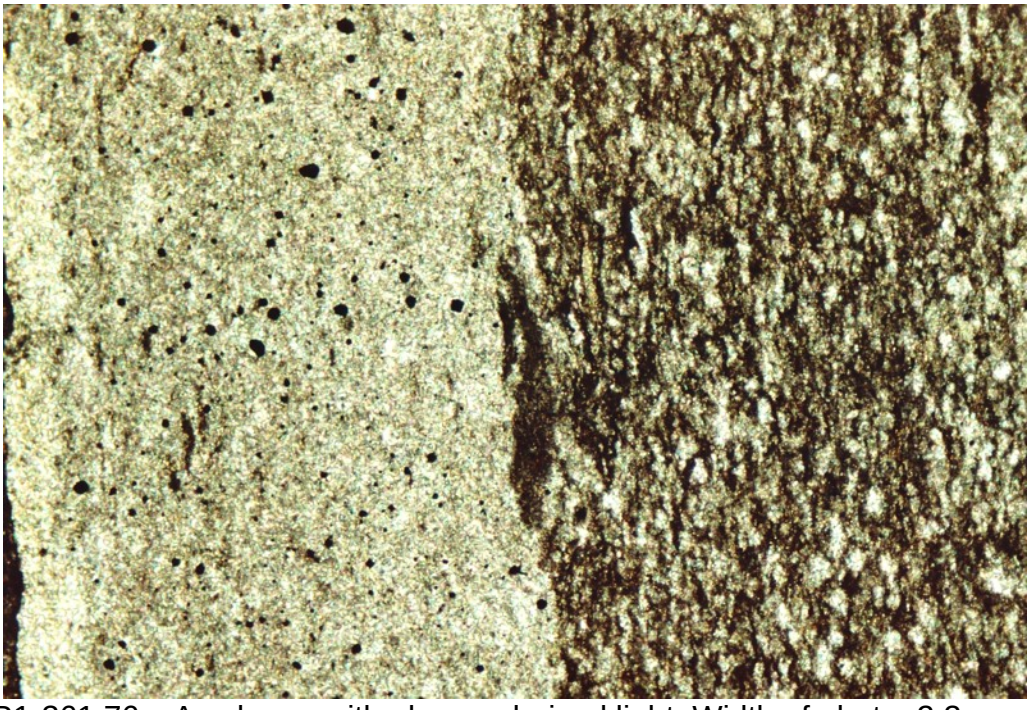
DGR1-361.76a. Laminated calcareous shale. Width of photo: 2.3mm. XN.



DGR1-361.76b. Fragmented fine-grained dark shale. Width of photo: 2.3mm. XN.



DGR1-361.76c. Fine-grained pyrite (white) in light-colored laminae. Width of photo: 2.3mm. Refl. light.



DGR1-361.76c. As above, with plane polarized light. Width of photo: 2.3mm. Ppl.

ETEC DGR-361.76 CALCITE RICH BAND
ETEC zaf cycles 4 bc drift=0.634
ETEC fac %el %ox stfm
ETEC CAO 0.92 37.97 53.13 3.927
ETEC MGO 0.48 0.43 0.71 0.073
ETEC total 38.40 53.84 4

ETEC DGR-361.76 DARK MATRIX
ETEC zaf cycles 4 bc drift=0.979
ETEC fac %el %ox stfm
ETEC SIO2 0.72 8.17 17.47 0.776
ETEC AL2O3 0.66 4.85 9.17 0.480
ETEC MGO 0.51 0.00 0.00 0.000
ETEC FEO 0.83 0.98 1.26 0.047
ETEC K2O 0.96 2.14 2.58 0.146
ETEC CAO 0.88 24.14 33.78 1.608
ETEC total 40.28 64.26 4

Sample Number: DGR1-399.85 **Rock Type: Fossiliferous packstone**

Petrographic Description:

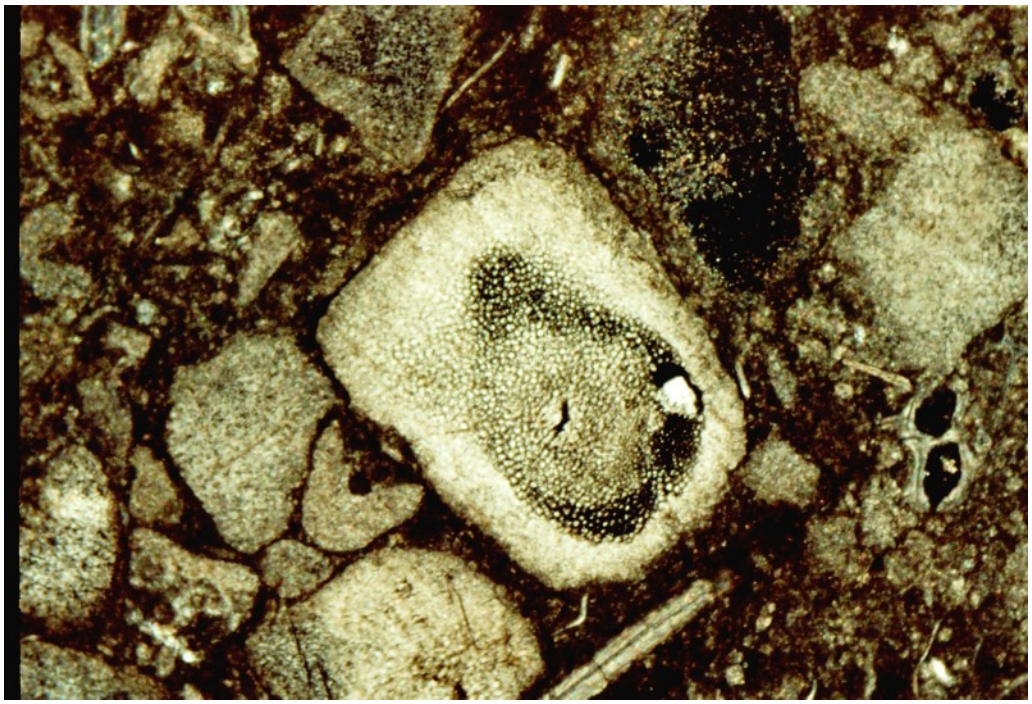
The rock consists mostly of calcareous fossils within carbonate-rich matrix and interstitial ferruginous mud. The broken fossil fragments include sponges, brachiopods, ostracods, crinoids, and other fossil bits. The dark, mud-like matrix is partly clayey, having an illite-like composition, and partly consists of fine-grained euhedral carbonates and fine-grained, granular, strained carbonates. Some of the fossil fragments are partly recrystallized at the selvages to fine-grained carbonate aggregates. The fibrous variety of fossil bits are partly replaced by the dark carbonate aggregates. Anastomosing dark, muddy (Fe-stained) illite veins are interstitial to the fossil fragments and boudinage some of the fragments. Dark green, weakly fibrous stringers within the dark anastomosing veins are interstitial to the illite veins and the carbonates. Subrounded, oval-shaped green grains of comparable texture have a composition between glauconite and illite – the glauconite is probably partly replaced by illite.

Very fine-grained euhedral / subhedral pyrite are disseminated throughout the matrix, and they also occur at the rims of the fossil fragments.

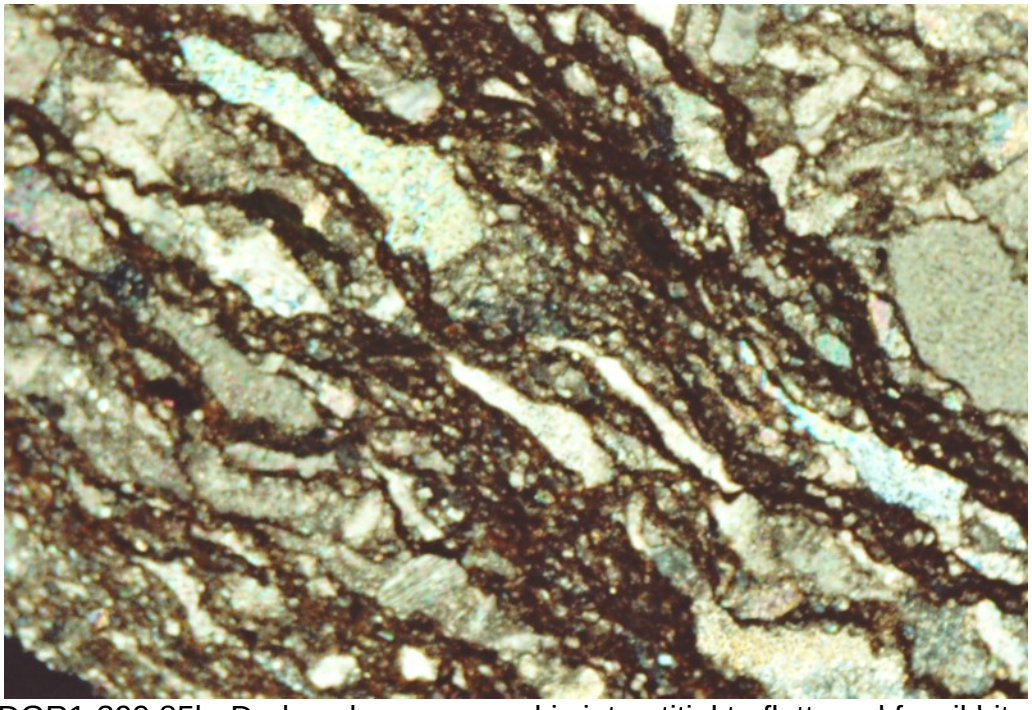
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Carbonate	90	Variable	Carbonates are fine-grained euhedral, subhedral and anhedral granular aggregates that are interstitial to the fossil fragments. They partly replace or form rims on the fossils. The fossils are calcareous and consist of massive or fibrous (less common) carbonates. Some of the fossils are, sponges, brachiopods, ostracods, and crinoids (?)
Illite	10		Illite occurs within stained clayey stringers that are interstitial to and form rims on the fossil fragments. The veins contain minute green stringers having a composition intermediate between glauconite and illite.

Accessory minerals: quartz, pyrite, glauconite

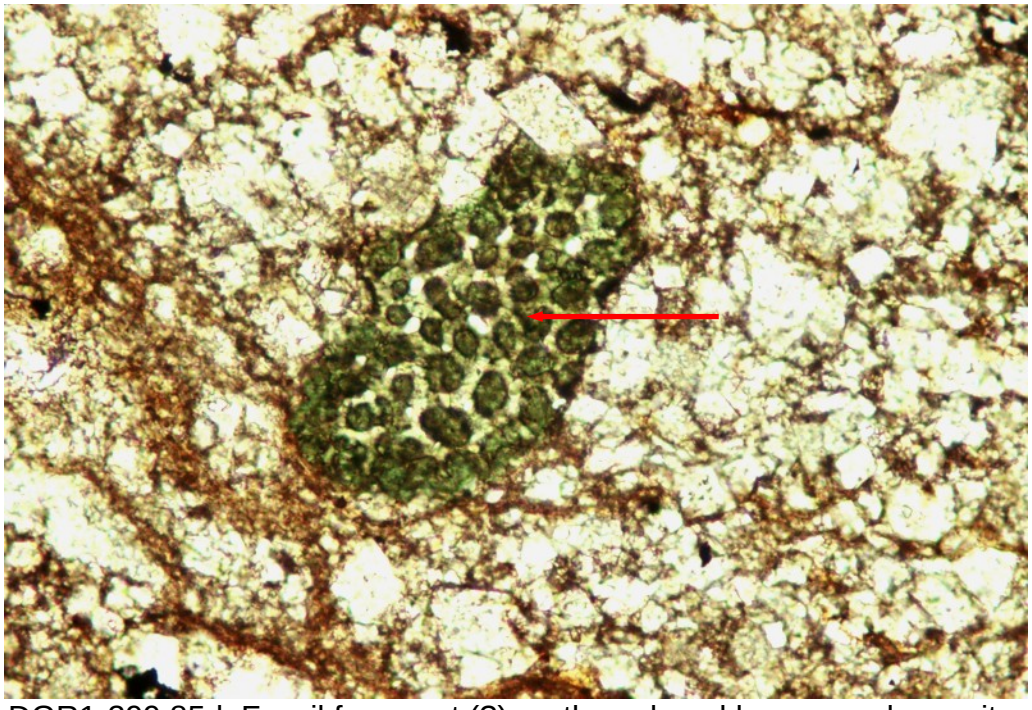


DGR1-399.85a. Fossil bits in packstone. Width of photo: 2.3mm. XN



DGR1-399.85b. Dark, calcareous mud is interstitial to flattened fossil bits. Width of photo: 2.3mm. XN.

DGR1-399.85c. Fe-stained fine-grained mud raps around green glauconite (?).
Width of photo: 0.9mm. Ppl.



DGR1-399.85d. Fossil fragment (?) partly replaced by green glauconite.
Width of photo: 2.3mm. Ppl.

```
ETEC                DGR1-399.85 GREEN ALTERED GLAUCONITE?
ETEC                zaf cycles  5    bc drift=0.970
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.70  22.88   48.94  1.424
ETEC                TIO2  0.85   0.00    0.00  0.000
ETEC                AL2O3 0.64   4.77    9.01  0.309
ETEC                FEO   0.84   9.88   12.71  0.309
ETEC                MGO   0.51   3.24    5.37  0.233
ETEC                K2O   0.86   6.52    7.85  0.291
ETEC                NA2O  0.34   0.00    0.00  0.000
ETEC                total       47.28   83.88   4

ETEC                DGR1-399.85 GREEN ALTERED GLAUCONITE?
ETEC                zaf cycles  5    bc drift=1.033
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.70  23.20   49.64  1.409
ETEC                TIO2  0.84   0.00    0.00  0.000
ETEC                AL2O3 0.65   5.94   11.22  0.375
ETEC                FEO   0.84   8.62   11.08  0.263
ETEC                MGO   0.53   3.06    5.08  0.215
ETEC                K2O   0.86   6.44    7.76  0.281
ETEC                NA2O  0.35   0.00    0.00  0.000
ETEC                total       47.26   84.78   4

ETEC                DGR1-399.85 85 DARK MATRIX
ETEC                zaf cycles  5    bc drift=1.056
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.69  22.92   49.03  1.329
ETEC                TIO2  0.83   0.68    1.13  0.023
ETEC                AL2O3 0.72  11.59   21.90  0.700
ETEC                FEO   0.83   1.29    1.66  0.038
ETEC                MGO   0.58   1.00    1.66  0.067
ETEC                K2O   0.85   6.72    8.10  0.280
ETEC                NA2O  0.39   0.00    0.00  0.000
ETEC                total       44.20   83.47   4
```

Sample Number: DGR1-419.99 **Rock Type: Oxidized shale**

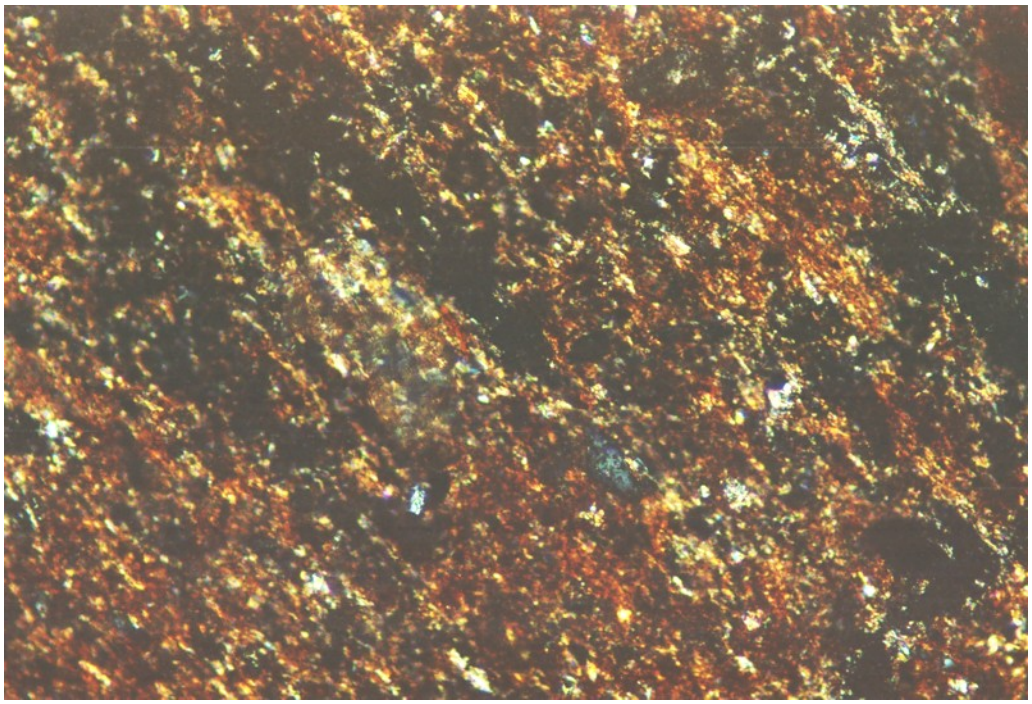
Petrographic Description:

A featureless, Fe-stained, very fine-grained oxidized shale. The rock has a simple mineralogy, consisting predominantly of Fe-stained illite, minute angular quartz clasts in illite and very fine-grained carbonates. The fine-grained carbonate is interstitial to illite, and fine-grained angular quartz occurs as inclusions in illite-rich domains. Illite stringers show weak alignment and define the rock fabric.

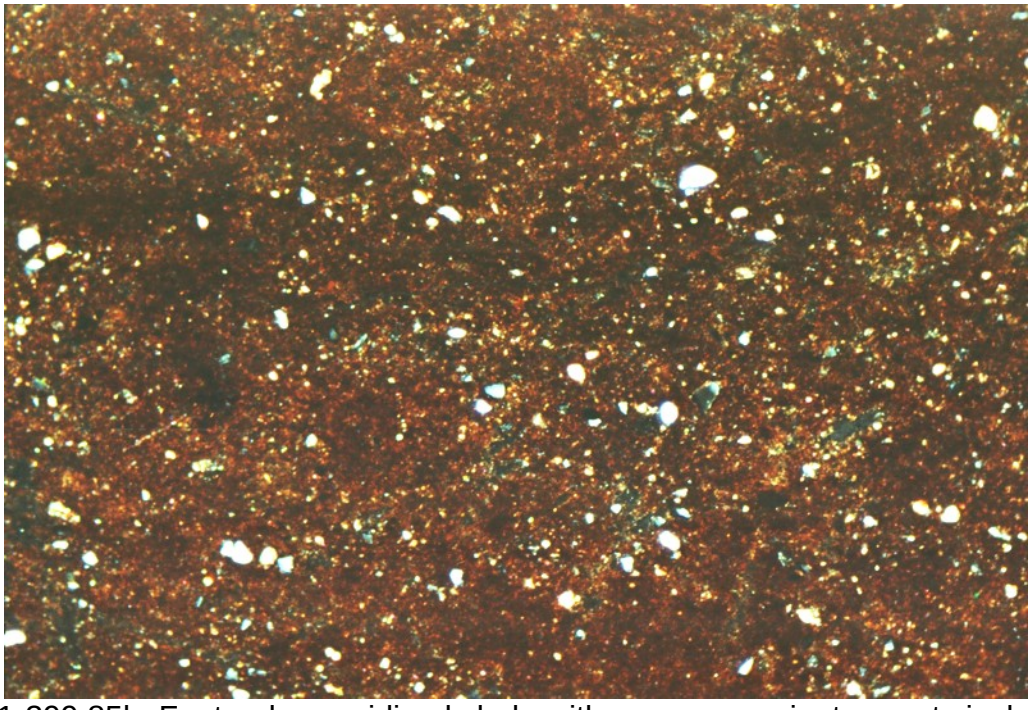
Minute grains of anhydrite are interstitial to illite. They occur as equant grains and also as small laths within the matrix.

Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Illite	80		Fe-stained fine-grained illite occurs as stringers that weakly define the rock fabric, and as un-oriented matrix to fine-grained quartz.
Quartz	10	<0.3	Minute grains of sub-angular quartz are interstitial to the illite matrix. The small grains are strained and have undulose extinction.
Carbonate	10	<0.3	Fine-grained aggregates of subhedral /anhedral carbonate are interstitial to illite.
Anhydrite	<1		Anhydrite occurs as small laths and as very fine-grained aggregates interstitial to illite.



DGR1-419.99a. Weakly laminated oxidized shale. Width of photo: 2.3mm. XN.



DGR1-399.85b. Featureless oxidized shale with numerous minute quartz inclusions (white). Width of photo: 2.3mm. XN.

```
ETEC                GGR1-419.99 DARK MATRIX
ETEC                zaf cycles  5    bc drift=0.833
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.69  20.22   43.25  1.340
ETEC                AL2O3 0.67   9.02   17.04  0.623
ETEC                FEO   0.84   6.78    8.72  0.226
ETEC                MGO   0.53   0.67    1.12  0.052
ETEC                K2O   0.86   4.52    5.45  0.215
ETEC                total       41.21   75.57   4

ETEC                GGR1-419.99  DARK MATRIX
ETEC                zaf cycles  5    bc drift=0.967
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.69  21.72   46.46  1.318
ETEC                AL2O3 0.69  10.44   19.73  0.660
ETEC                FEO   0.84   4.81    6.19  0.147
ETEC                MGO   0.55   1.06    1.76  0.074
ETEC                K2O   0.86   6.94    8.36  0.303
ETEC                total       44.97   82.50   4

ETEC                DGR1-419.99 DOLOMITE LATH
ETEC                zaf cycles  4    bc drift=0.940
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.89  17.57   24.58 10.812
ETEC                MGO   0.51  12.75   21.13 12.932
ETEC                FEO   0.83   0.58    0.75  0.170
ETEC                SRO   0.71   0.66    0.78  0.188
ETEC                total       30.90   46.47   24

ETEC                DGR1-419.99 DOLOMITE
ETEC                zaf cycles  4    bc drift=0.940
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.89  16.94   23.71 10.511
ETEC                MGO   0.51  13.18   21.87 13.490
ETEC                FEO   0.83   0.00    0.00  0.000
ETEC                SRO   0.71   0.66    0.78  0.000
ETEC                total       30.13   45.58   24
```

Sample Number DGR1-446.25 **Rock Type: Dolomitic shale**

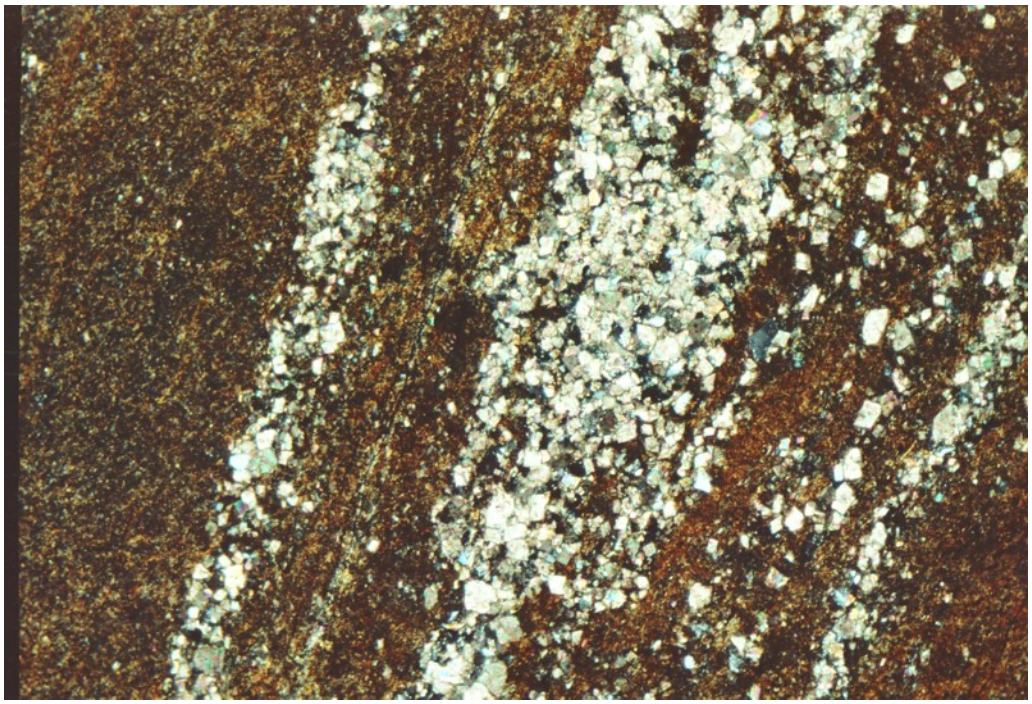
Petrographic Description:

A very fine-grained, laminated dolomitic shale. The rock consists of alternating bands of fine-grained equigranular dolomite and micaceous bands of illite. A well compacted, relatively undeformed rock, only some of the micaceous bands show weak kink-banding. Although the dolomite-rich bands are more or less monomineralic, the illite bands contain inclusions of fine-grained carbonate, a few minute grains of gypsum or anhydrite and angular quartz clasts. The micaceous bands also contain very fine-grained disseminated pyrite, but the carbonate-rich bands are pyrite-free. There is gradation between some of the clay-illite and dolomite bands, where the clay minerals overprint the carbonates and they are interstitial to some of the fine-grained carbonates.

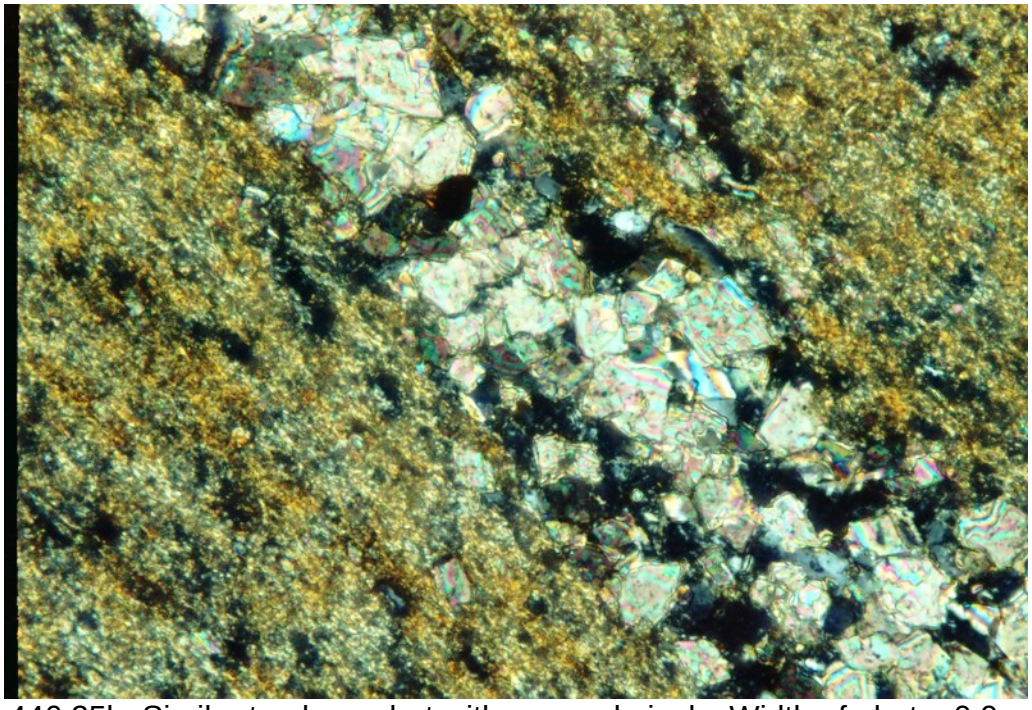
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Illite (clays)	60		Illite-rich laminae alternate with the carbonate-rich bands. The illite is slightly kink-banded and the micaceous bands are relatively Fe-rich (up to 5 wt% FeO). Parting and cleaving within the micaceous bands is common, and appear to contain shrinking cracks. The micaceous bands are Fe-stained.
Carbonate	39	Av. 0.3	Fine-grained, equigranular, euhedral / subhedral carbonates occur in bands interstitial to the micaceous bands. Some contain interstitial featureless clays.
Pyrite	0.5	<0.2	Very fine-grained pyrite is disseminated within the clay / illite-rich bands. Some occur in aggregates and some are small framboids.
Quartz	0.5	Av. 0.3	Fine-grained quartz clasts are semi-angular and occur as inclusions in the micaceous bands. They are also interstitial to some of the carbonates in the carbonate-rich bands.

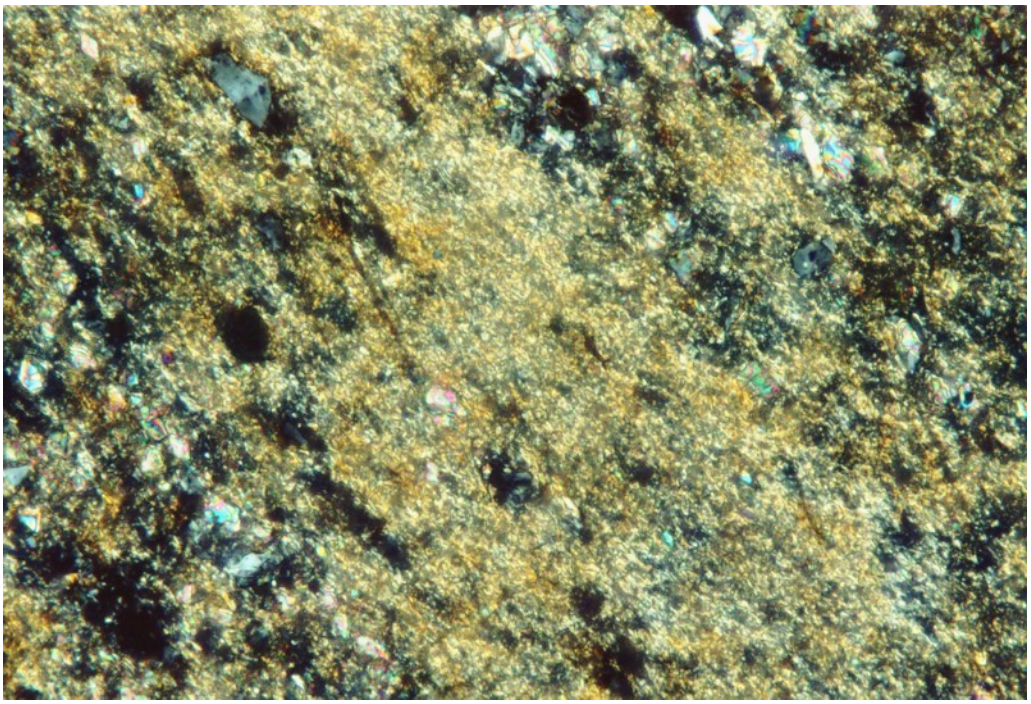
Accessory minerals: oxyhydroxide, gypsum



DGR1-446.25a. Alternating bands of fine-grained dolomite (light) and dark, micaceous bands. Width of photo: 2.3mm. ppl.



DGR1-446.25b. Similar to above, but with crossed nicols. Width of photo: 0.9mm. XN.



DGR1-446.25. Illite-rich domain in shale. Width of photo: 0.9mm. XN.

```
ETEC                DGR1-446.25 MICACEAOUS BAND
ETEC                zaf cycles  5    bc drift=0.755
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.69  23.55   50.37  1.335
ETEC                TIO2  0.84   0.29    0.48  0.010
ETEC                AL2O3 0.69  10.62   20.07  0.627
ETEC                MGO   0.56   2.05    3.40  0.134
ETEC                FEO   0.84   4.40    5.66  0.126
ETEC                K2O   0.85   5.40    6.50  0.220
ETEC                total       46.31   86.49   4

ETEC                DGR1-446.25 MICACEAOUS BAND
ETEC                zaf cycles  3    bc drift=0.973
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.77  18.65   39.91  1.814
ETEC                TIO2  0.85   0.29    0.48  0.016
ETEC                CR2O3 0.85   0.32    0.47  0.017
ETEC                MGO   0.51   0.00    0.00  0.000
ETEC                FEO   0.84   3.16    4.07  0.155
ETEC                K2O   0.88   4.56    5.49  0.319
ETEC                total       26.98   50.42   4

ETEC                DGR1-446.25 DOLOMITE BAND
ETEC                zaf cycles  4    bc drift=1.012
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  22.84   31.96  2.311
ETEC                MGO   0.50  10.13   16.79  1.689
ETEC                total       32.97   48.75   4

ETEC                DGR1-446.25 MICACEOUS BAND
ETEC                zaf cycles  5    bc drift=1.031
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.70  22.88   48.94  1.426
ETEC                TIO2  0.84   0.22    0.36  0.008
ETEC                CR2O3 0.85   0.43    0.63  0.014
ETEC                AL2O3 0.68   8.14   15.38  0.528
ETEC                MGO   0.55   1.33    2.20  0.096
ETEC                FEO   0.84   4.35    5.60  0.136
ETEC                K2O   0.85   3.82    4.61  0.171
ETEC                total       41.17   77.72   4
```

Sample Number: DGR1-455.45 **Rock Type: Ferruginous, calcareous shale**

Petrographic Description:

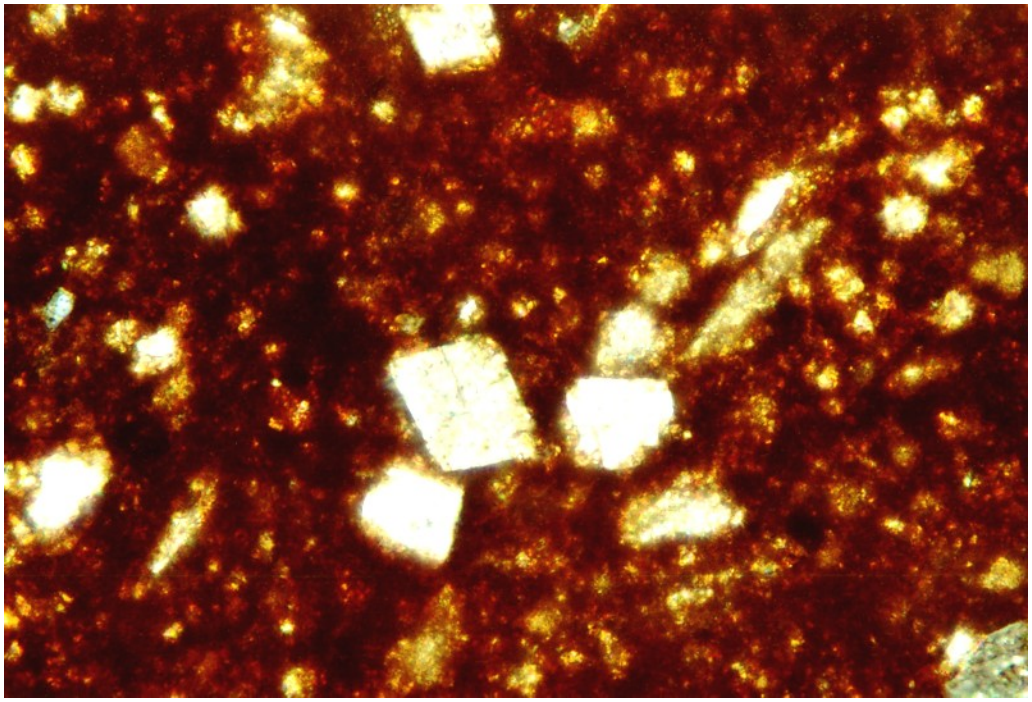
Iron-stained, fine-grained, featureless calcareous shale. Due to iron staining, most minerals, except for quartz and some of the carbonates, are difficult to identify optically. The matrix consists of what appears to be, very fine-grained carbonates, ferruginous clays, quartz and minor small fossil bits. Euhedral carbonates over-grow the matrix as small porphyroblasts, and anhedral fine-grained carbonates are randomly disseminated, representing an earlier generation. The relict carbonates have sutured and "frothy" grain boundaries, suggesting partial dissolution of the grains.

The rock has no identifiable internal structure, such as deformation, etc., nor is there any evidence of lamination. A few minute veinlets (randomly oriented) cross-cut the rock. They contain fine-grained calcite.

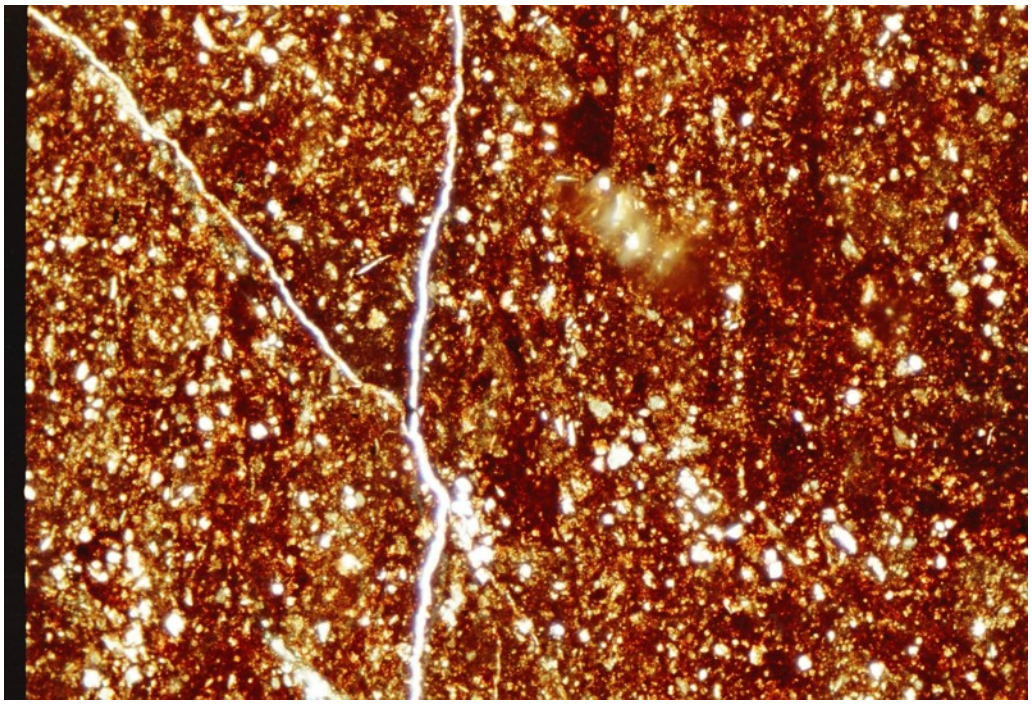
Very fine-grained hematite is sparsely disseminated through the rock, and pyrite or other sulfides are absent.

It is not possible to estimate the % of various minerals due to the strong iron staining in the rock, and are listed below in order of decreasing abundance:

Carbonate
Fe-stained clays
Quartz
Hematite



DGR1-455.45a. Carbonate inclusions (light color) in highly oxidized matrix of ferruginous shale. Width of photo: 0.9mm. Ppl.



DGR1-455.45b. Carbonate veinlets in ferruginous shale. Width of photo: 2.3mm. Ppl.

Sample Number: DGR1-456.01 vein **Rock Type: Ferruginous, calcareous shale**

Petrographic Description:

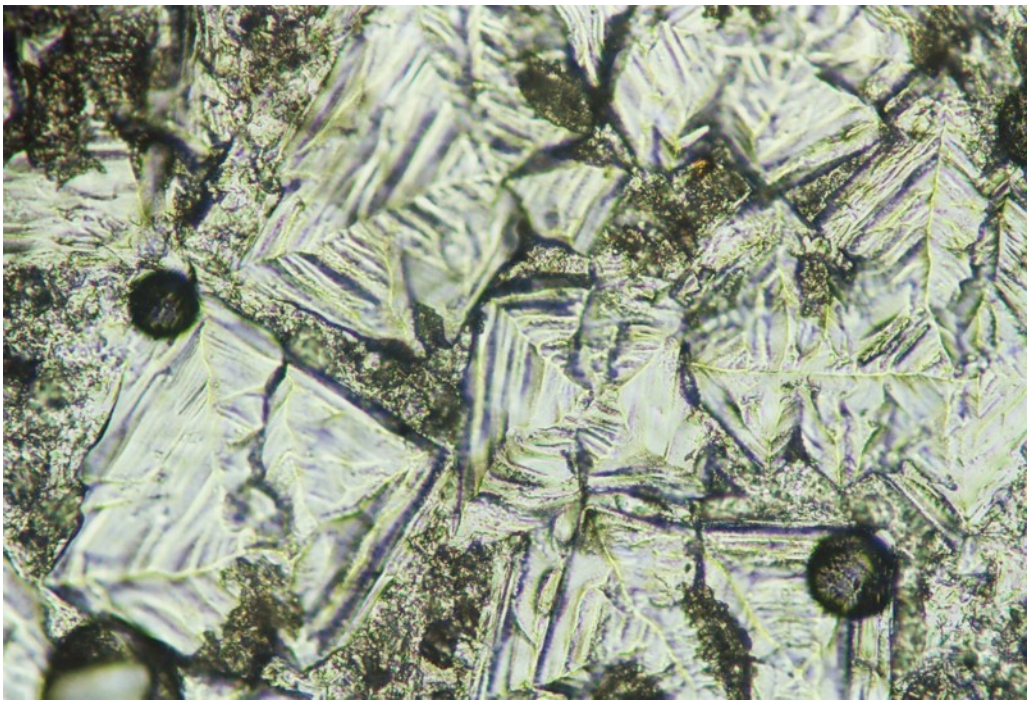
The rock is almost identical to sample DGR1-455.45. The major minerals are carbonates (mostly dolomite), illite and quartz, and minute fossil bits are interstitial to the matrix. The only notable differences between the two are - the presence of halite and minor gypsum in sample 456.01. The rock is iron-stained, and it is cross-cut by a 4-5 mm wide composite vein. The walls of the vein is lined by calcite, but the center of the vein (which was mostly removed during grinding), consisted of coarse-grained halite. In addition to the vein halite, there are several patches in the rock that contain medium-grained halite and interstitial fine-grained gypsum and carbonate. Although halite is missing from the thin section, it was possible to identify their original presence due to the impressions (chevron texture) left behind on the epoxy (see photomicrographs). The halite-rich domains appear as irregularly shaped vugs within the iron-stained fine-grained carbonate-rich matrix. Small carbonate veinlets cross-cut the matrix.

Detailed mineralogy

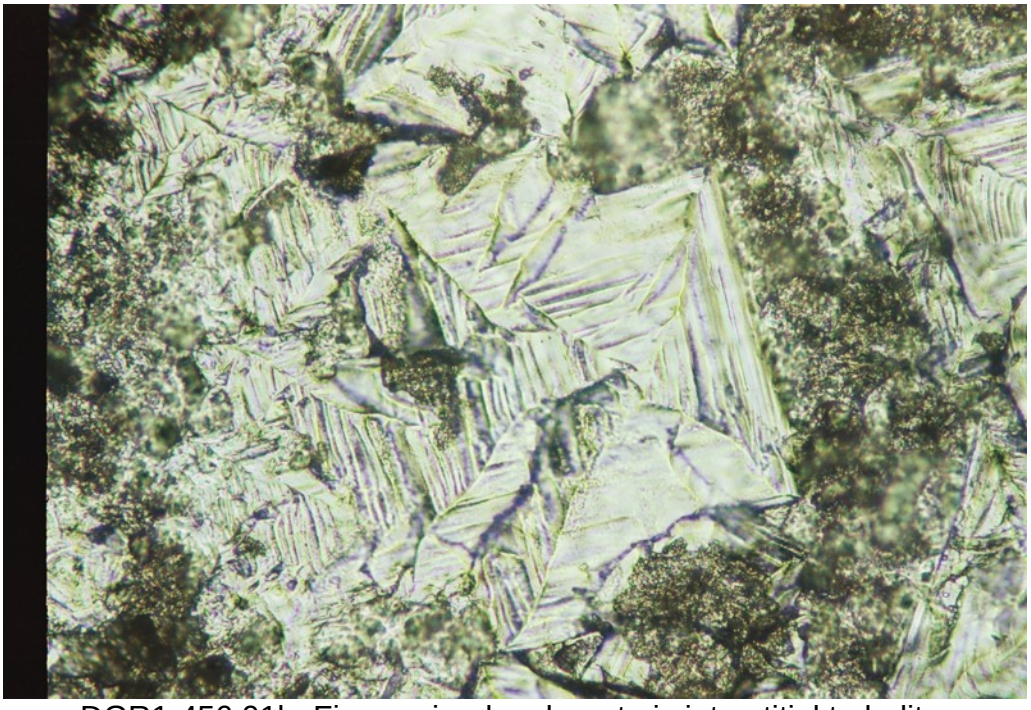
Mineral	%	Grain size(mm)	Comments
Carbonate	80	<0.2-0.3 (0.6 in vein)	Two carbonate generations were identified: the early carbonates are fine-grained, granular and Fe-stained, whereas the later carbonates are small, euhedral “porphyroblasts”. Most carbonates are dolomite, except for the calcite in the large vein and in the small veinlets that cross-cut the rock.
Quartz	5	Av. 0.3	Fine-grained, sub-angular quartz is part of the matrix. Some of the small grains are rimmed by fine-grained carbonate.
Halite	10	0.3-2.0	Halite was present in the original thin section, but it was removed from the friable rock during grinding (in-spite of using oil for preparation). However, as the shape of the mineral (chevron texture) was imprinted in the epoxy, it can be easily identified. All grains are zoned and form interlocking aggregates. Halite was analyzed by microprobe in the rock chip used for the thin section, and results are shown following the photomicrographs.

		Some of the halite-rich domains in the rock contain very fine-grained interstitial dolomite and gypsum (Fig. b).
Fe-hydroxide	5	Dark red Fe-hydroxide is disseminated through the thin section. The actual % in the rock may be an under or over-estimation due to the amorphous texture.

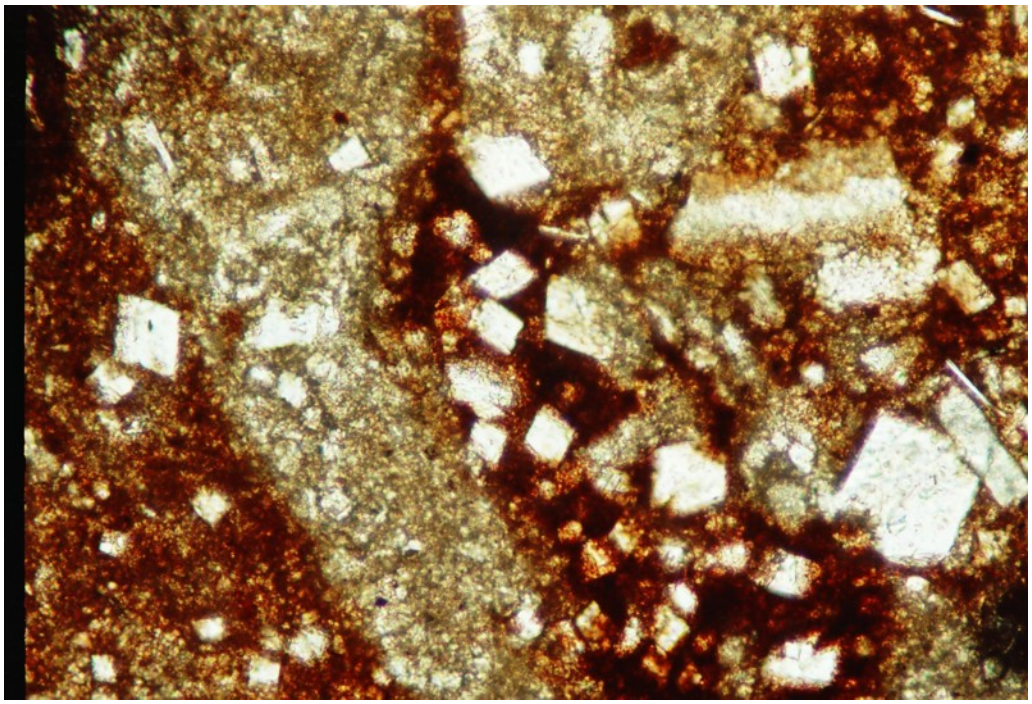
Accessory minerals: gypsum, illite



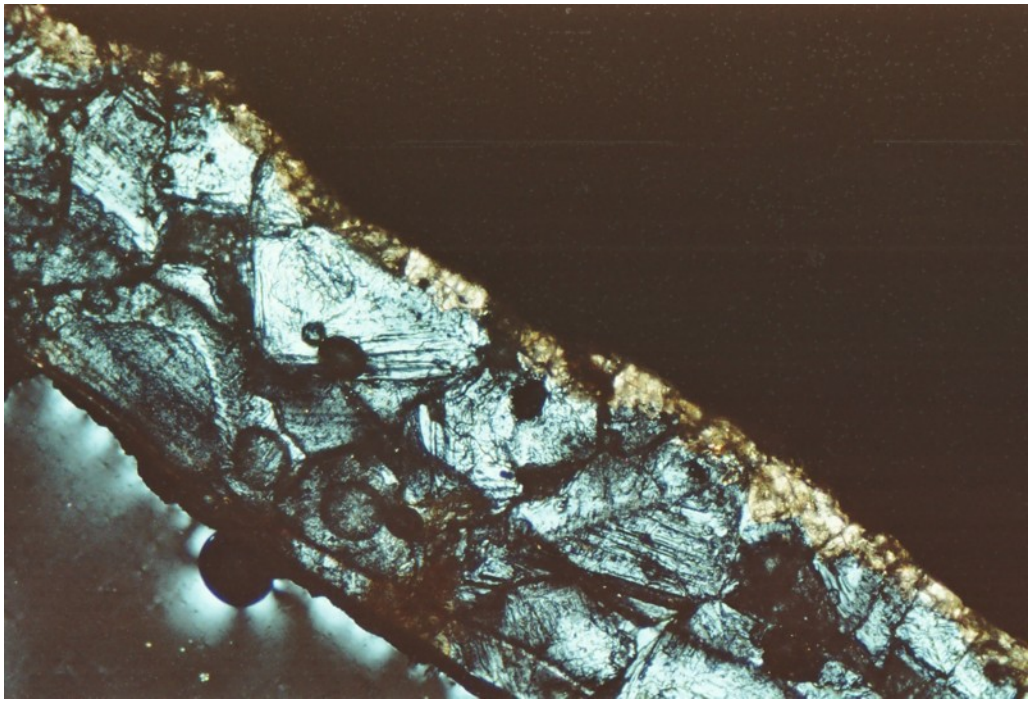
DGR1-456.01a. Chevron texture in halite. Width of photo: 0.9mm. Ppl.



DGR1-456.01b. Fine-grained carbonate is interstitial to halite.
Width of photo: 0.9mm. Ppl.



DGR1-456.01c. Ferruginous matrix contains euhedral / subhedral carbonate rhombs (white). Width of photo: 0.9mm XN.



DGR1-456.01d. Halite aggregates (gray) in wide vein. Vein walls are lined with carbonates. Width of photo: 0.9mm. XN.

```
ETEC                DGR1-456.01 CALCITE VEIN
ETEC                zaf cycles  4    bc drift=1.072
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.92  37.67   52.71  3.968
ETEC                FEO   0.82   0.42    0.54  0.032
ETEC                total       38.10   53.26   4

ETEC                DGR1-456.01 HALITE IN VEIN
ETEC                zaf cycles  4    bc drift=0.887
ETEC                       fac    %el    stfm
ETEC                NA    0.60  39.88   0.416
ETEC                CL    0.91  60.21   0.408
ETEC                total      100.09

ETEC                DGR1-456.01 HALITE IN VEIN
ETEC                zaf cycles  4    bc drift=0.89
ETEC                       fac    %el    stfm
ETEC                NA    0.59  38.56   0.413
ETEC                CL    0.91  59.3    0.401
ETEC                total       98.86

ETEC                DGR1-456.01 HALITE IN VUG
ETEC                zaf cycles  4    bc drift=0.866
ETEC                       fac    %el    stfm
ETEC                NA    0.59  39.46   0.412
ETEC                CL    0.91  60.61   0.410
ETEC                total       98.86

ETEC                DGR1-456.01 HALITE IN VUG
ETEC                zaf cycles  4    bc drift=0.879
ETEC                       fac    %el    stfm
ETEC                NA    0.59  38.63   0.403
ETEC                CL    0.91  60.61   0.401
ETEC                total       97.92

ETEC                DGR1-456.01 HALITE
ETEC                zaf cycles  4    bc drift=1.072
ETEC                       fac    %el    stfm
ETEC                NA    0.60  39.81   0.416
ETEC                CL    0.91  60.07   0.407
ETEC                total       99.88

ETEC                DGR1-456.01 GYPSUM IN MATRIX
ETEC                zaf cycles  4    bc drift=1.072
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.86  24.28   33.99  6.312
ETEC                SO3   0.82  18.15   45.32  5.897
ETEC                total       42.44   79.31   4

ETEC                DGR1-456.01 DOLOMITE IN MATRIX
ETEC                zaf cycles  4    bc drift=1.052
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  24.06   33.66  2.352
ETEC                MGO   0.50  10.23   16.96  1.649
ETEC                FEO   0.83   0.00    0.00  0.000
ETEC                total       34.29   50.62   4
```

```
ETEC                DGR1-456.01 ILLITE (+ CALCITE?)MATRIX
ETEC                zaf cycles  5    bc drift=1.083
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.68  21.00   44.93  1.221
ETEC                AL2O3 0.68  11.01   20.81  0.666
ETEC                K2O   0.86   4.74    5.72  0.198
ETEC                CAO   0.83   5.43    7.60  0.221
ETEC                FEO   0.84   4.75    6.11  0.139
ETEC                MGO   0.55   1.48    2.46  0.100
ETEC                total       48.42   87.61   4

ETEC                DGR1-456.01 ILLITE MATRIX
ETEC                zaf cycles  5    bc drift=1.055
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.70  28.72   61.44  1.472
ETEC                TIO2  0.84   0.31    0.52  0.009
ETEC                AL2O3 0.70   8.94   16.90  0.477
ETEC                FEO   0.84   5.74    7.38  0.148
ETEC                MGO   0.56   1.43    2.37  0.085
ETEC                K2O   0.84   4.83    5.82  0.178
ETEC                NA2O  0.38   0.00    0.00  0.000
ETEC                total       49.97   94.43   4
```

Sample Number: DGR1-460.77 **Rock Type: Calcareous shale**

Petrographic Description:

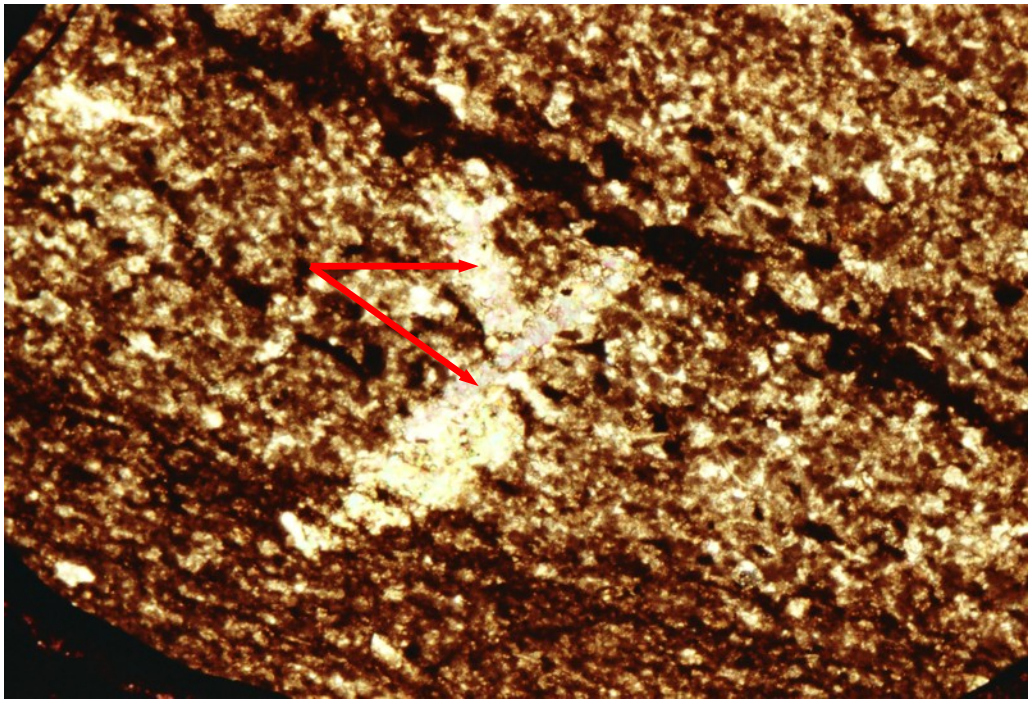
A slightly compacted calcareous shale. The rock is weakly laminated and consists of dark and light bands. The dark bands are calcareous mudstone. Part of the dark bands are fragmented and splays are included in the lighter bands. The dark bands consist of amorphous Fe-rich clays (see analysis), anhedral, fine-grained carbonates, and include small fossil bits. The matrix of the light domain consists of fine-grained anhedral carbonate matrix and of small fossil bits aligned parallel to the rock fabric. Some gypsum occur as minute anhedral grains and veinlets interstitial to the carbonate matrix. A few porphyroblastic calcite, gypsum, anhydrite, and dolomite over-grow the light domains.

Detailed mineralogy

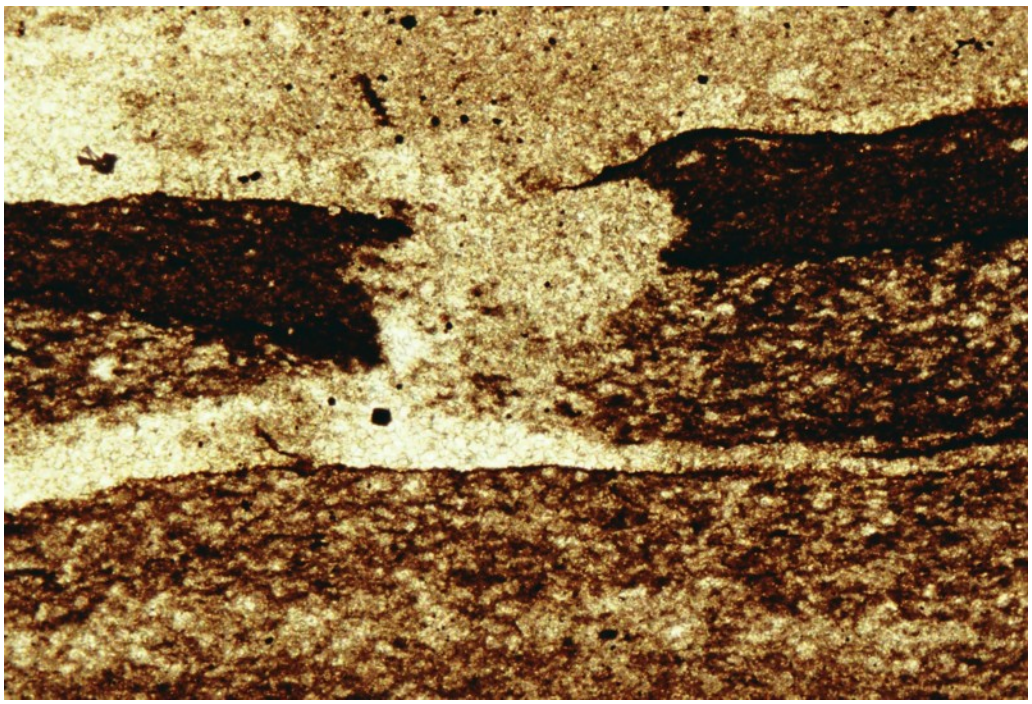
Mineral	%	Grain size(mm)	Comments
Carbonates	60	<0.3-1.5	Fine-grained anhedral carbonate makes up a significant part of the light-colored domain. It contains fossil bits and small gypsum veinlets within the somewhat flattened matrix. The composition of carbonates is calcite and dolomite. Some calcite occurs as porphyroblasts within the light domains. In the dark laminae, carbonate occurs as granular aggregates interstitial to the clays.
Fossil bits	15	Up to 1.0	Slightly curved, small fossil bits are part of the matrix in both, the light and dark domains. They are aligned more or less parallel to the rock fabric.
Clays	20		Amorphous dark brown clays are Fe-rich and relatively poor in K2O (see analysis)
Gypsum /anhydrite	2.5 2.5	Up to 1.5	Anhydrite occurs as replacement after some of the gypsum and the carbonates. They are generally lath-shaped porphyroblasts that over-grow the light colored domain. Small patches and veinlets of gypsum are interstitial to the light matrix.

Accessory minerals: quartz

DGR1-460.77a. Fine-grained matrix of calcareous shale. Note small anhydrite porphyroblast. Field of photo: 2.3mm. XN.



DGR1-460.77b. Anhydrite porphyroblast (arrow) Width of photo: 2.3mm. Ppl.



DGR1-460.77c. Fragmented dark-rich bands intruded by very fine-grained carbonate aggregates. Width of photo: 2.3mm. XN.

```
ETEC                DGR1-460.77 ANHYDRITE LATH
ETEC                zaf cycles  4    bc drift=0.938
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.86  29.34   41.05  1.096
ETEC                SO3   0.91  20.73   51.76  0.968
ETEC                total       50.07   92.82   4

ETEC                DGR1-460.77 GYPSUM PORPHYROBLAST
ETEC                zaf cycles  4    bc drift=1.072
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.86  23.34   32.66  6.227
ETEC                SO3   0.82  17.76   44.35  5.925
ETEC                total       41.10   77.01   24

ETEC                DGR1-460.77 DOLOMITE IN GYPSUM
ETEC                zaf cycles  4    bc drift=0.940
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.89  18.24   25.52 11.381
ETEC                MGO   0.51  11.92   20.91  2.013
ETEC                FEO   0.83   0.38    0.49  0.170
ETEC                SRO   0.71   0.66    0.78  0.188
ETEC                total       31.20   46.56   24

ETEC                DGR1-460.77 DARK MATRIX
ETEC                zaf cycles  5    bc drift=0.993
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.63  16.36   34.99  1.020
ETEC                AL2O3 0.60  10.42   19.69  0.677
ETEC                FEO   0.85  16.63   21.40  0.522
ETEC                MGO   0.48   4.20    6.97  0.303
ETEC                CAO   0.86   1.99    2.78  0.087
ETEC                K2O   0.87   1.50    1.81  0.067
ETEC                total       51.11   87.65   4

ETEC                DGR1-460.77 CALCITE
ETEC                zaf cycles  4    bc drift=1.068
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.92  37.47   52.43  4.000
ETEC                MGO   0.48   0.00    0.00  0.000
ETEC                total       37.47   52.43   4

ETEC                DGR1-460.77 CALCITE VEIN
ETEC                zaf cycles  4    bc drift=0.961
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.92  36.53   51.11  3.972
ETEC                MGO   0.47   0.00    0.00  0.000
ETEC                FEO   0.82   0.36    0.47  0.028
ETEC                total       36.89   51.58   4
```

APPENDIX B

DGR-2 Report, August 12, 2007 (DGR2-451.33 to DGR2-745.97)

NOTE

Ppl = plane polarized light

XN = crossed nicols

Refl. light = reflected light

Sample Number: DGR2-451.33 **Rock Type: Calcareous, fossiliferous shale**

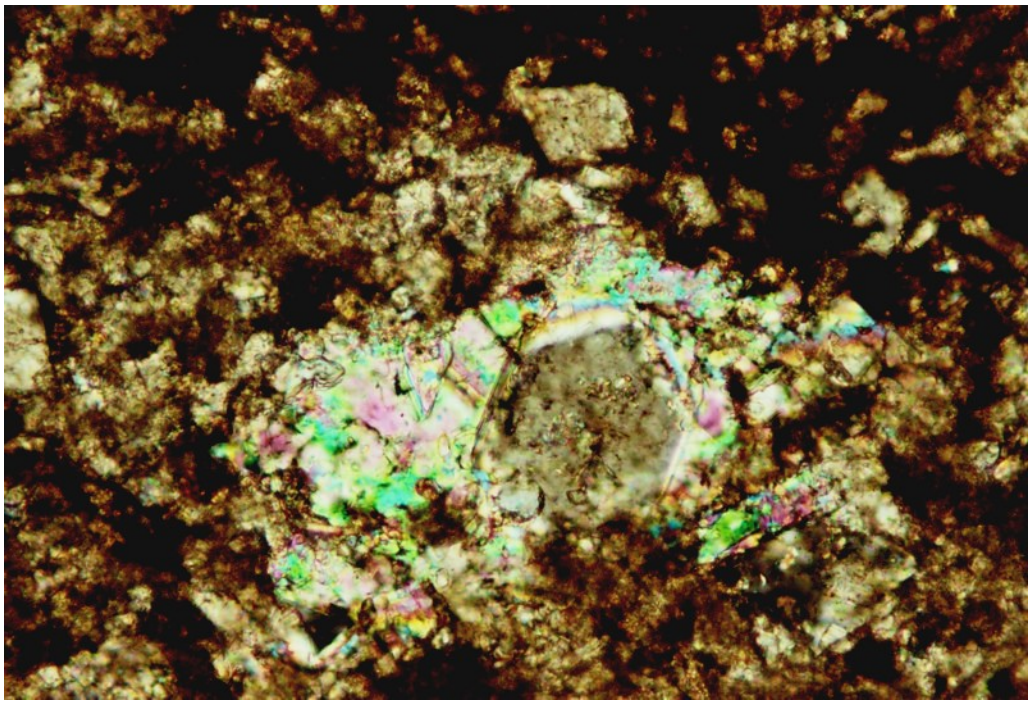
Petrographic Description:

Very fine-grained, oxidized (dark brown) calcareous “clotted” shale. The rock consists of calcareous mud fragments and the fragments are intercalated with and cemented by fossiliferous, carbonate-rich domains. The dark mudstone shows evidence of internal lamination and slumping. Although the dark brown domains contain a few inclusions of fossil bits, the fossil bits are unevenly distributed through the rock and they generally occur in “clumps” between the mudstone fragments. Fine-grained carbonates are disseminated through the thin section. Two carbonate generations were identified; the early carbonates are anhedral calcite, they are interstitial to the fossil bits and act as cement between some of the fragments. Discrete euhedral dolomite rhombs are secondary, some are interstitial to the fossil-rich domains, but they also occur as small porphyroblasts in the dark, calcareous, clayey matrix. A few small lath-shaped anhydrite grains over-grow some of the anhedral calcite and a few minute grains of anhedral anhydrite are interstitial to the carbonates. The anhydrite evidently post-dated both generations of carbonates. Minute quartz grains occur in the dark clayey matrix, but they are rare, and all have resorbed grain boundaries – suggesting disequilibrium with the enclosing matrix. Accessory minerals are rare, they include a few grains of quartz, anhydrite, sericite, rutile and minute grains of goethite.

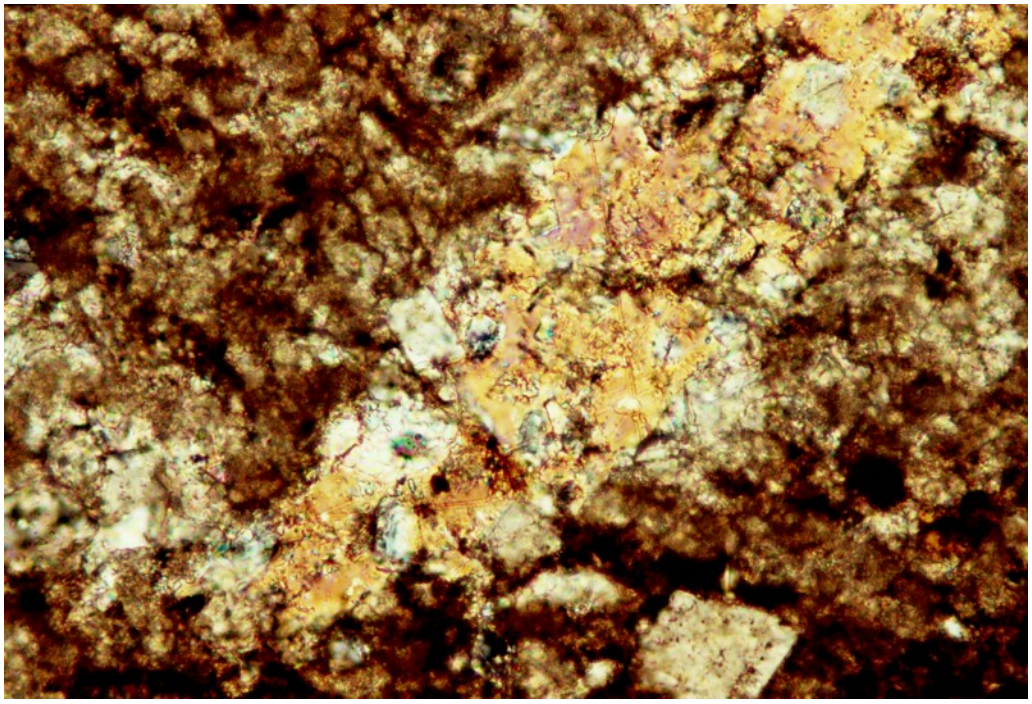
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Carbonate	50	Minute, up to 0.3	Carbonate occurs as part of the mudstone fragments, as calcite cement between the mudstone fragments and the fossil bits, and as late, euhedral dolomite rhombs that generally over-grow the rock fabric. Granular, anhedral carbonate aggregates make up a significant part of the mudstone fragments.
Fossil bits	15	Minute-0.5	Most fossil bits appear to be small, slightly curved bivalve fragments.
Illite clays	35		Amorphous dark, ferruginous clays are interstitial to the carbonates in the mudstone fragments. The dark brown coloration of the mudstone suggests some Fe content.

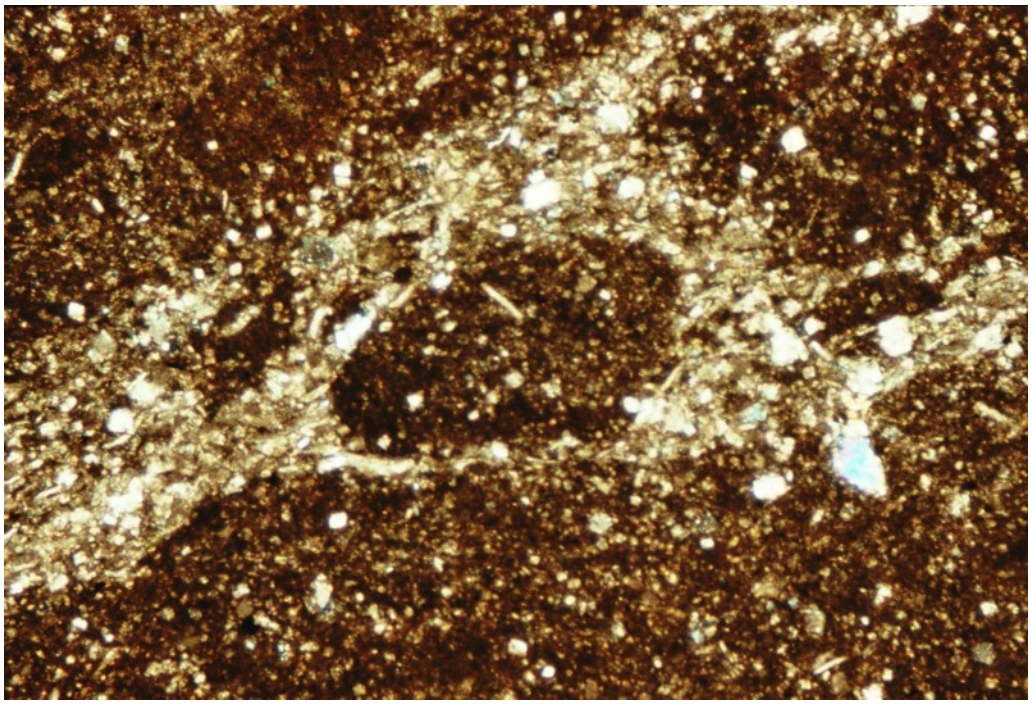
Accessory minerals: quartz, anhydrite, rutile, sericite, goethite



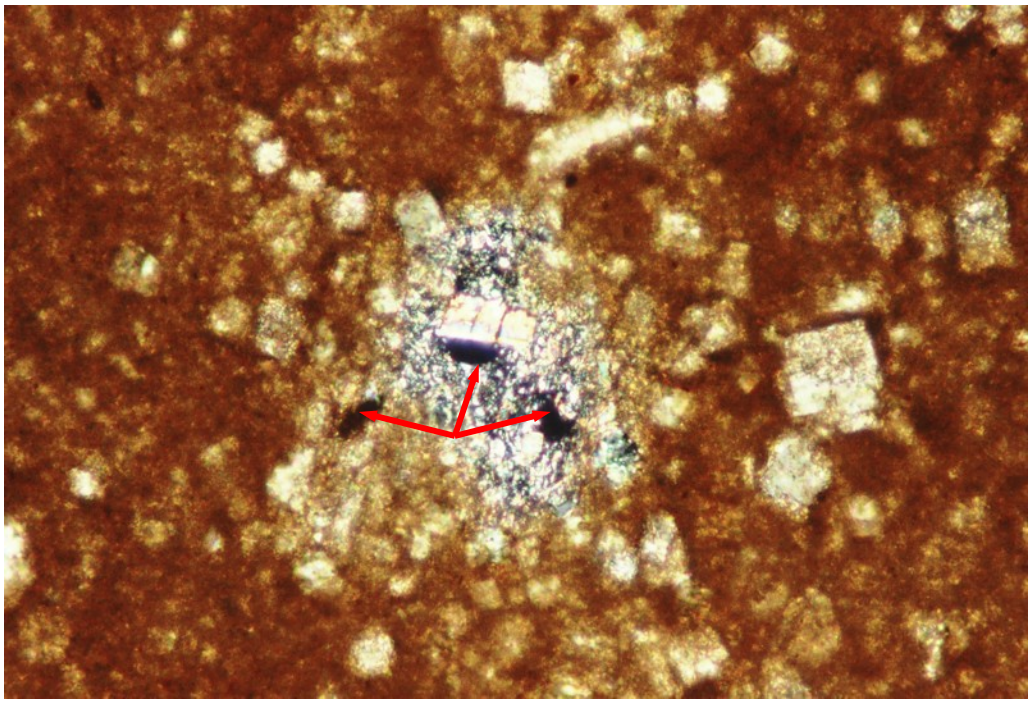
DGR2-451.33a. Anhydrite aggregates (green-pink) replace the carbonates.
Width of photo: 0.45mm. XN.



DGR2-451.33b. Anhydrite (yellow) replaces dolomite in Fe-stained clayey matrix.
Width of photo: 0.45mm. XN.



DGR2-451.33c. Fragmented Fe-stained clayey matrix in light band consisting of fossil bits. Width of photo: 2.3mm. XN.



DGR2-451.33d. Small interparticle pores . Width of photo: 0.45mm. XN.

```
ETEC                451.33 ANHYDRITE
ETEC                zaf cycles  4    bc drift=0.864
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.85  29.35   41.07  0.996
ETEC                SO3   0.91  23.61   58.96  1.001
ETEC                total       52.97  100.03   4

ETEC                451.33 CALCITE MATRIX
ETEC                zaf cycles  4    bc drift=1.136
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.92  38.76   54.24  3.940
ETEC                MGO   0.48   0.36    0.60  0.060
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       39.12   54.83   4

ETEC                451.33 DOLOMITE RHOMB
ETEC                zaf cycles  4    bc drift=1.143
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  23.26   32.54  2.268
ETEC                MGO   0.50  10.52   17.45  1.692
ETEC                FEO   0.83   0.31    0.40  0.022
ETEC                MNO   0.81   0.27    0.35  0.019
ETEC                total       34.36   50.73   4
```

Sample Number: DGR2-482.45 **Rock Type: Fossiliferous limestone / shale**

Petrographic Description:

The rock is laminated and consists of alternating bands of cemented large fossil fragments, dark fossiliferous, calcareous shale, and microcrystalline limestone. The fragmented shale is cemented by carbonates and fossil bits, and it is comparable to the previous sample: DGR2-451.33. Slumping and deformation of the shale fragments is apparent on the thin section scale.

The fossiliferous fragment makes up ca. 1/3 of the thin section. It contains large (up to 3.5 mm long) fragments of bryozoan, brachiopods and crinoids. The fossiliferous domain in the rock is completely cemented by anhedral calcite and some of the fossils are replaced by fine-grained, euhedral calcite, and subsequently by a few grains of small anhydrite and celestite grains. Calcification of the fossils is apparent as the structure of most fossil fragments were partly destroyed and were replaced by microcrystalline calcite. The fossiliferous fragment grades into microcrystalline limestone, and to calcareous shale / mudstone.

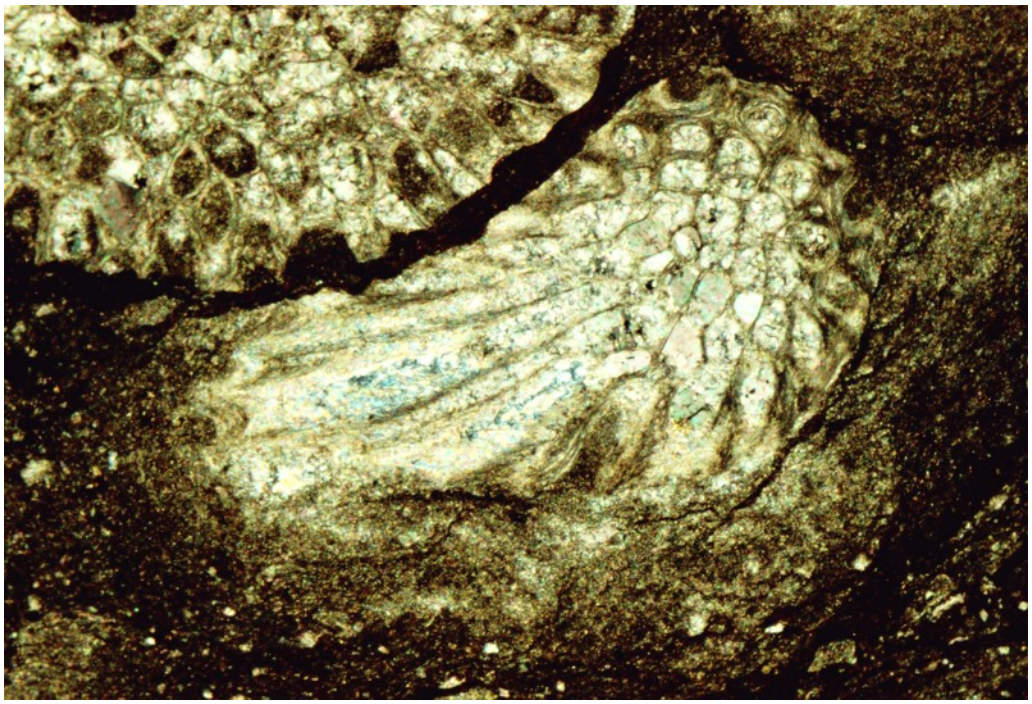
Unlike the previous rock, this sample does not contain any quartz, and the only accessory minerals identifies are, 3 chalcopyrite “nuggets”, small, replacement anhydrite and celestite in the fossiliferous fragment, and microcrystalline pyrite within the shale.

Detailed mineralogy

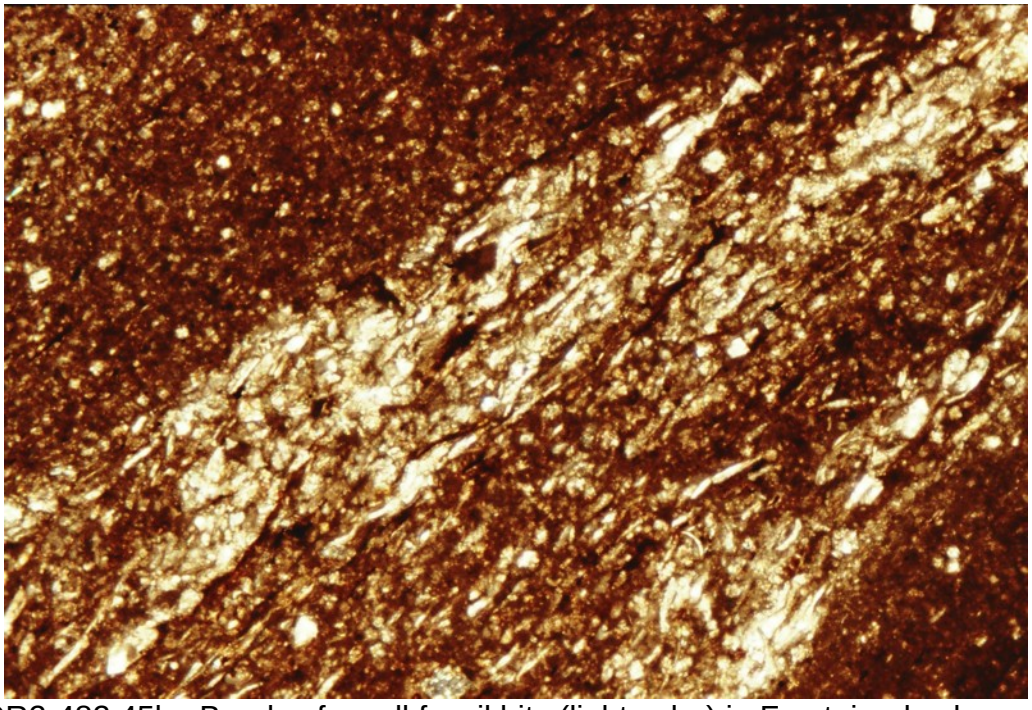
Mineral	%	Grain size(mm)	Comments
Carbonate	65	Minute-0.6	Various carbonate generations co-exist. Very fine-grained, microcrystalline carbonate replaces the calcified fossil fragments. Fine-grained, dark, granular carbonate occurs as part of the shale, and as cement interstitial to the fossiliferous fragment. Some of the more coarse grained carbonates occur in anhedral aggregates that replace the large fossil fragments. Fine-grained euhedral late dolomite occur as porphyroblasts that over-grow the cemented fossils and the dark shale.
Fossils	25	Minute-3.5	Bryozoan fragments make up most of the packstone domain in the shale. The fossil-rich zone also includes brachiopod and crinoid fragments. The zooecia in the bryozoan are all filled by secondary

		carbonates. The curved brachiopod (or ostracod?) bits are altered to calcite.
Dark clays	10	Fine-grained, granular dolomite make up a significant part of the dark shale, and the rest consists of microcrystalline illite and possibly other clays.

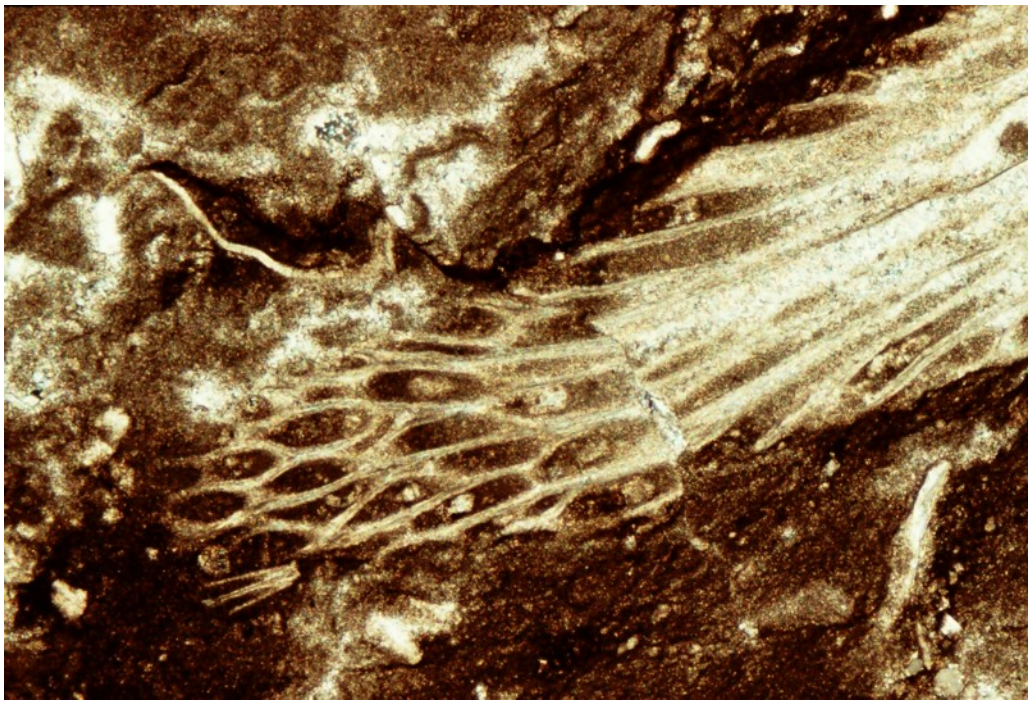
Accessory minerals: pyrite, chalcopyrite, anhydrite, celestite



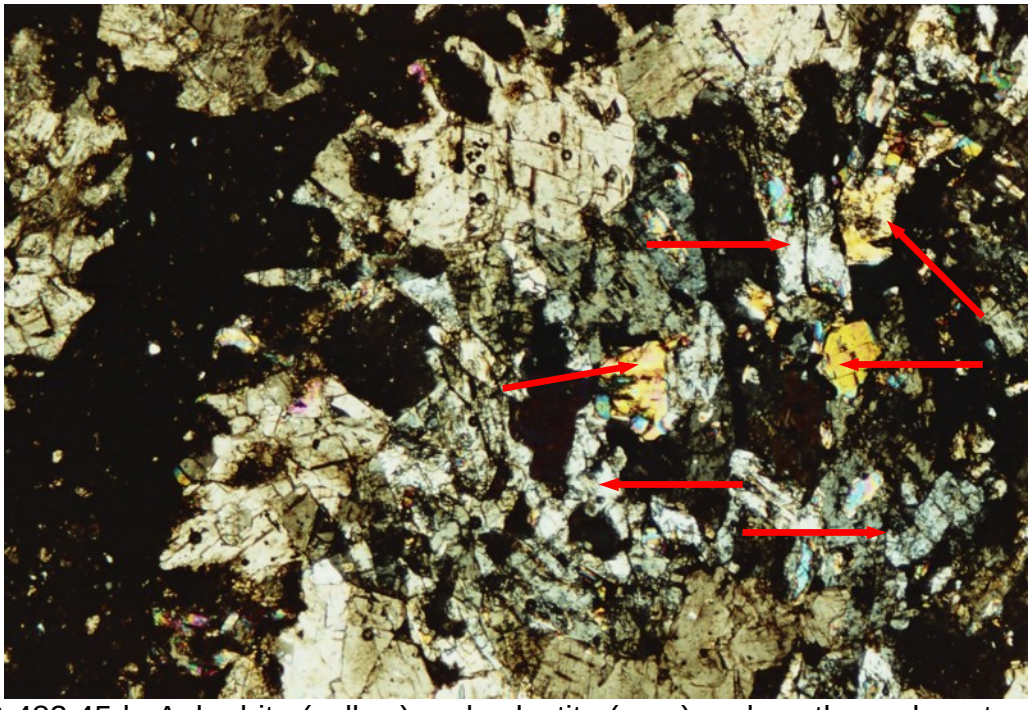
DGR2-482.45a. Calcified bryozoan. Width of photo: 2.3mm. XN.



DGR2-482.45b. Bands of small fossil bits (light color) in Fe-stained calcareous mudstone / shale fragment. Width of photo: 2.3mm. XN.



DGR2-482.45c. Bryozoan. Width of photo: 2.3mm. XN.



DGR2-482.45d. Anhydrite (yellow) and celestite (gray) replace the carbonate altered fossil. Width of photo: 2.3 mm. XN.

```
ETEC                482.45 BRYOZOAN RIM
ETEC                zaf cycles  4    bc drift=0.901
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  37.18   52.02 21.585
ETEC                MGO   0.48   0.43    0.72  0.415
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       37.61   52.74  22

ETEC                482.45 BRYOZOAN CORE
ETEC                zaf cycles  4    bc drift=1.097
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  36.55   51.15 21.559
ETEC                MGO   0.48   0.45    0.75  0.441
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       37.01   51.90  22

ETEC                482.45 MATRIX DOLOMITE
ETEC                zaf cycles  4    bc drift=1.112
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  22.39   31.32 12.257
ETEC                MGO   0.50  10.36   17.18  9.355
ETEC                FEO   0.83   0.99    1.27  0.389
ETEC                total       33.74   49.78  22

ETEC                482.45 DARK MATRIX
ETEC                zaf cycles  5    bc drift=1.121
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.71  20.95   44.82  8.011
ETEC                MGO   0.57  12.88   21.36  5.692
ETEC                CAO   0.85   0.54    0.76  0.145
ETEC                FEO   0.83   0.73    0.94  0.141
ETEC                total       35.10   67.88  22

ETEC                482.45 DARK MATRIX
ETEC                zaf cycles  5    bc drift=1.105
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.68  22.85   48.87  6.998
ETEC                AL2O3 0.68  10.71   20.23  3.415
ETEC                MGO   0.56   2.38    3.95  0.844
ETEC                K2O   0.86   4.81    5.79  1.058
ETEC                CAO   0.83   3.28    4.58  0.703
ETEC                FEO   0.84   5.23    6.72  0.805
ETEC                total       49.25   90.16  22

ETEC                482.45 GOOD CLAY MATRIX
ETEC                zaf cycles  6    bc drift=1.089
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.68  24.57   52.56  7.228
ETEC                TIO2  0.84   0.35    0.59  0.061
ETEC                AL2O3 0.69  11.39   21.53  3.489
ETEC                MGO   0.57   2.57    4.26  0.873
ETEC                FEO   0.84   5.14    6.61  0.760
ETEC                K2O   0.85   5.25    6.32  1.109
ETEC                NA2O  0.38   0.00    0.00  0.000
ETEC                total       49.27   91.87  22
```

Sample Number: DGR2-508.93 **Rock Type: Ferruginous, calcareous shale**

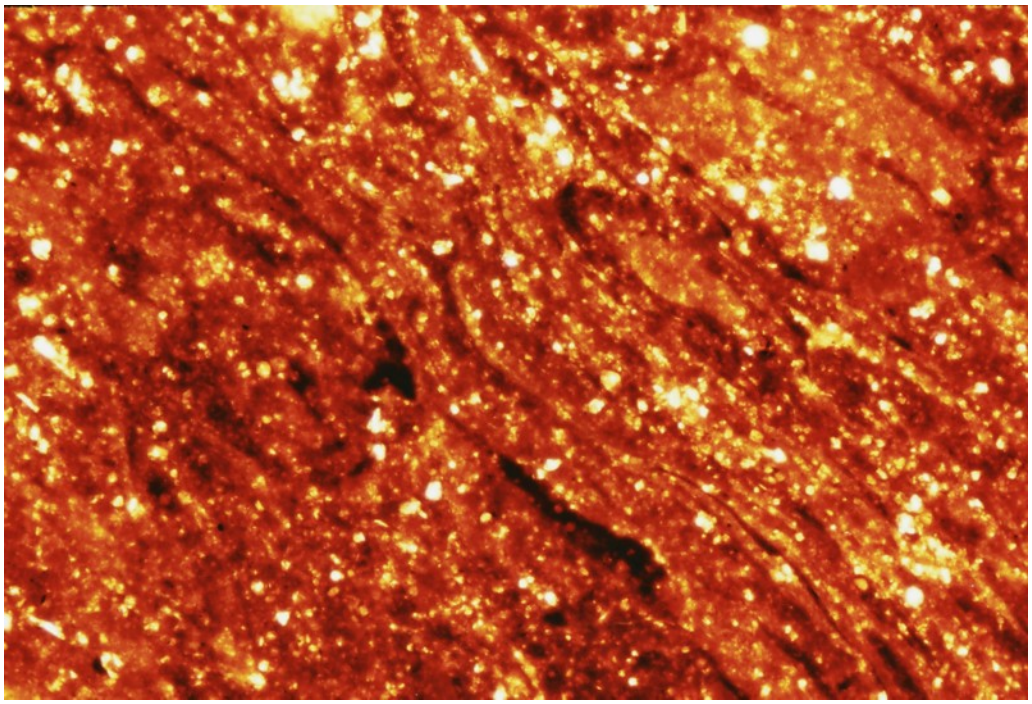
Petrographic Description:

A pervasively oxidized very fine-grained rock. The average grain size is ca. 0.1mm. Due to extensive Fe-staining, the individual minerals are difficult to see. Contorted laminae, minor slumping and soft-sediment deformation are characteristic features. The mineralogy appears to be very simple; the rock consists of fine-grained carbonates intercalated with micaceous clays. Anhedral, small quartz grains are included in the Fe-stained matrix. Plate-like carbonate aggregates and small, subhedral-euhedral carbonate grains are part of the matrix, which also contains a few minute grains of anhydrite (<0.1mm). They appear to be replacing the carbonates.

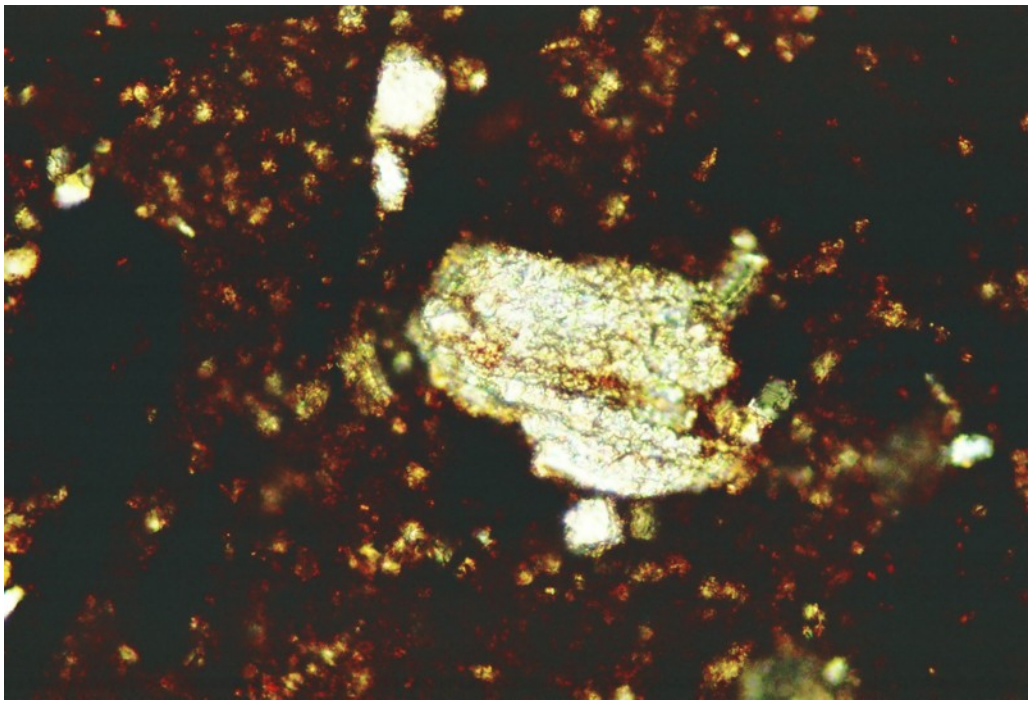
Calcified minute fossil bits (relatively rare) are part of the matrix.

Due to extensive Fe-staining, accessory minerals cannot be identified – with the exception of a few minute grains of pyrite.

Mineral	%
Carbonate	30
Micaceous clays	15
Fe-oxide/hydroxide	50
Quartz	5
Fossil bits	trace
Pyrite	trace
Anhydrite	trace



DGR2-508.93a. Oxidized, slightly deformed clayey matrix (illite composition).
Width of photo: 2.3mm. XN.



DGR2-508.93b. Carbonate inclusions (light) in oxidized illite-rich matrix.
Width of photo: 0.45mm. XN.

```
ETEC                508.93 CLAY MATRIX
ETEC                zaf cycles  5    bc drift=1.035
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.67  18.79   40.19  7.147
ETEC                TIO2  0.84   0.16    0.26  0.035
ETEC                AL2O3 0.68  11.65   22.01  4.613
ETEC                MGO   0.55   1.45    2.40  0.635
ETEC                FEO   0.84   4.66    5.99  0.891
ETEC                K2O   0.86   6.26    7.53  1.709
ETEC                CAO   0.83   1.26    1.76  0.335
ETEC                total       44.21   80.14  24

ETEC                508.93 CALCITE
ETEC                zaf cycles  4    bc drift=0.477
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.92  38.77   54.24 23.443
ETEC                MGO   0.48   0.40    0.66  0.398
ETEC                FEO   0.82   0.37    0.47  0.159
ETEC                total       39.53   55.38  24
```

Sample Number: DGR2-535.56 **Rock Type: Calcareous shale**

Petrographic Description:

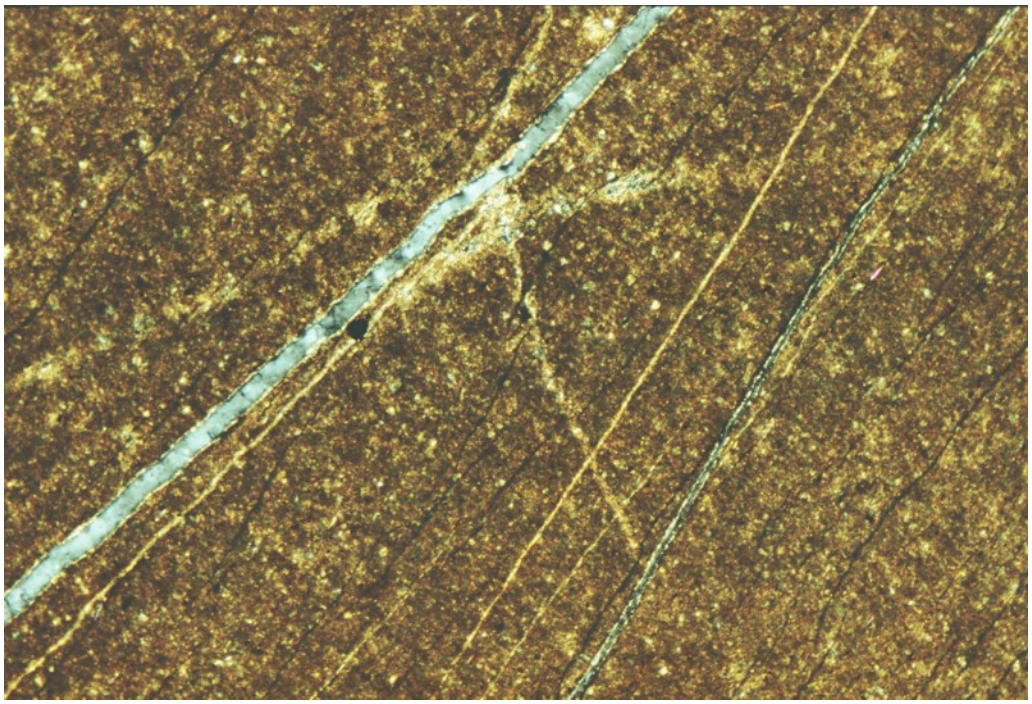
A dark brown, very fine-grained clotted shale. The shale is fragmented, and aggregates of anhedral quartz and carbonate clasts are interstitial to the dark brown, almost amorphous fragments. Slumping and weak deformation is evident as bands of the dark brown shale alternates with discontinuous bands consisting of anhedral quartz and carbonate clasts. The matrix material of the dark brown shale is difficult to identify, but it contains a few very small fossil bits and fine-grained anhedral carbonates. Microprobe analysis of the average matrix suggests that illite (Fe-stained) is an important component. The carbonates are cemented by microcrystalline clays, and a few larger grains (up to 0.5mm) occur as porphyroblasts in the matrix. Some of the parallel, discontinuous bands consist of quartz and carbonate clasts, and a few grains of fine-grained anhydrite.

Very fine-grained pyrite and chalcopyrite occur in clusters within the clayey matrix. A few small veinlet, consisting of clays and fine-grained carbonates cross-cuts, and also parallels the rock fabric.

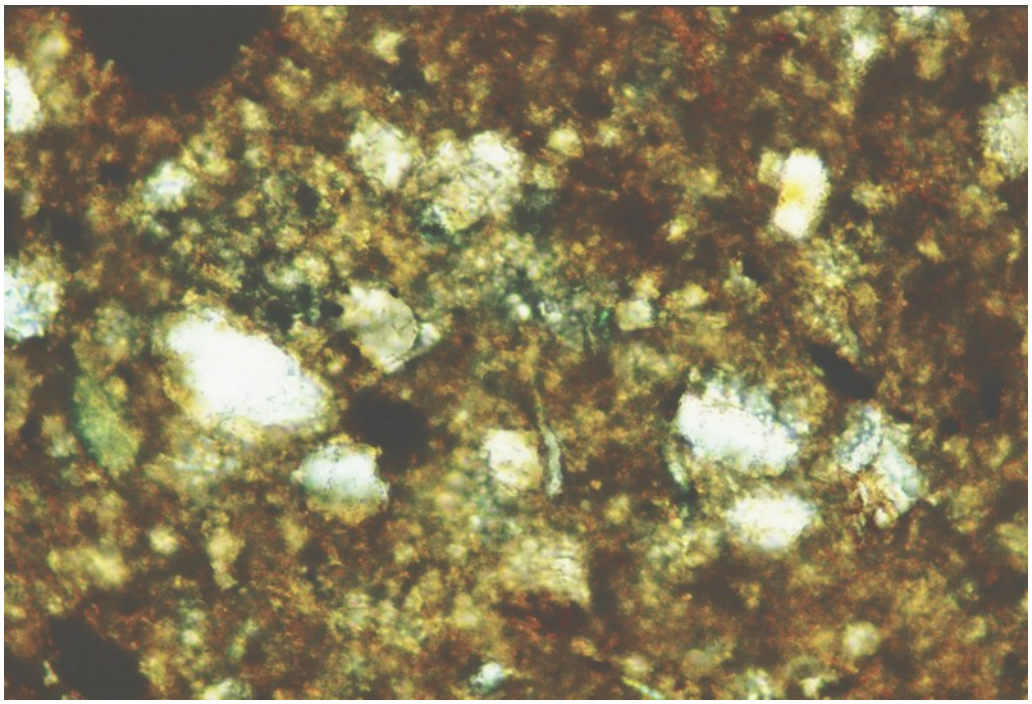
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Carbonate	45	Minute-up to 0.5	Very fine-grained, anhedral carbonate is part of the shale fragment. They are interstitial to the brown, micaceous Fe-stained clays. Anhedral, somewhat more coarse-grained carbonates are also part of the discontinuous bands that alternate with the shale fragments. A few larger (0.5mm) grains of subhedral carbonate (dolomite?) porphyroblasts are included in the rock.
Quartz	20	Minute-up to 0.3	Fine-grained quartz clasts are part of the discontinuous bands. The angular, anhedral grains occur with carbonates and a few grains of anhydrite.
Clays	35		Microcrystalline dark brown clays (amorphous appearance) make up a significant part of the rock. They are interstitial to the fine-grained carbonates.

Accessory minerals: pyrite, chalcopyrite, anhydrite, oxyhydroxide, rutile



DGR2-535.56a. Illite-rich clayey matrix is cross-cut by minute veins consisting of illite. Width of photo: 2.3mm. XN.



DGR2-535.56a. Inclusions of anhedral quartz clasts in fine-grained clayey matrix. Width of photo: 0.45mm. XN.

```
ETEC                535.56 MATRIX QTZ+CLAY
ETEC                zaf cycles  5    bc drift=1.009
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.74  33.38   71.41  1.655
ETEC                TIO2  0.83   0.42    0.71  0.012
ETEC                AL2O3 0.72   6.15   11.63  0.318
ETEC                MGO   0.58   1.09    1.81  0.063
ETEC                FEO   0.84   3.22    4.14  0.080
ETEC                K2O   0.83   2.52    3.04  0.090
ETEC                total       46.79   92.73   4

ETEC                535.56 MATRIX CLAY
ETEC                zaf cycles  5    bc drift=1.124
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.68  17.10   36.58  1.240
ETEC                TIO2  0.85   0.37    0.62  0.016
ETEC                AL2O3 0.65   8.54   16.15  0.645
ETEC                MGO   0.52   2.04    3.39  0.171
ETEC                FEO   0.84   6.56    8.44  0.239
ETEC                K2O   0.87   4.22    5.08  0.220
ETEC                total       38.84   70.26   4
```

Sample Number: DGR2- 550.28 **Rock Type: Calcareous shale**

Petrographic Description:

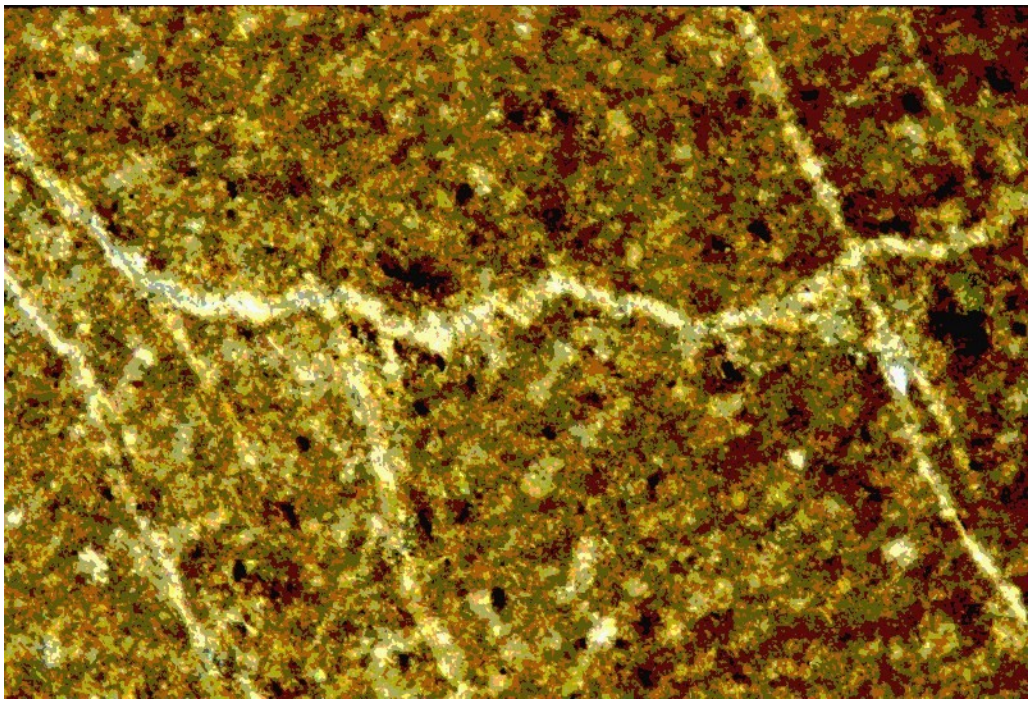
A weakly laminated, very fine-grained shale. The rock consists predominantly of illite, fine-grained, anhedral carbonates and quartz. Parallel partings in the thin section suggest a fissile texture, and minute grains and aggregates of chalcopyrite occur in small stringers that parallel the rock fabric. Minute dark stringers (carbonaceous material?) also parallel the rock fabric. Although most of the thin section consists of microcrystalline illite and fine-grained interstitial carbonates, slightly more coarse-grained quartz + carbonate aggregates occur in small, discontinuous bands, defining the rock fabric. Small, poorly defined veinlets of illite + carbonates cross-cut the rock at various angles. Very fine-grained anhedral quartz and carbonate clasts occur throughout the shale matrix.

Unlike in the previous samples, the fine-grained sulfides are chalcopyrite, only rarely pyrite. The rock is weakly oxidized.

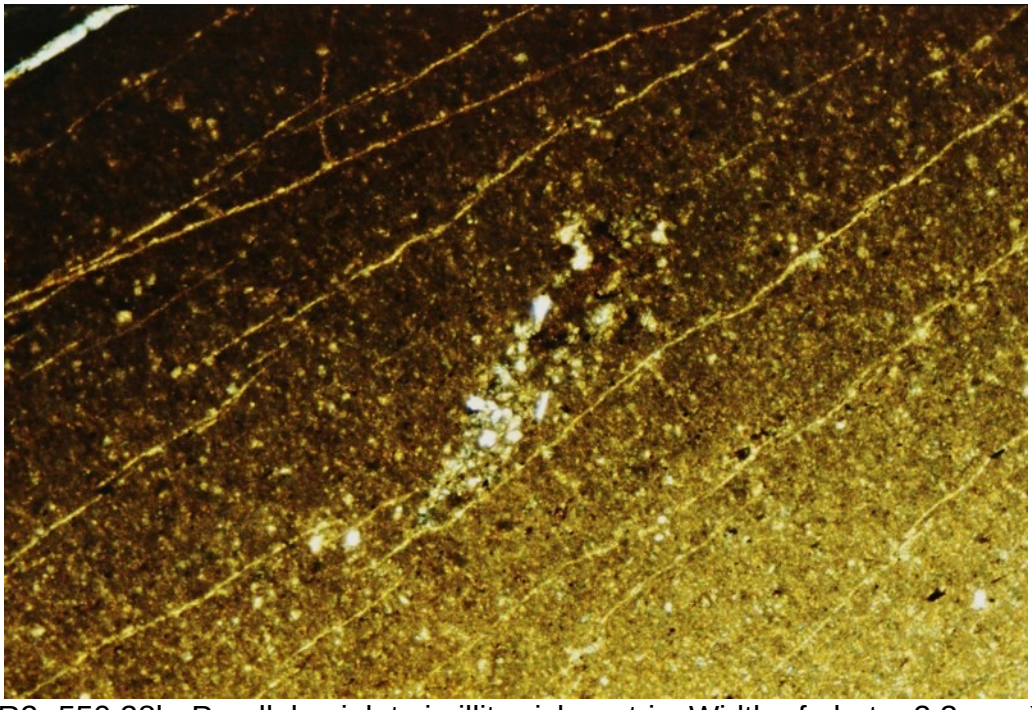
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Illite	55		Very fine-grained illite makes up most of the matrix. Illite also occurs in veinlets that define the rock fabric, and others that cross-cuts the rock fabric.
Carbonate	24.5	<0.2-0.3	Very fine-grained anhedral carbonates are interstitial to the illite-rich matrix. They also occur as small clasts included in the matrix, and as small, subhedral grains within the illite veinlets. Anhedral carbonates also occur in slightly more coarse-grained bands with quartz.
Quartz	20	Up to 0.4	Small quartz clasts are disseminated through the matrix. Quartz also occurs as small discontinuous bands that parallel the rock fabric.
Chalcopyrite	0.5	Minute (few µm)	Very fine-grained chalcopyrite occurs in minute stringers that are aligned parallel to the rock fabric.

Accessory minerals: pyrite, rutile, chlorite



DGR2- 550.28a. Ladder-like veinlets in illite-rich matrix. Veinlets consist of illite. Width of photo: 0.45mm. XN.



DGR2- 550.28b. Parallel veinlets in illite-rich matrix. Width of photo: 2.3mm. XN.

```
ETEC                550.28 CLAY MATRIX
ETEC                zaf cycles  6    bc drift=0.978
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.69  28.94   61.92  8.242
ETEC                TIO2  0.83   0.31    0.51  0.052
ETEC                AL2O3 0.71  12.35   23.34  3.663
ETEC                MGO   0.59   2.14    3.55  0.704
ETEC                FEO   0.84   3.49    4.49  0.500
ETEC                K2O   0.84   5.25    6.33  1.075
ETEC                CAO   0.81   0.88    1.23  0.176
ETEC                total       53.37  101.37  24

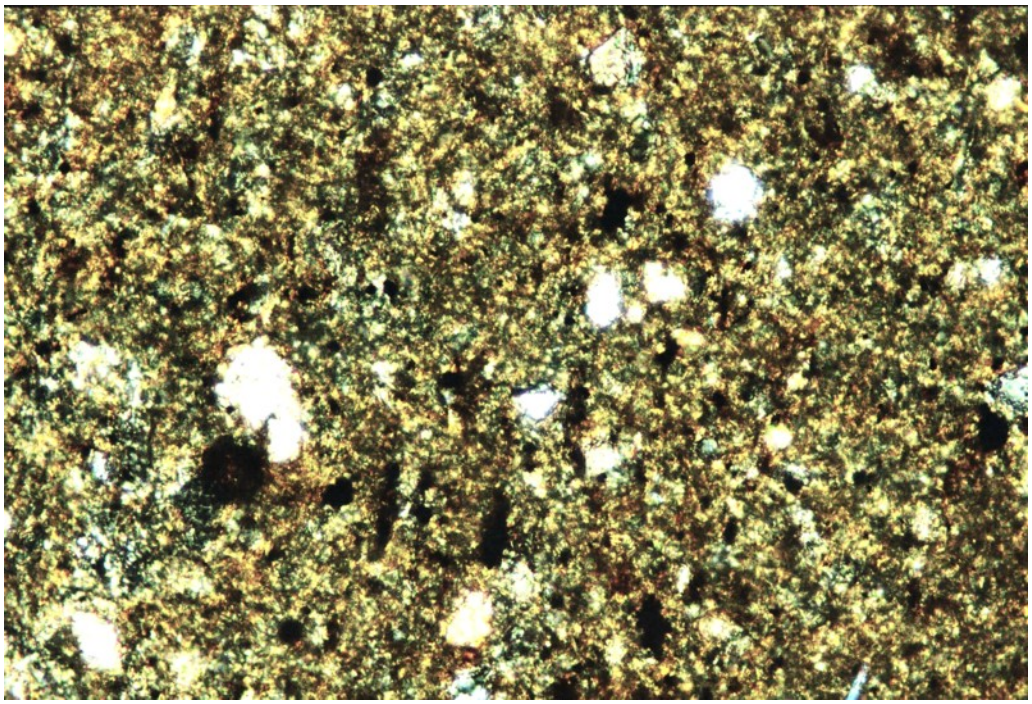
ETEC                550.28 CLAY MATRIX
ETEC                zaf cycles  5    bc drift=1.048
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.67  21.92   46.89  7.571
ETEC                TIO2  0.84   0.17    0.29  0.035
ETEC                AL2O3 0.67  11.05   20.89  3.975
ETEC                MGO   0.55   2.35    3.90  0.938
ETEC                FEO   0.84   6.81    8.76  1.183
ETEC                K2O   0.85   5.11    6.15  1.268
ETEC                CAO   0.83   0.29    0.41  0.071
ETEC                total       47.70   87.28  24
```

Sample Number: DGR2-570.73 **Rock Type: Calcareous shale**

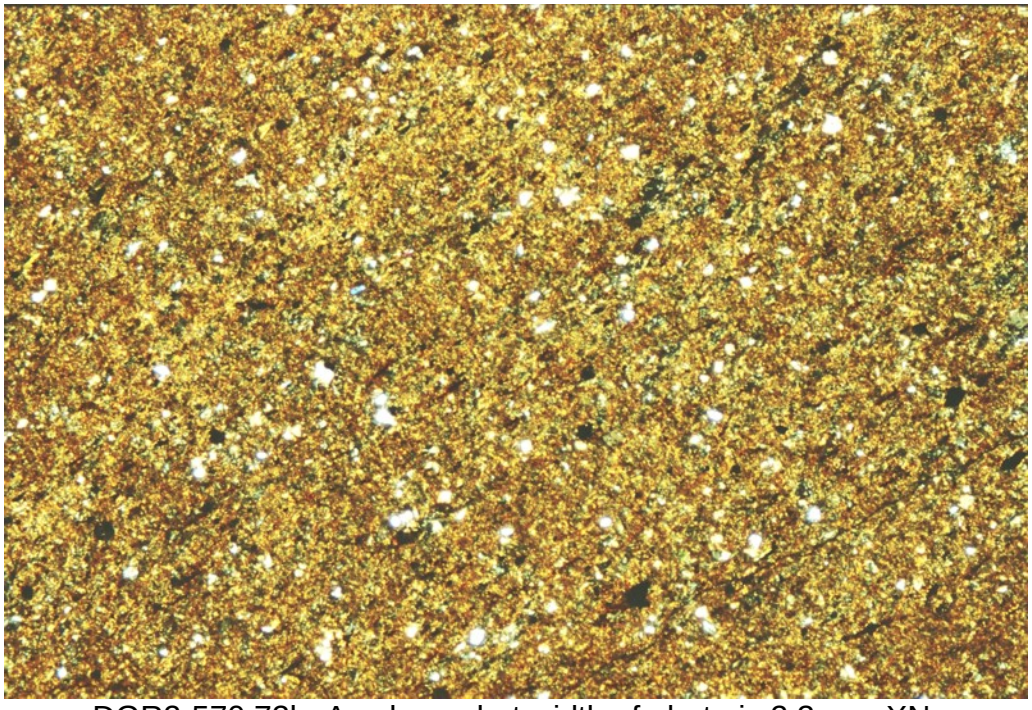
Petrographic Description:

A weakly laminated, featureless shale that consists predominantly of Fe-stained microcrystalline clays, illite, interstitial quartz and carbonate. The quartz and carbonates also occur as small clasts. The quartz clasts are generally angular and the carbonates are subhedral to anhedral dolomite. The rock fabric is defined by small stringers of Fe-hydroxide and fine-grained aggregates of chalcopyrite and pyrite framboids. Anhedral quartz and carbonate clasts are disseminated through the matrix, the rock is fine-grained and more or less equigranular. Needles of small illite or sericite are interstitial to the Fe-stained clays. A few very narrow (width <0.1mm) veinlets consisting mostly of illite (?) are parallel, as well as diagonal to the rock fabric. The sample contains a relative abundance of sulfides (in comparison with the other samples), most of which are chalcopyrite.

Mineral	%
Clays (Fe-stained)	30
Illite	30
Quartz	10
Carbonate	25
Chalcopyrite/pyrite	5
Glauconite	trace
Rutile	trace
Chlorite	trace
Oxyhydroxide	trace



DGR2-570.73a. Illite-rich shale with anhedral quartz clasts (white). Width of photo: 0.45mm. XN.



DGR2-570.73b. As above, but width of photo is 2.3mm. XN.

```
ETEC                570.73 DOLOMITE
ETEC                zaf cycles  4    bc drift=0.927
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  19.91   27.85 11.914
ETEC                MGO   0.47   9.20   15.26  9.083
ETEC                FEO   0.84   6.51    8.37  2.796
ETEC                MNO   0.82   0.48    0.61  0.208
ETEC                total       36.10   52.11  24

ETEC                570.73 CLAY MATRIX
ETEC                zaf cycles  5    bc drift=1.048
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.69  17.10   36.58  7.479
ETEC                TIO2  0.84   0.42    0.71  0.109
ETEC                AL2O3 0.66   8.63   16.30  3.929
ETEC                MGO   0.53   1.75    2.90  0.885
ETEC                FEO   0.84   4.59    5.90  1.009
ETEC                K2O   0.87   4.67    5.63  1.468
ETEC                CAO   0.84   0.99    1.38  0.302
ETEC                total       38.14   69.40  24
```

Sample Number: DGR2-590.10 **Rock Type: Calcareous shale**

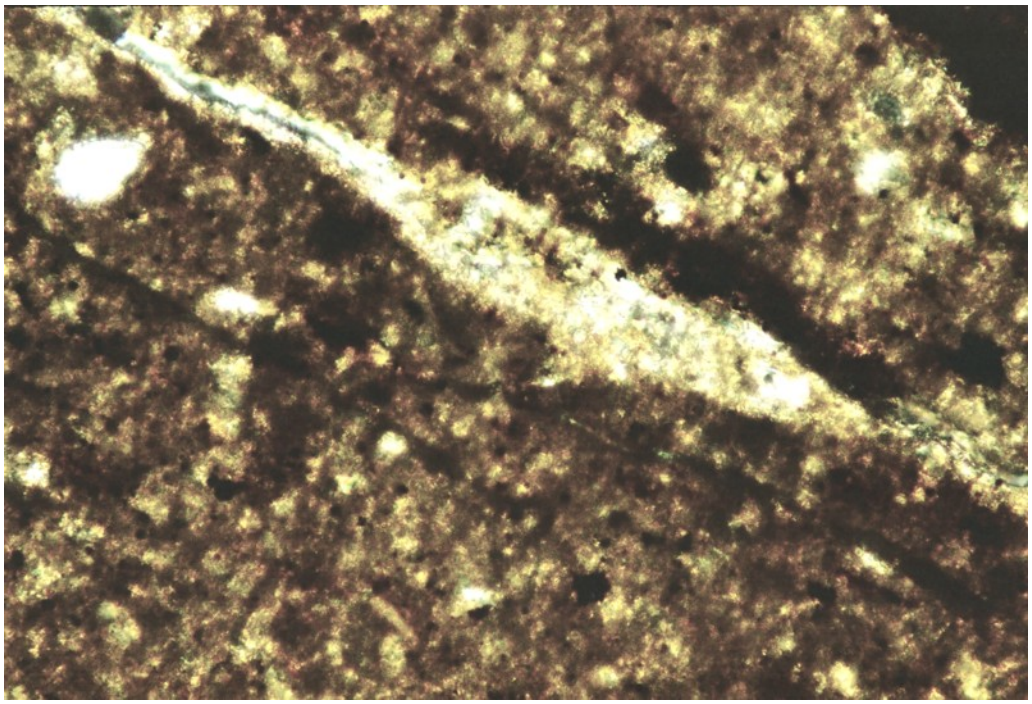
Petrographic Description:

The rock is similar in mineralogy and texture to the previous sample, DGR2-570.73. The only minor differences are, the presence of a few additional sericite/illite veinlets, slightly better defined lamination by Fe-hydroxide stringers, and the presence of a 3 mm long and 0.4 mm wide depression (parallel to the rock fabric) that is filled by granular aggregates of quartz and carbonates.

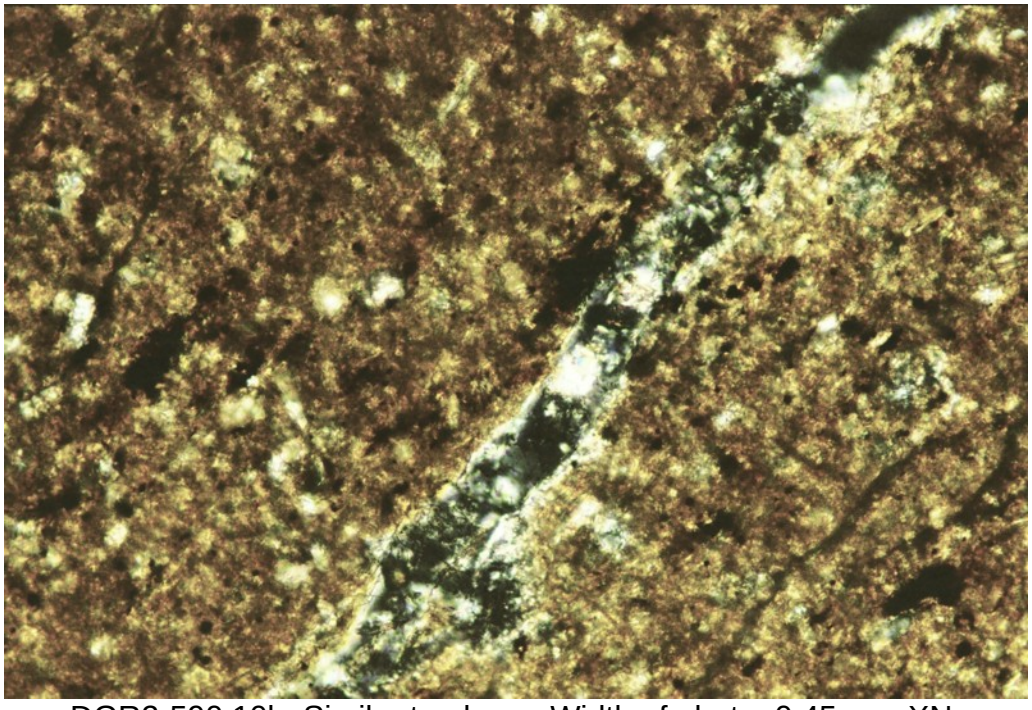
The matrix is Fe-stained and it consists predominantly of Fe-stained illite with interstitial dolomite, and lesser quartz. Very fine-grained, anhedral quartz and carbonate clasts are included in the matrix.

Pyrite and chalcopyrite occur in groups of minute framboids that are aligned parallel to the rock fabric. Minute stringers of Fe-hydroxide parallel the alignment of the sulfide aggregates.

Mineral	%
Illite	37
Clays (Fe-stained)	15
Carbonate	35
Quartz	10
Chalcopyrite & pyrite	3
Oxyhydroxide	trace



DGR2-590.10a. Calcite vein in illite (?)-rich clayey matrix. Width of photo: 0.45mm. XN.



DGR2-590.10b. Similar to above. Width of photo: 0.45mm. XN.

```
ETEC                590.10 CALCITE IN PYRITE
ETEC                zaf cycles  4    bc drift=0.631
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  34.06   47.66  3.763
ETEC                MGO   0.47   0.66    1.09  0.119
ETEC                FEO   0.83   1.49    1.91  0.118
ETEC                total       36.20   50.66   4

ETEC                590.10 K-FELDSPAR
ETEC                zaf cycles  5    bc drift=1.144
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.74  28.72   61.45  9.028
ETEC                AL2O3 0.75   9.21   17.41  3.015
ETEC                K2O   0.85  12.57   15.14  2.838
ETEC                total       50.51   94.00  24

ETEC                590.10 CLAY MATRIX
ETEC                zaf cycles  5    bc drift=1.141
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.71  19.35   41.40  8.544
ETEC                TIO2  0.84   0.18    0.30  0.047
ETEC                AL2O3 0.68   6.86   12.95  3.151
ETEC                MGO   0.54   1.10    1.82  0.560
ETEC                FEO   0.84   3.57    4.60  0.794
ETEC                K2O   0.86   3.49    4.20  1.106
ETEC                SO3   0.73   0.16    0.40  0.061
ETEC                total       34.71   65.67  24

ETEC                590.10 DOLOMITE
ETEC                zaf cycles  4    bc drift=1.153
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  22.86   31.98 13.563
ETEC                MGO   0.48   8.61   14.28  8.428
ETEC                FEO   0.83   4.72    6.07  2.010
ETEC                total       36.19   52.33  24
```

Sample Number: DGR2-606.62 **Rock Type: Fossiliferous limestone + shale**

Petrographic Description:

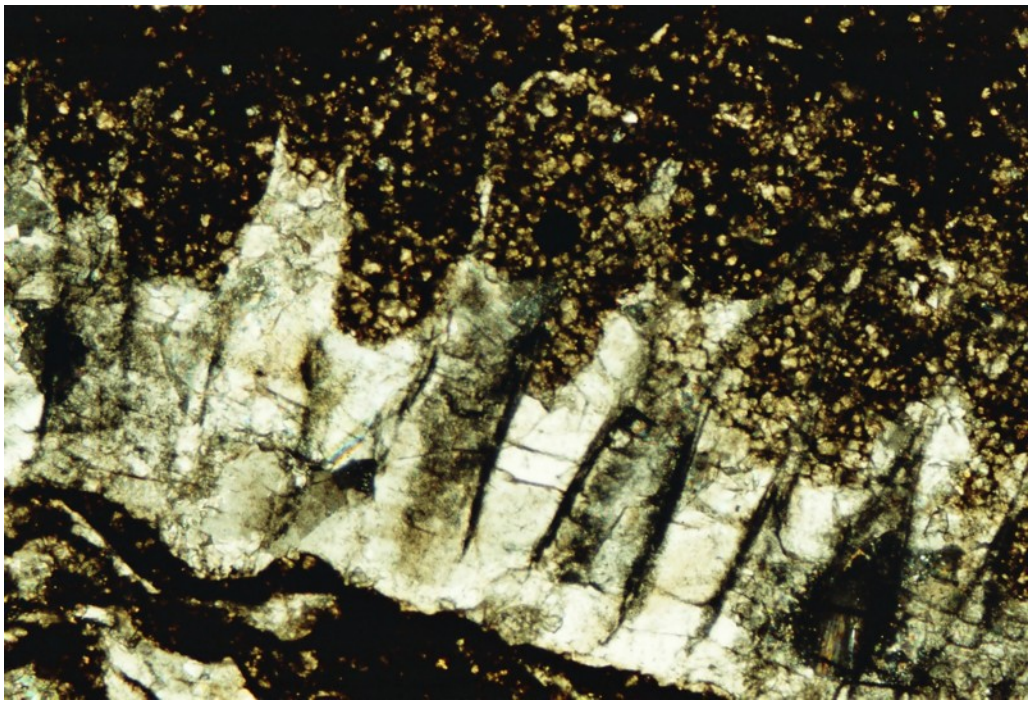
The thin section demonstrates a relatively abrupt change from a weakly laminated dark shale to fossiliferous limestone. The shale is slightly clotted and fragmented, and consists of dark clays and fine-grained carbonates. The fossils are fragments of bryozoan, ranging from 0.5 to 4.5 mm in size. Several of the fossils recrystallized to clear calcite and are subsequently replaced, in part, by fine-grained equigranular dolomite and / or calcite. One of the large fossils (ovoid) is filled by relatively coarse-grained saddle carbonates. The fine-grained dolomite that makes up much of the matrix interstitial to the fossils is, intercalated with very fine, dark brown clays. This matrix appears to be “squeezed” into openings between the fossil fragments, and where in contact with the calcareous shale, the clays dominate over the granular carbonates. Veins are absent from the thin section.

Pyrite occurs as small framboids within the carbonate aggregates (after the fossils) and they are more abundant in the fossil-rich zone than in the shale.

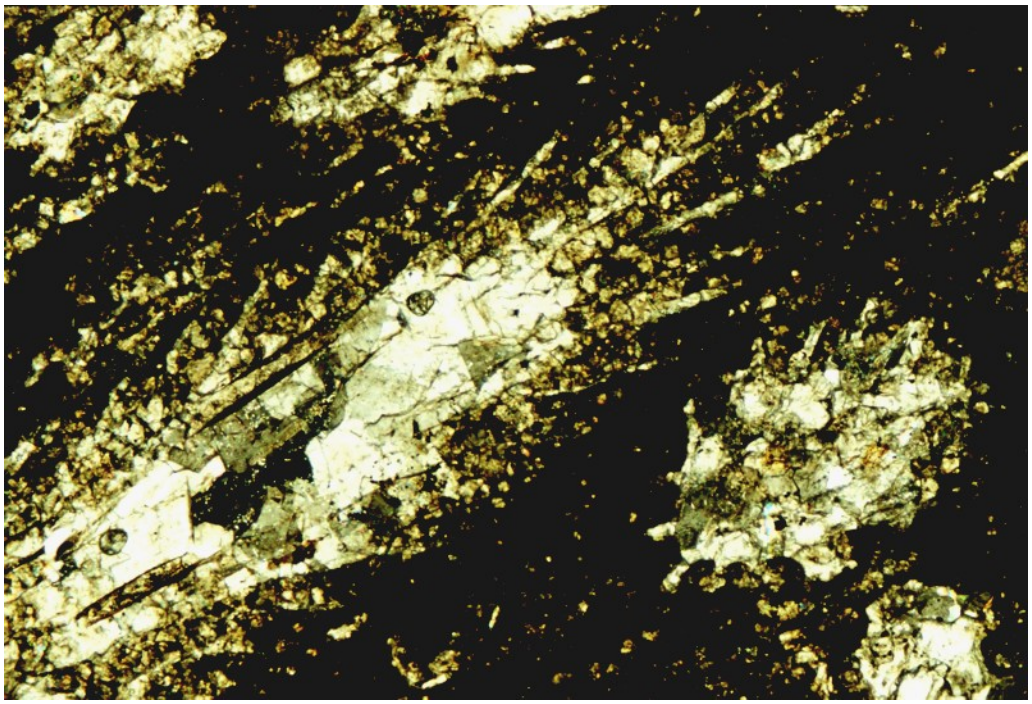
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Carbonate	40	0.1-2.0	Carbonate occurs as replacement after the fossil fragments, as void filling (saddle dolomite), as part of the fine-grained calcareous matrix, and as equigranular aggregates that replace the earlier, more coarse grained carbonates. The replaced fossils are mostly bryozoan fragments and all of the zooecia are filled by carbonates.
Fossil fragments	35	0.6-4.5	Large bryozoa are the most common fossils. They are partly replaced by calcite aggregates, some of which are subsequently replaced by fine-grained granular calcite and / or dolomite.
Clays	25		The clays cannot be identified optically, but microprobe analysis suggests it consists mostly of illite. Much of the clays are contained in the shale, but they are also interstitial to the fine-grained matrix between the fossil fragments.

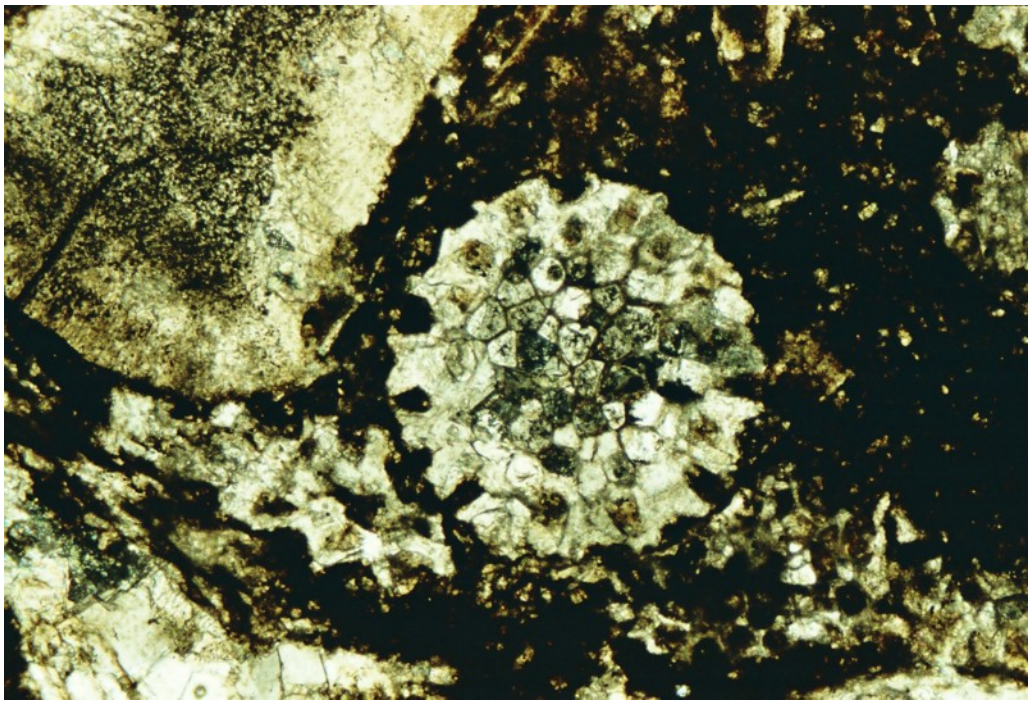
Accessory minerals: pyrite, sericite, quartz



DGR2-606.62a. Bryozoan is replaced by fine-grained calcite.
Width of photo: 2.3mm. XN.



DGR2-606.62b. Bryozoan is replaced by fine-grained granular calcite.
Width of photo: 2.3mm. XN.



DGR2-606.62c. Bryozoan is replaced by fine-grained calcite.
Width of photo: 2.3mm. XN.

```
ETEC                606.62 COARSE DOLOMITE
ETEC                zaf cycles  4    bc drift=0.747
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  23.80   33.29  2.312
ETEC                MGO   0.49   9.70   16.08  1.553
ETEC                FEO   0.83   1.94    2.50  0.135
ETEC                total       35.43   51.87   4

ETEC                606.62 FINE CALCITE
ETEC                zaf cycles  4    bc drift=1.067
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.92  38.87   54.39  3.928
ETEC                MGO   0.48   0.43    0.71  0.072
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       39.31   55.11   4

ETEC                606.62 CLAY MATRIX
ETEC                zaf cycles  5    bc drift=1.131
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.69  23.64   50.57  1.363
ETEC                TIO2  0.84   0.29    0.48  0.010
ETEC                AL2O3 0.68   9.36   17.69  0.562
ETEC                MGO   0.56   2.20    3.65  0.147
ETEC                FEO   0.84   4.35    5.59  0.126
ETEC                CAO   0.83   1.42    1.98  0.057
ETEC                K2O   0.85   3.92    4.72  0.162
ETEC                total       45.18   84.69   4
```

Sample Number: DGR2-606.96 **Rock Type: Fossiliferous limestone**

Petrographic Description:

A fossiliferous limestone consisting of large bryozoan fragments set in a fine-grained matrix of illite-rich clays and euhedral dolomite. Most of the fossil fragments are replaced by medium to coarse-grained carbonates and some of the carbonate aggregates are partly replaced by anhydrite. Remnant of an encrusting bryozoan forms a rim on what presently consists of equidimensional carbonate and anhydrite aggregates.

The dark, clayey, locally illite-rich matrix that cements the large fossil fragments include an abundance of fine-grained, subhedral / euhedral equigranular dolomite. The matrix also fills some of the zooecia in the bryozoan, and it commonly "oozes" into fractures and crevices of the fossil fragments. Although anhydrite replacement is most common after the well crystallized carbonate aggregates that replace the fossil fragments, a few small anhydrite grains and replacement celestite (after anhydrite and carbonate) are also included in the dark, clayey matrix.

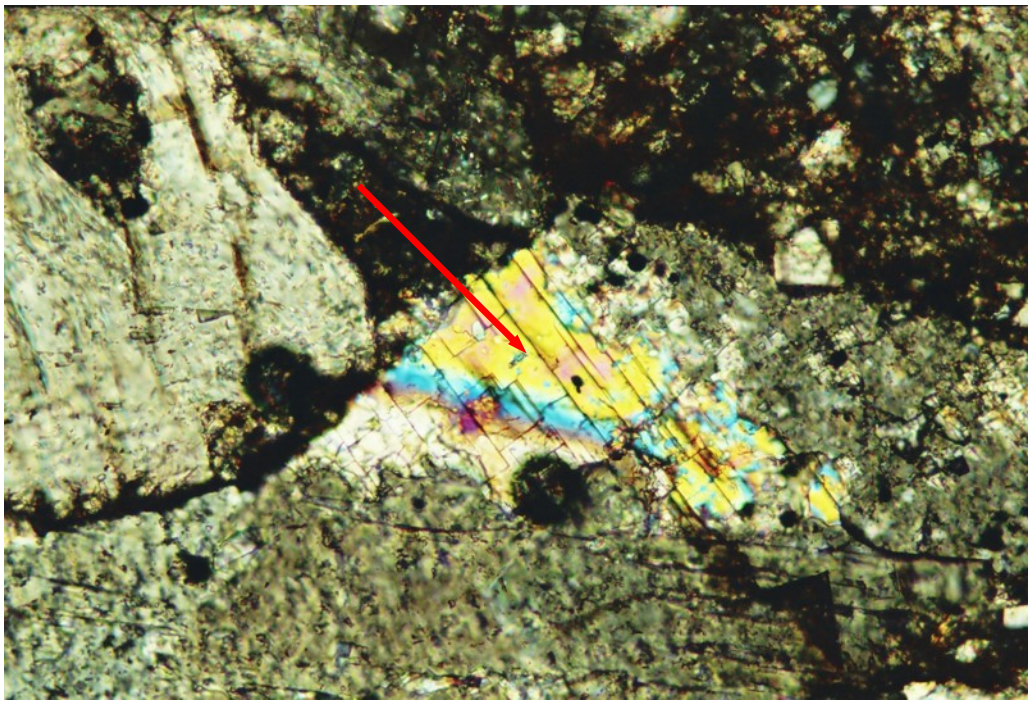
NOTE: A small fragment of a narrow halite vein (ca. 2.5 cm long) was identified within the dark clayey matrix. Although the original halite was lost from the thin section, its characteristic chevron texture left an imprint in the epoxy. As only the rock chip could be "zapped" with the microprobe, the analytical results are poor. Never the-less, it was possible to identify halite in the rock.

Detailed mineralogy

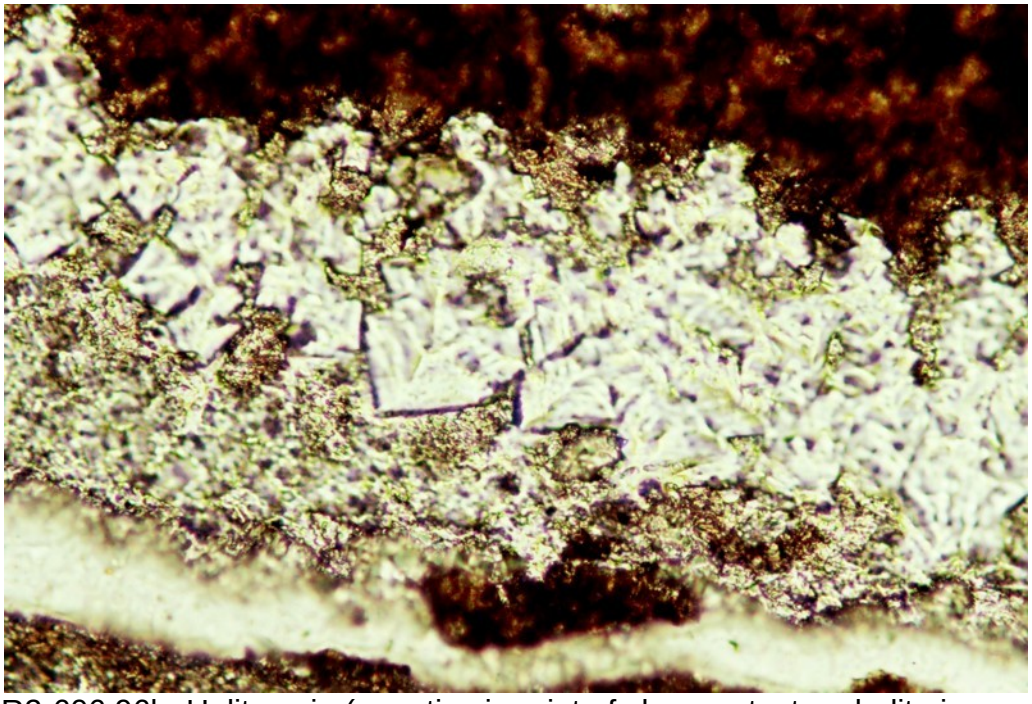
Mineral	%	Grain size(mm)	Comments
Carbonate	40	<0.1-2.0	Fine-grained dolomite aggregates occur as replacement after the fossil fragments and as part of the dark, clayey matrix. Recrystallization and coarsening of the grains occur in some of the carbonate aggregates that replace the fossil fragments. These coarse-grained aggregates form triple junctions. Some of the dolomite are replaced by anhydrite aggregates and celestite via fractures, and they most commonly occur as coarse-grained aggregates.
Fossil fragments	35	0.5-5.0	Large bryozoan fragments are partly replaced by calcite, and the calcite are

			partly replaced by fine-grained dolomite.
Clays with illite	23		Dark brown “amorphous” clays make up a significant part of the cementing matrix between the fossil fragments. The matrix also contains subhedral to euhedral fine-grained, equidimensional carbonates. Illite is part of the matrix.
Anhydrite	1.5		Blocky anhydrite partly replaced some of the recrystallized carbonates. They also fill fractures, and some are included in the fine-grained matrix.
Halite	0.5	0.1-0.2	Fine-grained halite vein occurs within the massive fossil-free carbonate-poor clays. The halite has been ripped out from the thin section, but was identified by the imprint of chevron texture it left in the epoxy. The vein was analyzed within the cut-off rock chip. Although pure halite analysis couldn’t be obtained from the rock chip, the impure analysis demonstrates the presence of halite fraction in the analyzed vein.

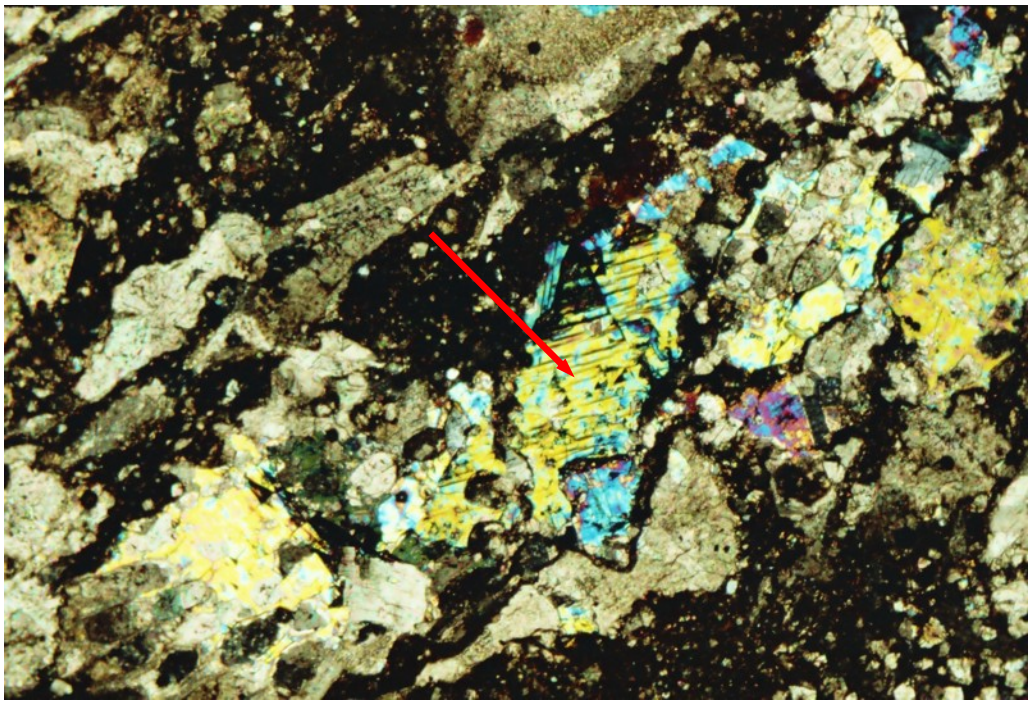
Accessory minerals: pyrite, quartz, celestite



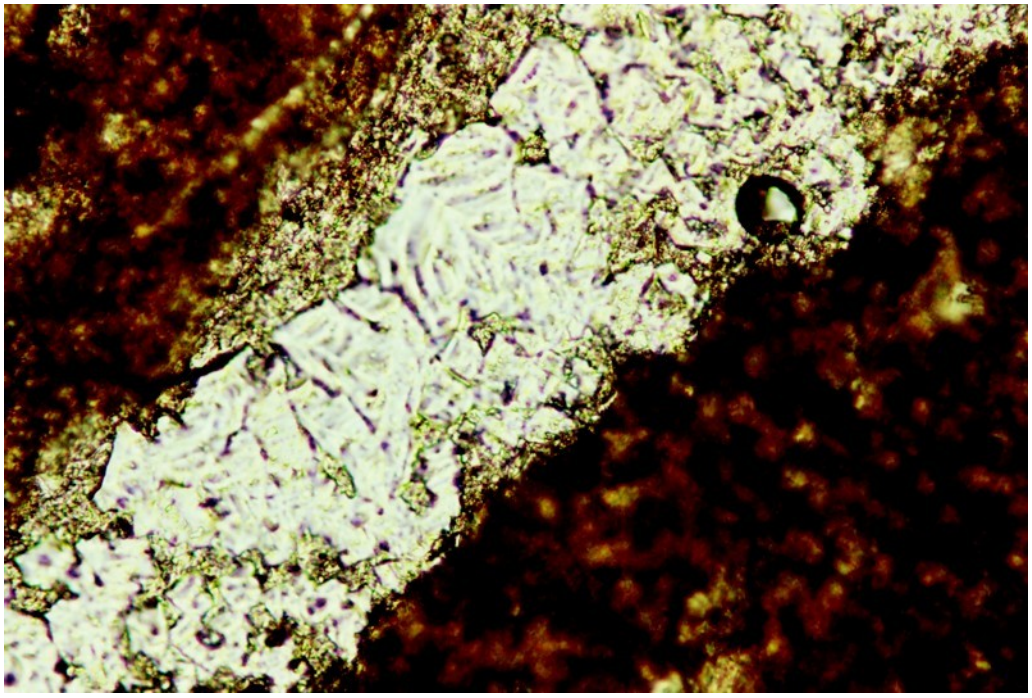
DGR2-606.96a. Anhydrite replaces calcite. Width of photo: 0.45mm. XN.



DGR2-606.96b. Halite vein (negative imprint of chevron texture halite in epoxy). Width of photo: 0.45mm. Ppl.



DGR2-606.96c. Anhydrite replaces calcite in fossil. Width of photo: 2.3mm. XN.



DGR2-606.96d. Halite vein (negative imprint of chevron texture halite in epoxy). Width of photo: 0.45mm. Ppl.

```
ETEC                606.96 ANHYDRITE
ETEC                zaf cycles  4    bc drift=0.420
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.85  29.60   41.41  6.055
ETEC                SO3   0.91  23.39   58.41  5.982
ETEC                total       52.99   99.82  24

ETEC                606.96 CALCITE
ETEC                zaf cycles  4    bc drift=0.947
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  35.28   49.37 24.000
ETEC                MGO   0.48   0.00    0.00  0.000
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       35.28   49.37  24

ETEC                606.93 DOLOMITE MATRIX RHOMB
ETEC                zaf cycles  4    bc drift=1.074
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  21.05   29.45 13.182
ETEC                MGO   0.49   9.28   15.39  9.584
ETEC                FEO   0.83   2.75    3.53  1.235
ETEC                total       33.08   48.38  24

ETEC                606.96 CELESTITE
ETEC                zaf cycles  5    bc drift=1.096
ETEC                       fac    %el    %ox   stfm
ETEC                SRO   0.86  42.63   50.41  5.165
ETEC                SO3   0.58  18.72   46.75  6.200
ETEC                BAO   0.72   3.08    3.44  0.238
ETEC                total       64.43  100.60  24

ETEC                606.96 CELESTITE
ETEC                zaf cycles  5    bc drift=1.061
ETEC                       fac    %el    %ox   stfm
ETEC                SRO   0.86  43.34   51.25  5.182
ETEC                SO3   0.58  18.98   47.40  6.203
ETEC                BAO   0.71   2.77    3.10  0.212
ETEC                total       65.09  101.74  24

ETEC                606.96 AHYDRITE
ETEC                zaf cycles  4    bc drift=1.080
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.85  27.32   38.22  5.778
ETEC                SO3   0.91  22.98   57.37  6.075
ETEC                total       50.29   95.60  24

ETEC                606.96 SECONDARY DOLOMITE
ETEC                zaf cycles  4    bc drift=1.083
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  21.46   30.02 12.582
ETEC                MGO   0.48   9.84   16.32  9.516
ETEC                FEO   0.83   4.52    5.82  1.903
ETEC                total       35.82   52.16  24
```

ETEC 606.96 NACL VEIN (+ MATRIX CLAYS: ROCK CHIP ANALYZED)
ETEC zaf cycles 5 bc drift=0.239

	fac	%el	%ox	stfm
SIO2	0.74	12.84	27.47	9.207
AL2O3	0.64	1.38	2.62	1.033
K2O	0.84	1.29	1.56	0.666
NA2O	0.38	8.45	**11.39**	**7.401**
CL	0.84	10.45	**10.45**	**5.937**
total		34.42	53.48	24

ETEC 606.96 NACL VEIN (+ MATRIX CLAYS: ROCK CHIP ANALYZED)
ETEC zaf cycles 6 bc drift=0.619

	fac	%el	%ox	stfm
SIO2	0.70	5.92	12.66	4.051
AL2O3	0.59	2.28	4.30	1.624
K2O	0.73	0.43	0.52	0.213
NA2O	0.55	31.92	**43.03**	**26.709**
CL	0.87	46.83	**46.83**	**25.413**
total		87.38	107.34	24

Sample Number: DGR2-626.29 **Rock Type: Shale**

Petrographic Description:

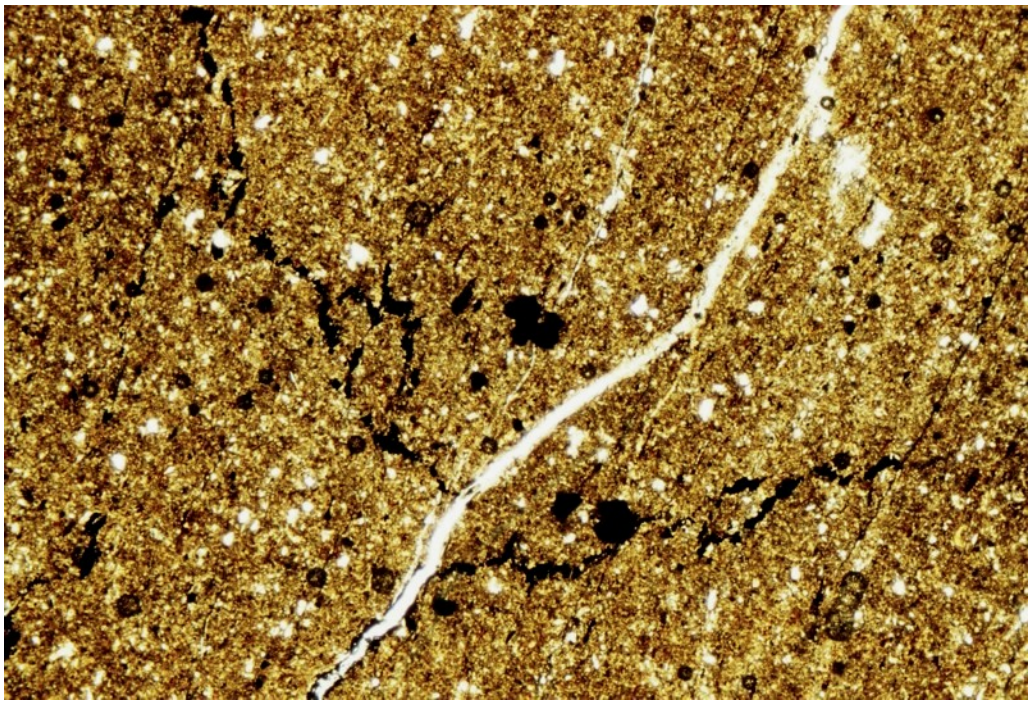
A very fine-grained, weakly laminated shale, comparable in mineralogy and texture to samples DGR2-570.73 & DGR2-590.10. The fine-grained matrix consists predominantly of illite, mixed with dark brown amorphous clays, and minute stringers of Fe-hydroxide that parallel the rock fabric. Randomly distributed small (<0.1 mm) grains of angular quartz and anhedral carbonate are included in the matrix. Some of the carbonates are up to 0.4 mm in diameter and appear to be detrital in origin, whereas others are small, broken fossil bits (rare). Some fine-grained carbonate occur in aggregates with quartz. A few wispy illite veinlets randomly cross-cut the rock.

Very fine-grained pyrite occurs within the illite-rich matrix, some are framboidal, others are blocky grains. They are disseminated through the matrix.

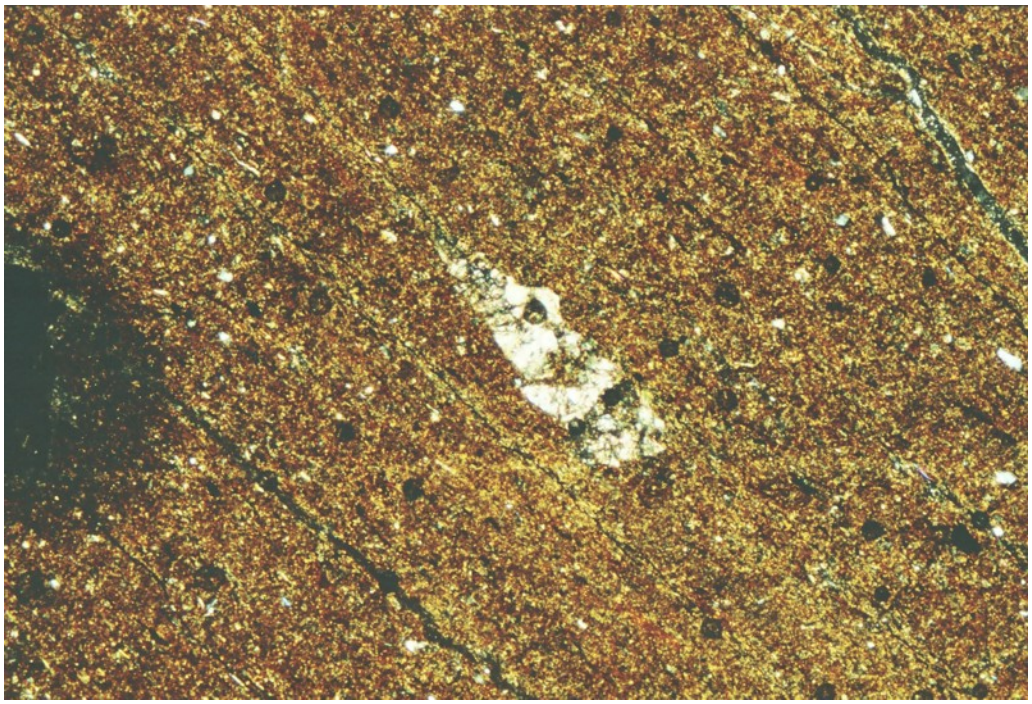
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Illite	60		Very fine-grained Fe-stained illite makes up much of the matrix, and small micaceous veinlets cross-cut the rock fabric. The micaceous illite is intercalated with amorphous dark clays.
Quartz	5	<0.1-0.3	Anhedral quartz occurs as inclusions in the illite-rich matrix. Their resorbed grain boundaries suggests disequilibrium. Most quartz are strained and have undulose extinction.
Carbonate	10		Carbonate clasts are included in the illite-rich matrix. Some occur in aggregates and some are single, anhedral grains. They often have resorbed grain boundaries.
Poorly defined clays	25		Dark, amorphous clays are intercalated with the illite.

Accessory minerals: pyrite



DGR2-626.29a. Minute pyrite veinlets and aggregates (black) in oxidized, illite-rich matrix. White “vein” is a scratch in the thin section. Width of photo: 2.3mm. XN.



DGR2-626.29b. Carbonate aggregate in fine-grained clayey matrix. Width of photo: 2.3mm. XN.

```
ETEC                626.29 MATRIX CLAY
ETEC                zaf cycles  5    bc drift=1.014
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.69  13.69   29.28  7.284
ETEC                TIO2  0.85   0.44    0.73  0.137
ETEC                AL2O3 0.64   6.82   12.89  3.781
ETEC                MGO   0.51   1.64    2.72  1.007
ETEC                FEO   0.84   6.17    7.94  1.652
ETEC                K2O   0.88   3.50    4.22  1.339
ETEC                CAO   0.85   0.42    0.59  0.156
ETEC                total       32.68   58.36  24
```

Sample Number: DGR2-644.49 **Rock Type: Shale**

Petrographic Description:

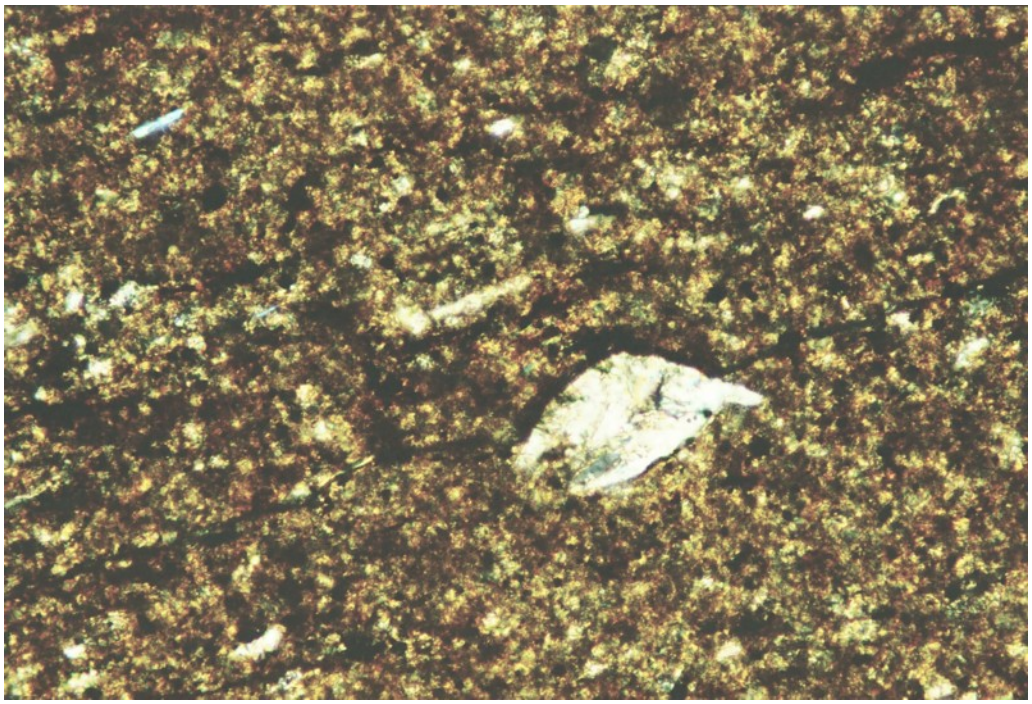
Very fine-grained, equigranular shale / mudstone, consisting predominantly of Fe-stained clays, lesser, very fine-grained calcite and quartz. The rocks is weakly laminated and contains minute stringers of Fe-hydroxide aligned parallel the rock fabric. Minute anhedral quartz and anhedral, subhedral to euhedral carbonate grains are interstitial to the fine-grained clays. Most of the quartz have resorbed grain boundaries and the fine-grained carbonates dominate over quartz. A few very small, discontinuous carbonate veinlets are parallel and orthogonal to the rock fabric. As the Fe-stained clays make up much of the matrix, they “engulf” the small grains of carbonate and quartz.

Granular framboidal pyrite is disseminated through the rock. Some form minute stringers that parallel the hydroxide stringers, and others occur as fine-grained aggregates

Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Clays	83		The rock consists predominantly of microcrystalline, Fe-stained clays. The clay minerals contain 4.7 wt% K2O and 5.9 wt% FeO. Most occurs in amorphous-looking matrix that contains minute sericite needles, and fine-grained anhedral grains of carbonate and quartz.
Carbonate	10	Up to 0.4	Very fine-grained calcite is disseminated through the clayey matrix. Some occur as anhedral to subhedral clasts (having resorbed grain boundaries), and some form minute veinlets.
Quartz	5	Up to 0.3	Very fine-grained, anhedral quartz is part of the matrix, and small, broken clasts are interstitial to the clays. Most have resorbed grain boundaries, that would suggest disequilibrium.
Pyrite	2		Very fine-grained pyrite framboids are disseminated through the matrix, and some form minute stringers and aggregates within the clays.

DGR2-644.49a. Fine-grained framboidal pyrite aggregates are interstitial to illite-rich matrix. Width of photo: 0.45mm. Refl. light.



DGR2-644.49b. Calcite (light color) included in illite-rich matrix. Width of photo: 0.45mm. XN.

```
ETEC                644.49 CALCITE
ETEC                zaf cycles  4    bc drift=0.503
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.92  36.88   51.60 23.353
ETEC                MGO   0.48   0.40    0.67  0.420
ETEC                FEO   0.82   0.50    0.64  0.227
ETEC                total       37.78   52.91  24

ETEC                644.49 CALCITE
ETEC                zaf cycles  4    bc drift=0.917
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  33.90   47.44 23.688
ETEC                MGO   0.47   0.00    0.00  0.000
ETEC                FEO   0.82   0.62    0.80  0.312
ETEC                total       34.53   48.24  24

ETEC                644.49 MATRIX CALCITE
ETEC                zaf cycles  4    bc drift=1.022
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  35.24   49.31 23.562
ETEC                MGO   0.48   0.40    0.66  0.438
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       35.64   49.97  24

ETEC                644.49 MATRIX CLAY
ETEC                zaf cycles  5    bc drift=1.051
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.70  24.04   51.43  8.494
ETEC                TIO2  0.84   0.29    0.48  0.059
ETEC                AL2O3 0.69   8.89   16.81  3.272
ETEC                MGO   0.55   1.64    2.72  0.670
ETEC                FEO   0.84   4.58    5.89  0.814
ETEC                K2O   0.85   3.95    4.75  1.002
ETEC                total       43.39   82.08  24
```

Sample Number: DGR2-659.31 Rock Type: Fossiliferous limestone-mudstone

Petrographic Description:

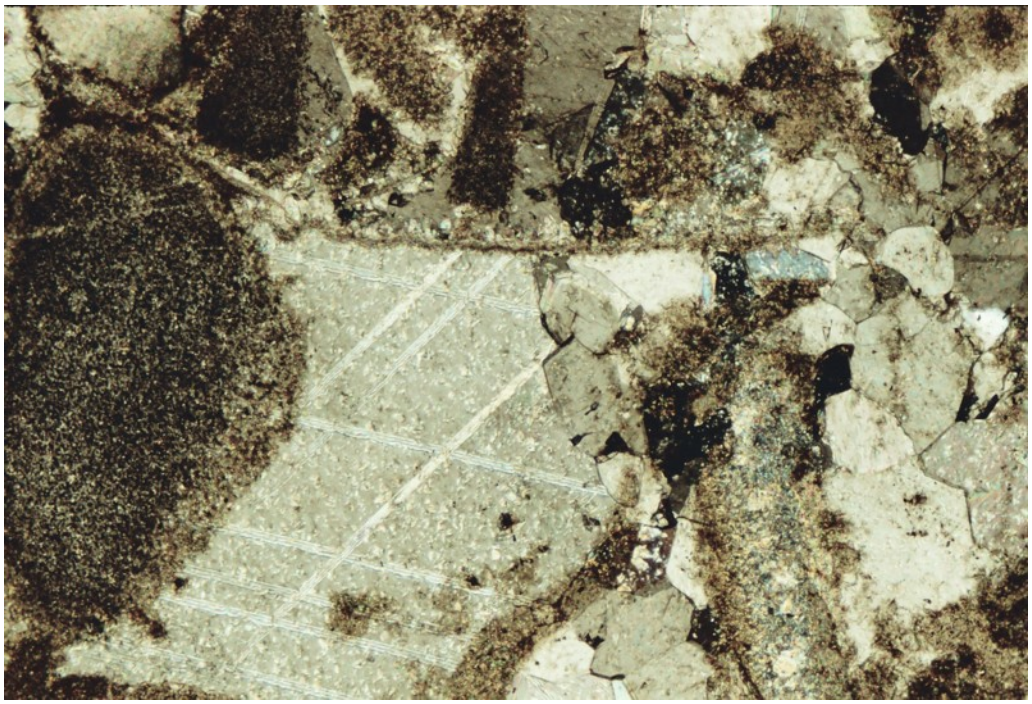
Fossiliferous limestone with minor mudstone domains. The rock consists of a variety of fossil fragments (mostly crinoids, some corals?), which are set in a matrix of very fine-grained anhedral carbonates, and locally, mudstone. There are numerous small domains (1-3mm diameter) that consist of secondary, sub to euhedral fine-grained dolomite. The dolomite are not zoned and the aggregates do not contain inter particle pores. In one large domain (4X4 mm), the fossil bits are cemented by calcite and the calcite aggregates contain inclusions of fossil fragments. Some of the fossils are replaced by recrystallized carbonates. In the mudstone-rich domains, the cryptocrystalline matrix contains randomly distributed fossil fragments of various size and shape.

Anhedral and framboidal pyrite are disseminated through the rock. They are most abundant in the recrystallized carbonate aggregates and tend to replace some of the carbonates.

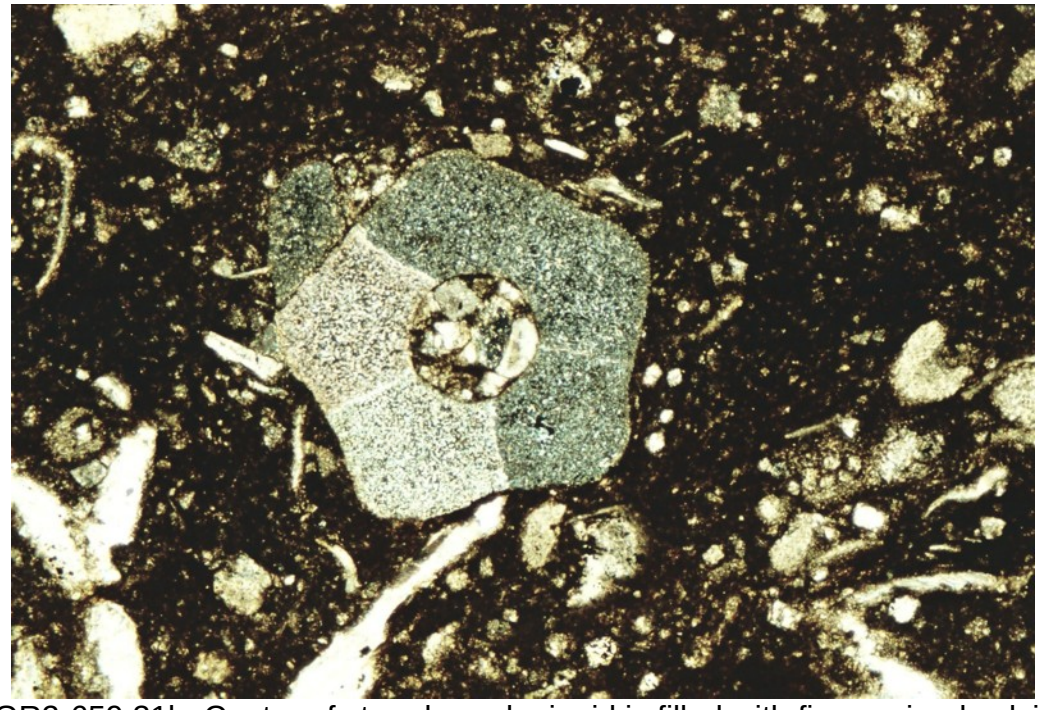
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Carbonate	30	<0.2-2.5	The carbonates occur as calcite after the fossil fragments, as part of the matrix (brown, very fine-grained), and as dolomite aggregates that appear to replace some of the fossils. The dolomite is relatively Fe-poor, it contains 1.7 wt% FeO.
Fossil fragments	50	0.3-4.0	Fossil fragments are randomly distributed in the fine-grained matrix and greatly vary in size. The calcite-aragonite fossil fragments include crinoids and numerous small fibrous fossil bits. Some are partly replaced by fine-grained dolomite
Clays (illite)	20		Very fine-grained, cryptocrystalline clays form the matrix to some of the fossil fragments. Weakly Fe-stained, they contain a few small broken quartz clasts.

Accessory minerals: pyrite



DGR2-659.31a. Dolomite replaces calcite-altered fossil. Width of photo: 2.3mm. XN.



DGR2-659.31b. Center of star-shaped crinoid is filled with fine-grained calcite. Width of photo: 2.3mm. XN.

```
ETEC                659.31 FIBROUS CALCITE
ETEC                zaf cycles  4    bc drift=0.673
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  36.49   51.05 23.626
ETEC                MGO   0.48   0.35    0.58  0.375
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       36.84   51.63  24

ETEC                659.31 BLOCKY DOLOMITE
ETEC                zaf cycles  4    bc drift=0.973
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  21.81   30.52 13.534
ETEC                MGO   0.50   9.63   15.97  9.851
ETEC                FEO   0.83   1.38    1.78  0.615
ETEC                total       32.82   48.26  24
```

Sample Number: DGR2-669.27 Rock Type: Fossiliferous limestone - packstone

Petrographic Description:

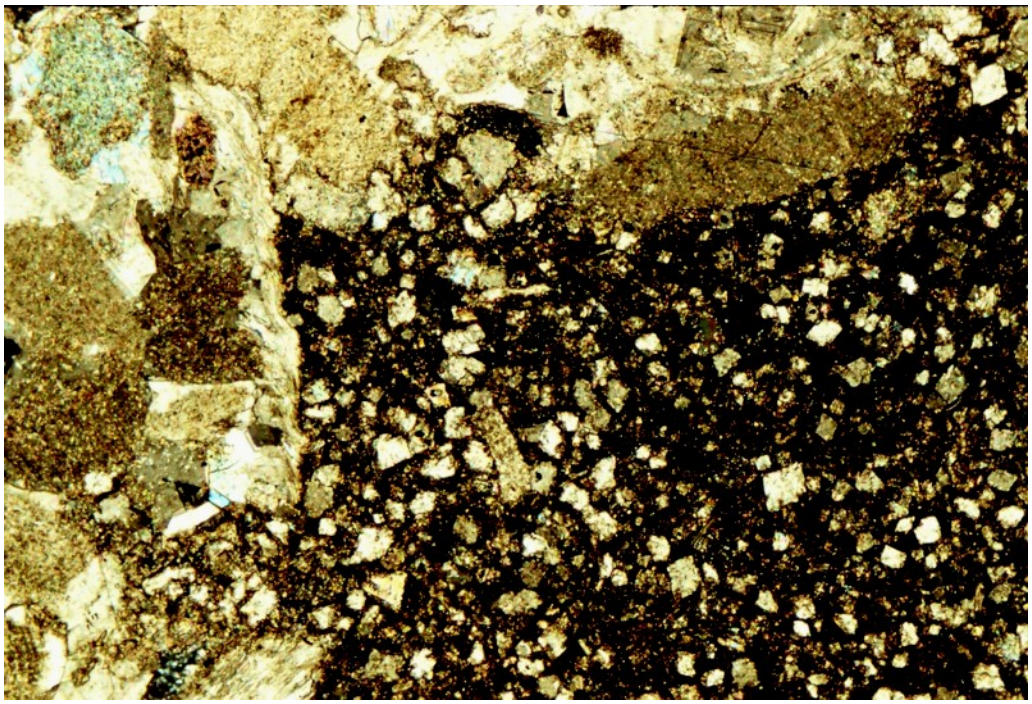
A fossil-rich rock that consists of various fossil fragments, some of which are partly replaced and included in late coarse-grained dolomite, and some are included in fine-grained calcareous Fe-stained matrix. Replacement by dolomite is extensive and some of the more coarse-grained dolomite-rich domains contain a few small intergranular pores. Where dolomite aggregates are fine-grained and are intercalated with the Fe-stained clayey matrix, the pore spaces have been filled by the clays. Some fossils are partly dissolved and range in size from <0.5 mm to 4.0 mm. They include fragments of crinoids, brachiopods and trilobite segments. The locally dark matrix consists predominantly of fine-grained carbonates and interstitial clays (in variable proportions).

Fine-grained pyrite occurs in aggregates and as small framboids. They are disseminated through the rock and are often included in the partly altered fossil fragments.

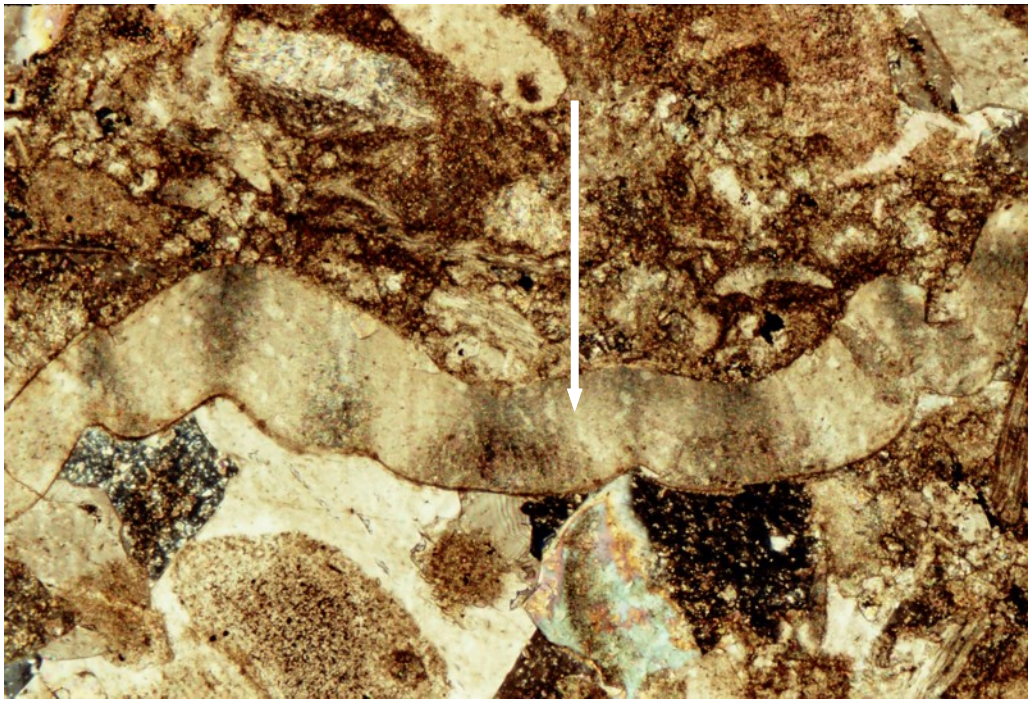
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Carbonate	40	0.1-3.0	Coarse-grained carbonates crystallized at the expense of some of the fossils and they are also interstitial to fossils. A few of these late dolomite aggregates contain minor intergranular pores. Other carbonates are fine-grained, subhedral-euhedral grains that are often weakly Fe-stained and occur as equigranular aggregates intercalated with dark clays.
Fossils (calcareous)	40	0.3-5.0	Fossil fragments in the rock include crinoids, trilobite segments, brachiopods and fibrous fragments. All fossils are calcite in composition.
Clays	20		Very fine-grained Fe-stained clays are matrix to some of the fossil fragments. They are also interstitial to the fine-grained, late Fe-stained carbonates.

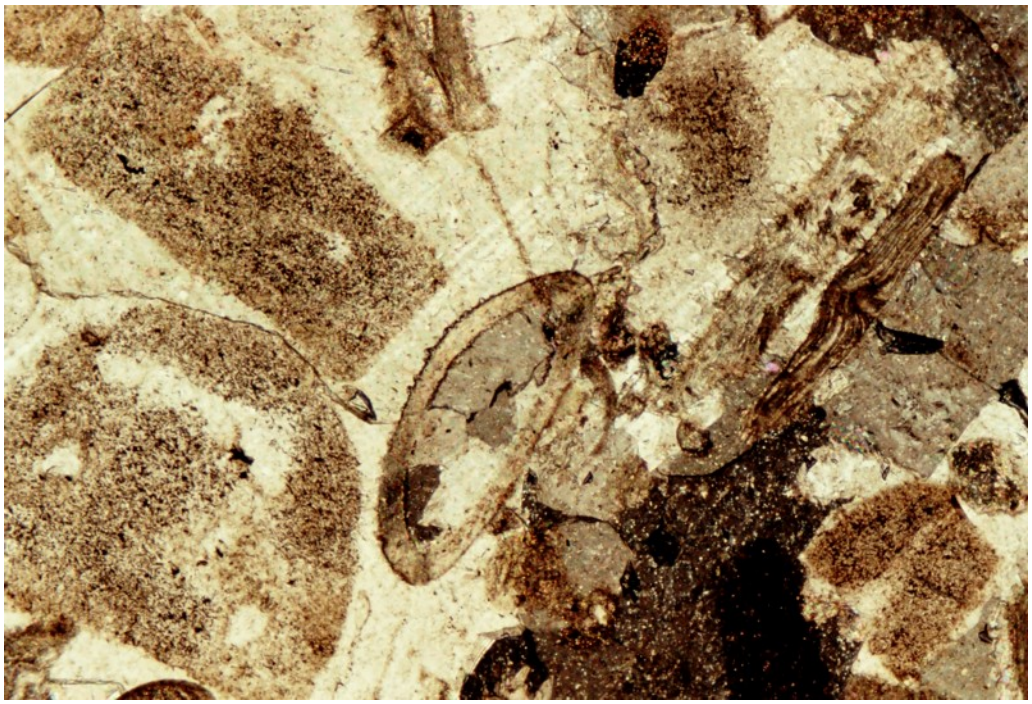
Accessory minerals: pyrite, quartz



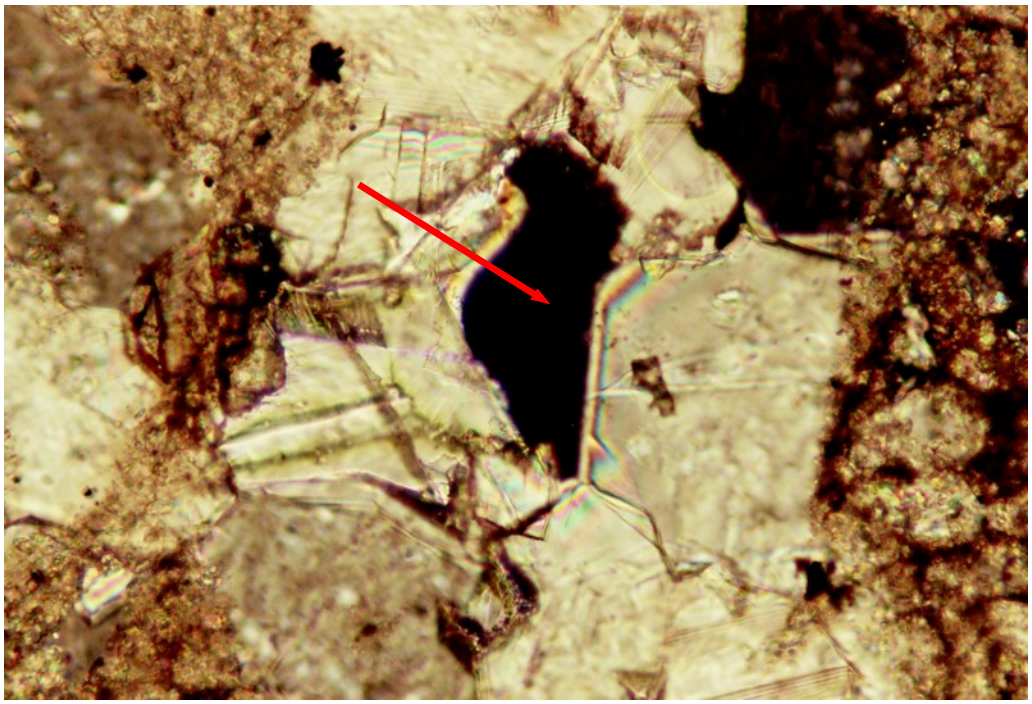
DGR2-669.27a. Fine-grained dolomite in dark, Fe-stained matrix .
Width of photo: 2.3mm. XN.



DGR2-669.27b. Trilobite (?) fragment in fossiliferous limestone.
Width of photo: 2.3mm. XN.

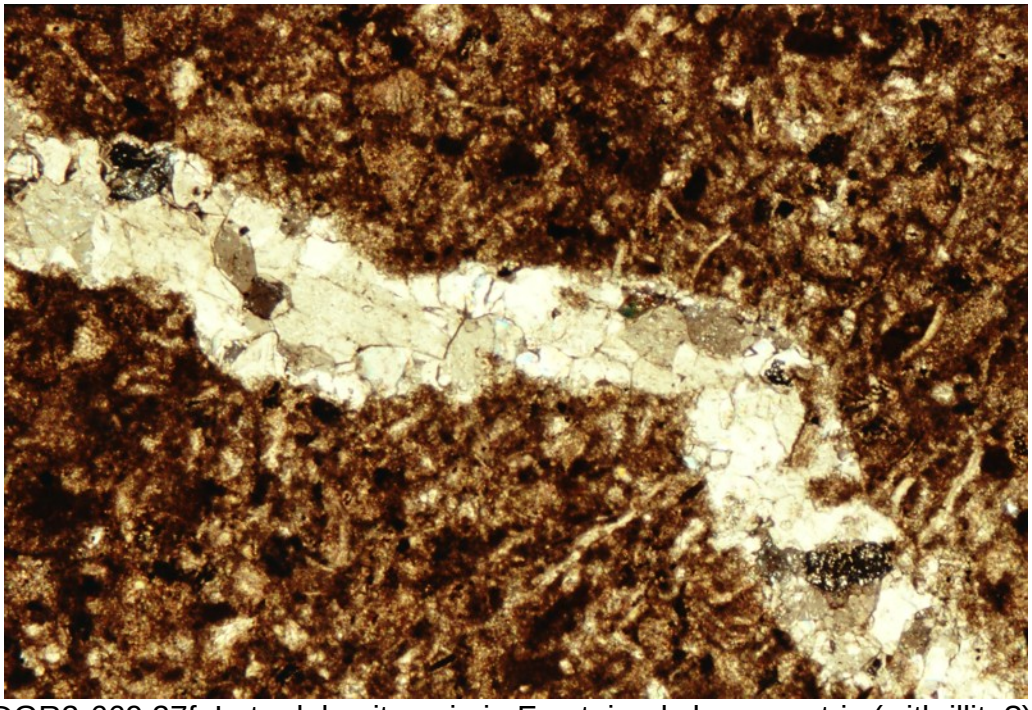


DGR2-669.27c. Brachiopod and other fossil fragments are included in coarse-grained secondary dolomite. Width of photo: 2.3mm. XN.



DGR2-669.27d. Intergranular pore in coarse-grained secondary dolomite. Width of photo: 0.45mm. XN.

DGR2-669.27e. Intergranular pore in coarse-grained secondary dolomite.
Width of photo: 0.45mm. XN



DGR2-669.27f. Late dolomite vein in Fe-stained clayey matrix (with illite?).
Width of photo: 2.3mm. XN.

Sample Number: DGR2-677.93 Rock Type: Fossiliferous limestone - packstone

Petrographic Description:

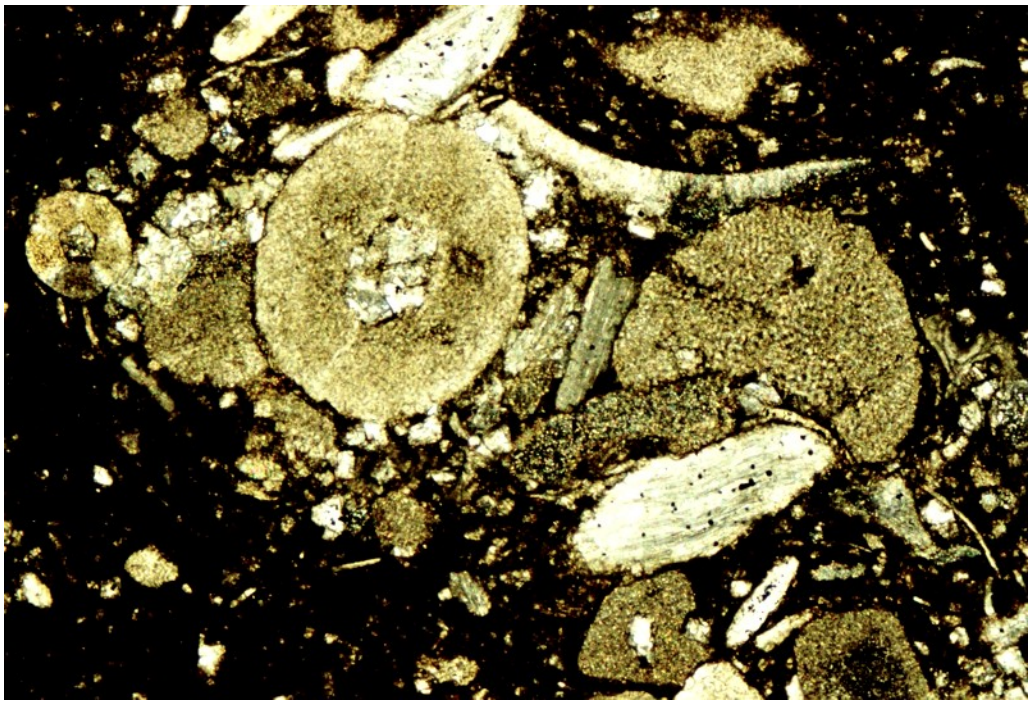
The mineralogy and texture of the rock is somewhat similar to the previous sample, DGR-2-669.27. It differs however in the type of fossils present, and in the ratio of fossils to clay minerals and carbonates. The fossils are significantly smaller, they are fragmented, and most are partly replaced by murky carbonate aggregates. They are also included in the late carbonate aggregates. The fossil bits are mostly crinoids fragments and minor brachiopods. The host carbonate aggregates are recrystallized, Fe-stained and partly replace some of the fossil inclusions. Intergranular pores are absent in the host carbonates. Fe-stained clays (illite) occur in anastomosing veins and as part of the matrix interstitial to the fine-grained, equigranular carbonate aggregates.

Pyrite is abundant and is most commonly associated with the Fe-stained dark clays. Very fine-grained pyrite are disseminated through the rock. Some are minute framboids which occur in aggregates, partly replacing the fossils.

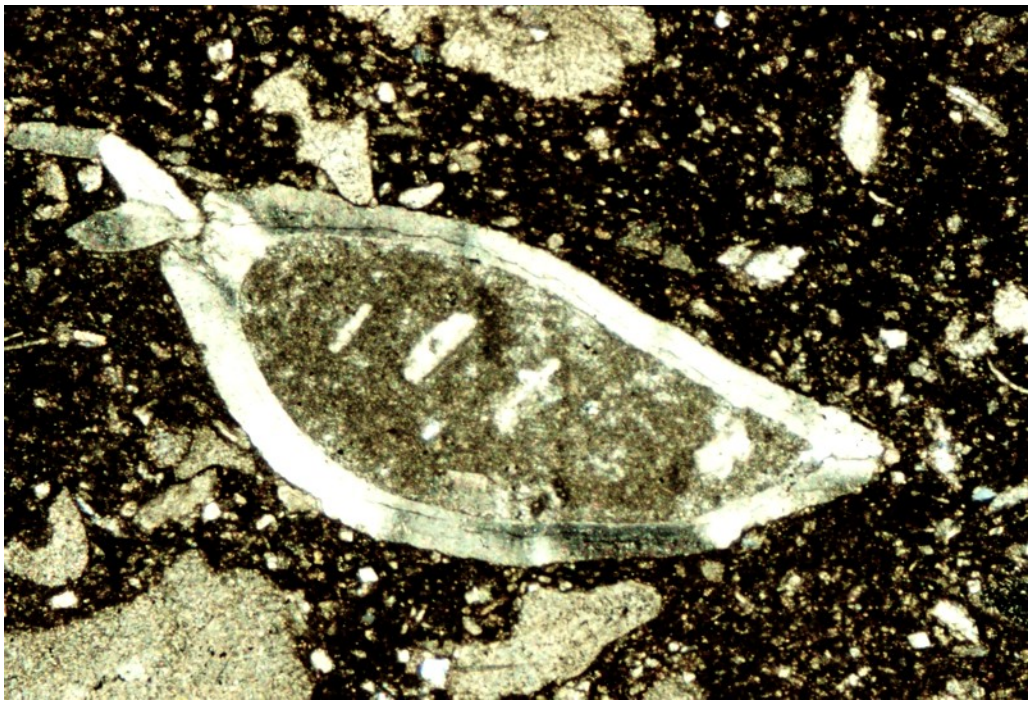
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Carbonate	40	Minute-2.5	Carbonate occurs as host to the fossil fragments, and as equigranular fine-grained aggregates within the interstitial clays. Some of the fossils are partly or completely recrystallized to fine-grained carbonate aggregates.
Fossils	33	Av. 2.0	With the exception of a few crinoids and brachiopods, fossil fragments are relatively small, and are often broken. In the host carbonate aggregates they are poorly visible due to their partial recrystallization.
Clays	25		Dark, Fe-stained clays (illite) are interstitial to the subhedral–euhedral calcite aggregates. The clays also occur as anastomosing veins that cross-cut the rock fabric and contain fragments of fossils.
Pyrite	2	Up to 0.2	Pyrite aggregates partly replace some of the carbonate-altered fossils and form veins within the clay-rich matrix.

Accessory minerals: quartz



DGR2-677.93a. Crinoid and other fossil fragments in dark, clayey (illite-bearing) matrix. Width of photo: 2.3mm. XN.



DGR2-677.93a. Brachiopod - partly recrystallized. Width of photo: 2.3mm. XN.

```
ETEC                677.93 FIBROUS CALCITE
ETEC                zaf cycles  4    bc drift=0.674
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.92  36.22   50.68 24.000
ETEC                MGO   0.48   0.00    0.00  0.000
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       36.22   50.68  24

ETEC                677.93 BLOCKY CALCITE
ETEC                zaf cycles  4    bc drift=0.913
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  36.21   50.67 24.000
ETEC                MGO   0.48   0.00    0.00  0.000
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       36.21   50.67  24

ETEC                677.93 MATRIX
ETEC                zaf cycles  5    bc drift=1.082
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.70  22.54   48.22  7.833
ETEC                TIO2  0.82   0.31    0.51  0.062
ETEC                AL2O3 0.69   9.29   17.56  3.362
ETEC                MGO   0.57   2.17    3.59  0.870
ETEC                FEO   0.83   2.51    3.23  0.439
ETEC                K2O   0.86   4.55    5.48  1.136
ETEC                CAO   0.83   5.29    7.40  1.288
ETEC                total       46.66   85.99  24
```

Sample Number: DGR2-687.47 **Rock Type: Fossiliferous (ferruginous) limestone**

Petrographic Description:

A partly recrystallized fossiliferous limestone. The rock is different from the other samples in that, it contains an abundance of pyrite, most of which partly replace some of the fossil fragments. The fossil bits are partly dissolved, partly recrystallized, and the fragments are annealed. The rock consists of several domains: 1. dissolved / annealed and partly recrystallized fossil-rich massive carbonates, 2. aggregates of fine-grained, euhedral, equigranular carbonates, and 3. oxidized clayey matrix with fossil fragments and pyrite. The highly oxidized clayey matrix occurs as a small lens and is penetrated by anastomosing Fe-rich veins, suggesting the late introduction of Fe-rich solutions to the rock. These solutions penetrated and also filled the pore space between the fine-grained euhedral carbonates in domain 2. A few anhedral quartz clasts are included in the rock.

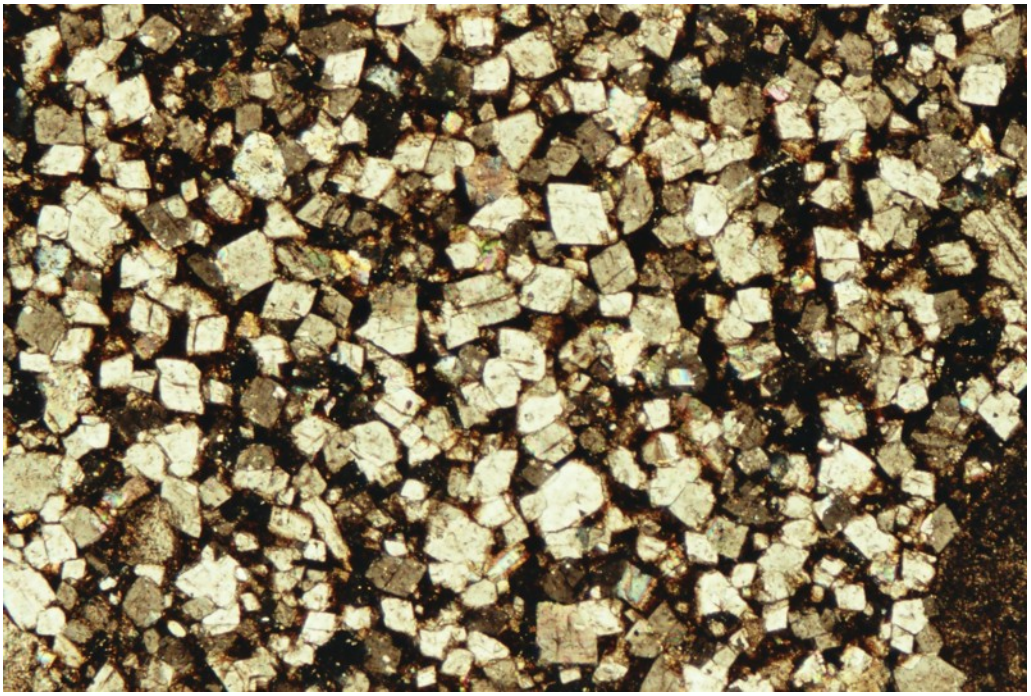
Although a minor component, very fine-grained pyrite occurs throughout the rock, it is mostly concentrated in the clayey domain and the Fe-stained veins. All pyrite are porous, and some occur as small framboids.

Detailed mineralogy

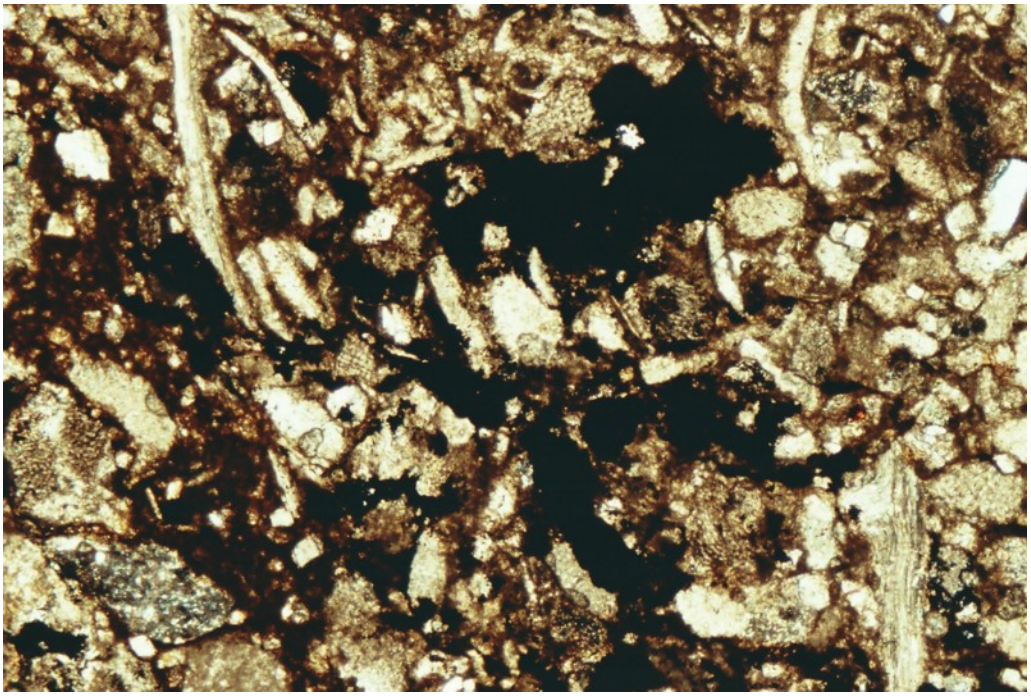
Mineral	%	Grain size(mm)	Comments
Carbonate	55	Minute-0.5	Carbonate occurs as cement between the fossil fragments, as fine-grained, euhedral aggregates in a large domain, and as microcrystalline grains that partly replace some of the fossil fragments at the grain boundaries.
Fossil fragments	25		All fossil fragments consist of carbonate (probably calcite). They include mostly bivalve and crinoid fragments. Most fossils are partly dissolved and some are partly recrystallized to very fine-grained granular carbonates.
Clays	15		Fe-stained clays occur in irregularly shaped domains within the carbonate-rich rock. They probably consist mostly of illite, mixed with very fine-grained carbonates. The clay-rich domains contain numerous anastomosing Fe-hydroxide veins with disseminated porous pyrite aggregates.

Pyrite	5	Very fine-grained pyrite is disseminated through the rock. Porous pyrite is most abundant within the clay-rich domains, where it occurs as aggregates and also as small, discontinuous veins.

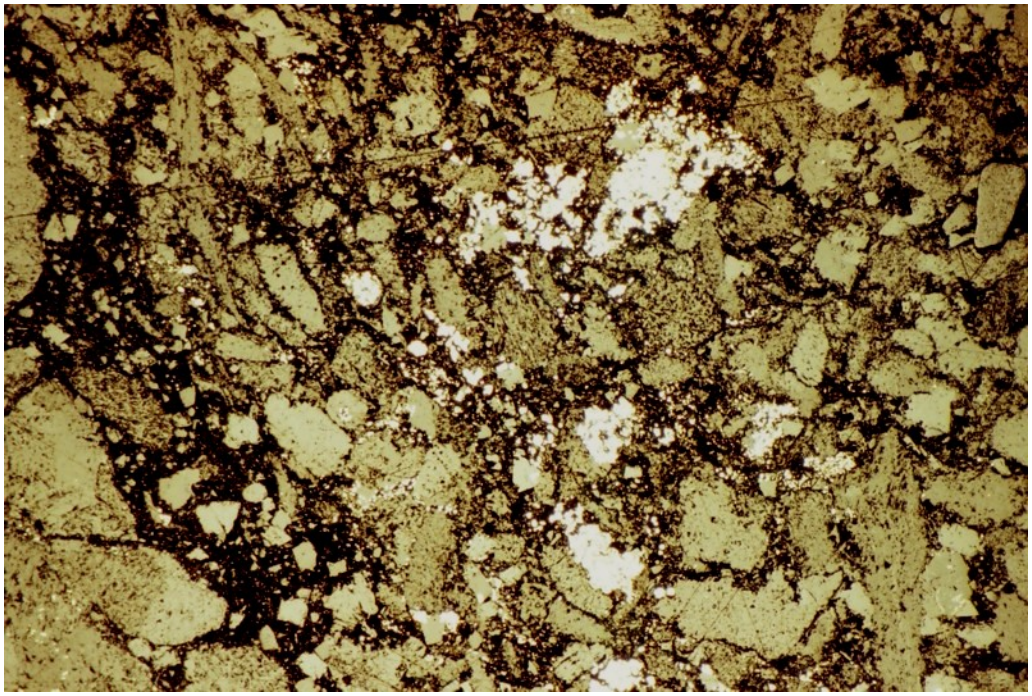
Accessory minerals: quartz, rutile



DGR2-687.47a. Fine-grained secondary dolomite. Width of photo: 2.3mm. XN.



DGR2-687.47b. Fossil fragments in dark clay and pyrite-bearing matrix. Width of photo: 2.3mm. XN.



DGR2-687.47c. Pyrite aggregates (white) in above. Refl. light.

Sample Number: DGR2-695.51 **Rock Type: Fossiliferous limestone**

Petrographic Description:

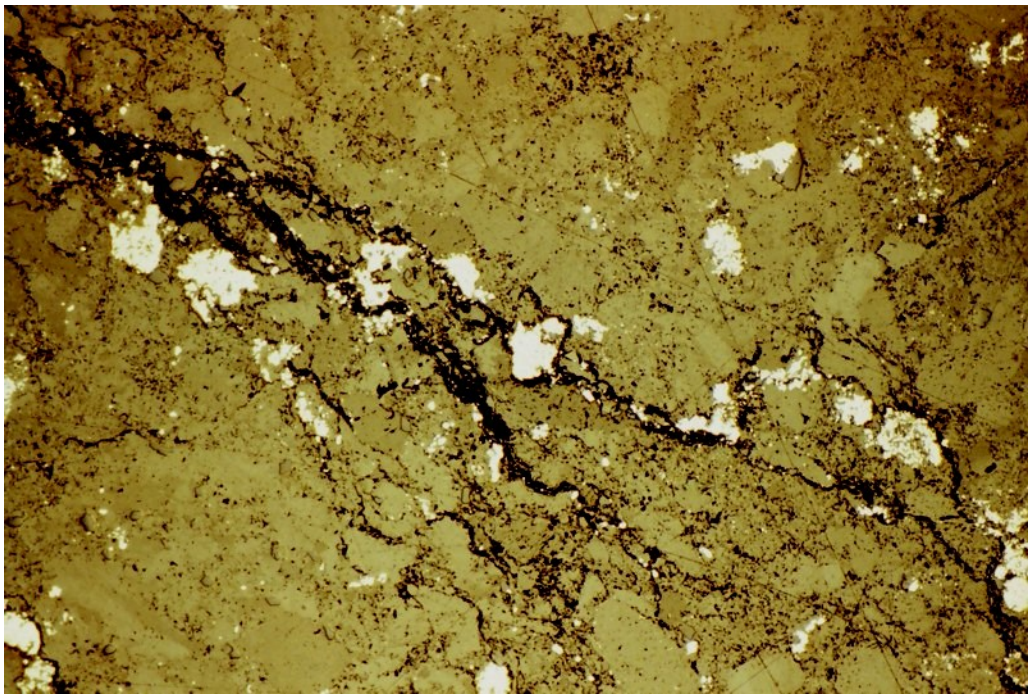
A fine-grained, more or less equigranular dense, fossiliferous limestone. The rock consists predominantly of well packed and sorted fossil fragments intercalated with carbonate aggregates. A thin (0.5mm wide) laminae at the base of the thin section consists of microcrystalline Fe-stained clays that is capped by a contorted 0.2mm wide domain that consists of small carbonate fragments floating in a ferruginous microcrystalline matrix (a transition zone between the laminated clays and the limestone?). A few small Fe-stained veinlets within the limestone parallel the clay-rich domain. The small fossil fragments appear to be mostly bivalves and small crinoids. They are partly dissolved and cemented with anhedral to subhedral carbonates. All of the original pore space within carbonate aggregates has been filled by amorphous Fe-rich substance.

Pyrite is relatively rare. Only a few small porous grains and minute framboids occur within the fossiliferous limestone and the Fe-rich veins. A few veins, consisting of amorphous Fe-hydroxide are parallel to the clay-rich domain.

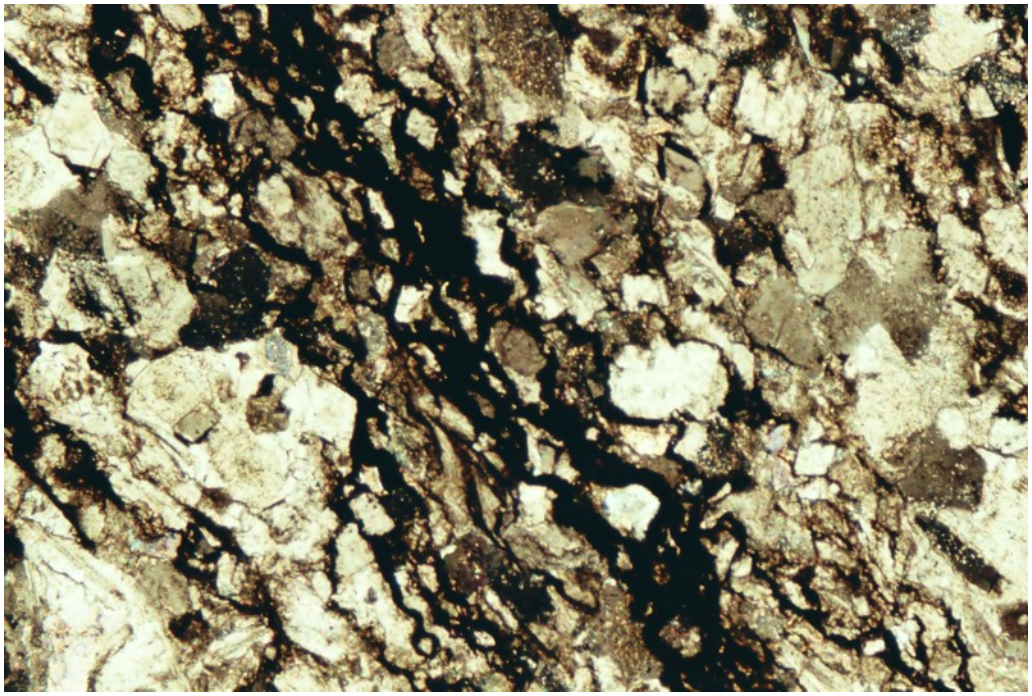
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Carbonate	70	Minute-1.0	The carbonates occur as subhedral – anhedral aggregates interstitial to the fossil fragments, and as minute grains that crystallized (at the grain boundaries) at the expense of the fossils and the earlier carbonates. They act as cement between the various fossil fragments.
Fossils	20	Av. 0.6	All fossils are calcite. The small fragments of crinoid and bivalve are partly dissolved and included in and cemented by the carbonate aggregates.
Clays	10		A narrow band, consisting of very fine-grained Fe-stained clays is part of the rock. It appears to represent a change in the depositional environment.

Accessory minerals: pyrite, quartz



DGR2-695.51a. Pyrite (white) in vein. Width of photo: 2.3mm. Refl. light.



DGR2-695.51b. Dark, pyrite-rich vein in fossiliferous limestone.
Width of photo: 2.3mm. XN.

Sample Number: DGR2-704.87 **Rock Type: Fossiliferous limestone**

Petrographic Description:

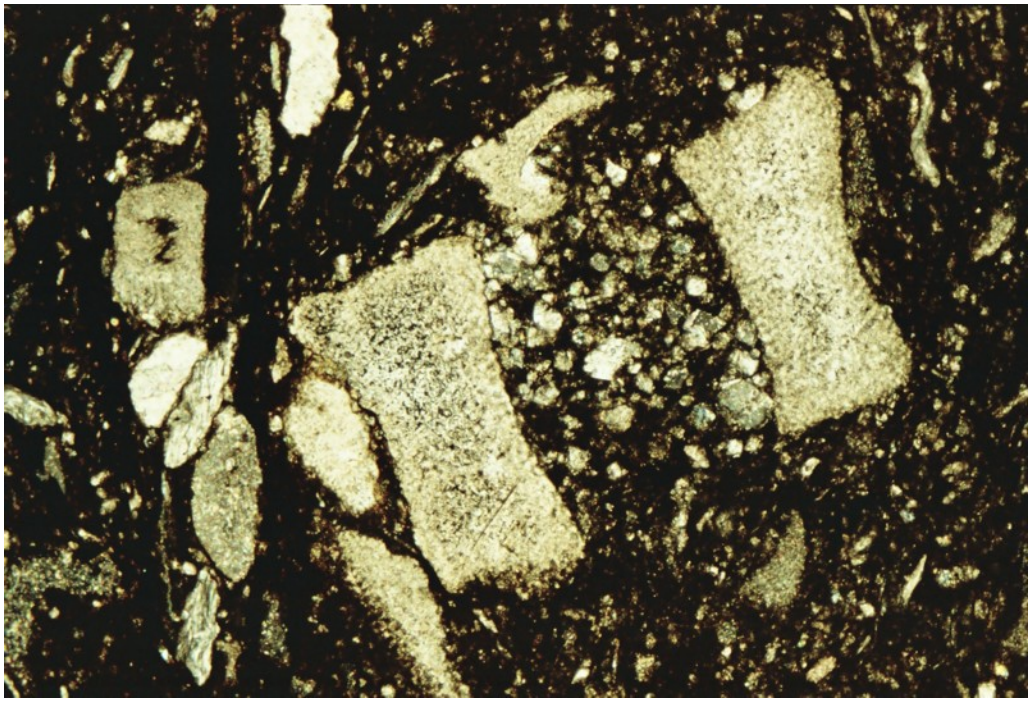
The rock consists predominantly of fine-grained fossiliferous limestone. The limestone is intercalated with Fe-rich clayey bands that contain very large fossil fragments – several of which are partly replaced by pyrite, and some contain small domains of chalcedony. This would suggest that the original large fossils may have been siliceous, and were later replaced by calcite, and subsequently, by pyrite. The clay-rich domains also contain aggregates of euhedral, fine-grained dolomite. Calcite veinlets cross-cut the rock fabric and are more or less orthogonal to the Fe-stained clay-rich bands. There must have been a significant difference in the depositional environment between the fine-grained fossiliferous limestone, and the ferruginous clay-rich matrix that contains the very large fossil fragments.

Fine-grained anhedral pyrite occurs within fossil fragments and the matrix.

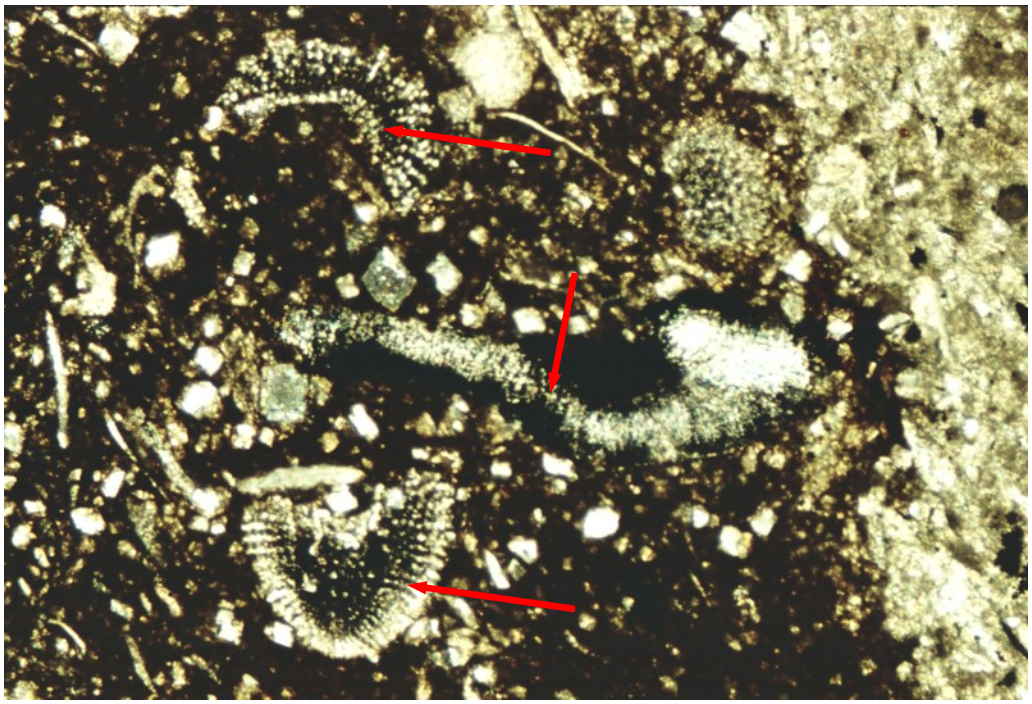
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Carbonate	45	Minute-0.6	Fine-grained, granular carbonates make up the matrix interstitial to the euhedral dolomite aggregates. Anhedral calcite is interstitial to and cements the small fossil fragments in the limestone.
Fossil fragments	30	<0.3-3.0	In the limestone, the fossils are small (<0.8 mm), partly dissolved fragments. They are most commonly bivalve and crinoid fragments. In the clays, the average fossil fragments are 2.5mm (or larger). Some fossils are partly replaced by fine-grained pyrite, and some contain siliceous domains of fibrous chalcedony.
Clays	25		Very fine-grained Fe-stained clays (illite) and fine-grained carbonates make up the clay-rich matrix. These domains more or less parallel the rock fabric.
Pyrite	trace		Very fine-grained pyrite partly replace some of the large fossils and they are disseminated through the matrix.

Accessory minerals: chalcedony



DGR2-704.87a. Large fossil fragments in dark, Fe-stained clayey illite-rich matrix.
Width of photo: 2.3mm. XN.



DGR2-704.87b. Fossil fragments are partly replaced by fine-grained pyrite (black).
Width of photo: 2.3mm. XN.

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ETEC                704.87 EUHEDRAL DOLOMITE
ETEC                zaf cycles  4    bc drift=0.494
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.90  26.50   37.09 15.300
ETEC                MGO   0.49   8.55   14.18  8.137
ETEC                FEO   0.83   1.36    1.75  0.563
ETEC                total       36.41   53.01  24

ETEC                704.87 MATRIX
ETEC                zaf cycles  5    bc drift=1.060
ETEC                       fac    %el    %ox   stfm
ETEC                SIO2  0.71  20.42   43.68  8.090
ETEC                TIO2  0.83   0.35    0.58  0.081
ETEC                AL2O3 0.68   7.65   14.46  3.157
ETEC                MGO   0.55   2.01    3.33  0.920
ETEC                FEO   0.84   2.58    3.32  0.514
ETEC                K2O   0.87   4.55    5.48  1.294
ETEC                CAO   0.84   3.02    4.23  0.840
ETEC                total       40.58   75.09  24

ETEC                704.87 CALCITE VEIN
ETEC                zaf cycles  4    bc drift=1.080
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  35.55   49.74 24.000
ETEC                MGO   0.48   0.00    0.00  0.000
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       35.55   49.74  24

ETEC                704.87 CALCITE
ETEC                zaf cycles  4    bc drift=1.117
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  34.21   47.87 22.908
ETEC                MGO   0.47   0.50    0.83  0.551
ETEC                FEO   0.83   1.13    1.45  0.541
ETEC                total       35.84   50.14  24
```

Sample Number: DGR2-745.97 **Rock Type: Fossiliferous shale - packstone**

Petrographic Description:

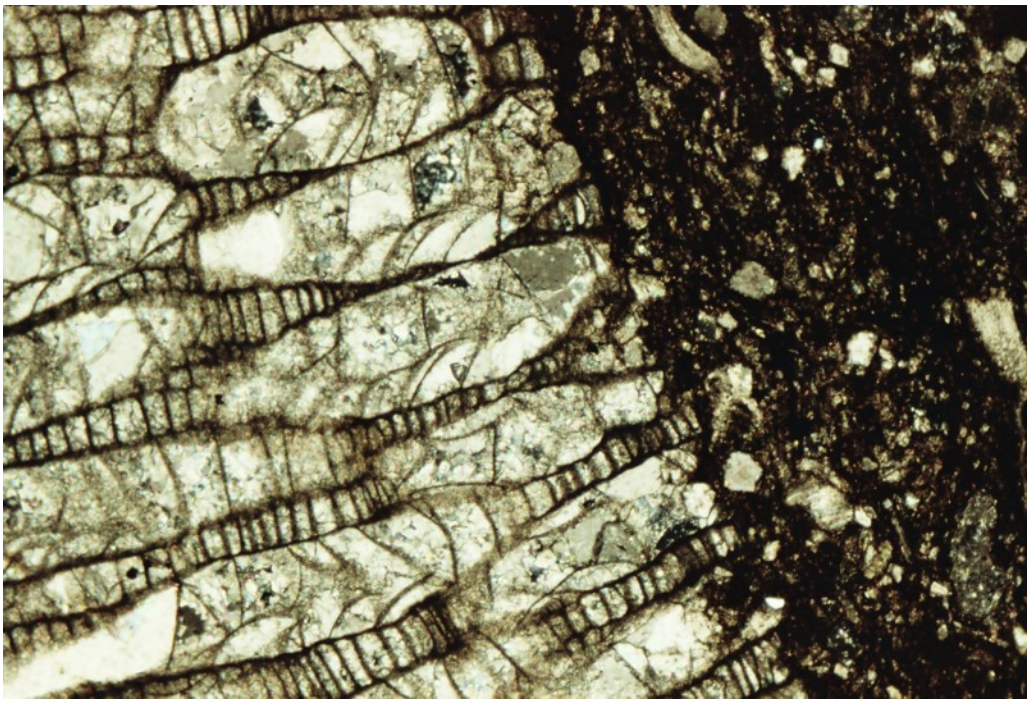
The rock is characterized by very large fossil fragments – most of which are derived from bryozoan. The rock consists of carbonate-rich and clay-rich domains. The carbonate-rich domains contain bryozoan fragments, fragments of trilobite (?), as well as crinoids and bivalve. Some of the large bryozoan (?) fragments are replaced by fibrous calcite. The fossil fragments in the carbonate-rich domains are more abundant, and some are partly dissolved or recrystallized at the selvages. The Fe-stained clays (with illite) contain fine-grained, euhedral grains of dolomite, in addition to the fossil fragments. Although most fossil fragments are large in the clay-rich matrix, they are fewer and not as well packed as in the carbonate-rich matrix.

Very fine-grained pyrite is disseminated through the rock.

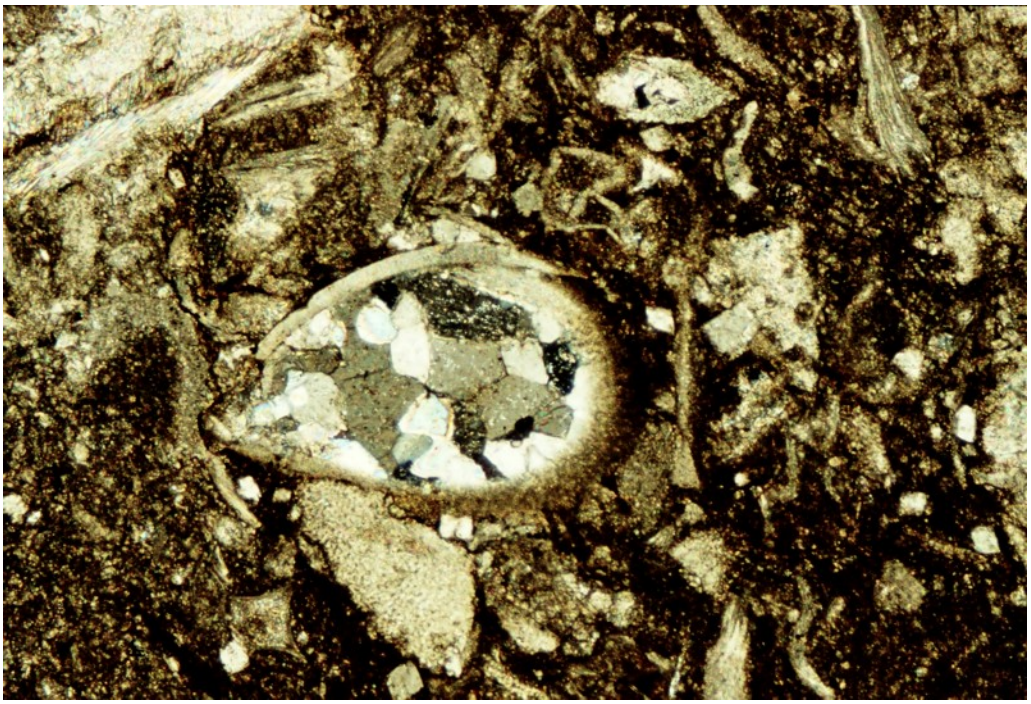
Detailed mineralogy

Mineral	%	Grain size(mm)	Comments
Carbonate	40	Minute->4.0	Calcite occurs as anhedral aggregates that host a significant part of the fossil fragments. They occur as very fine-grained aggregates interstitial to the fossils, as anhedral, interlocking aggregates, and as small, euhedral grains within the Fe-stained clayey matrix. Some fossil fragments are replaced by fibrous calcite.
Fossil fragments	30	0.5-1cm	All fossil fragments are calcite. The largest fragments are bryozoan and trilobite, and the smaller fragments are crinoids and brachiopods. Some sinuous fragments are replaced by fibrous calcite.
Clays	30		Fe-stained clay-rich matrix consists of fine-grained illite and minor fine-grained carbonates. It also contains interstitial fine-grained, euhedral dolomite – and several large fossil fragments.

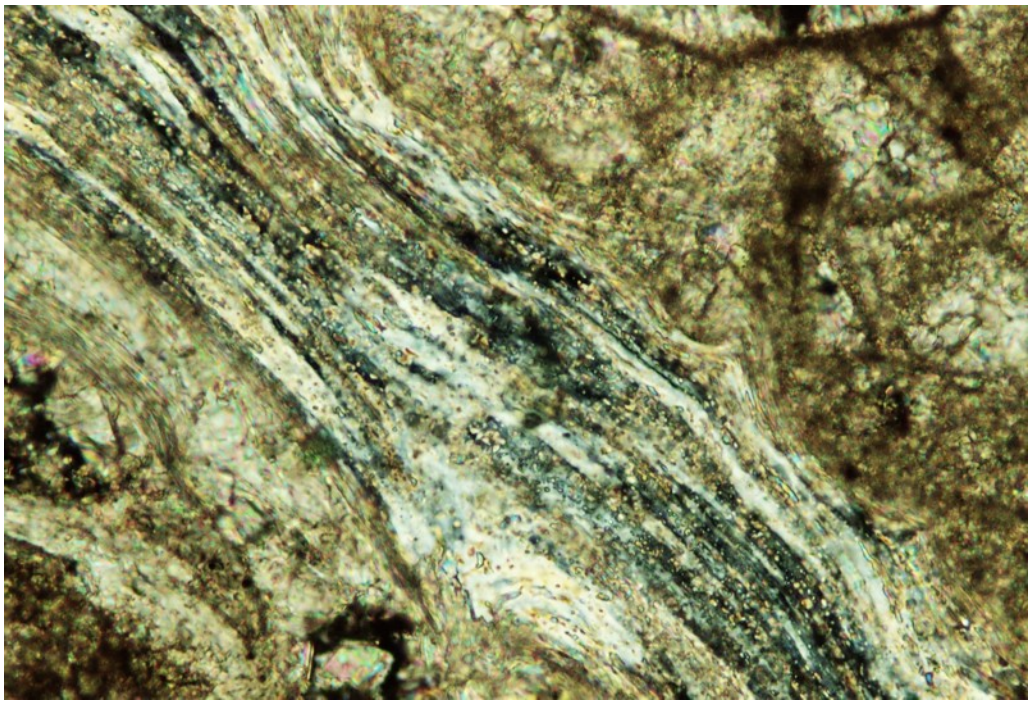
Accessory minerals: pyrite



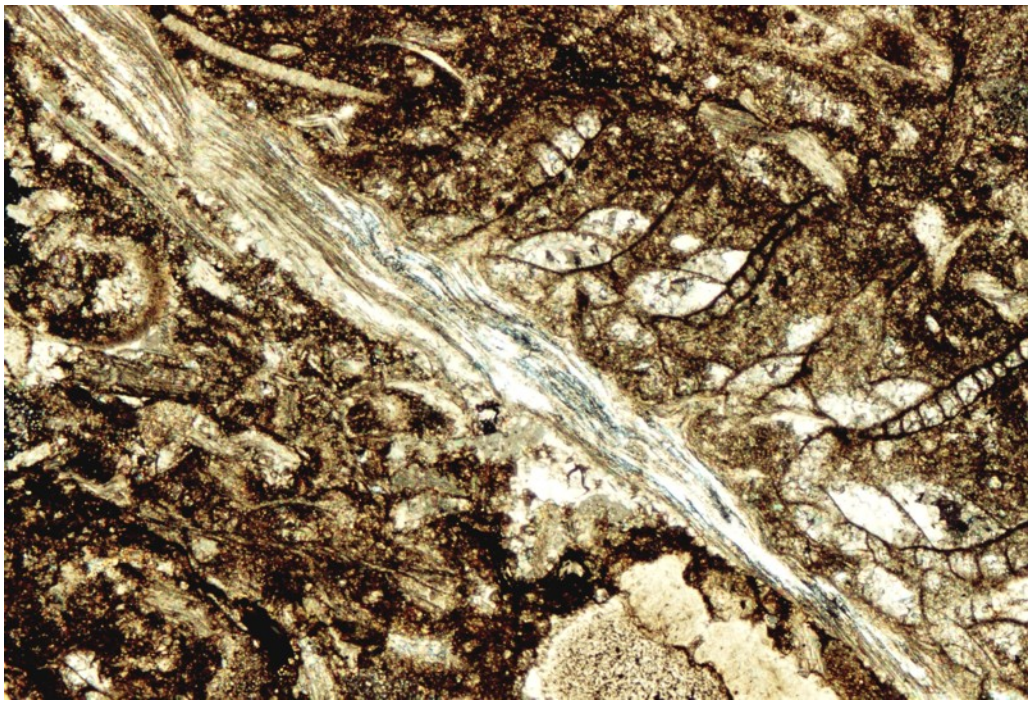
DGR2-745.97a. large bryozoan fragment in dark, clayey matrix.
Width of photo: 2.3mm. XN.



DGR2-745.97b. Brachiopod is partly replaced by aggregates of calcite.
Width of photo: 2.3mm. XN.



DGR2-745.97c. Fibrous calcite “vein”. Width of photo: 0.45mm. XN.



DGR2-745.97d. Fibrous calcite (as above) in fossil-rich domain.
Width of photo: 2.3mm. XN.

```
ETEC                745.97 APATITE
ETEC                zaf cycles  4    bc drift=0.935
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.88  36.57   51.16  9.355
ETEC                P2O5  0.86  17.70   40.55  5.859
ETEC                CL    0.84   0.17    0.17  0.050
ETEC                SO3   0.77   0.00    0.00  0.000
ETEC                total       54.44   91.89  24

ETEC                745.97 FIBROUS CALCITE
ETEC                zaf cycles  4    bc drift=1.144
ETEC                       fac    %el    %ox   stfm
ETEC                CAO   0.91  36.18   50.63 24.000
ETEC                MGO   0.48   0.00    0.00  0.000
ETEC                FEO   0.82   0.00    0.00  0.000
ETEC                total       36.18   50.63  24
```

APPENDIX C

DGR-2 Report, September 25, 2007 (DGR2-816.85 & DGR2-844.95)

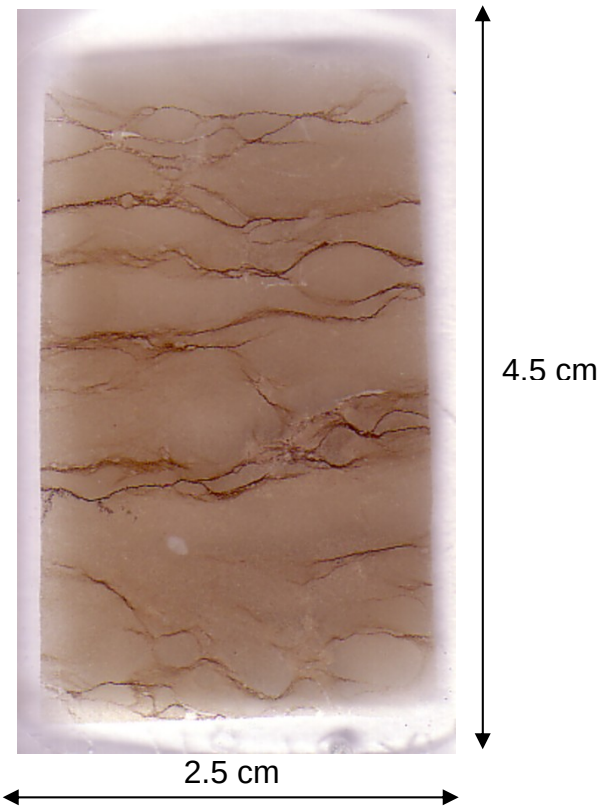
NOTE

Ppl = plane polarized light
XN = crossed nicols
Refl. light = reflected light

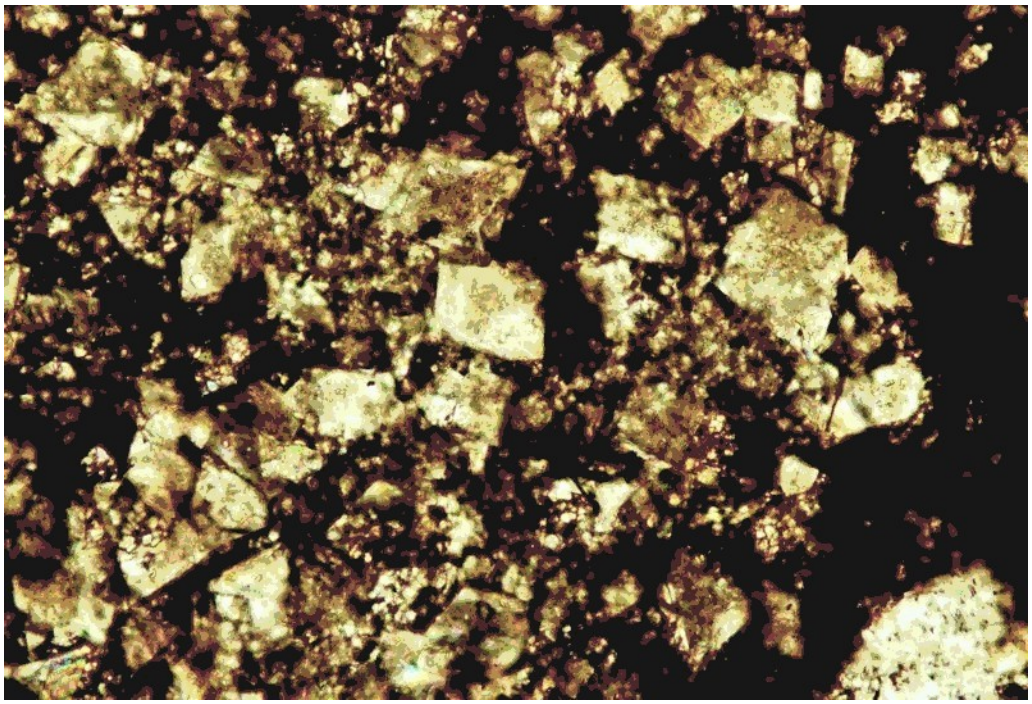
Sample Number: DGR2-816.85 **Rock Type: Dolomite**

Petrographic Description:

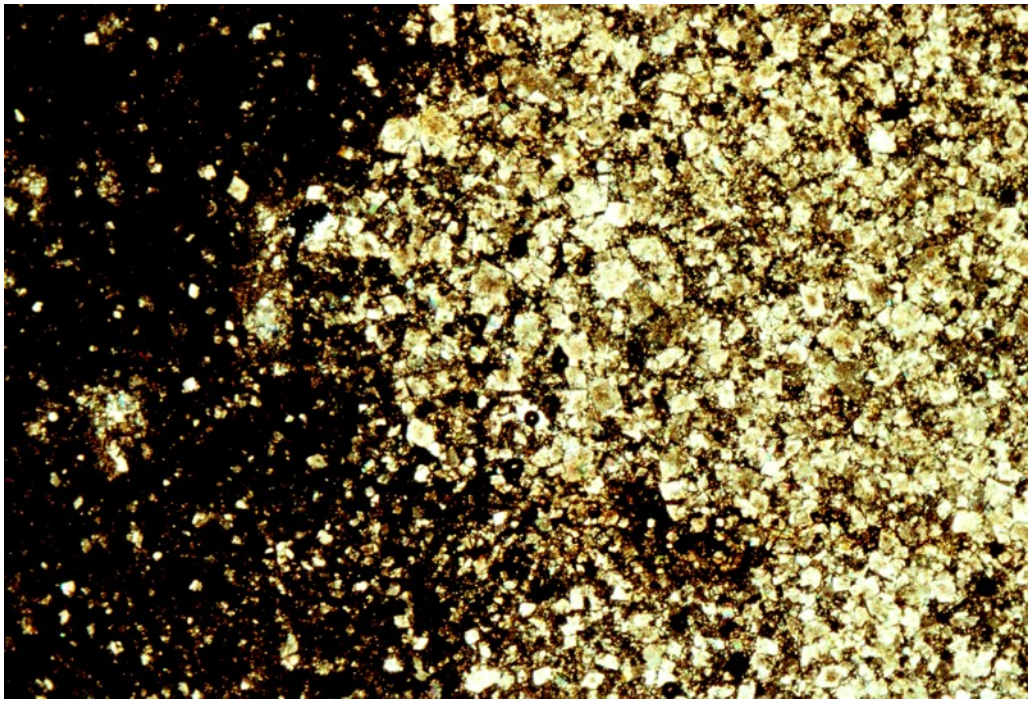
The rock consists of fine-grained equigranular saddle dolomite and variable proportions of brown, amorphous-looking clayey matrix. Parallel bands of Fe-stained clays occur at 0.3-1.0cm intervals throughout the entire thin section, giving the rock a laminated appearance. The presence of very fine-grained (Fe-rich) interstitial clays is apparent from the dark brown coloration of some microcrystalline domains in the polished thin section. Wispy Fe-veinlets are relatively abundant in the rock, and where they occur, the saddle dolomite recrystallized to very fine-grained granular aggregates (photo DGR2-816.85C). This would suggest the percolation of Fe-rich fluids through the rock. The parallel orientation of the Fe-veinlets – as shown below on the polished thin section - may be an inherited syn-depositional phenomenon, but it could also represent post-depositional infiltration of fluids along planes of weakness (porosity) in the rock. Approximately 30m below this depth, the veinlets disappear and the carbonates become more coarse-grained with interlocking texture.



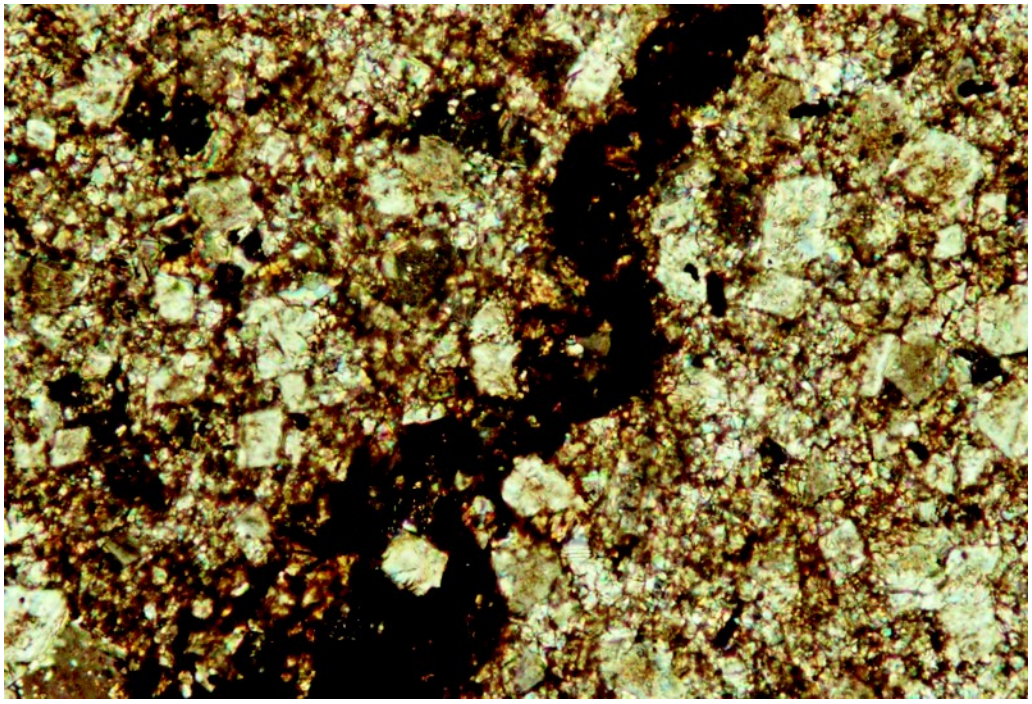
Mineral	%	Grain size
Carbonate	75	5 µm-1.5mm, av. 0.05mm
Fe-clays	25	few microns



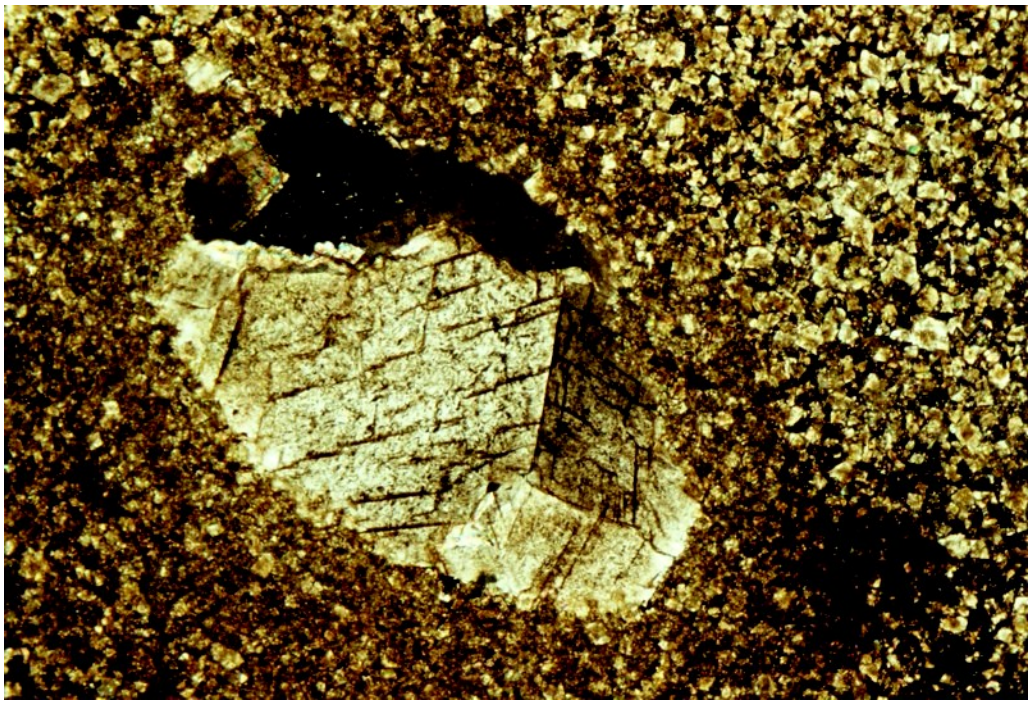
DGR2-816.85A. Saddle dolomite with interstitial Fe-stained clays. Width of photo: 0.45mm. XN.



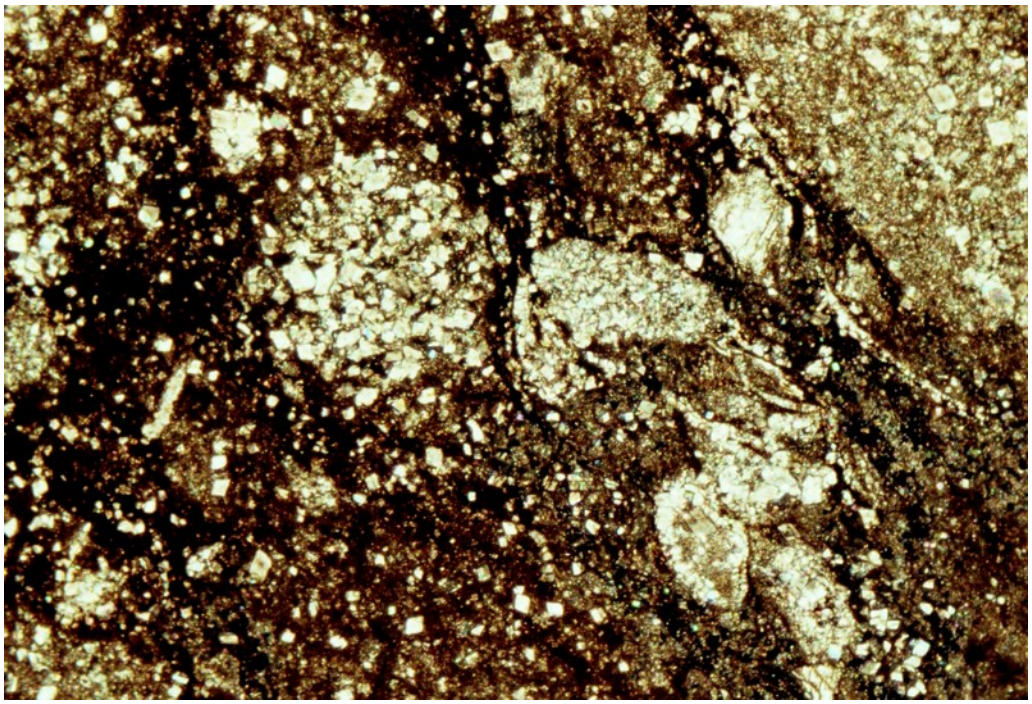
DGR2-816.85B. Fine-grained saddle dolomite rich domain alternates with Fe-stained clayey domain. Width of photo: 2.3mm. XN.



DGR2-816.85C. Saddle dolomite is partly recrystallized to fine-grained granular aggregates. Width of photo: 0.45mm. XN.



DGR2-816.85D. Coarse-grained carbonates within fine-grained saddle-dolomite aggregates. Width of photo: 2.3 mm. XN.



DGR2-816.85E. Fragmented dolomite in Fe-rich clayey matrix.
Width of photo: 2.3mm. XN.

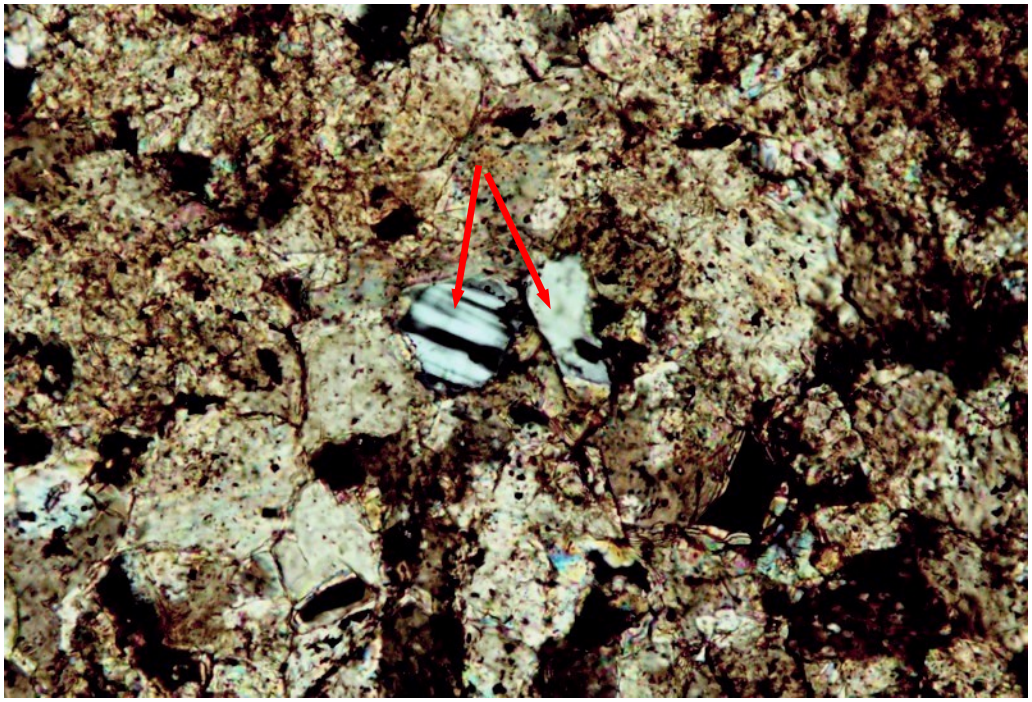
Sample Number: DGR2-844.95 **Rock Type: Dolomite**

Petrographic Description:

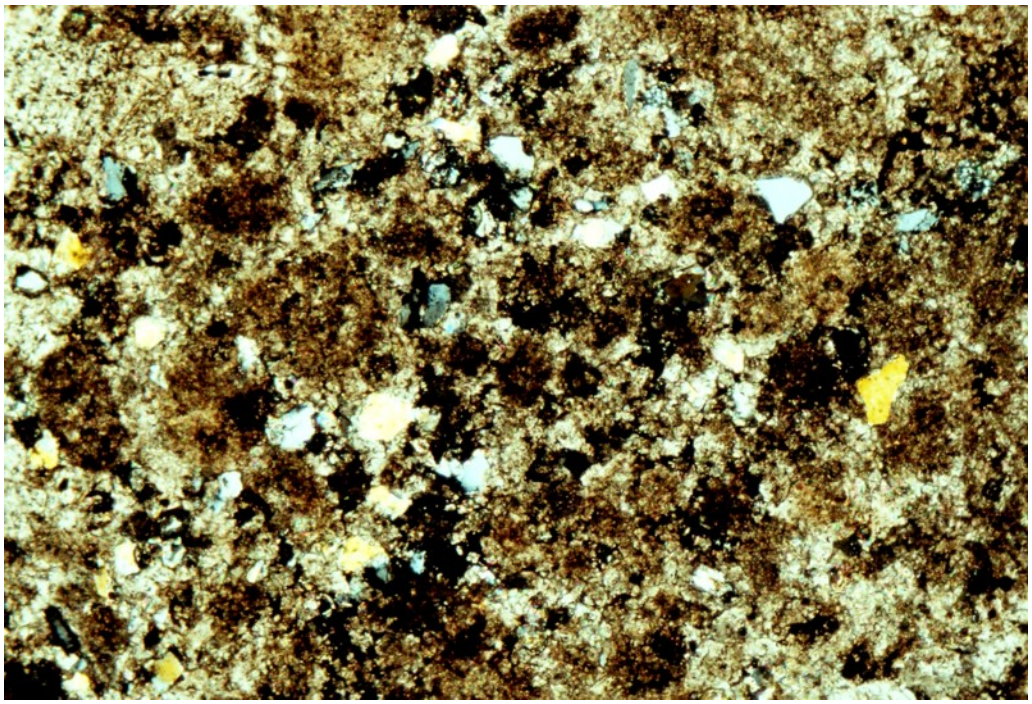
Medium-grained, recrystallized dense carbonate rock with very small clasts of interstitial detrital quartz and lesser feldspars (ca. 5%). The rock consists of domains that contain 1) very dark, anhedral “old” carbonate aggregates, 2) recrystallized clear, euhedral grains of interlocking carbonate aggregates where individual grains are up to 3mm, and 3) minor relict oolites. Very fine-grained quartz, plagioclase, and a few microcline clasts are disseminated within the matrix. A few small intergranular pores were identified within recrystallized carbonates. For the most part however, the “pores” were superimposed on the thin section during preparation (plucked from the section during grinding).

Minute grains of detrital (not framboidal nor cube-shaped) anhedral pyrite are disseminated through the rock (<0.5%). A relatively large sulfide aggregate (ca. 0.35 mm across) consists of marcasite. The marcasite was identified by its light color and anisotropism.

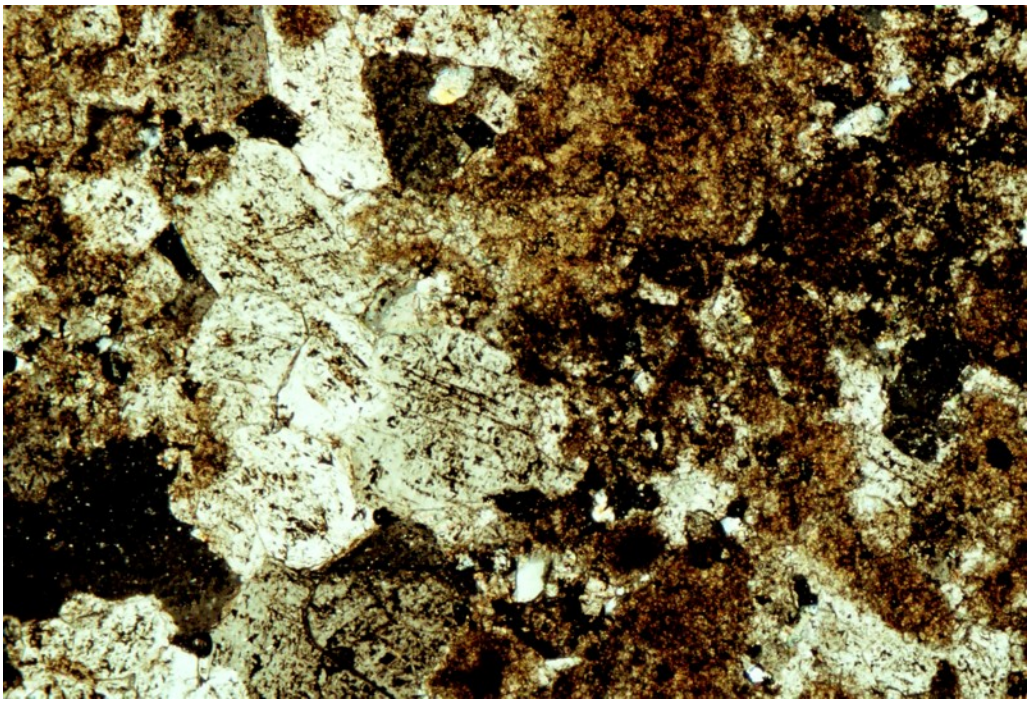
Mineral	%	Grain size
Carbonate	95	0.1-2.5, av. 1.0
Quartz	4.5	av. 0.1
Plagioclase	0.5	0.05
K-feldspars	trace	0.1
Pyrite/marcasite	trace	<0.05-0.35
Fe-stained qtz.		
Spherule	trace	1.0



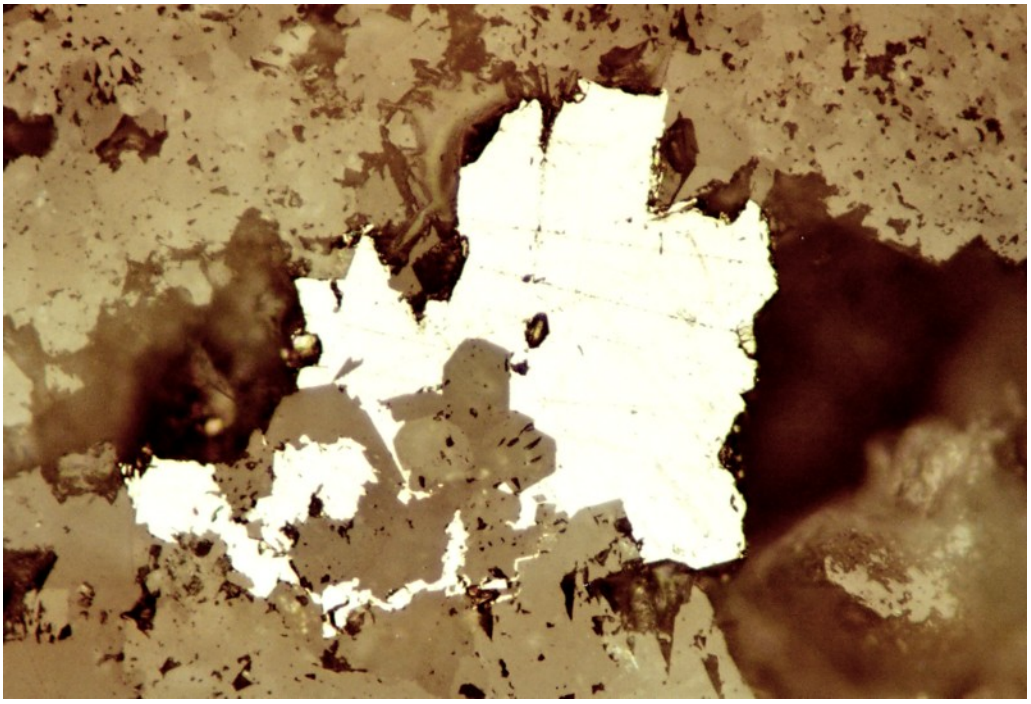
DGR2-844.95A. Relict dolomite with minute interstitial quartz and feldspar clasts. Width of photo: 0.45mm. XN.



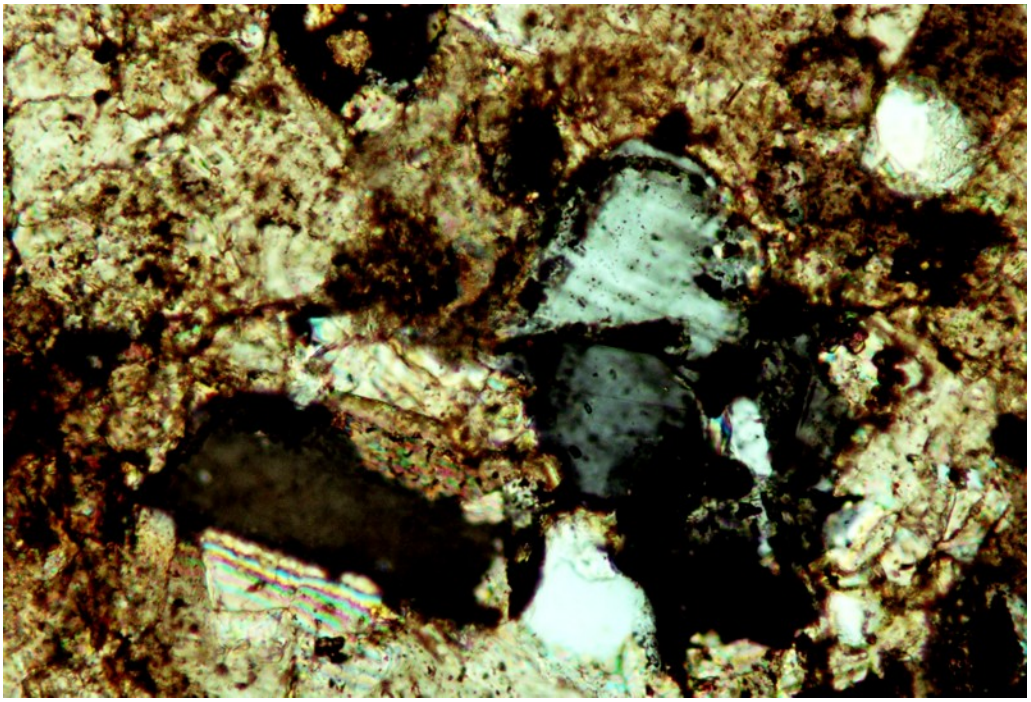
DGR2-844.95B. Fine-grained quartz and lesser feldspar clasts in Fe-stained carbonates. With of photo: 2.3mm. XN.



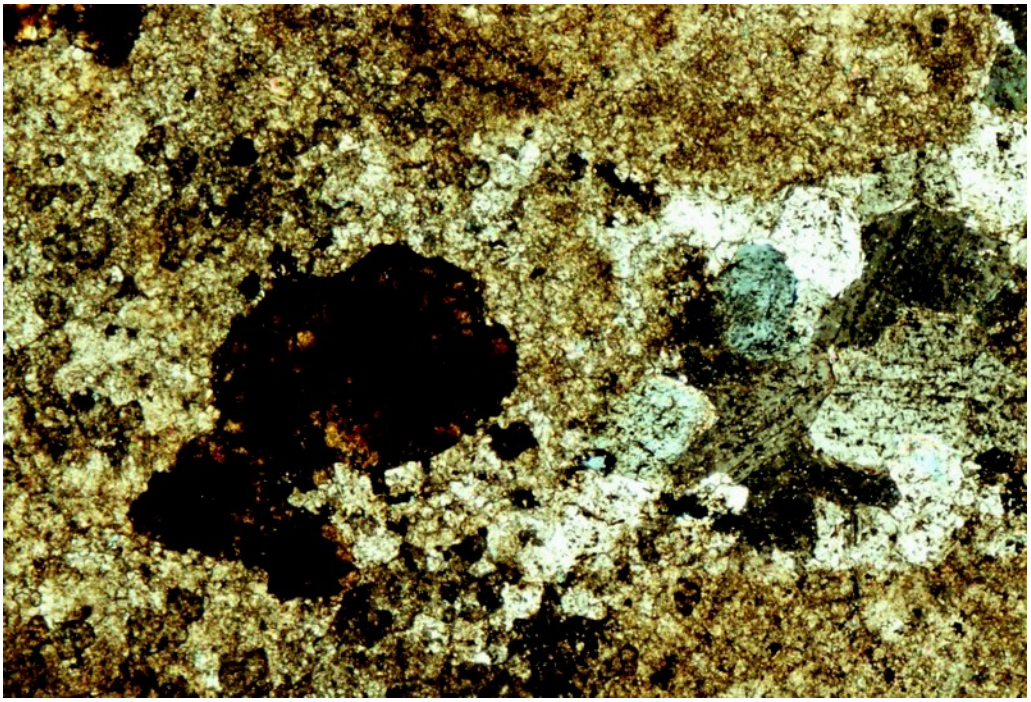
DGR2-844.95C. Clear, recrystallized carbonates. Width of photo: 2.3mm. XN.



DGR2-844.95D. Aggregate of marcasite (white) in carbonate-rich matrix. Width of photo: 2.3mm.



DGR2-844.95E. Aggregates of quartz and feldspars in carbonate-rich matrix.
Width of photo: 0.45mm. XN.



DGR2-844.95F. Fe-stained chalcedony spherule inclusion in carbonate.
Width of photo: 2.3mm. XN.