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Descriptions of Paleozoic cores and thin sections from the Gudrid H-55, Roberval K-92, Indian Harbour M-52, and Freydis B-87 wells, offshore Labrador (Newfoundland and Labrador)

N. Bingham-Koslowski

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Canada

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Abstract

The Paleozoic of offshore Labrador has received minimal attention due to its limited geographic extent and the lack of reliable biostratigraphic data, preventing correlation of these strata on a regional to global scale. Paleozoic strata are encountered in seven wells in the Hopedale Basin, of which, only four wells have cores associated with the pre-Mesozoic interval (Gudrid H-55, Roberval K-92, Indian Harbour M-52, and Freydis B-87). Six cores from the four wells, along with their associated 43 thin sections, are described here in an attempt to document lithological similarities between the wells that might provide insight into the timing and depositional environments of these rocks. Five of the six cores are composed of carbonate rocks with compositions ranging from dolostone (Gudrid H-55, Roberval K-92), to limestone and dolostone (Indian Harbour M-52), to primarily limestone with minimal diagenetic alteration (Freydis B-87 Core #2). Fossil material is rare to absent in pervasively dolomitized cores. Small, taxonomically indeterminate fossil fragments are common in the cores from Indian Harbour M-52 and Freydis B-87, along with shell fragments, articulated bivalve and brachiopod shells, echinoderms (crinoids), gastropods, sponge spicules, bryozoans, dasycladacean green algae, trilobites, ostracods, and calcimicrobes (*Girvanella*). Core #1 from the Freydis B-87 well, the only siliciclastic Paleozoic core, is composed of sandstones, siltstones, and mudstones. Roberval K-92 Core #6 contains two, mafic igneous intervals and hydrocarbon-charged porosity is observed in both cores from this well. Correlation of these Paleozoic strata, although consistent with similarities in the quantity and nature of fossil content, must await rigorous biostratigraphic assessment.

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1. Introduction

The Labrador margin has been an area of hydrocarbon exploration activity that commenced with the drilling of the first well, Leif E-33, by Tenneco et al. in August 1971 (Daneliuk and Bell, 1972). Currently there are 27 exploration wells scattered throughout the Hopedale and Saglek Basins, south of Hudson Strait (C-NLOPB, 2016). Despite the economic potential of the region and historical exploration efforts, the Paleozoic strata that underlie the southern portion of the Labrador margin have received only minor attention from industry and academia. This is likely due to the sporadic distribution of the Paleozoic, as it is found in isolated patches, and the fact that it occurs at depths greater than 1.9 km, typically beyond the extent of the exploration wells, resulting in limited data available for this interval.

Paleozoic strata occur in seven wells located offshore Labrador, all of which are situated in the Hopedale Basin: (from north to south) Hopedale E-33, South Hopedale L-39, Tyrk P-100, Gudrid H-55, Roberval K-92, Indian Harbour M-52, and Freydis B-87 (Fig. 1). Biostratigraphic studies have been previously attempted on the Paleozoic rocks with varying degrees of success resulting in age dates for the wells ranging from undifferentiated Paleozoic, to Ordovician, to Devonian, to Carboniferous (Moir, 1986; Bell and Howie, 1990; Williams et al., 1990). The inconsistencies in the age data combined with the discontinuous nature of the interval has thwarted attempts to correlate the Labrador Paleozoic on a well-to-well basis, and has prevented the inclusion of these rocks in regional and global studies. In the absence of reliable palynological data, other means of comparison, such as lithology, may be used to try and determine whether the Paleozoic strata in the wells are syndepositional and therefore, potentially, correlatable. This study presents detailed lithological descriptions of the Paleozoic from the Labrador margin based on conventional core and thin section analysis. Of the seven wells that contain Paleozoic rocks, only the four southernmost wells (Gudrid H-55, Roberval K-92, Indian Harbour M-52, and Freydis B-87) have Paleozoic cores and associated thin sections (Table 1). This report presents only the lithological data from this study; interpretations on the lithology and its significance on a regional-scale are reserved for publication at a later date in a peer-reviewed journal.

Table 1: Well information for the Paleozoic interval in the Gudrid H-55, Roberval K-92, Indian Harbour M-52, and Freydis B-87 wells (C-NLOPB, 2007a-d).

<table>
<tr><th rowspan="2">Well</th><th rowspan="2">Location</th><th rowspan="2">Total Depth (m)</th><th colspan="2">Paleozoic</th><th colspan="2">Core #</th><th rowspan="2" colspan="2">Thin Sections</th></tr>
<tr><th>Top (m)</th><th>Bottom (m)</th><th>Top (m)</th><th>Bottom (m)</th></tr>
<tr><td rowspan="2">Gudrid H-55</td><td rowspan="2">54º 54’ 30.19” N;
55º 52’ 28.47” W</td><td rowspan="2">2838</td><td rowspan="2">2663.5</td><td rowspan="2">2804</td><td colspan="2">1</td><td rowspan="2" colspan="2">6</td></tr>
<tr><td>2675.99</td><td>2680.87</td></tr>
<tr><td rowspan="4">Roberval K-92</td><td rowspan="4">54º 51’ 35.69” N;
55º 44’ 32.01” W</td><td rowspan="4">3874</td><td rowspan="4">3544</td><td rowspan="4">3874</td><td colspan="2">6</td><td rowspan="2">8</td><td rowspan="4">17</td></tr>
<tr><td>3578</td><td>3582.5</td></tr>
<tr><td colspan="2">7</td><td rowspan="2">9</td></tr>
<tr><td>3870</td><td>3874</td></tr>
<tr><td rowspan="2">Indian Harbour M-52</td><td rowspan="2">54º 21’ 51.42” N;
54º 23’ 47.81” W</td><td rowspan="2">3958.2</td><td rowspan="2">3531</td><td rowspan="2">3958.2</td><td colspan="2">1</td><td rowspan="2" colspan="2">12</td></tr>
<tr><td>3952.04</td><td>3958.13</td></tr>
<tr><td rowspan="2">Freydis B-87</td><td rowspan="2">53º 56’ 13.48” N;
54º 42’ 35.86” W</td><td rowspan="2">2314.1</td><td rowspan="2">1905</td><td rowspan="2">2314.1</td><td colspan="2">1</td><td rowspan="2">4</td><td rowspan="2">8</td></tr>
<tr><td>1934.87</td><td>1941.27</td></tr>
</table>

					2		4	
					2307.34	2313.43		

2. Geology of the area

The Paleozoic coverage of offshore eastern Canada has been depicted in some publications as a laterally continuous interval ranging from the Strait of Bell Isle to the Hopedale E-33 well in the Hopedale Basin, offshore Labrador (Moir, 1986; Bell and Howie, 1990). Other studies, involving geophysical data, have, however, suggested that the Paleozoic occurs instead in isolated, non-continuous packages interpreted primarily as erosional features commonly associated with Cretaceous syn-rift structures (McWhae et al., 1980; Miller and D'Eon, 1987). The discontinuous nature of the Paleozoic strata in the Hopedale Basin coupled with the lack of consistent age data has prevented the Paleozoic interval from being sub-divided into formal units.

Paleozoic rocks located along the Labrador margin were primarily deposited in an epeiric sea environment where they unconformably overlie Precambrian granites and gneisses and are unconformably overlain by Mesozoic strata (Moir, 1986; Bell and Howie, 1990). Offshore Labrador, Paleozoic rocks occur in the Hopedale Basin where they are penetrated by seven wells and range in thickness from 4 m in the Tyrk P-100 well to over 400 m in the Indian harbor M-52 well (Fig. 1; Bell and Howie, 1990; C-NLOPB, 2007a,e). The majority of the Paleozoic strata known from these wells are composed of carbonate rocks (limestones and dolostones), although, a significant interval (over 300 m) of siliciclastics occurs in the Freydis B-87 well (Laborde et al., 1975; Plé and Ferrero, 1976).

3. Methodology

Six Paleozoic cores from four wells (Gudrid H-55, Roberval K-92, Indian Harbour M-52, and Freydis B-87) in the Hopedale Basin (southern Labrador margin; Table 1; Fig. 1) were examined and described at the Canada-Newfoundland and Labrador Offshore Petroleum Board's (C-NLOPB) core storage facility. Details regarding the composition (siliciclastic or carbonate, limestone or dolostone) and lithological classification (mud percentage or grain-size composition) of the cores were recorded and annotations were made on observed physical/sedimentary structures, the degree of bioturbation, biological components (fossils), as well as diagenetic features such as cements and stylolites. For detailed core descriptions please refer to Appendix A. There may be slight discrepancies between the length of core stated on the core descriptions and the original lengths reported in the well history reports for each well. This is likely due to the distribution of core in the boxes, which may have shifted over time.

Forty-three thin sections were described and photographed for this report (Table 2). Twenty-five thin sections from the Paleozoic interval of the four wells were created for previous work on the Labrador margin and are part of the GSC's archived collection. These 25 thin sections are unequally distributed across the cored sections with some wells only having one thin section for the entire interval (e.g. Gudrid H-55 and Freydis B-87). Considering this, 18 new samples from under-represented intervals were taken by the author in 2017 for the creation of new thin sections. All 43 thin sections (25 archived and 18 2017 slides) were described in terms of their sedimentological, paleontological, and diagenetic composition (Appendix B). The slides were analyzed using a Zeiss Axio Scope A1 petrographic microscope, photographed with an Axiocam 12 Mb camera, and captured digitally using the Zeiss ZEN software (Appendix C).

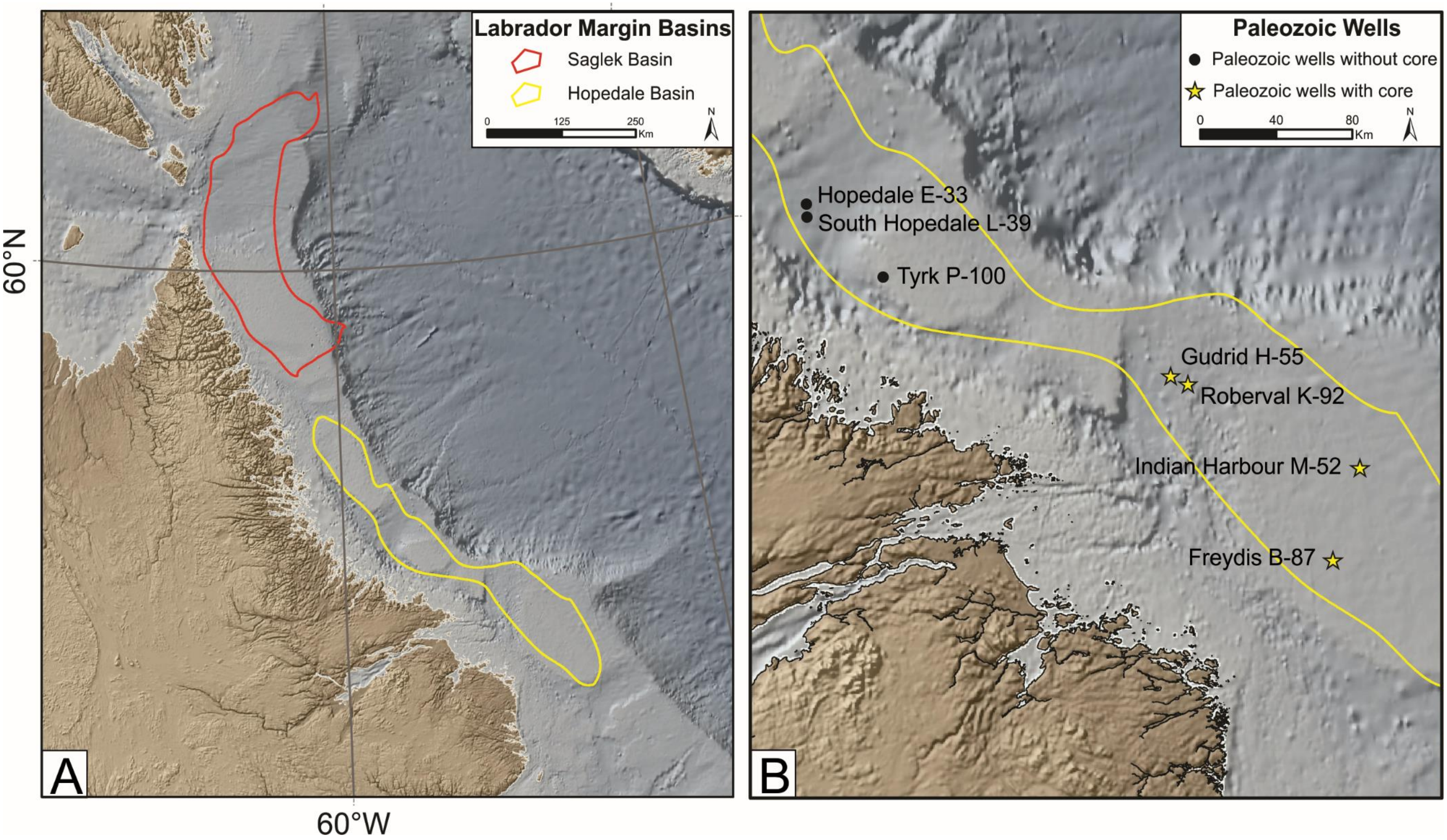

Figure 1: Regional maps showing (A) the location of the two major basins, Saglek (red) and Hopedale (yellow), offshore Labrador, and (B) the wells that intersect Paleozoic strata in the Hopedale Basin (stars indicate wells from which Paleozoic core was recovered and available for study).

Table 2: Thin sections associated with the Paleozoic cores of the Hopedale Basin.

Well	Core #	Depth of thin section (m)	Vintage
Gudrid H-55	1	2676.44	2017
	1	2677.78	2017
	1	2677.85	Archived
	1	2678.06	2017
	1	2678.98	2017
	1	2679.43	2017
Roberval K-92	6	3578.06	Archived
	6	3578.38	Archived
	6	3578.69	2017
	6	3578.78	2017
	6	3578.96	2017
	6	3579.1	Archived
	6	3580	Archived
	6	3581	Archived
	7	3870	Archived
	7	3870.5	Archived
	7	3870.85	2017
	7	3870.9	Archived
	7	3871.45	2017
	7	3872	Archived
	7	3872.34	Archived
	7	3872.8	2017
	7	3873.3	Archived
Indian harbour M-52	1	3952.48	Archived
	1	3952.54	Archived
	1	3952.69	Archived
	1	3952.91	Archived
	1	3952.94	Archived
	1	3953.09	Archived
	1	3953.73	Archived
	1	3954.22	Archived
	1	3954.49	Archived
	1	3955.35	Archived
	1	3956.2	Archived
	1	3956.47	Archived
Freydis B-87	1	1935.6	2017
	1	1935.79	2017
	1	1938.34	2017
	1	1941.15	2017
	2	2307.64	2017
	2	2311.21	2017
	2	2313.16	2017
	2	2313.46	Archived

4. Well summaries and lithological descriptions

The following sections provide an overview of the drilling histories for each well, as well as summaries of the primary lithological observations from core and thin section analyses. For detailed well descriptions, the reader is referred to Appendix A. Descriptions of each thin section are given in Appendix B, and corresponding photomicrographs of the thin sections are provided in Appendix C. Wells are presented from north to south starting with Gudrid H-55 and ending with Core #2 from the Freydis B-87 well.

4.1. Gudrid H-55

4.1.1. Well summary

The Eastcan et al. Gudrid H-55 well is located at 54^o 54’ 30.19” N and 55^o 52’ 28.47” W in the Hopedale Basin, offshore Labrador (C-NLOPB, 2007c). The well was spudded on 12 July 1974 and drilled to a total depth of 2838 m before being abandoned on 30 September 1976 (Corgnet and McWhae, 1975; C-NLOPB, 2007c). The well was drilled to investigate the sedimentary strata sandwiched between a tilted fault block and a wedge of Cretaceous-Tertiary clastic sediment (Corgnet and McWhae, 1975). Approximately 140.5 m of Paleozoic gas-bearing dolomite was encountered between 2663.5 m and 2804 m resulting in the issuing of a significant discovery license (SDL-184) for this well (Corgnet and McWhae, 1975; C-NLOPB, 2016). A 4 m long core of the Paleozoic dolomite was taken from 2675.99 m to 2680.87 m and represents the northernmost Paleozoic core in the Hopedale Basin and, consequently, the northernmost core described in this report. The Paleozoic interval at Gudrid H-55 has had an array of age assignments ranging from ?Late Devonian (Laborde et al., 1974), to Carboniferous – Visean (Corgnet and McWhae, 1975), to Carboniferous – Westphalian D to Stephanian (Barss, 1975; Umpleby, 1979; Barss et al., 1979; Moir, 1986; Bell and Howie, 1990; Williams et al., 1990). The inconsistency in age data is likely due to the high degree of diagenesis (pervasive dolomitization) which negatively impacts palynological preservation and recovery.

4.1.2. Core description (Fig. 2; Appendix A, Fig. A2)

The Paleozoic core recovered from Gudrid H-55 is just over 4 meters of dolostone (2675.99 to 2680.87 m). The Paleozoic interval has been so pervasively dolomitized that the majority of the core appears glassy (Fig. 2). The core has an overall mottled appearance (buff to dark brown to brown-grey) composed of a dolomitic mudstone with some wackestone intervals. Fractures and stylolites are common throughout the core as are calcite cement and pyrite precipitation. Fractures are typically filled with calcite cement. However, the fracture noted at 2677.91 m contains sediment (mud), which may be the result of dissolution and subsequent pitting. Calcite cement may also be found filling pores where it can range from clear to white in colour. Shell fragments occur around 2678.12 m and possible crinoid fragments as well as other potential fossil pieces were noted throughout the core but are too highly altered to definitively identify. The mottled appearance that characterizes this core may be an indication of pre-diagenesis bioturbation. Overall, the core has a very homogeneous, glassy, fractured appearance and terminates with a concrete plug at 2679.8 m.

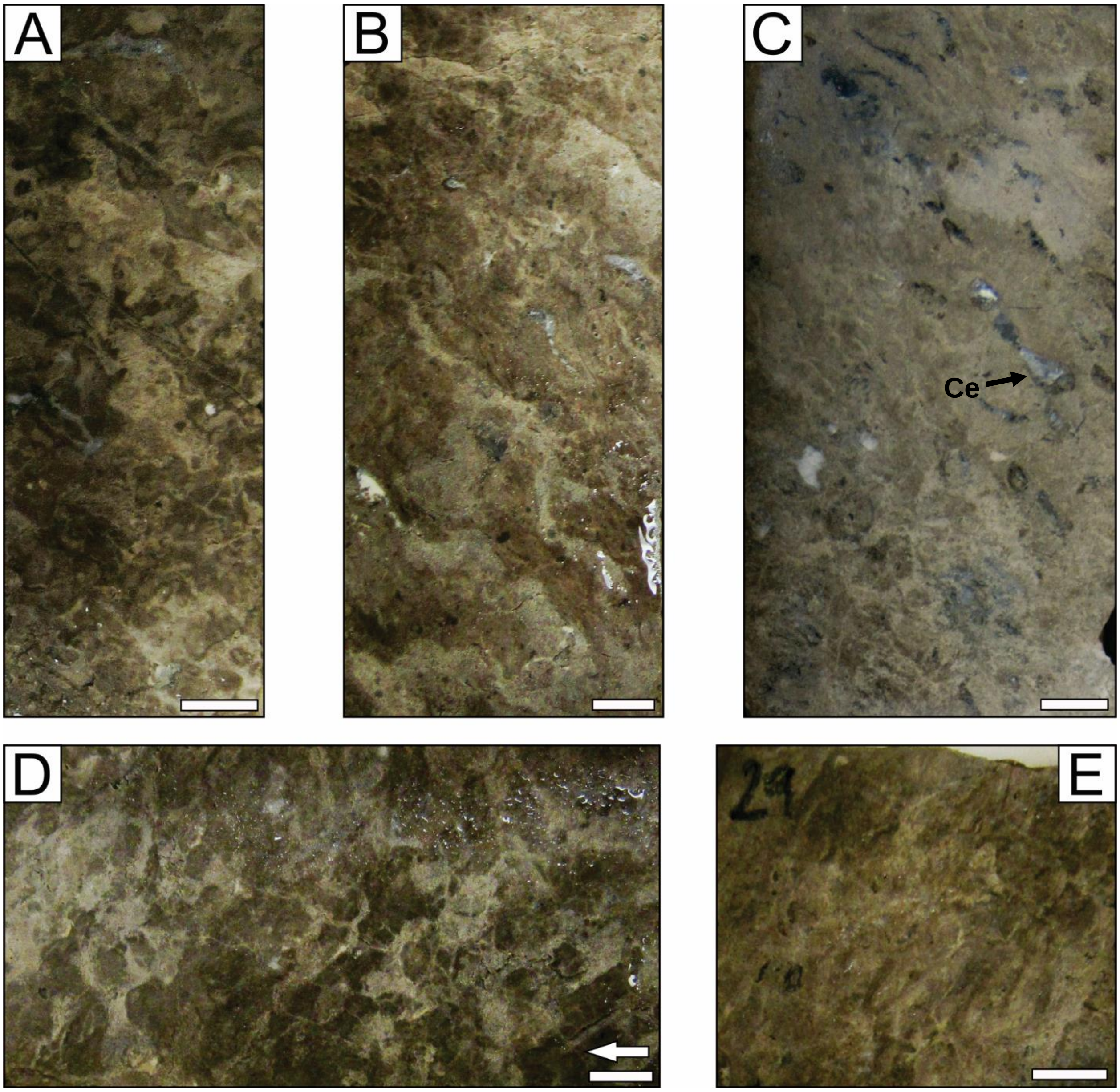

Figure 2: Photographs of the Gudrid H-55 Paleozoic core showing pervasive dolomitization throughout the core. Photographs taken at varying depths, with all core pieces exhibiting similar lithologies: A – top at 2676.36 m, B – top at 2678.85 m, C – top at 2679.41 m (note cement in pores; Ce), D – top at 2679.64 m (arrow indicates up direction), and E – Top at 2679.16 m. Scale bars = 1 cm.

4.1.3. Thin section descriptions (Appendix B; Appendix C, Figs. C1-C6)

Six thin sections were produced from samples taken from the Gudrid H-55 Paleozoic core, one of which (2677.85 m) belongs to the GSC archived collection. The remaining five thin sections were all made in 2017 with the intention of providing better coverage of the Paleozoic interval represented by the core (2676.44 m, 2677.78 m, 2678.06 m, 2678.98 m, and 2679.43 m). All thin sections associated with the Paleozoic at Gudrid H-55 represent a dolostone lithology with evidence of pervasive, fabric-destructive dolomitization throughout the core. Varying sizes and types of dolomite are observed in the thin sections with anhedral to subhedral, buff-colour, dirty/cloudy dolomite being the most abundant form. Subhedral to euhedral dolomite is common, especially in areas where the dolomite is less dense (such as in and around pores and fractures). Zoning is common in the euhedral dolomite and includes limpid dolomite (cloudy cores and clear rims) as well as crystals that display multilayered zonation. Smaller, finer dolomite may be present intermixed with the larger anhedral to subhedral and subhedral to euhedral dolomite. This smaller size fraction of dolomite can be anhedral to euhedral and may represent a later phase of dolomitization.

Opaque minerals (likely pyrite) are common dispersed throughout the dolomite. They occur inter-crystalline and may be observed in small aggregations. Calcite cement is also present in minor amounts, particularly within larger pore spaces and fractures. Definitive fossil content is lacking in thin section, likely due to the extensive dolomitization. A possible altered shell fragment is noted in the thin section from 2678.06 m as is evidence of an original argillaceous texture (Fig. C4). The variation in colour between the varieties of dolomites gives the thin sections a mottled appearance (also visible in the core) and may be indicative of an original bioturbated fabric.

4.2. Roberval K-92

4.2.1. Well summary

The Total Eastcan et al. Roberval K-92 well is located at 54^o 51’ 35.69” N and 55^o 44’ 32.01” W, approximately 10 km south of the Gudrid H-55 well (Total Eastcan Exploration Ltd., 1979; C-NLOPB, 2007d). The well was spudded on 2 October 1978 and was suspended with the cessation of the drilling season on 27 October 1978 at a depth of 1680 m (Cadenel et al., 1978; Total Eastcan Exploration Ltd., 1979; Steeves, 1982; C-NLOPB, 2007d). Re-entry occurred on 4 July 1979 and the well was drilled to a depth of 3874 m before once again being suspended at the end of the drilling season on 3 October 1979 (Total Eastcan Exploration Ltd., 1979). Final re-entry took place on 1 July 1982 where the well was plugged before being abandoned on 8 July 1982 (Cadenel et al., 1978; Steeves, 1982). The well was drilled primarily to target the Paleozoic interval and find additional reserves in close proximity to the gas-bearing Gudrid H-55 well (Total Eastcan Exploration Ltd., 1979). The Paleozoic interval is approximately 330 m thick spanning from 3544 m to 3874 m (total depth) and is composed predominantly of dolostone (Total Eastcan Exploration Ltd., 1979). Seven conventional cores were recovered during the drilling of this well, two of which occur in Paleozoic strata: Core #6 (3578 m to 3582.5 m) and Core #7 (3870 m to 3874 m; Total Eastcan Exploration Ltd., 1979; C-NLOPB, 2007d). Similarly to the Paleozoic encountered at the nearby Gudrid H-55 well, the extensive alteration of the Paleozoic strata at Roberval K-92 has resulted in poor palynological recovery and as such, age dates for this interval include undifferentiated Paleozoic (Ainsworth et al., 2014), as well as Carboniferous-Westphalian D to Stephanian (Caro and Villain, 1980; Barss, 1981; Moir, 1986; Bell and Howie, 1990;

Williams et al., 1990). However, unlike the Gudrid H-55 well, the dolostones at Roberval K-92 are not gas-bearing and therefore no SDLs were issued for this well (Total Eastcan Exploration Ltd., 1979).

4.2.2. Core #6 description (Fig. 3; Appendix A, Fig. A3)

The first of the two cores recovered from the Paleozoic interval at Roberval K-92, Core #6 (3578 to 3582.5 m), is highly mottled (buff to dark brown to brown-grey) and has been pervasively dolomitized. The origin of the mottling is difficult to discern. It may be the result of previous bioturbatic activity or may represent altered skeletal components such as macro-algae, oncolites, or stromatoporoids. There is no gradation between the lighter (buff) and darker (brown to grey) components, with the darker components having defined, irregular edges (Fig. 3B). The classification of the majority of this core as a dolomitic mudstone is based on the interpretation of the mottling as a product of bioturbation rather than a skeletal feature. Fracturing occurs between 3578 m and 3579.9 m and stylolites were observed around 3579.1 m. No definitive fossils were identified in Core #6.

Core #6 is not homogenous; the predominant lithology is the mottled dolomitic limestone described above which characterizes the core from 3578 m to 3580 m. Within this interval, however, lithological variations are noted. Dark grey to black thin (<10 cm) sections of core occur from 3578.45 m to 3578.48 m (Fig. 3A) and from 3578.67 m to 3578.72 m and are interpreted as a type of mafic igneous rock. Both intervals exhibit sharp, discontinuous upper and lower contacts with the adjacent dolostone; no chill margins are noted. The core abruptly loses its mottled appearance between 3578.94 m and 3579.05 m where it is composed of uniform dolo-mudstone. Below this dolo-mudstone layer is an interval approximately 15 cm in length that is characterized by dark brown, angular clasts (breccia-like) in a buff, light-coloured matrix that can be slightly darker between the clasts (Fig. 3C). The angular clasts occur in vaguely-defined layers that are gently dipping. Below this interval, the core returns to the typical mottled dolostone lithology. The basal section of the core (from 3580 m onwards) is composed of rubble, consisting of intermixed buff and blue-green coloured, fine-grained, muddy pieces the size of which ranges from small pebbles to several centimeters (~10 cm) in length (Fig. 3E). The rubble is rough with no cut surfaces and no obvious sedimentary features.

4.2.3. Thin section descriptions – Core #6 (Appendix B; Appendix C, Figs. C7-C14)

A total of 17 thin sections were produced from Paleozoic core samples from the Roberval K-92 well. Eight of these thin sections are associated with Core #6 with five belonging to the GSC archived collection (3578.06 m, 3578.38 m, 3579.1 m, 3580 m, and 3581 m) and three being produced in 2017 (3578.69 m, 3578.78 m, and 3578.96 m). Six of the eight thin sections from Core #6 exhibit a similar dolostone lithology. Pervasive, fabric-destructive dolomitization has occurred throughout the interval with upper thin sections (3578.06 m and 3578.38 m) exhibiting larger-sized dolomite crystals. Two primary types of dolomite are observed intermixed with one another in these thin sections: anhedral to subhedral dolomite and subhedral to euhedral dolomite. Anhedral to subhedral, buff-coloured, dirty/cloudy dolomite crystals are the most common. Subhedral to euhedral dolomite is also abundant, especially in less dense areas, some of which can be classified as limpid dolomite while others may exhibit evidence of multilayered zonation. A transition to finer, anhedral to subhedral sucrosic dolomite occurs with depth (3578.78 m, 3578.96 m, and 3579.1 m) and this smaller size fraction of dolomite may represent a later phase of dolomitization. The finer-crystalline dolomite observed at greater depths in the core is primarily anhedral, with some subhedral crystals observed.

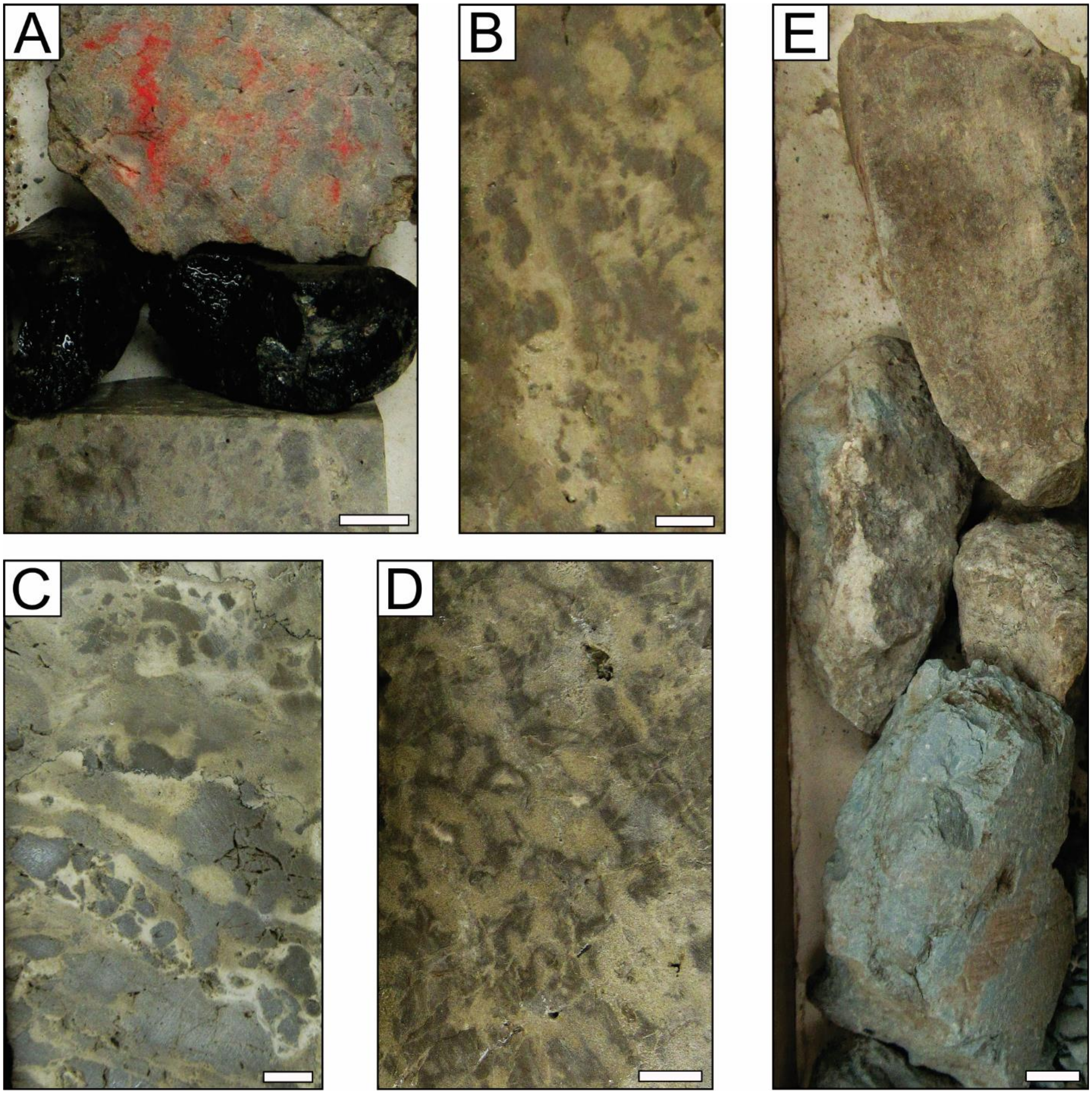

Figure 3: Photographs of Core #6 (Paleozoic) from the Roberval K-92 well. Scale bars = 1 cm. (A) Igneous rocks (black) interbedded with buff-coloured dolostones (top of photograph at 3578.42 m). (B) Mottled, buff-coloured dolostone, the typical lithology in Core #6 (top at 3579.7 m). (C) Angular darker-coloured fragments in a buff, dolomitic matrix (top at 3579.13 m). (D) Mottled dolostone (top at 3578.53 m). (E) Rubble at base of Core #6 composed of buff and blue-green pieces (top at 3580.44 m).

The finer dolomite appears to be cloudy/dirty with no evidence of zonation though this would be difficult to detect given the small size of the crystals. The thin section at 3580 m shows a resurgence of the larger-fraction of dolomite (though in a lesser amount than observed near the top of the core) as well as an associated increase in the presence of subhedral to euhedral crystals, including limpid dolomite (Fig. C13).

Opaque minerals (pyrite) are common in the inter-crystalline areas between dolomite throughout the core. Calcite cement occurs in pores as well as in fractures. Definitive fossil content is rare, although some possible, highly-altered fossils were noted at 3578.38 m (a possible dissolved shell) and at 3578.78 m (possible echinoderm fragments). Variations in the colour and density of the dolomite gives the thin sections a mottled appearance. This mottling may be evidence of previous bioturbatic activity with circular patterns in the dolomite possibly representing burrows. Hydrocarbons of unknown origin are observed in several thin sections: 3578.06 m, 3578.38 m, 3578.96 m, 3579.1 m, and 3580 m. The hydrocarbons are typically associated with fractures and stylolites and may be found lining pores.

Two of the thin sections do not conform to the dolomite-dominant lithology that categorizes the majority of this core. The thin section at 3578.69 m was produced from a sample taken in 2017 of a dark-coloured, non-sedimentary section of the core in order to better determine its lithology. The thin section contains a mafic igneous mineral suite primarily composed of plagioclase (most abundant; occurs as thin, bladed to rectangular crystals), pyroxene, and amphibole (Fig. C9). Opaque minerals (cubic; likely a sulphide) are present (10-15%) as is an unidentified rounded mineral (<5% of composition). The deepest thin section in Core #6, 3581 m, appears to represent an altered carbonate. Anhedral to euhedral dolomite is present as are opaque minerals, however the slide is dominated by an unknown, orange-coloured mineral (Fig. C14). This mineral has a somewhat fibrous appearance and occurs in pores as well as between the dolomite. It is possible that this orange mineral is a product of alteration (perhaps metamorphism or hydrothermal alteration) and may be siderite or sphalerite; further investigation is required. This thin section is part of the GSC archived set and as such, the core sample from which this thin section was produced is unknown. The depth of 3581 m currently falls below the core available in the core boxes (though the cored interval is reported to extend to 3582.5 m) and as such the original lithology of the sample is indeterminate. Furthermore, the last meter of core available (3580 m to 3580.84 m) is composed of rubble consisting of dolomite and blue-green mudstone pieces further complicating the matter.

4.2.4. Core #7 description (Fig. 4; Appendix A, Fig. A4)

Core #7 from Roberval K-92 (3870 m to 3874 m) is similar in lithology to Core #6 in that it has been pervasively dolomitized and is highly mottled. It appears to be darker in colour than Core #6, with an overall dark grey appearance. The mottling is also not as distinct as it was in Core #6, but rather the dark grey and dark buff colours are more intermixed with boundaries that are not well defined. As in Core #6, the mottling may be evidence of past biological activity, although no distinct burrows are observed. Fossil content includes a potential dissolved shell around 3873.3 m as well as some possible stromatoporoids fragments at 3873.16 m and 3874.18 m. Core #7 is highly fractured with large pores and vugs scattered throughout its length. There is a minor, temporary change in lithology at the base of the core in Box 1 that extends into the top of Box 2 (3871.4 m to 3871.55 m). This interval is characterized by angular dark grey clasts that are surrounded by a light-colored (beige to light-orange) matrix (Fig. 4C). The colour of the matrix and the

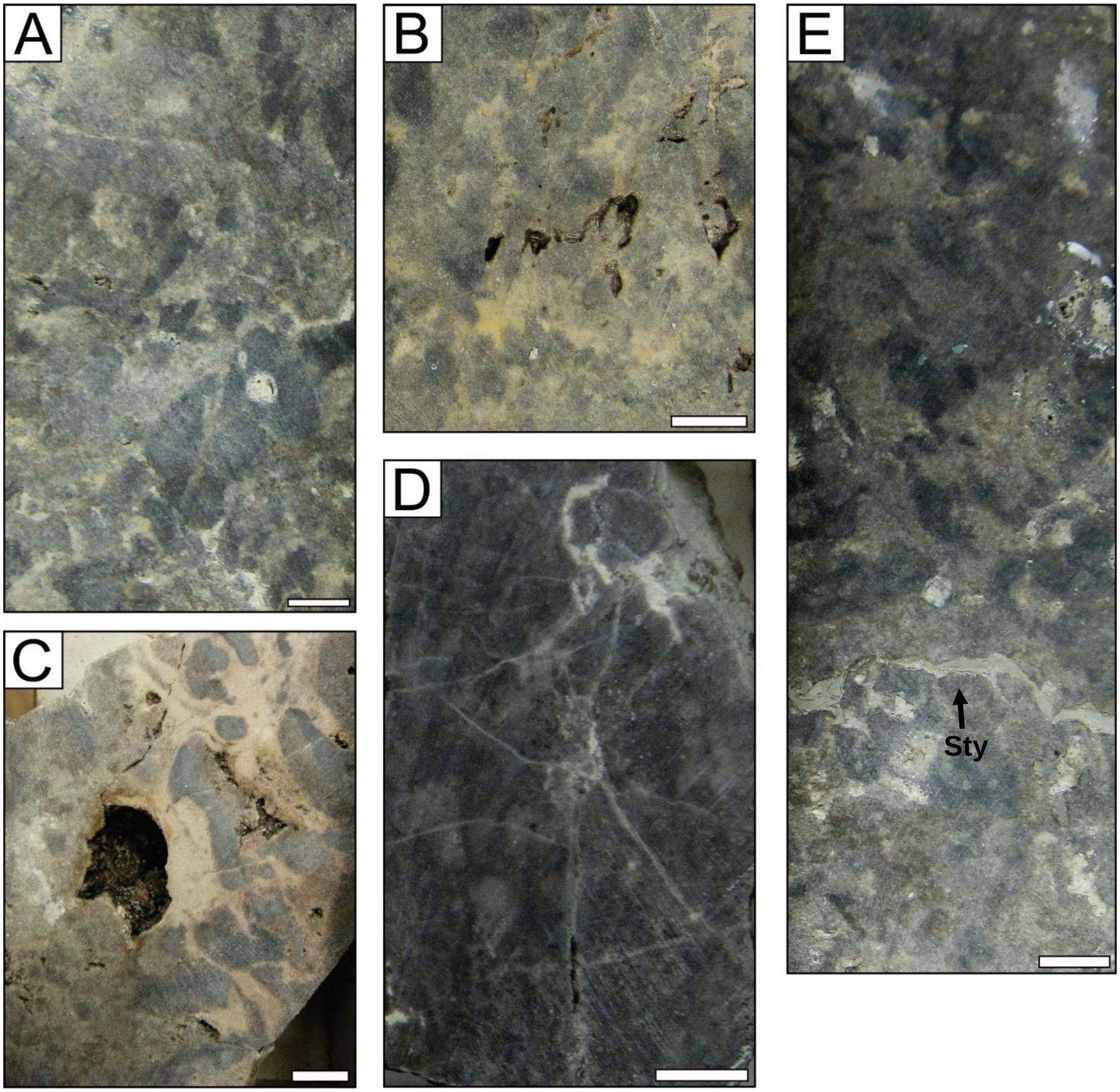

Figure 4: Photographs of Core #7 from the Roberval K-92 well. Scale bars = 1 cm. (A) Mottled grey to buff dolostone (top of photograph at 3870.08 m). (B) Mottled buff to light grey dolostone with cavities (top at 3872.33 m). (C) Dark grey clasts in a light-orange to buff-coloured matrix with a large vug (top at 3871.41 m). (D) Slightly mottled light grey to dark grey dolostone (top at 3874.41 m). (E) Typical dark grey to buff mottling with a mud-filled stylolite (Sty; top at 3870.22 m).

angularity of the clasts is unlike the rest of the core and its origin is not currently known. Poorly-cemented mud occurs in the 12 centimeters directly above this angular clast unit and appears to be a product of weathering and/or dissolution.

4.2.5. Thin section descriptions – Core #7 (Appendix B; Appendix C, Figs. C15-C23)

Nine thin sections were produced from Core #7, six of which are part of the GSC archived collection (3870 m, 3870.5 m, 3870.9 m, 3872 m, 3872.34 m, and 3873.3 m). The remaining three thin sections were produced from samples taken in 2017 (3870.85 m, 3871.45 m, and 3872.8 m). All seven thin sections represent a similar, fabric-destructive dolostone lithology with minor variations noted between slides. Two primary types of dolomite occur intermixed: anhedral to subhedral, buff-coloured, cloudy/dirty dolomite and subhedral to euhedral dolomite that may exhibit zoning (limpid or multilayered dolomite). More finely crystalline dolomite occurs throughout and may represent a later phase of dolomitization.

Opaque minerals (likely pyrite) occur disseminated throughout the core. Calcite cement is observed in limited quantities in-filling several pores and in fractures. Fossil content is practically absent with a possible replaced shell observed at 3870 m. The thin sections have a mottled appearance caused by variations in the type, colour, and density of the dolomite which may be indicative of pre-diagenesis bioturbation. Hydrocarbons of unknown origin are also noted in several thin sections from Core #7 (3870.5 m, 3871.45 m, 3872 m, 3872.34 m, and 3873.3 m). Similar to Core #6, the hydrocarbon material observed in Core #7 occurs lining fractures and pores as well as within stylolites. A possible altered phosphate grain is present at 3870.85 m with some smaller quartz grains noted in close proximity.

4.3. Indian Harbour M-52

4.3.1. Well summary

The BP Columbia et al. Indian Harbour M-52 well is located at 54° 21’ 51.42” N and 54° 23’ 47.81” W. It was spudded 21 August 1975 with the intention of investigating the potential accumulation of hydrocarbons in a structure defined in the seismic data (BP Exploration Canada Ltd., 1975; C-NLOPB, 2007a). Operations were suspended on 23 October 1975 due to deteriorating weather conditions that heralded the end of the drilling season after reaching a depth of approximately 2380 m. Attempts to re-enter the well began on 15 August 1976. Due to difficulty in locating the wellhead, drilling did not recommence until 5 September 1976 (BP Exploration Canada Ltd., 1975). The well reached a total of 3958.2 m during the 1976 drilling season and was abandoned on 5 November 1976 (BP Exploration Canada Ltd., 1975; C-NLOPB, 2007a). The Paleozoic interval at Indian Harbour is the thickest Paleozoic section recorded in the Hopedale Basin at 427.2 m (3531 m to 3958.2 m; C-NLOPB, 2007a). It is composed of a mixture of fossiliferous limestones and dolostones with a core recovered from 3952.04 m to 3958.13 m. The Paleozoic interval at Indian Harbour M-52 is regarded as being Ordovician in age (Jenkins, 1984; Moir, 1986; Bell and Howie, 1990; Williams et al., 1990; C-NLOPB, 2007a).

4.3.2. Core description (Fig. 5; Appendix A, Fig. A5)

The Paleozoic core recovered from Indian Harbour M-52 (3952.04 m to 3958.13 m) is composed of a combination of limestone and dolomite. It is primarily a fossiliferous wackestone with preferential dolomitization occurring along argillaceous stringers and

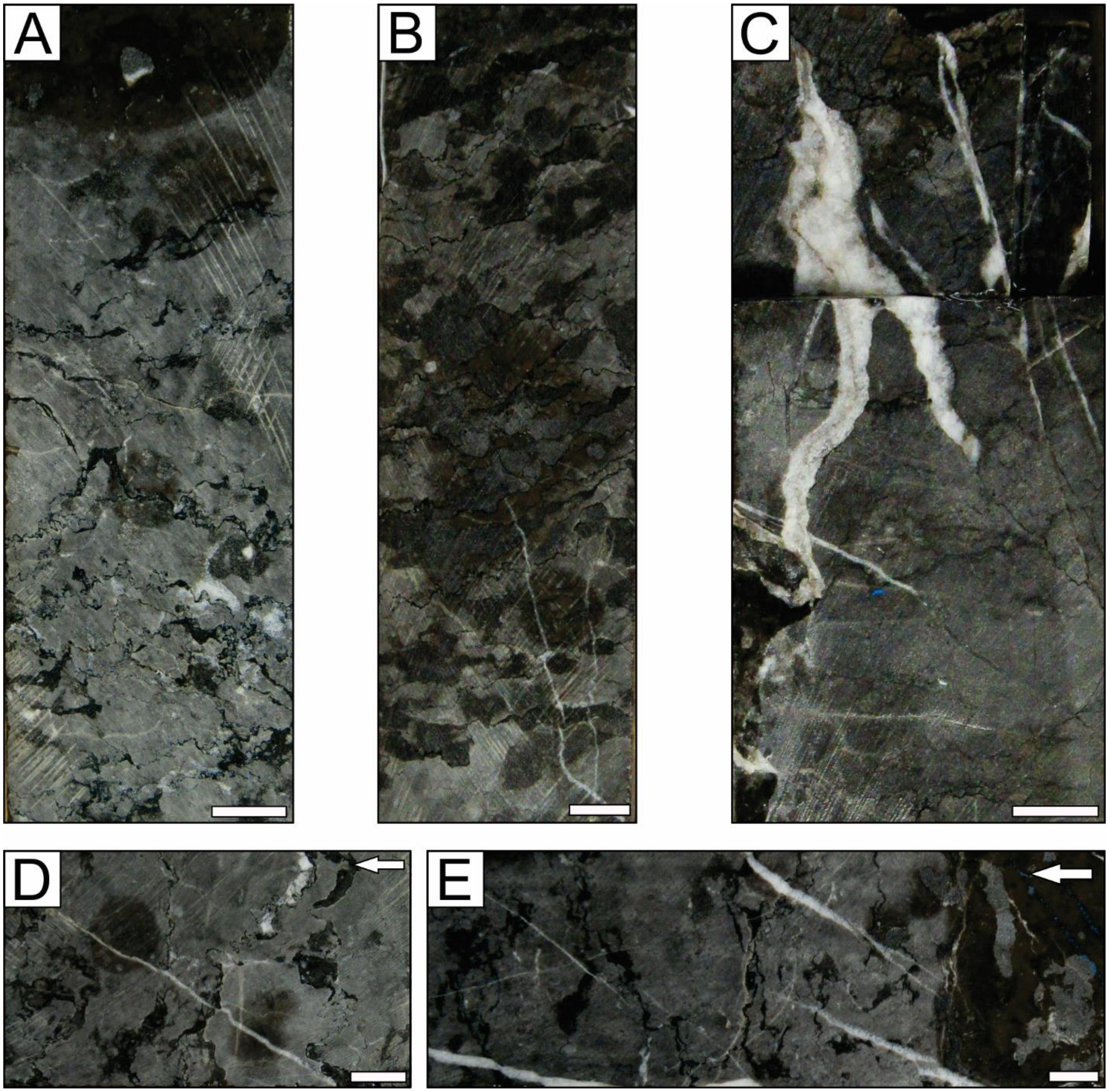

Figure 5: Photographs of the Indian Harbour M-52 Paleozoic core. Scale bars = 1 cm. (A) Stylolitic dolomite and limestone. Grey areas have been dolomitized whereas brown areas (near top of photograph) are less altered (top of photograph at 3652.06 m). (B) Intermixed limestone and dolomite. Contains cement-filled fractures and stylolites (top at 3955.96 m). (C) A large, cement-filled fracture in a limestone and dolomite core. Stylolites and smaller, cement-filled fractures are also present (top at 3956.46 m). (D) Intermixed limestone and dolomite with cement-filled fractures and stylolites. Arrow indicates up direction (top at 3955.59 m). (E) Intermixed limestone and dolomite with cement-filled fractures and stylolites. Arrow indicates up direction (top at 3955.44 m).

stylolites. The core is rather homogenous along its length and consists of dark brown unaltered mud and grey crystalline sediment that has either been subjected to crystallization and/or dolomitization. The core is highly fractured and stylolitc. Cement (consisting of calcite and/or dolomite) occurs as large (centimeter-scale) aggregations within the matrix as well as within fractures (Fig. 5C). The extent of crystallization and dolomitization has hindered the identification of fossils in core although, small, unidentifiable fossil fragments are common in the brown, muddy, less-altered sections. A few questionable crinoid fragments (3952.54 m and 3952.93 m) and a possible replaced shell (3952.48 m) were observed in the core. An increase in the amount of argillaceous material (abundance of argillaceous stringers) is noted towards the base of the core (3956.5 m to base).

4.3.3. Thin section descriptions (Appendix B; Appendix C, Figs. C24-C35)

Twelve thin sections, all associated with the GSC archived collection, were produced from the Paleozoic core associated with the Indian Harbour M-52 well (3952.48 m, 3952.54 m, 3952.69 m, 3952.91 m, 3952.94 m, 3953.09 m, 3953.73 m, 3954.22 m, 3954.49 m, 3955.35 m, 3956.2 m, and 3956.47 m). With the exception of one slide (3956.2 m), the thin sections are lithologically homogeneous, composed primarily of limestone (fossiliferous wackestone) with a significant amount of dolomite present. Argillaceous stringers, fractures, and stylolites are prevalent throughout the thin sections and appear to be associated closely to the dolomite. The matrix is composed of a dark-coloured, microbial-looking, mud that has undergone varying degrees of crystallization. The calcimicrobe *Girvanella* is observed in areas of the matrix that have not been heavily crystallized, accounting for the microbial appearance of the mud. Peloidal textures are also somewhat common and may be emphasized by higher degrees of crystallization. Fossil fragments are abundant, many of which are too small to identify. Observed fossils include echinoid fragments (crinoids), bivalves (some of which are articulated), sponge spicules, bryozoans, dasycladacean green algae, trilobite fragments, brachiopods, and gastropods as well as possible radiolarians and calcispheres.

Dolomite forms a significant component of the lithology where it is present as anhedral crystals to euhedral rhombs. It occurs along argillaceous stringers that have been preferentially dolomitized, in fractures, associated with stylolites, as well as within the matrix where it is observed in aggregations that range from floating rhombs to extensive dolomite sections that may be bound by stylolites. Hydrothermal dolomite is present in varying abundances in all thin sections with the exception of 3956.2 m. It typically occurs within fractures as well as within larger dolomitized sections within the matrix. Minor amounts of opaque minerals (likely pyrite) were observed disseminated throughout the thin sections with increases in opaque minerals noted along stylolites. Calcite cement is common in pores as well as in fractures where it can occur as smaller crystals lining the fractures (sometimes isopachous) and as blocky cement in-filling the fractures. Based on cross-cutting relationships, the stylolites were the first diagenetic feature to form and were followed by the dolomitization of argillaceous stringers, then fracturing and calcite cement infill, with hydrothermal dolomite occurring last.

The second deepest thin section from the Indian Harbour M-52 core (3956.2 m; Fig. C34) is the only thin section that exhibits a somewhat different lithology. Limestone is absent in this thin section which is dominated by fabric-destructive dolomite with argillaceous stringers present. The dolomite primarily occurs as buff-coloured, subhedral to euhedral crystals, giving the dolomite a sucrosic texture, with some anhedral dolomite observed within the pores. The size of the dolomite varies with larger dolomite found infilling pores that may have been created by the dissolution of fossils. Limpid dolomite is present, especially in less dense areas such as within pores. There is no evidence of hydrothermal dolomite in this thin section. Opaque minerals (pyrite) are common disseminated throughout the thin section and can occur in small clusters. A minor amount of calcite cement was also noted in this thin section. Fossil content is limited due to the pervasive nature of the dolomite, although possible echinoderm fragments are observed.

4.4. Freydis B-87

4.4.1. Well summary

The Eastcan et al. Freydis B-87 is the southernmost well on the Labrador margin (located at 53° 56’ 13.48” N and 54° 42’35.86” W) that penetrates Paleozoic strata (C-NLOPB, 2007b). The well was drilled to investigate Cretaceous and Pre-Cretaceous strata on the up-dip section of a tilted graben, at a relatively shallow depth (Plé and Ferrero, 1976). The Freydis B-87 well was drilled between 2 July 1975 and 9 August 1975 at which point it was abandoned after reaching a total depth of 2314.1 m (Plé and Ferrero, 1976; C-NLOPB, 2007b). The Paleozoic interval at Freydis B-87 is over 409 m thick and has been informally subdivided into two units based on lithology: the Freydis sandstone (1905 m to 2238.5 m) and the Freydis limestone (2238.5 m to 2314.1 m; Laborde et al., 1975; Plé and Ferrero, 1976; Bell and Howie, 1990). The Freydis sandstone represents the only occurrence of siliciclastic Paleozoic rocks in the Hopedale Basin and has previously been described as a combination of interbedded sandstones, silts, and shales (Laborde et al., 1975; Plé and Ferrero, 1976; Miller and D’Eon, 1987; Bell and Howie, 1990). The underlying Freydis limestone, in contrast, is composed of micritic, fossiliferous limestone. Two cores were recovered during the drilling of the Freydis B-87 well: Core #1 (Freydis sandstone, 1934.87 m to 1941.27 m) and Core #2 (Freydis limestone, 2307.34 m to 2313.43 m; C-NLOPB, 2007b). The entire Paleozoic section at Freydis B-87 is considered Late Ordovician in age (Laborde et al., 1975; Rauwerda, 1975; Barss et al., 1979; Jenkins, 1984; Moir, 1986; Bell and Howie, 1990; Williams et al., 1990; Ainsworth et al., 2016).

4.4.2. Core #1 description (Fig. 6; Appendix A, Fig. A6)

Core #1 (1934.87 m to 1941.27 m) represents the only siliciclastic Paleozoic core in the Hopedale Basin. It consists of varying grain sizes and lithologies including mudstones, siltstones, sandstones and even some interbedded carbonate intervals. Bioturbation is common in finer-grained beds (mudstones to very fine sand) with the degree of bioturbation and abundance of trace fossils typically ranging from moderate to pervasive. Burrows are observed throughout the core and are dominated by horizontal traces primarily associated with the *Glossifungites* and *Chondrites* ichnofacies (Fig. 6B). Lam-scram bedding produced by intense bioturbation is observed in some interbedded siltstones to very fine sandstones (1937.69-1937.75 m and 1938.84-1938.92 m; Fig. 6A). Siltstones to fine sandstones can also appear massive (1935.34-1935.41 m, 1936.6-1936.4 m, and 1938.34-1938.54 m, 1939.21-1939.29 m) or laminated with planar laminations (common throughout core) and/or ripple cross-laminations (1935.04-1935.06 m, 1935.41-1935.5 m, 1935.81-1935.86 m, 1938.13 m, 1939.07 m, 1939.58 m, and 1940.56 m; Fig. 6C) noted in several intervals. Fractures, some of which contain calcite cement, are infrequent throughout the length of the core. Eight discrete carbonate (limestone-appearing) intervals occur in Core #1 each with sharp upper and lower contacts (Fig. 6D). These “limestone” units are typically grey in colour and have been classified as either a lime mudstone or fossiliferous wackestone to floatstone. Small,

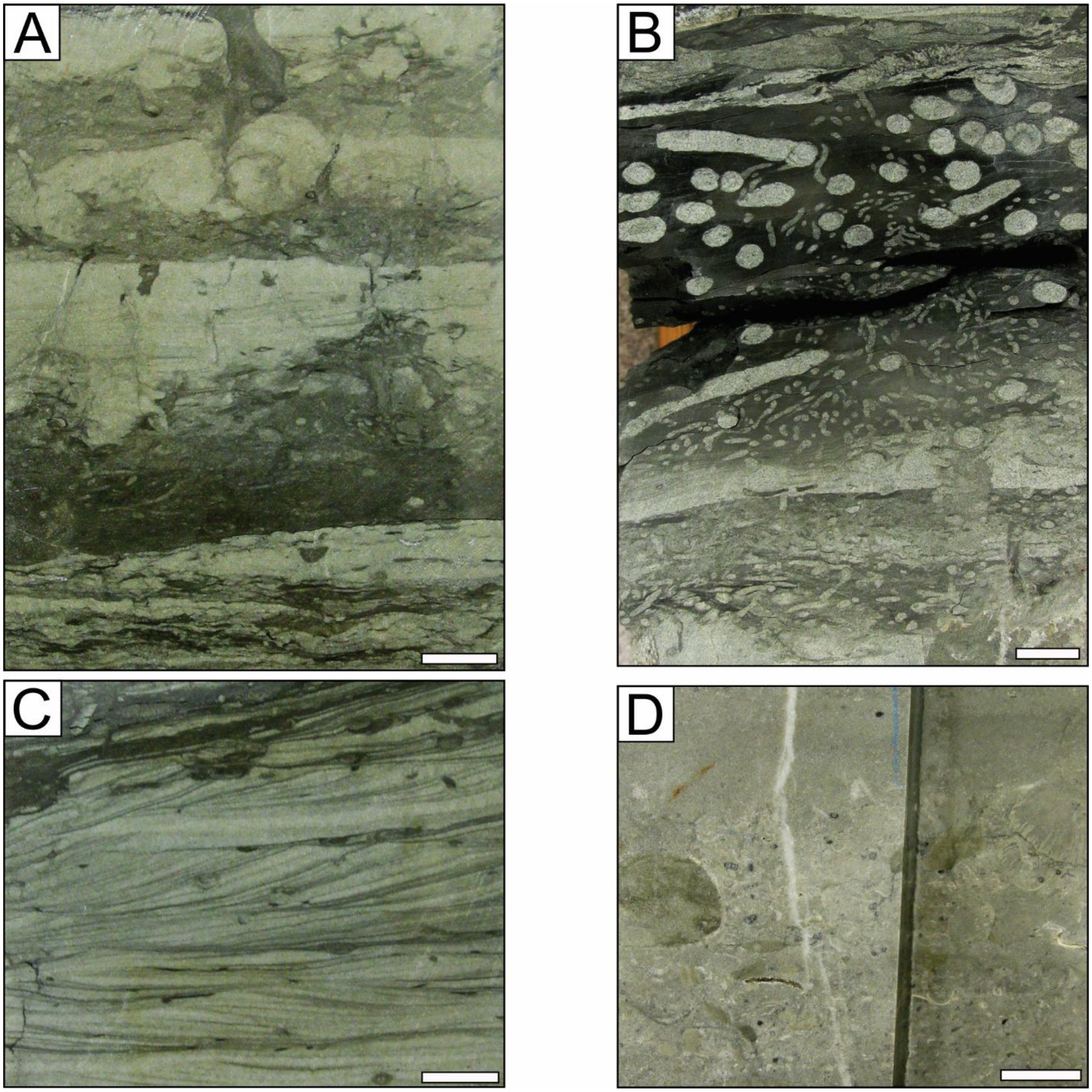

Figure 6: Photographs of Core #1 from the Freydis B-87 well (Freydis sandstone). Scale bars = 1 cm. (A) Lam-scram bedding characterized by intermixing of mud to silt-sized particles and pervasive bioturbation (top of photograph at 1935.7 m). (B) Larger (*Glossifungites*) and smaller (*Chondrites*) burrows in a dark mudstone. Silt and very-fine grained sand increases towards the base of the piece of core (fining up; top at 1940.27 m). (C) Ripple cross-laminations in a siltstone to very fine sandstone (top at 1935.82 m). (D) Carbonate unit in a predominantly siliciclastic core (top at 1939.72 m).

indeterminate fossil fragments are common in these units and several shell fragments are observed. Stylolites and fractures (some of which contain calcite cement) are also noted from these carbonate beds.

4.4.3. Thin section descriptions – Core #1 (Appendix B; Appendix C, Figs. C36-C39)

Eight thin sections were produced from the Freydis B-87 Paleozoic cores. Four of these thin sections are associated with Core #1 (siliciclastic) and were made in 2017 (1935.6 m, 1935.79 m, 1938.34 m, and 1941.15 m). These four thin sections were taken in an attempt to capture the variations in siliciclastic lithologies and features exhibited in Core #1. The thin section at 1935.6 m (Fig. C36) was produced from an interval in the core that was believed to be limestone due to its grey colour, high carbonate content, and the abundance of fossils. The thin section, on the other hand, reveals that angular quartz grains account for the majority of the thin section with some darker, muddier sections present. Several fossil fragments occur within this thin section and include large bivalve shell fragments, echinoderm (crinoid fragments), shell fragments (brachiopods and bivalves), a coral or bryozoan fragment, and bryozoans. Calcite cement occurs throughout the matrix as well as within recrystallized shells and in cavities created by large shell fragments. Opaque minerals (likely pyrite) are common disseminated throughout the thin section and also form aggregations.

The thin section at 1935.79 m (Fig. C37) reflects the laminated sandstone interval it was produced from. It is dominated by very fine to fine, angular quartz grains with some lithic fragments noted throughout. The sandstone is poorly sorted and laminations are defined by increases in silt and mud content. Opaque minerals are present throughout and may occur in clusters. A few possible shell fragments were observed. The thin section at 1938.34 m (Fig. C38) represents a massive very fine sandstone. It consists of angular to sub-rounded quartz grains with some lithic fragments present. Little to no mud is observed and laminations are absent. Opaque minerals are minor and occur disseminated throughout the thin section. Possible thin, shell fragments were noted.

The deepest thin section from Core #1, 1941.15 m (Fig. C39) was produced from a burrowed mudstone to siltstone interval. The burrows observed in the core are also present in thin section and two ichnofacies can be distinguished based on size: larger burrows (likely a representative of the *Glossifungites* Ichnofacies) and smaller burrows (*Chondrites*). The burrows are infilled with very fine sand composed of angular quartz grains and lithic fragments. Internal architecture is apparent in some of the larger burrows, but it is not common nor prevalent enough to determine if it is the result of biological activity or whether it is a product of compaction.

4.4.4. Core #2 description (Fig. 7; Appendix A, Fig. A7)

Core #2 from the Freydis B-87 well (2307.34 to 2313.43 m) is here described as a brown to grey lime mudstone to wackestone. The core contains numerous, thin argillaceous stringers, and fractures are common throughout. Calcite cement occurs within fractures as well as in aggregations within pores in the matrix. Small, unidentifiable fossil fragments are observed throughout the core with clusters of shells noted at 2311.71 m, and 2311.92 m, as well as from 2313 m to 2313.42 m. A small (less than 1 cm in diameter) shell was noted at 2309.02 m and a definitive crinoid fragment was observed at 2309.79 m. Larger macro fossils can also be identified in Core #2 and include replaced shells (bivalve or gastropod) at 2310.67 m (Fig. 7A), a 2 cm in length bivalve shell at 2311.4 m, a gastropod shell at 2311.5 m (Fig. 7C), another replaced bivalve shell at 2311.74 m, as well as a round (3 cm in diameter), replaced shell which may be a cross section of a cephalopod or an articulated brachiopod (Fig. 7D).

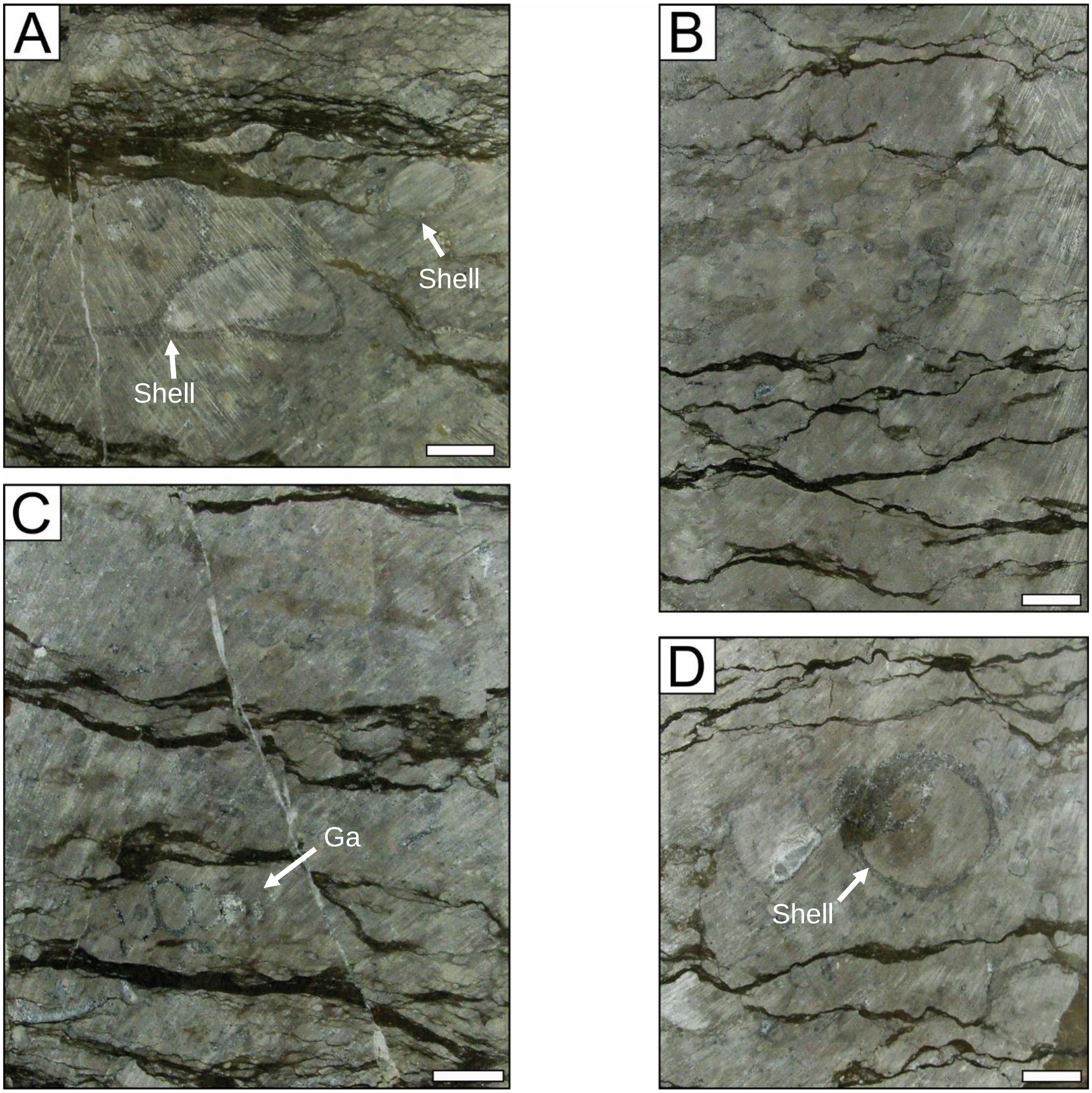

Figure 7: Photographs of Core #2 from the Freydis B-87 well (Freydis limestone). Scale bars = 1 cm. (A) Fossiliferous wackestone with argillaceous stringers and replaced shells (top of photograph at 2311.40 m). (B) Fossiliferous wackestone with argillaceous stringers (top at 2313.04 m). (C) Fossiliferous wackestone with a replaced gastropod shell (Ga), argillaceous stringers, and a cement-filled fracture (top at 2311.47 m). (D) Fossiliferous wackestone with a replaced shell and argillaceous stringers (top at 2313.09 m).

4.4.5. Thin Section descriptions – Core #2 (Appendix B; Appendix C, Figs. C40-C43)

Four thin sections were produced from the Freydis B-87 carbonate core (Core #2), three of which were made in 2017 (2307.64 m, 2311.21 m, and 2313.16 m) and one of which belongs to the GSC archived collection (2313.46 m). All four thin sections show a similar lithology characteristic of a fossiliferous wackestone. The matrix is composed of a dark, microbial lime mudstone that has undergone varying degrees of crystallization. Patches of the calcimicrobe *Girvanella* are observed in areas of the matrix that have not been altered. Small fossil fragments are abundant but are typically too small to identify definitively. Other fossils observed include gastropods, bivalves (some of which are articulated), echinoderms (crinoids), dasycladacean green algae, bryozoans (with some fenestrate bryozoans present), trilobites, brachiopods, sponge spicules, ostracods, cephalopods, and calcispheres. Possible radiolarians as well as some unknown circular to hexagonal fossils (problematica) were also noted from the thin sections.

Fractures, stylolites, and argillaceous stringers are common and preferential dolomitization of the argillaceous stringers is noted. Calcite cement occurs in-filling fractures and pores, as well as within recrystallized fossils. Opaque minerals (pyrite) are common disseminated throughout the thin sections and can occur in small aggregations.

5. Summary and conclusions

Despite a relatively continuous exploration effort along the Labrador margin, minimal attention has been given to the Paleozoic strata. The Paleozoic interval in the Hopedale Basin is not formally subdivided and no consistent age controls have been determined for the strata preventing the correlation of the Paleozoic on a regional (well-to-well) to global scale. Of the seven wells that intersect Paleozoic strata, only four of the wells (Gudrid H-55, Roberval K-92, Indian Harbour M-52, and Freydis B-87) have associated core and thin sections. Lithological analyses of these cores and thin sections have demonstrated that the majority of the Paleozoic represented in the cored intervals (five out of six cores) is composed of carbonate sediment that has undergone varying degrees of diagenetic alteration. The northernmost wells (Gudrid H-55 and Roberval K-92) have been pervasively dolomitized and little to no fossil content is evident in either core or thin section. The three cores from these two wells appear mottled at both the macro (core) and micro (thin section) scale, possibly related to pre-diagenetic bioturbation. Dolomitization appears to decrease to the south as Indian Harbour M-52 is composed primarily of a fossiliferous wackestone with a significant percentage of dolomite, and Freydis B-87 is largely unaltered with dolomite largely limited to argillaceous stringers in the carbonate core. The fossil assemblages noted in the Indian Harbour M-52 and Freydis B-87 wells are similar and represent a shallow water (within the photic zone) low-energy environment with taxa typical of the Lower Paleozoic.

Carbonate lithologies are prevalent in the Paleozoic of the Hopedale Basin. However, siliciclastics and even igneous intervals are also observed. Core #1 of the Freydis B-87 well is representative of the informally named Freydis sandstone and is siliciclastic in nature, being composed of mudstones, siltstones, and sandstones. Core #6 from the Roberval K-92 well contains two intervals of mafic igneous rocks, likely related to early Cretaceous rifting. Roberval K-92 is also the only well in which hydrocarbons are observed. The majority of the dolomite noted in the cores and thin sections was anhedral to euhedral fabric-destructive dolomite associated with burial diagenesis. However, hydrothermal dolomite occurs in the Indian Harbor M-52 well. Variations observed related to the shape, size, colouration and type of dolomite suggests multiple diagenetic phases. Despite the unique characteristics of each well, their lithological similarities (composition and fossil content) vaguely suggests that the wells may be syndepositional and therefore correlatable. However, the cores represent a very small portion of the Paleozoic interval and without reliable biostratigraphic constraints, the exact relationship between wells will remain unknown. A detailed palynological study of the entire Paleozoic of the Labrador margin is required before any significant regional or global scale correlations can be made.

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Appendices

Appendix A

Paleozoic core descriptions from Gudrid H-55, Roberval K-92 (Cores #6 and #7), Indian Harbour M-52, and Freydis B-87 (Cores #1 and #2)

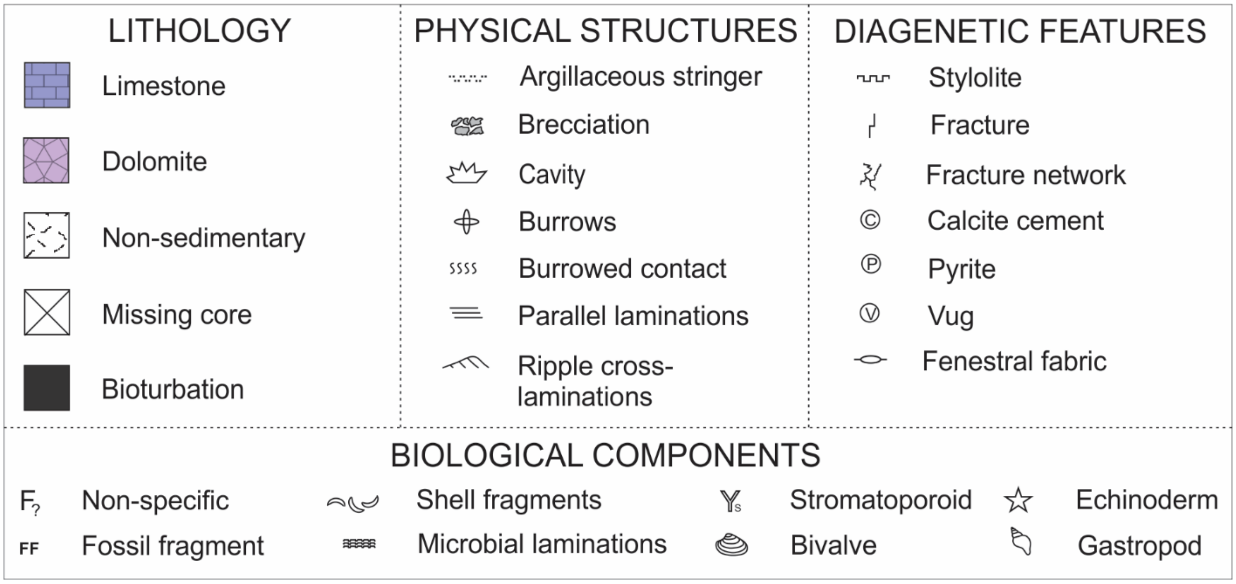
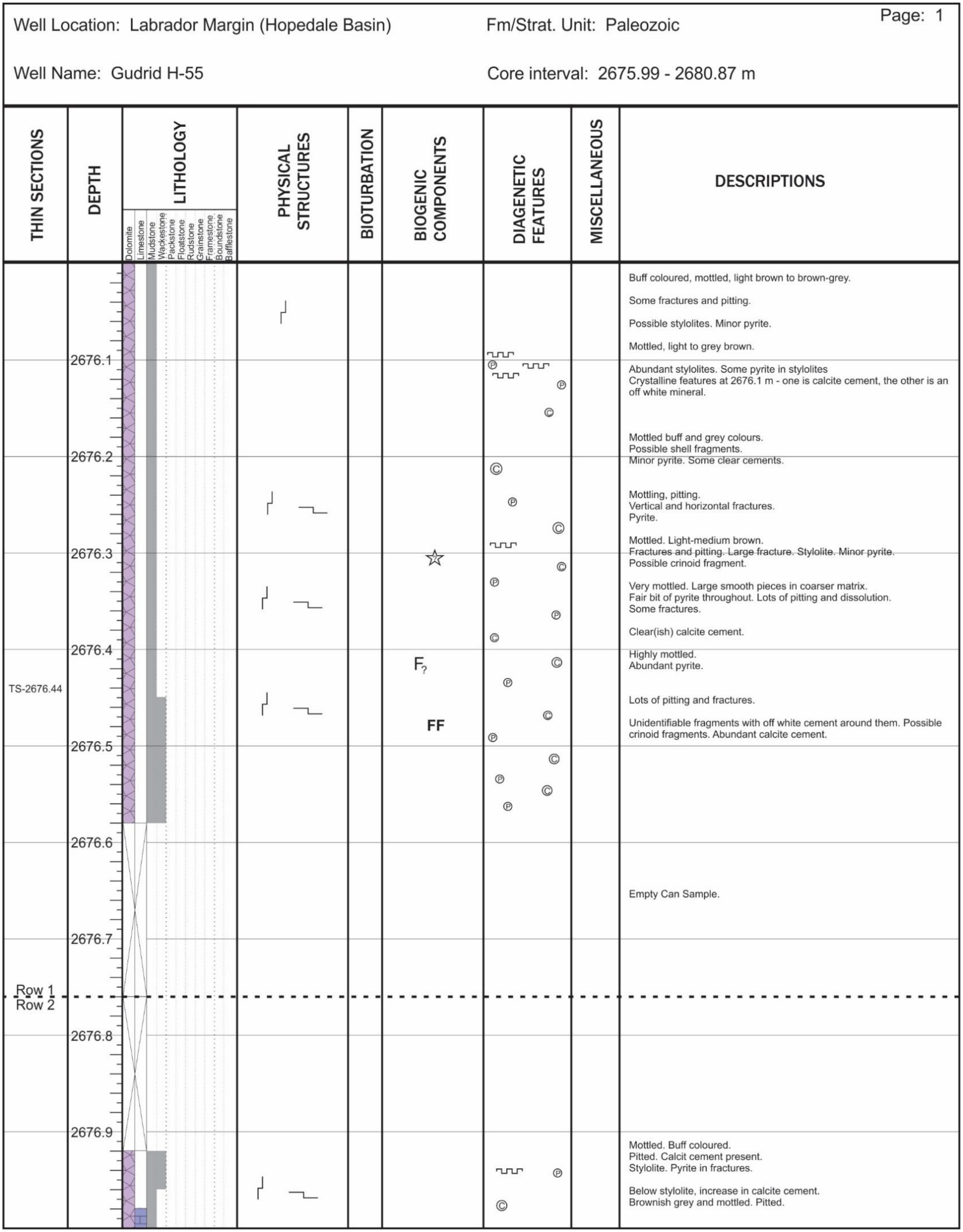


Figure A1: Legend for core descriptions.



Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 1

Well Name: Gudrid H-55

Core interval: 2675.99 - 2680.87 m

DESCRIPTIONS

Buff coloured, mottled, light brown to brown-grey.

Some fractures and pitting.

Possible stylolites. Minor pyrite.

Mottled, light to grey brown.

Abundant stylolites. Some pyrite in stylolites
Crystalline features at 2676.1 m - one is calcite cement, the other is an off white mineral.

Mottled buff and grey colours.
Possible shell fragments.
Minor pyrite. Some clear cements.

Mottling, pitting.
Vertical and horizontal fractures.
Pyrite.

Mottled. Light-medium brown.
Fractures and pitting. Large fracture. Stylolite. Minor pyrite.
Possible crinoid fragment.

Very mottled. Large smooth pieces in coarser matrix.
Fair bit of pyrite throughout. Lots of pitting and dissolution.
Some fractures.

Clear(ish) calcite cement.

Highly mottled.
Abundant pyrite.

Lots of pitting and fractures.

Unidentifiable fragments with off white cement around them. Possible crinoid fragments. Abundant calcite cement.

Empty Can Sample.

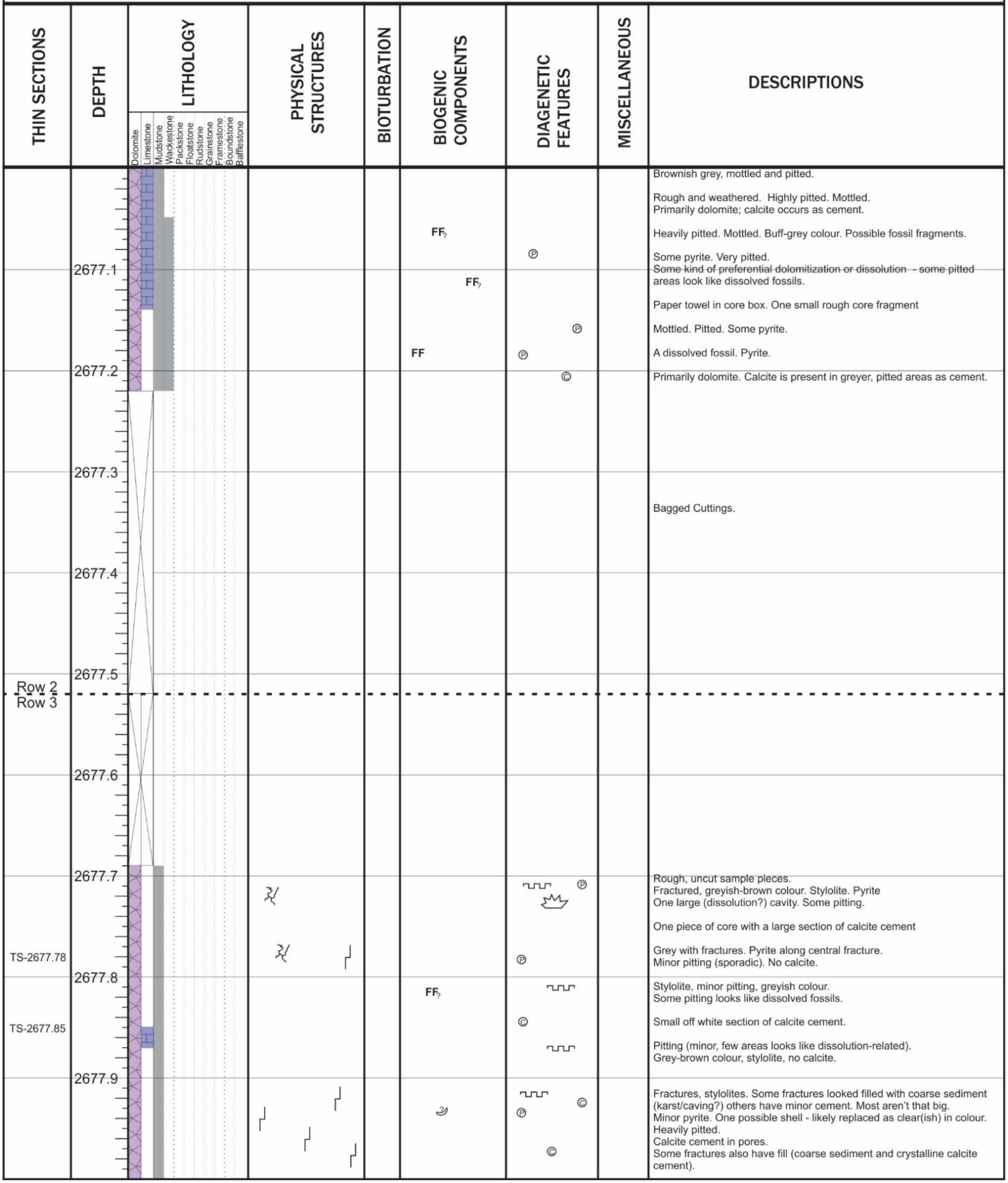
Mottled. Buff coloured.
Pitted. Calcit cement present.
Stylolite. Pyrite in fractures.

Below stylolite, increase in calcite cement.
Brownish grey and mottled. Pitted.

Figure A2: Core description for Gudrid H-55.

Well Location: Labrador Margin (Hopedale Basin)
Fm/Strat. Unit: Paleozoic
Page: 2

Well Name: Gudrid H-55
Core interval: 2675.99 - 2680.87 m



Brownish grey, mottled and pitted.

Rough and weathered. Highly pitted. Mottled.
Primarily dolomite; calcite occurs as cement.

Heavily pitted. Mottled. Buff-grey colour. Possible fossil fragments.

Some pyrite. Very pitted.
~~Some kind of preferential dolomitization or dissolution - some pitted~~
areas look like dissolved fossils.

Paper towel in core box. One small rough core fragment

Mottled. Pitted. Some pyrite.

A dissolved fossil. Pyrite.

Primarily dolomite. Calcite is present in greyer, pitted areas as cement.

Bagged Cuttings.

Rough, uncut sample pieces.
Fractured, greyish-brown colour. Stylolite. Pyrite
One large (dissolution?) cavity. Some pitting.

One piece of core with a large section of calcite cement

Grey with fractures. Pyrite along central fracture.
Minor pitting (sporadic). No calcite.

Stylolite, minor pitting, greyish colour.
Some pitting looks like dissolved fossils.

Small off white section of calcite cement.

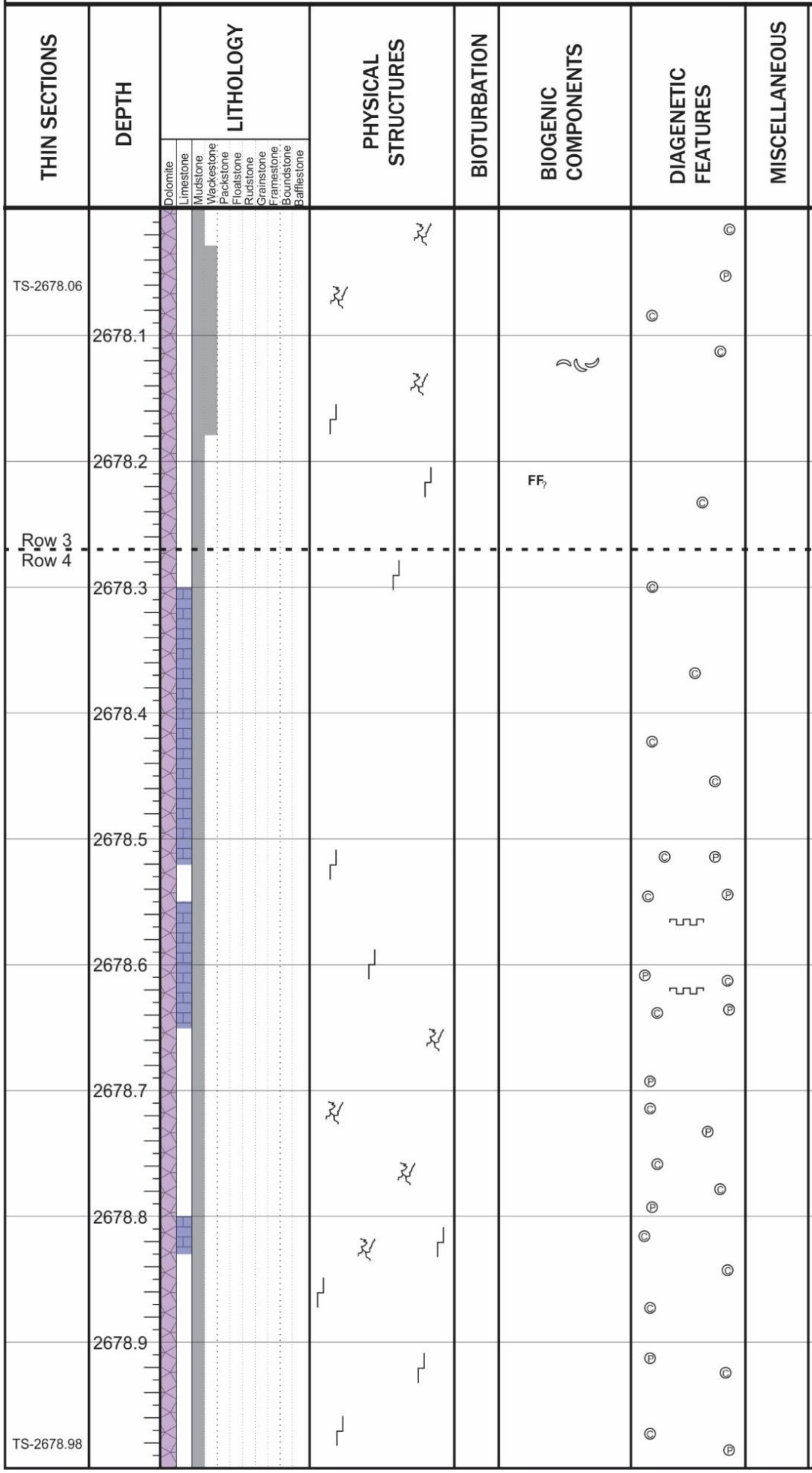
Pitting (minor, few areas looks like dissolution-related).
Grey-brown colour, stylolite, no calcite.

Fractures, stylolites. Some fractures looked filled with coarse sediment (karst/caving?) others have minor cement. Most aren't that big.
Minor pyrite. One possible shell - likely replaced as clear(ish) in colour.
Heavily pitted.
Calcite cement in pores.
Some fractures also have fill (coarse sediment and crystalline calcite cement).

Figure A2 continued: Core description for Gudrid H-55.

Well Location: Labrador Margin (Hopedale Basin)
Fm/Strat. Unit: Paleozoic
Page: 3

Well Name: Gudrid H-55
Core interval: 2675.99 - 2680.87 m



DESCRIPTIONS

Very mottled.
Glassy appearance.
Highly fractured.
Lighter coloured minerals (likely calcite) throughout.
Minor pyrite.
Pitting.
Fractures - some with calcite cement.

Some shells bits.
Lighter sections are calcite rich.
Highly fractured, mottled.
Large fracture around 2678.13 m with non-carbonate infill.

Lots of pitting.

Minor possible fossils - crinoids or *Amphipora* (very degraded).
Some calcite cement, especially near bottom of row.
Dark brown in colour.

Mottled. Brownish grey.
Minor fractures.
Some cement in pores.

Pitting.

Fair amount of calcite throughout (still minor compared to dolomite).

Mottled brown to grey.
Pitting.
Calcite cement.

Minor fracture. Grey-brown mottling.
Pitting and possible dissolution.
Minor pyrite.
Predominantly dolomite.
Stylolite.

Mottled- buff, dark brown, grey.
Grey is probably calcite cement rich areas.

Fractures present.

Shiny/glassy appearance, heavily fractured and pitted (dissolution).

Calcite cement in bottom corner of piece.

Round spheres (looks like cement) with pyrite flecks in them.

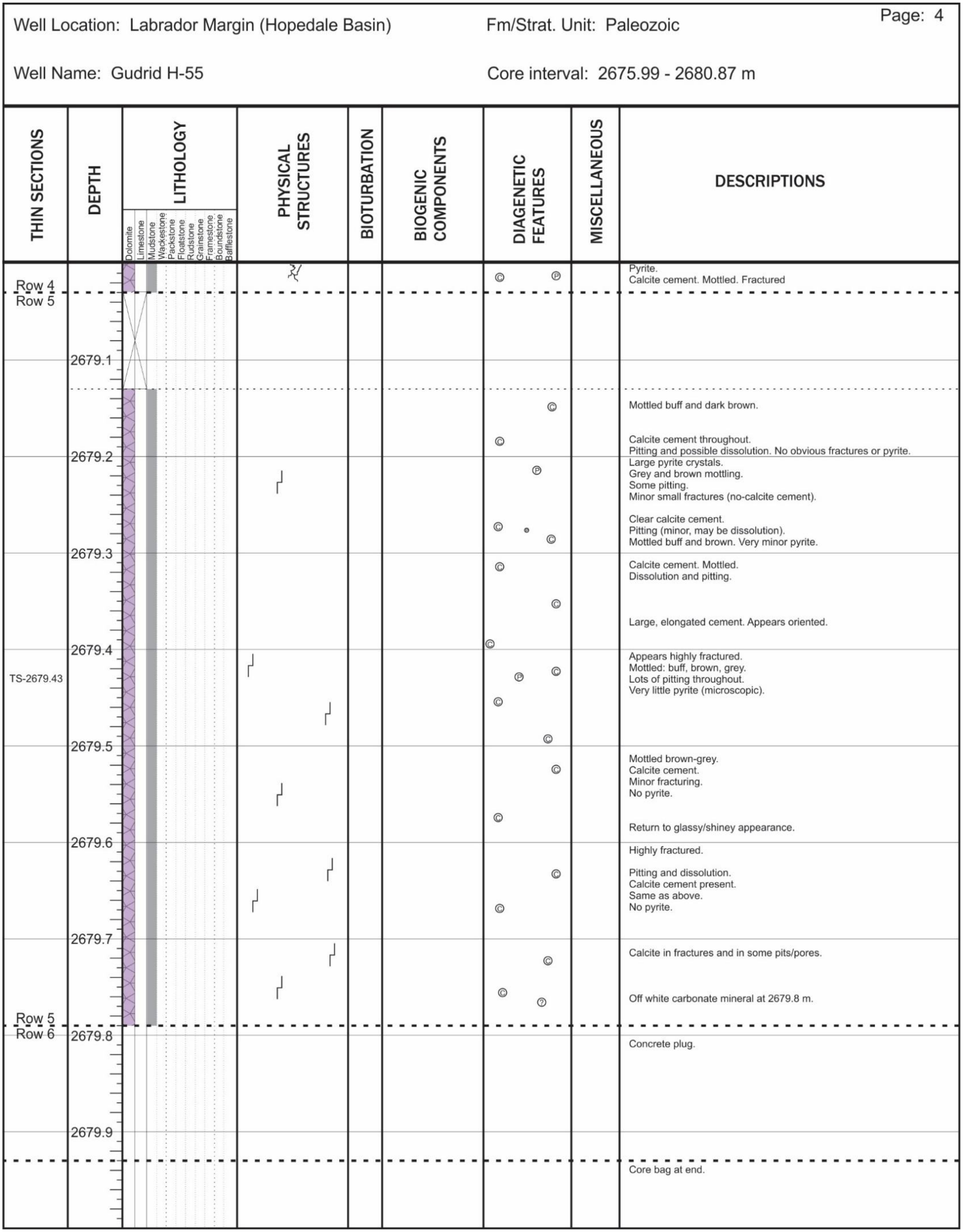
Pitting.
Fractures though not as common as above.
Lots of calcite cement in pores.
Minor pyrite. Pitting and dissolution present.
Fair amount of calcite cement throughout.

Heavily fractured. Abundant calcite cement.

Dissolution common throughout.

Pyrite increases towards 2679 m but does occur throughout core.
Calcite restricted to cement.

Figure A2 continued: Core description for Gudrid H-55.



Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 4

Well Name: Gudrid H-55

Core interval: 2675.99 - 2680.87 m

Pyrite.
Calcite cement. Mottled. Fractured

Mottled buff and dark brown.

Calcite cement throughout.
Pitting and possible dissolution. No obvious fractures or pyrite.
Large pyrite crystals.
Grey and brown mottling.
Some pitting.
Minor small fractures (no-calcite cement).

Clear calcite cement.
Pitting (minor, may be dissolution).
Mottled buff and brown. Very minor pyrite.

Calcite cement. Mottled.
Dissolution and pitting.

Large, elongated cement. Appears oriented.

Appears highly fractured.
Mottled: buff, brown, grey.
Lots of pitting throughout.
Very little pyrite (microscopic).

Mottled brown-grey.
Calcite cement.
Minor fracturing.
No pyrite.

Return to glassy/shiney appearance.

Highly fractured.

Pitting and dissolution.
Calcite cement present.
Same as above.
No pyrite.

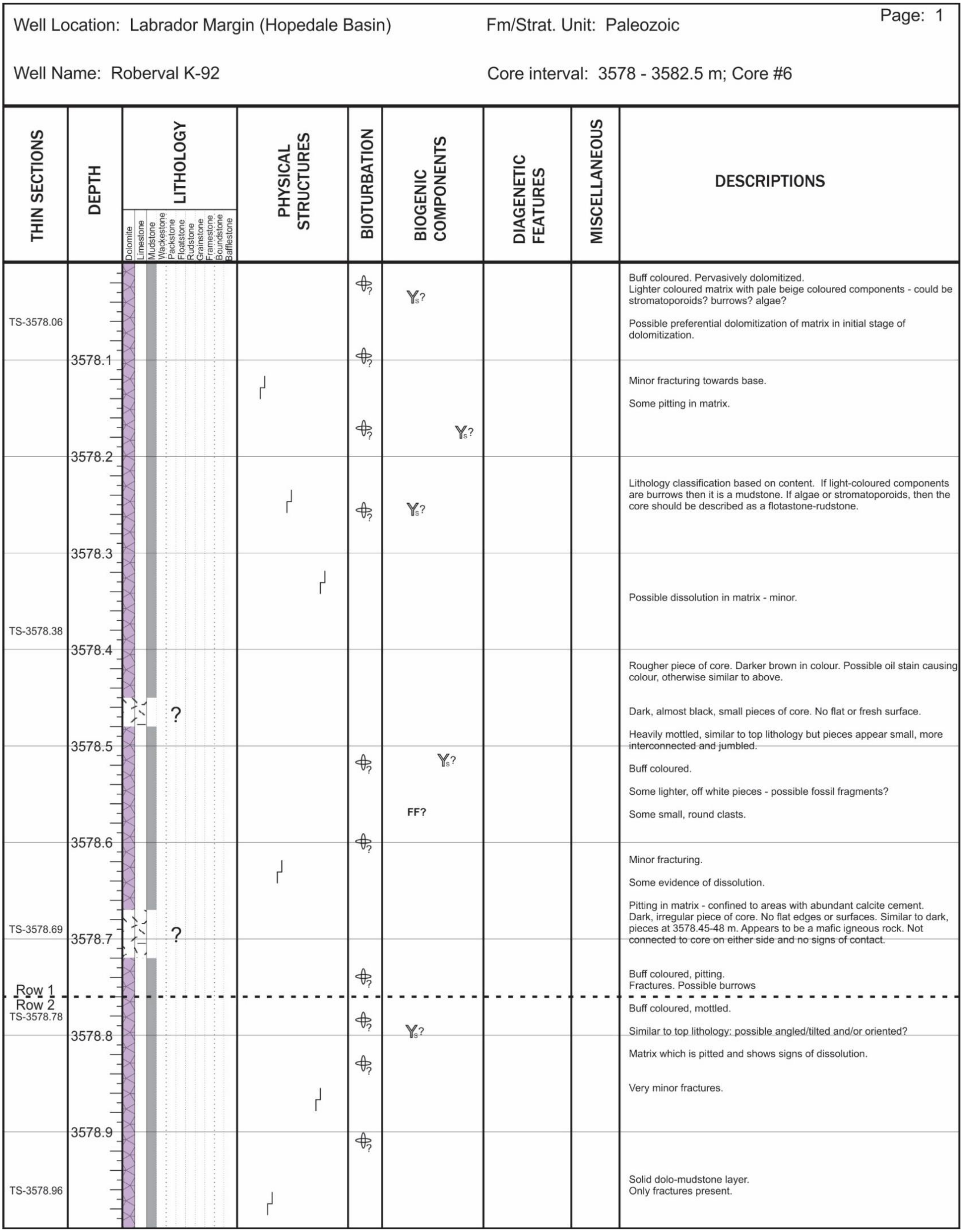
Calcite in fractures and in some pits/pores.

Off white carbonate mineral at 2679.8 m.

Concrete plug.

Core bag at end.

Figure A2 continued: Core description for Gudrid H-55.



Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 1

Well Name: Roberval K-92

Core interval: 3578 - 3582.5 m; Core #6

Buff coloured. Pervasively dolomitized.
Lighter coloured matrix with pale beige coloured components - could be stromatoporoids? burrows? algae?

Possible preferential dolomitization of matrix in initial stage of dolomitization.

Minor fracturing towards base.

Some pitting in matrix.

Lithology classification based on content. If light-coloured components are burrows then it is a mudstone. If algae or stromatoporoids, then the core should be described as a flotastone-rudstone.

Possible dissolution in matrix - minor.

Rougher piece of core. Darker brown in colour. Possible oil stain causing colour, otherwise similar to above.

Dark, almost black, small pieces of core. No flat or fresh surface.

Heavily mottled, similar to top lithology but pieces appear small, more interconnected and jumbled.

Buff coloured.

Some lighter, off white pieces - possible fossil fragments?

Some small, round clasts.

Minor fracturing.

Some evidence of dissolution.

Pitting in matrix - confined to areas with abundant calcite cement.
Dark, irregular piece of core. No flat edges or surfaces. Similar to dark, pieces at 3578.45-48 m. Appears to be a mafic igneous rock. Not connected to core on either side and no signs of contact.

Buff coloured, pitting.
Fractures. Possible burrows

Buff coloured, mottled.

Similar to top lithology: possible angled/tilted and/or oriented?

Matrix which is pitted and shows signs of dissolution.

Very minor fractures.

Solid dolo-mudstone layer.
Only fractures present.

Figure A3: Core description for Roberval K-92, Core #6.

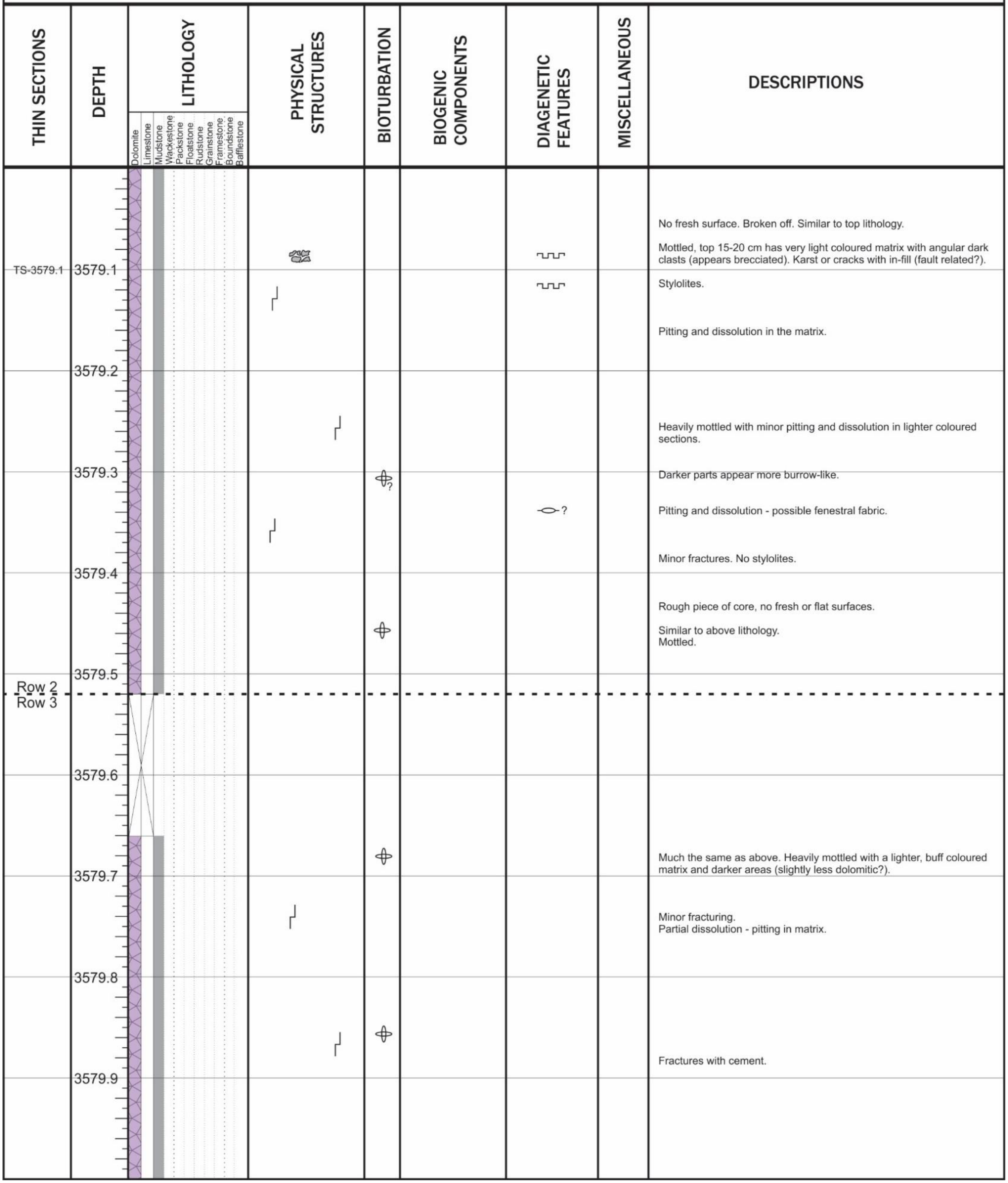
Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 2

Well Name: Roberval K-92

Core interval: 3578 - 3582.5 m; Core #6



No fresh surface. Broken off. Similar to top lithology.

Mottled, top 15-20 cm has very light coloured matrix with angular dark clasts (appears brecciated). Karst or cracks with in-fill (fault related?).

Stylolites.

Pitting and dissolution in the matrix.

Heavily mottled with minor pitting and dissolution in lighter coloured sections.

Darker parts appear more burrow-like.

Pitting and dissolution - possible fenestral fabric.

Minor fractures. No stylolites.

Rough piece of core, no fresh or flat surfaces.

Similar to above lithology.
Mottled.

Much the same as above. Heavily mottled with a lighter, buff coloured matrix and darker areas (slightly less dolomitic?).

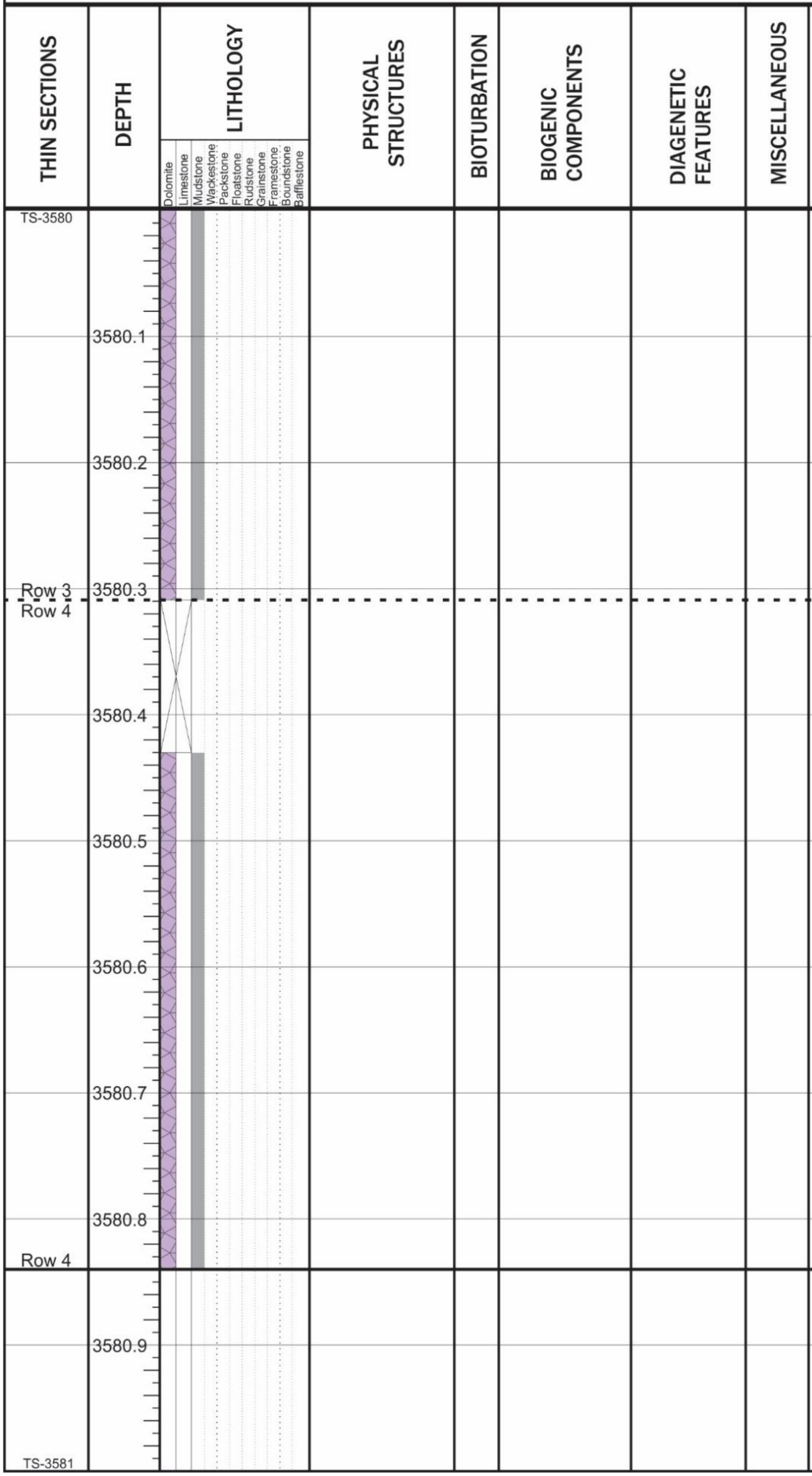
Minor fracturing.
Partial dissolution - pitting in matrix.

Fractures with cement.

Figure A3 continued: Core description for Roberval K-92, Core #6.

Well Location: Labrador Margin (Hopedale Basin) Fm/Strat. Unit: Paleozoic Page: 3

Well Name: Roberval K-92 Core interval: 3578 - 3582.5 m; Core #6



DESCRIPTIONS

Rubble.

Intermixed buff coloured and blue-green pieces.

Blue green pieces are very slick, limey, shaley/muddy.

Large (>10 cm), rough pieces of core.

Buff coloured with minor blue-green component.

2 large blue-green pieces.

3 medium pieces, mostly buff coloured but minor blue-green component.

No noticeable features.
No fresh, flat surfaces.

Small rubble.

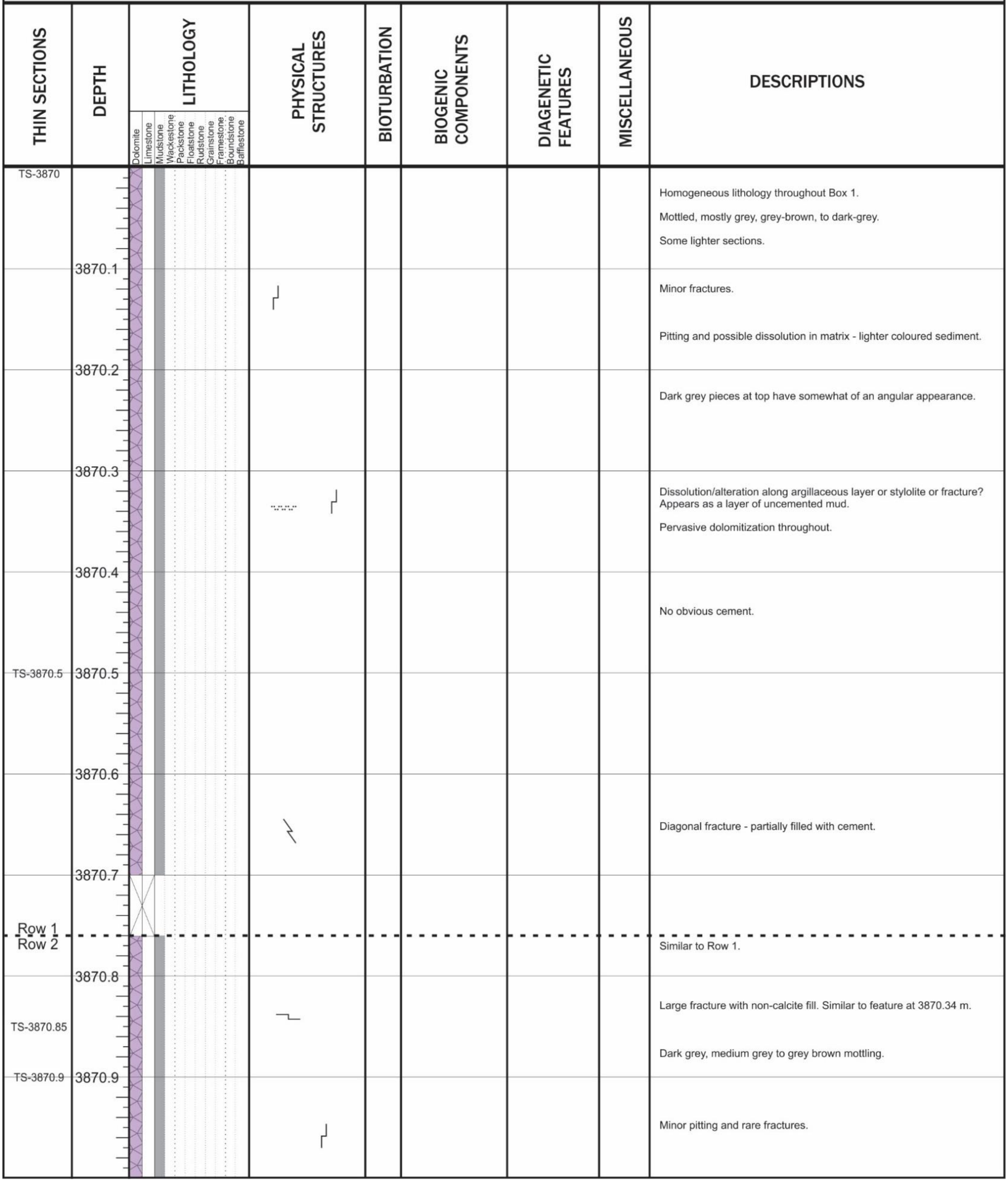
Core missing? Only two boxes of core containing approximately 150 cm of core per box for a total of 3 m of core. This is quite a bit less than the reported 4.5 m of core (3578 m to 3582.5 m) indicated on the core boxes.

Thin section from 3581 m is from the archived GSC collection. No core in core box at 3581 m and rubble up until 3580.8. Uncertain as to where this thin section was taken from and what lithology the core was.

Figure A3 continued: Core description for Roberval K-92, Core #6.

Well Location: Labrador Margin (Hopedale Basin) Fm/Strat. Unit: Paleozoic Page: 1

Well Name: Roberval K-92 Core interval: 3870 - 3874 m; Core #7



Homogeneous lithology throughout Box 1.

Mottled, mostly grey, grey-brown, to dark-grey.

Some lighter sections.

Minor fractures.

Pitting and possible dissolution in matrix - lighter coloured sediment.

Dark grey pieces at top have somewhat of an angular appearance.

Dissolution/alteration along argillaceous layer or stylolite or fracture? Appears as a layer of uncemented mud.

Pervasive dolomitization throughout.

No obvious cement.

Diagonal fracture - partially filled with cement.

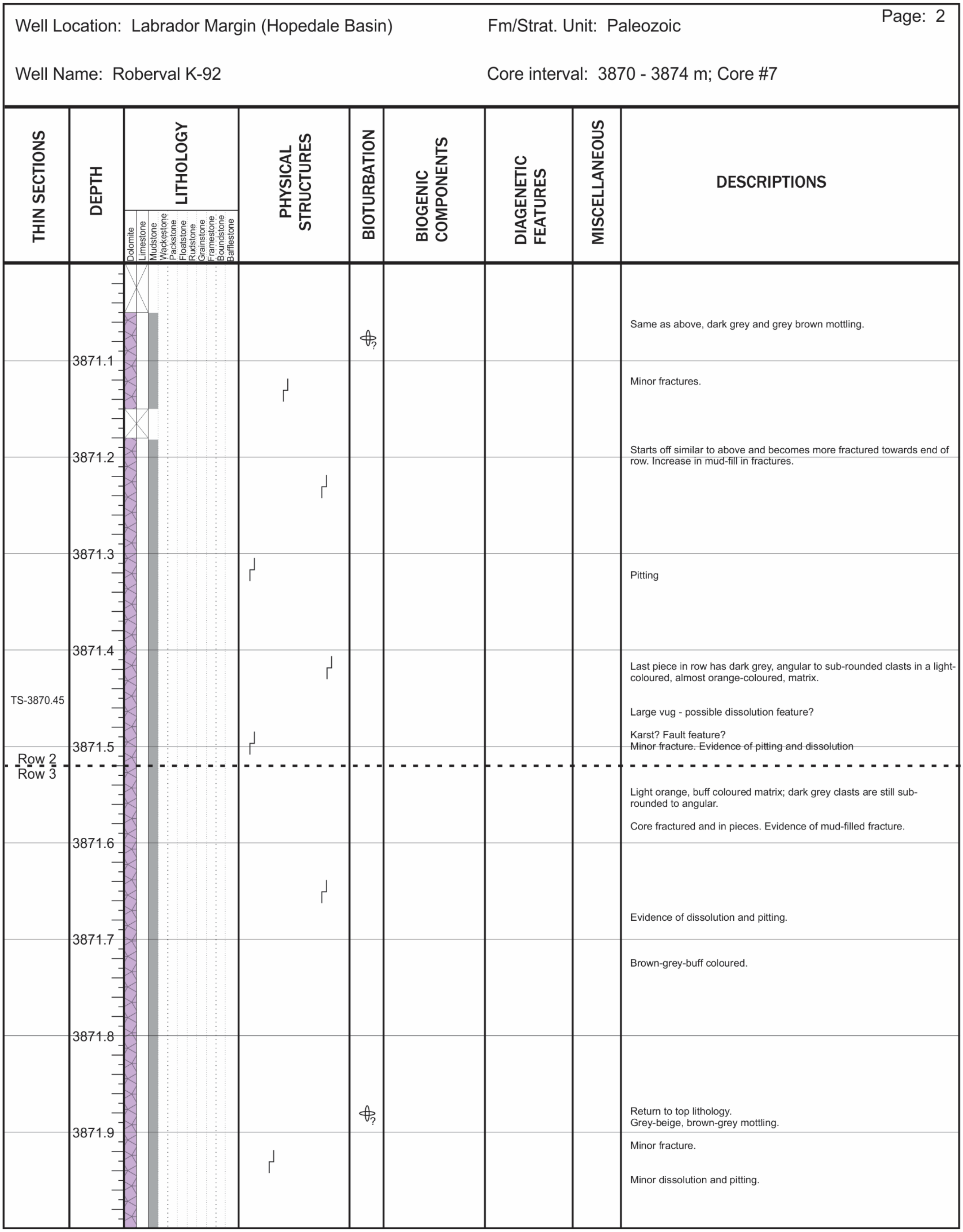
Similar to Row 1.

Large fracture with non-calcite fill. Similar to feature at 3870.34 m.

Dark grey, medium grey to grey brown mottling.

Minor pitting and rare fractures.

Figure A4: Core description for Roberval K-92, Core #7.



Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 2

Well Name: Roberval K-92

Core interval: 3870 - 3874 m; Core #7

Same as above, dark grey and grey brown mottling.

Minor fractures.

Starts off similar to above and becomes more fractured towards end of row. Increase in mud-fill in fractures.

Pitting

Last piece in row has dark grey, angular to sub-rounded clasts in a light-coloured, almost orange-coloured, matrix.

Large vug - possible dissolution feature?

Karst? Fault feature?

Minor fracture. Evidence of pitting and dissolution

Light orange, buff coloured matrix; dark grey clasts are still sub-rounded to angular.

Core fractured and in pieces. Evidence of mud-filled fracture.

Evidence of dissolution and pitting.

Brown-grey-buff coloured.

Return to top lithology.
Grey-beige, brown-grey mottling.

Minor fracture.

Minor dissolution and pitting.

Figure A4 continued: Core description for Roberval K-92, Core #7.

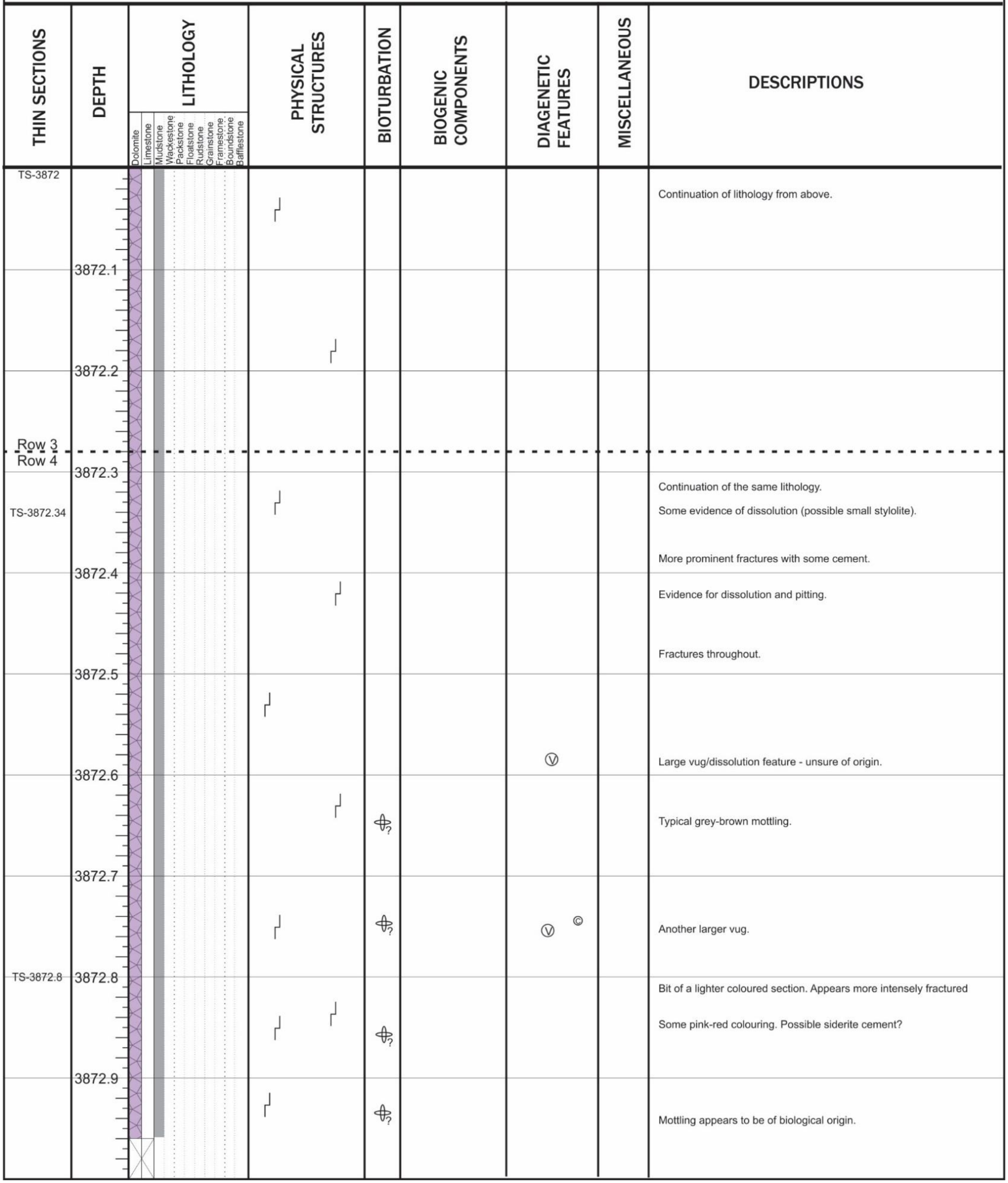
Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 3

Well Name: Roberval K-92

Core interval: 3870 - 3874 m; Core #7



Continuation of lithology from above.

Continuation of the same lithology.

Some evidence of dissolution (possible small stylolite).

More prominent fractures with some cement.

Evidence for dissolution and pitting.

Fractures throughout.

Large vug/dissolution feature - unsure of origin.

Typical grey-brown mottling.

Another larger vug.

Bit of a lighter coloured section. Appears more intensely fractured

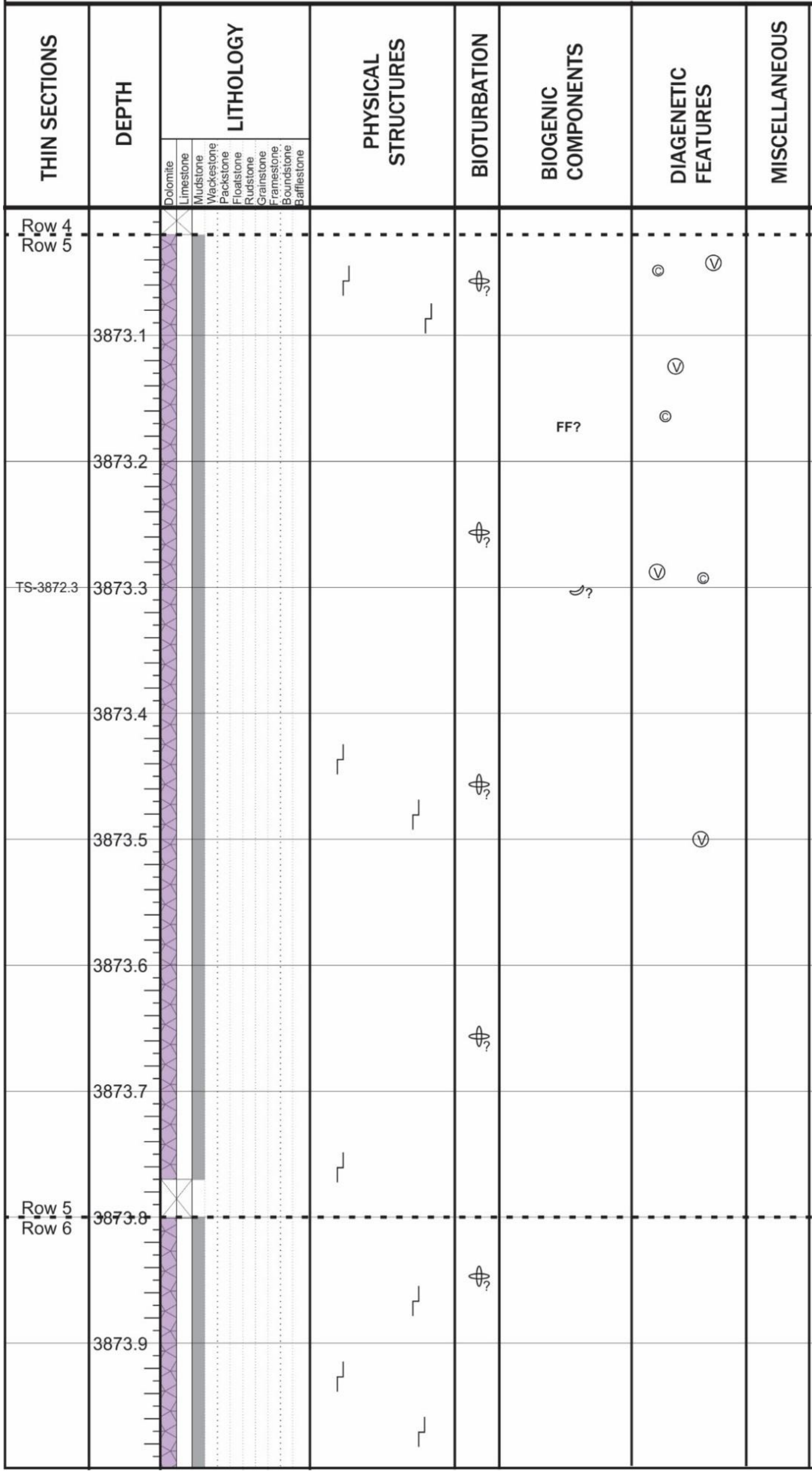
Some pink-red colouring. Possible siderite cement?

Mottling appears to be of biological origin.

Figure A4 continued: Core description for Roberval K-92, Core #7.

Well Location: Labrador Margin (Hopedale Basin) Fm/Strat. Unit: Paleozoic Page: 4

Well Name: Roberval K-92 Core interval: 3870 - 3874 m; Core #7



DESCRIPTIONS

1 full-sized core piece in entire row. Large pieces of core.
Vug with cement.
Mottled (dark to light grey).
Highly fractured.

2 possible dissolution features on edge of core piece.

Some white to white-grey rounded pieces possible calcite cement or fossil fragments?

Minor pitting

Large, ~5cm dissolution feature - appears to be a vug created by the dissolution of a large bivalve shell. Contains cement.

Pitting throughout.

Highly fractured.

Another void - hole in core but does not appear to contain cement.

Continuation of same lithology.

Same lithology as above.

Dark grey in colour, may be slightly less mottled. Vugs/cavities common.

Highly fractured. Core is in large pieces.

Some lighter grey patches in mottling may indicate preferential dolomitization of an original fabric.

Figure A4 continued: Core description for Roberval K-92, Core #7.

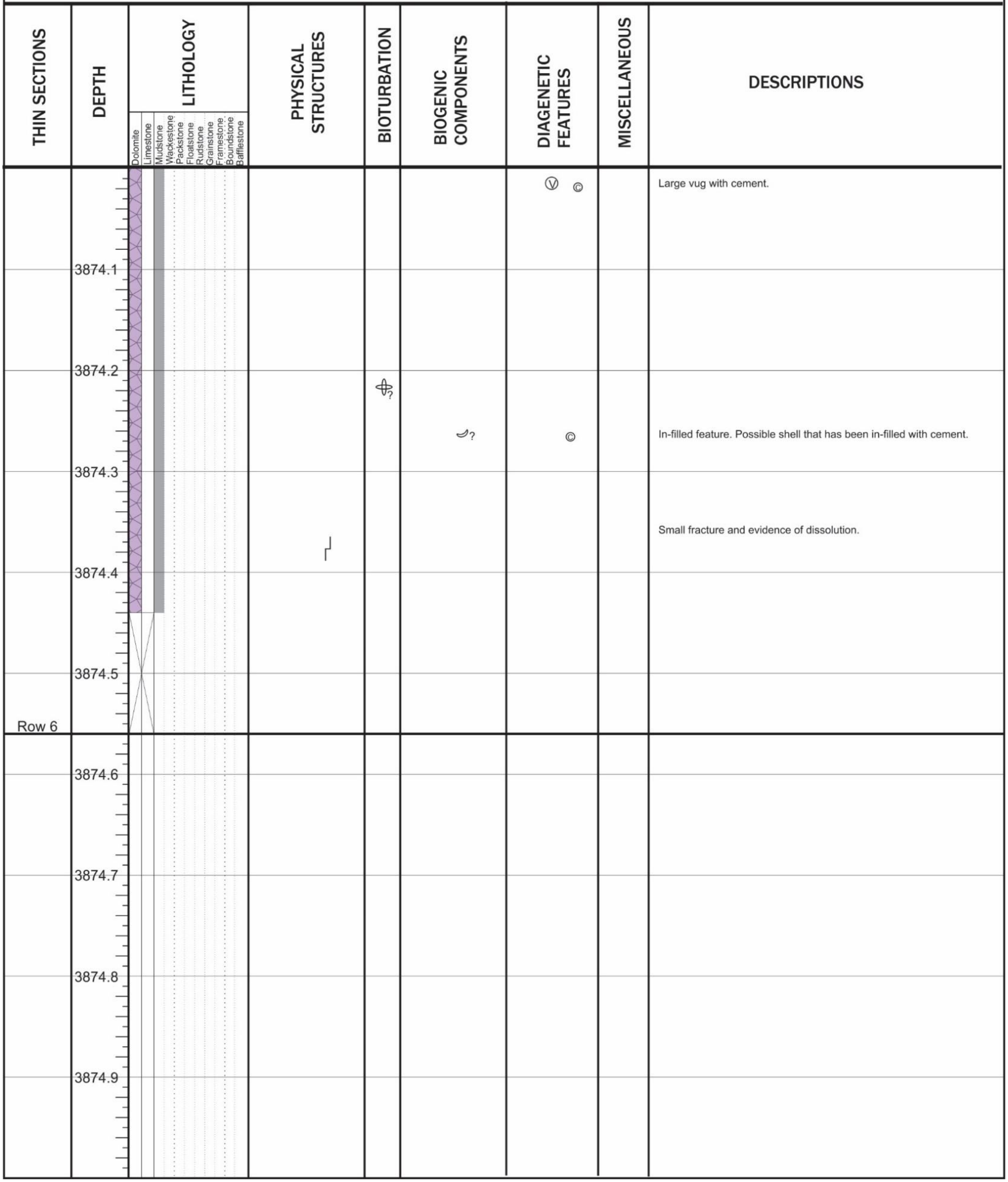
Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 5

Well Name: Roberval K-92

Core interval: 3870 - 3874 m; Core #7



Large vug with cement.

In-filled feature. Possible shell that has been in-filled with cement.

Small fracture and evidence of dissolution.

Figure A4 continued: Core description for Roberval K-92, Core #7.

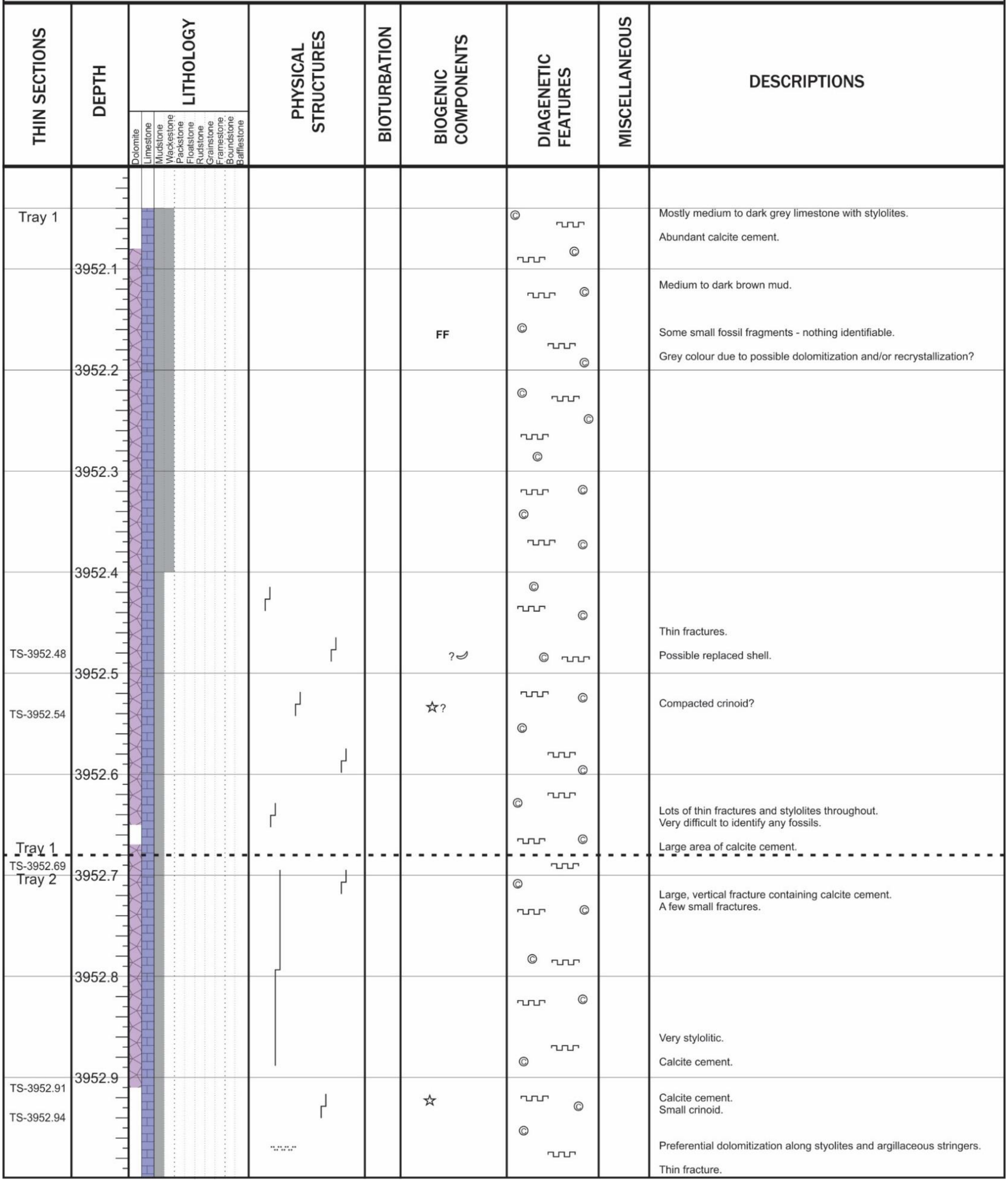
Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 1

Well Name: Indian Harbour M-52

Core interval: 3652.04 - 3958.13 m



Mostly medium to dark grey limestone with stylolites.

Abundant calcite cement.

Medium to dark brown mud.

Some small fossil fragments - nothing identifiable.

Grey colour due to possible dolomitization and/or recrystallization?

Thin fractures.

Possible replaced shell.

Compacted crinoid?

Lots of thin fractures and stylolites throughout.
Very difficult to identify any fossils.

Large area of calcite cement.

Large, vertical fracture containing calcite cement.
A few small fractures.

Very stylolitic.

Calcite cement.

Calcite cement.
Small crinoid.

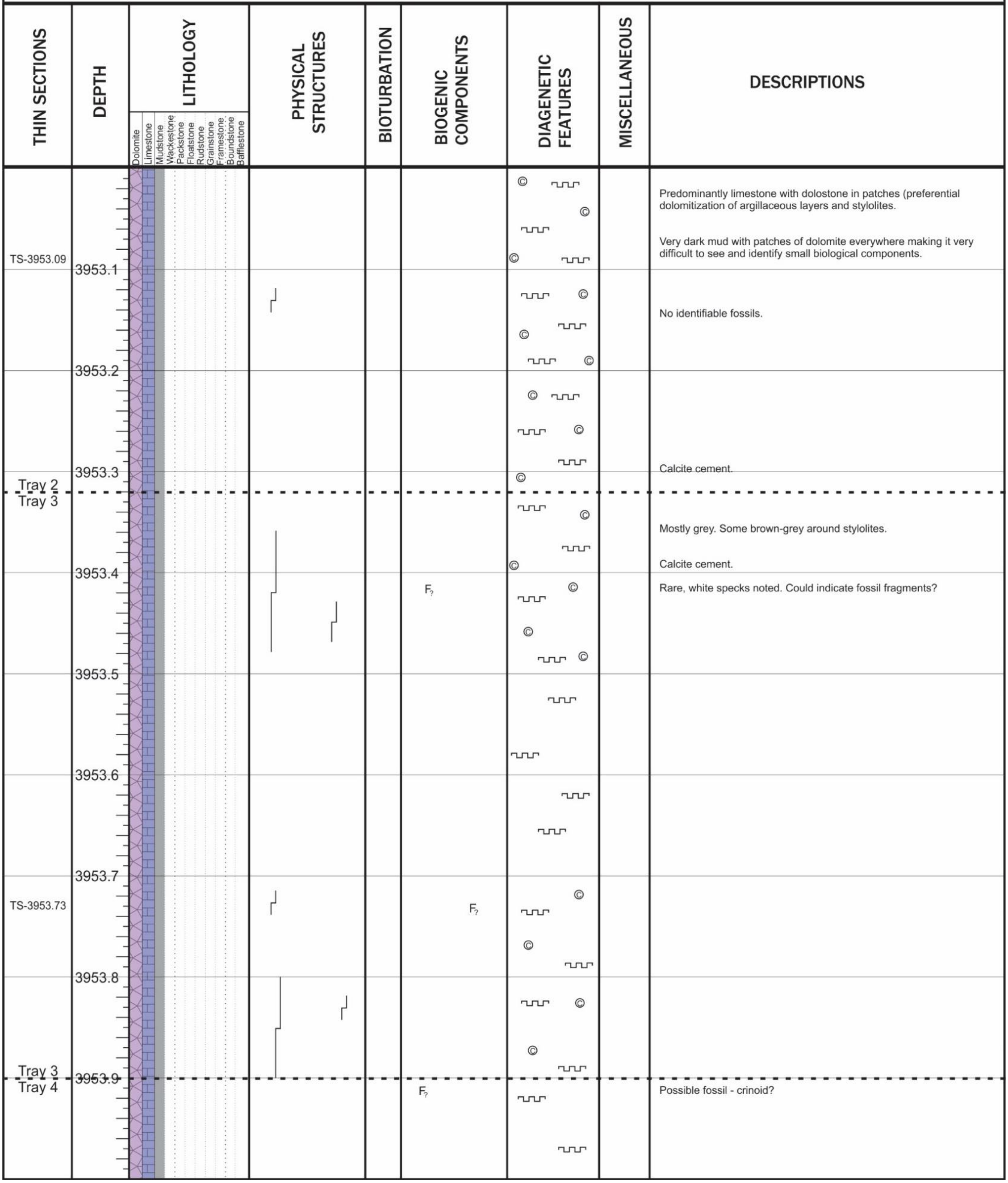
Preferential dolomitization along styolites and argillaceous stringers.

Thin fracture.

Figure A5: Core description for Indian Harbour M-52.

Well Location: Labrador Margin (Hopedale Basin) Fm/Strat. Unit: Paleozoic Page: 2

Well Name: Indian Harbour M-52 Core interval: 3652.04 - 3958.13 m



Predominantly limestone with dolostone in patches (preferential dolomitization of argillaceous layers and stylolites.

Very dark mud with patches of dolomite everywhere making it very difficult to see and identify small biological components.

No identifiable fossils.

Calcite cement.

Mostly grey. Some brown-grey around stylolites.

Calcite cement.

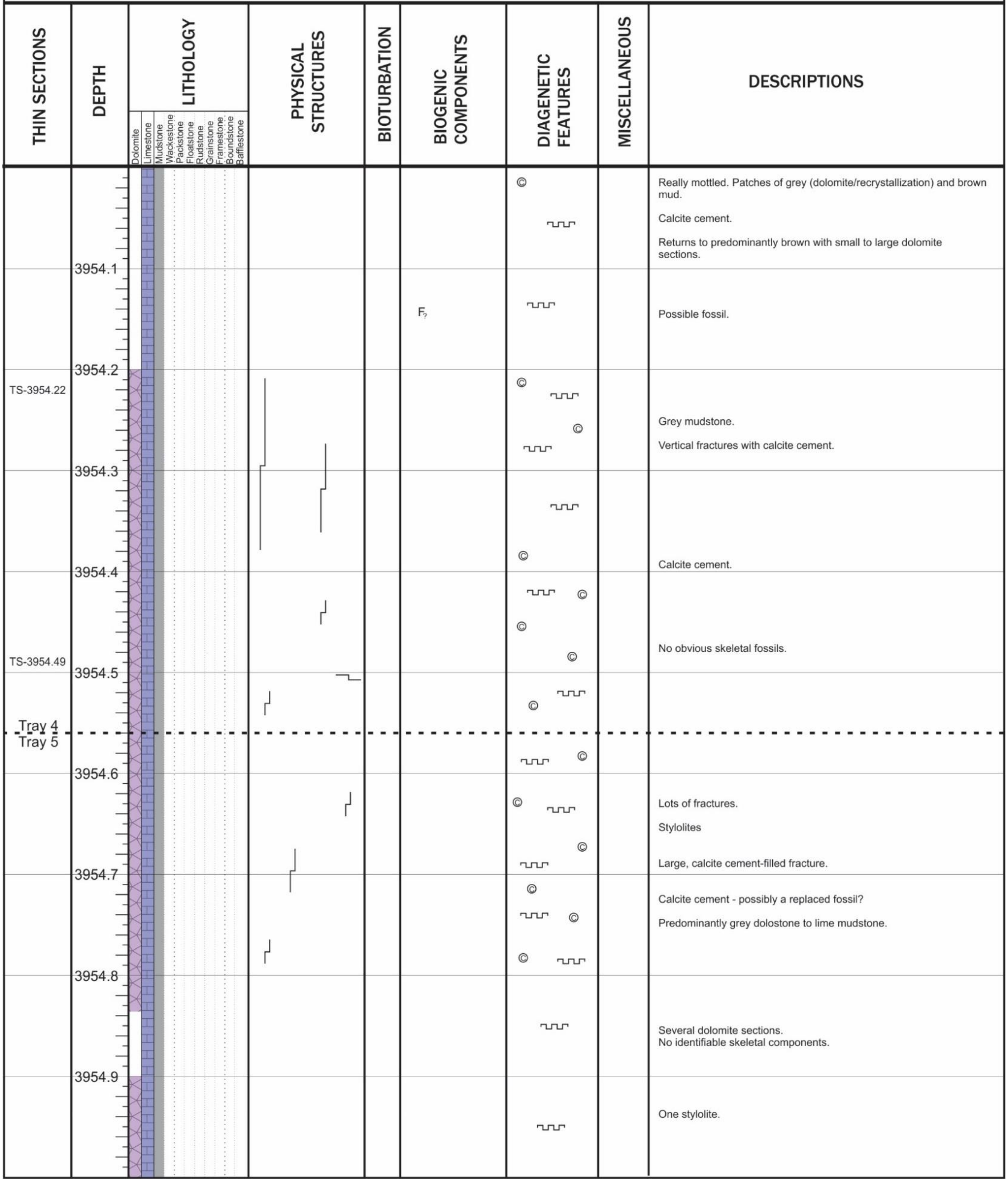
Rare, white specks noted. Could indicate fossil fragments?

Possible fossil - crinoid?

Figure A5 continued: Core description for Indian Harbour M-52.

Well Location: Labrador Margin (Hopedale Basin) Fm/Strat. Unit: Paleozoic Page: 3

Well Name: Indian Harbour M-52 Core interval: 3652.04 - 3958.13 m



Really mottled. Patches of grey (dolomite/recrystallization) and brown mud.

Calcite cement.

Returns to predominantly brown with small to large dolomite sections.

Possible fossil.

Grey mudstone.

Vertical fractures with calcite cement.

Calcite cement.

No obvious skeletal fossils.

Lots of fractures.

Stylolites

Large, calcite cement-filled fracture.

Calcite cement - possibly a replaced fossil?

Predominantly grey dolostone to lime mudstone.

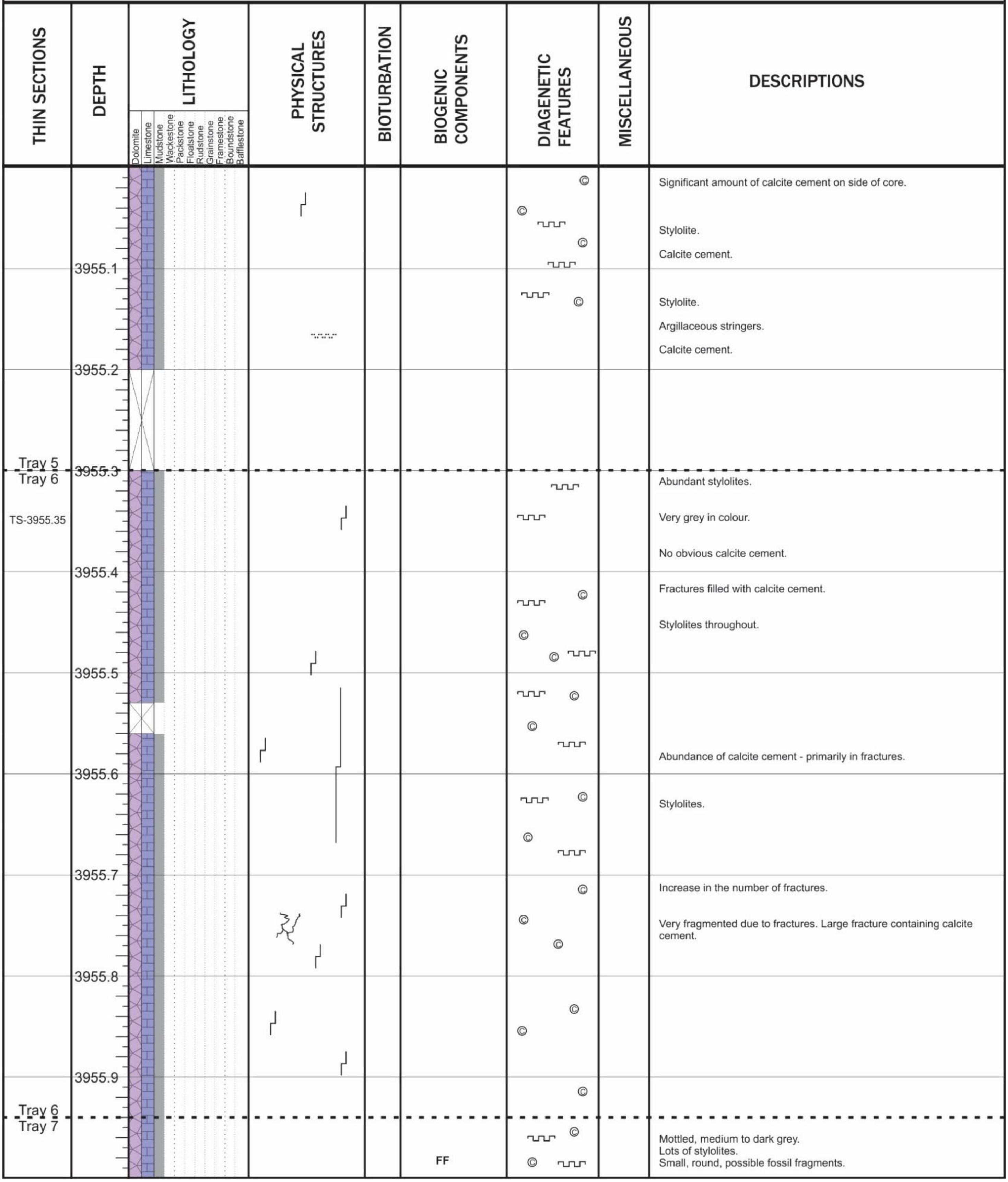
Several dolomite sections.
No identifiable skeletal components.

One stylolite.

Figure A5 continued: Core description for Indian Harbour M-52.

Well Location: Labrador Margin (Hopedale Basin)
Fm/Strat. Unit: Paleozoic
Page: 4

Well Name: Indian Harbour M-52
Core interval: 3652.04 - 3958.13 m



Significant amount of calcite cement on side of core.

Stylolite.

Calcite cement.

Stylolite.

Argillaceous stringers.

Calcite cement.

Abundant stylolites.

Very grey in colour.

No obvious calcite cement.

Fractures filled with calcite cement.

Stylolites throughout.

Abundance of calcite cement - primarily in fractures.

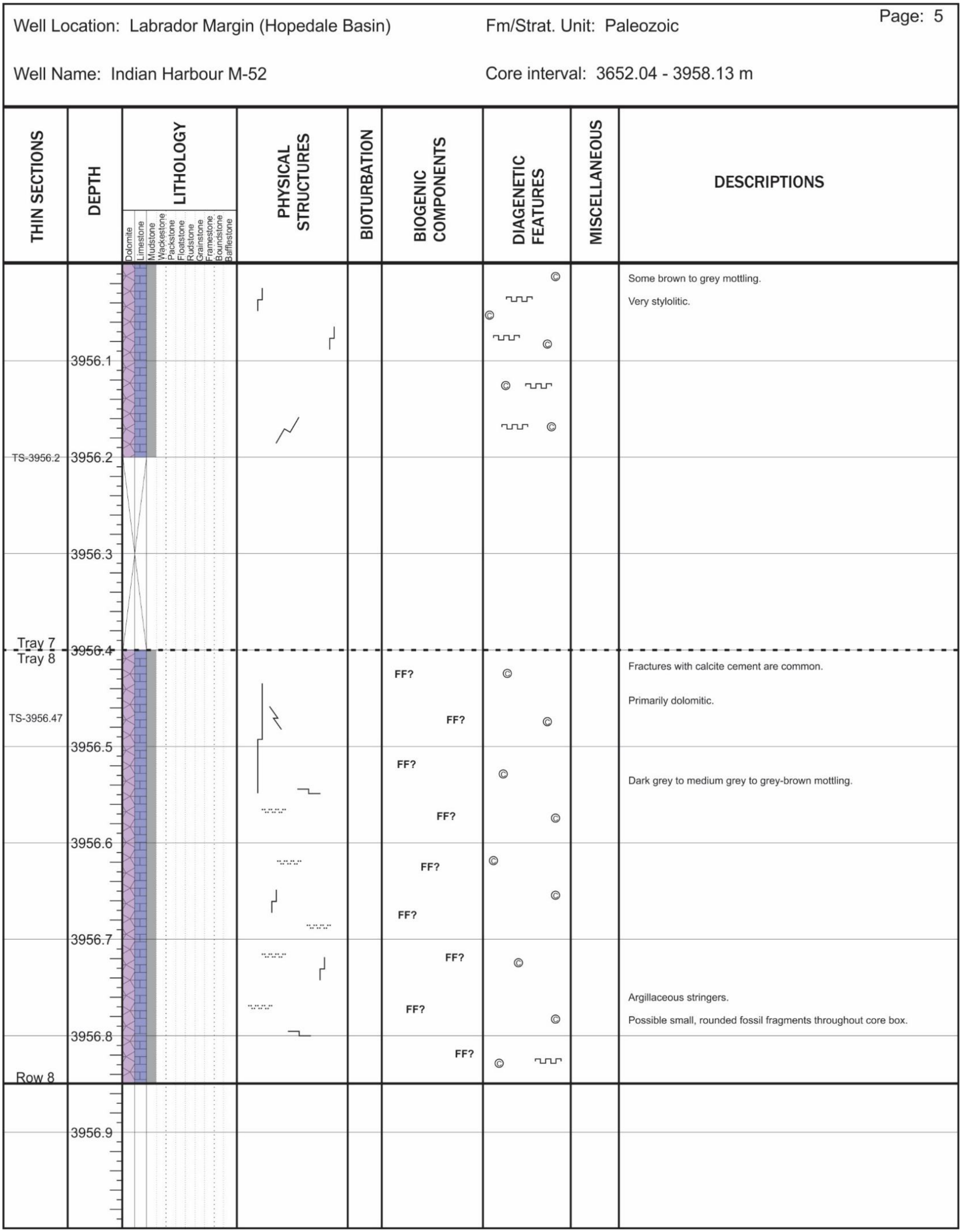
Stylolites.

Increase in the number of fractures.

Very fragmented due to fractures. Large fracture containing calcite cement.

Mottled, medium to dark grey.
Lots of stylolites.
Small, round, possible fossil fragments.

Figure A5 continued: Core description for Indian Harbour M-52.



Some brown to grey mottling.

Very stylolitic.

Fractures with calcite cement are common.

Primarily dolomitic.

Dark grey to medium grey to grey-brown mottling.

Argillaceous stringers.

Possible small, rounded fossil fragments throughout core box.

Figure A5 continued: Core description for Indian Harbour M-52.

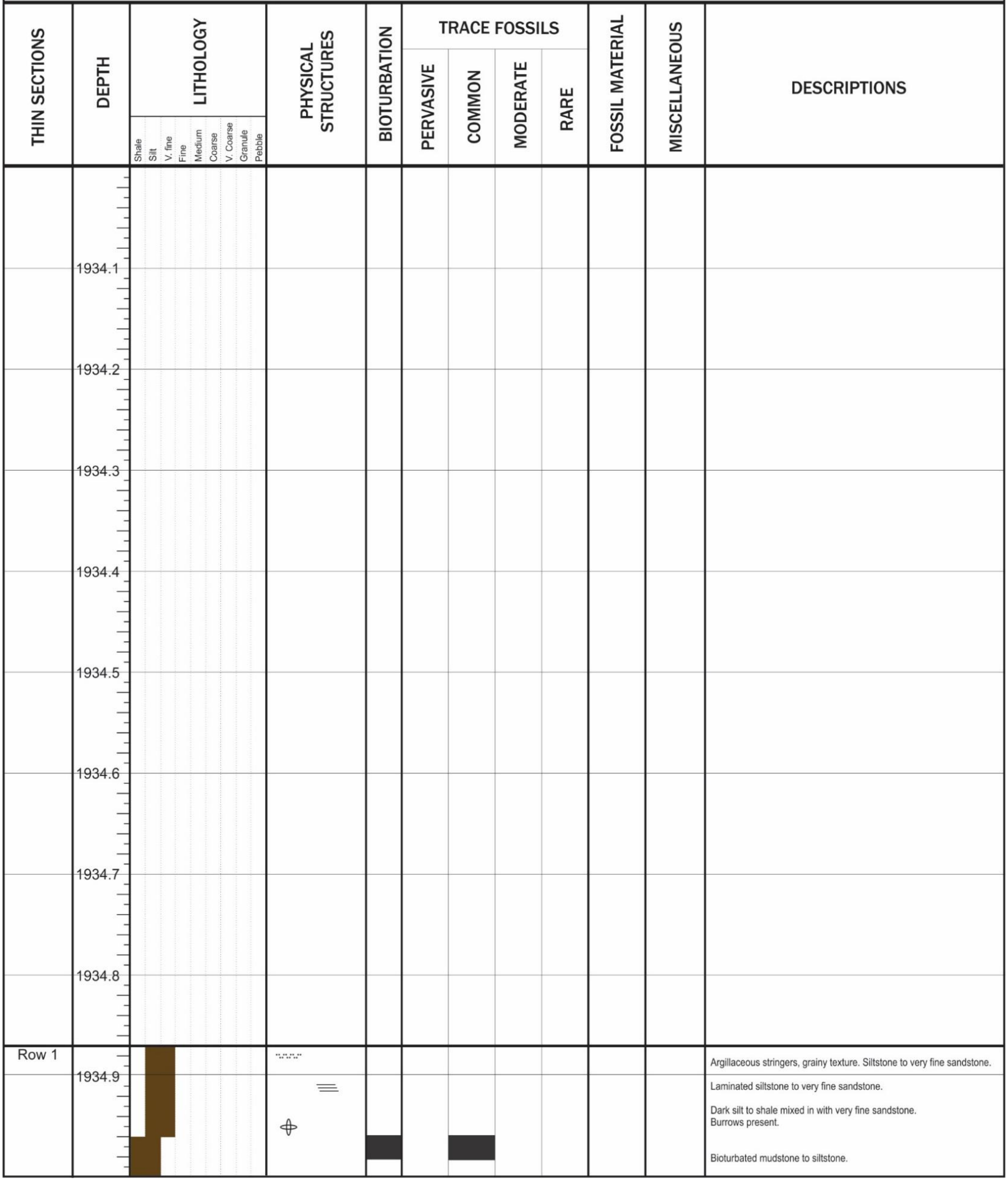
Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 1

Well Name: Freydis B-87

Core interval: 1934.87 - 1941.29 m; Core #1



Argillaceous stringers, grainy texture. Siltstone to very fine sandstone.

Laminated siltstone to very fine sandstone.

Dark silt to shale mixed in with very fine sandstone.
Burrows present.

Bioturbated mudstone to siltstone.

Figure A6: Core description for Freydis B-87, Core #1.

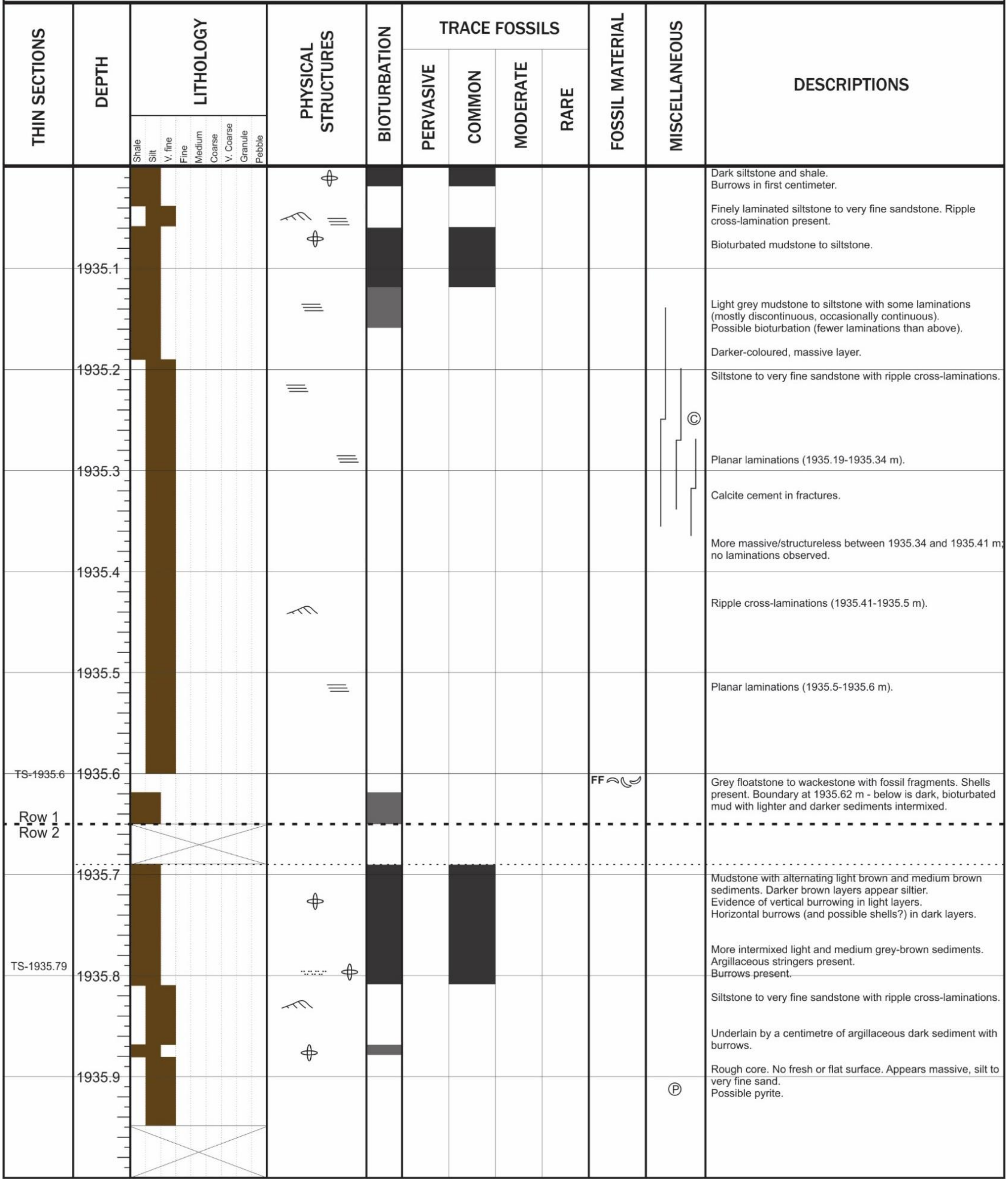
Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 2

Well Name: Freydis B-87

Core interval: 1934.87 - 1941.29 m; Core #1



Dark siltstone and shale.
Burrows in first centimeter.

Finely laminated siltstone to very fine sandstone. Ripple cross-lamination present.

Bioturbated mudstone to siltstone.

Light grey mudstone to siltstone with some laminations (mostly discontinuous, occasionally continuous).
Possible bioturbation (fewer laminations than above).

Darker-coloured, massive layer.

Siltstone to very fine sandstone with ripple cross-laminations.

Planar laminations (1935.19-1935.34 m).

Calcite cement in fractures.

More massive/structureless between 1935.34 and 1935.41 m; no laminations observed.

Ripple cross-laminations (1935.41-1935.5 m).

Planar laminations (1935.5-1935.6 m).

Grey floatstone to wackestone with fossil fragments. Shells present. Boundary at 1935.62 m - below is dark, bioturbated mud with lighter and darker sediments intermixed.

Mudstone with alternating light brown and medium brown sediments. Darker brown layers appear siltier.
Evidence of vertical burrowing in light layers.
Horizontal burrows (and possible shells?) in dark layers.

More intermixed light and medium grey-brown sediments.
Argillaceous stringers present.
Burrows present.

Siltstone to very fine sandstone with ripple cross-laminations.

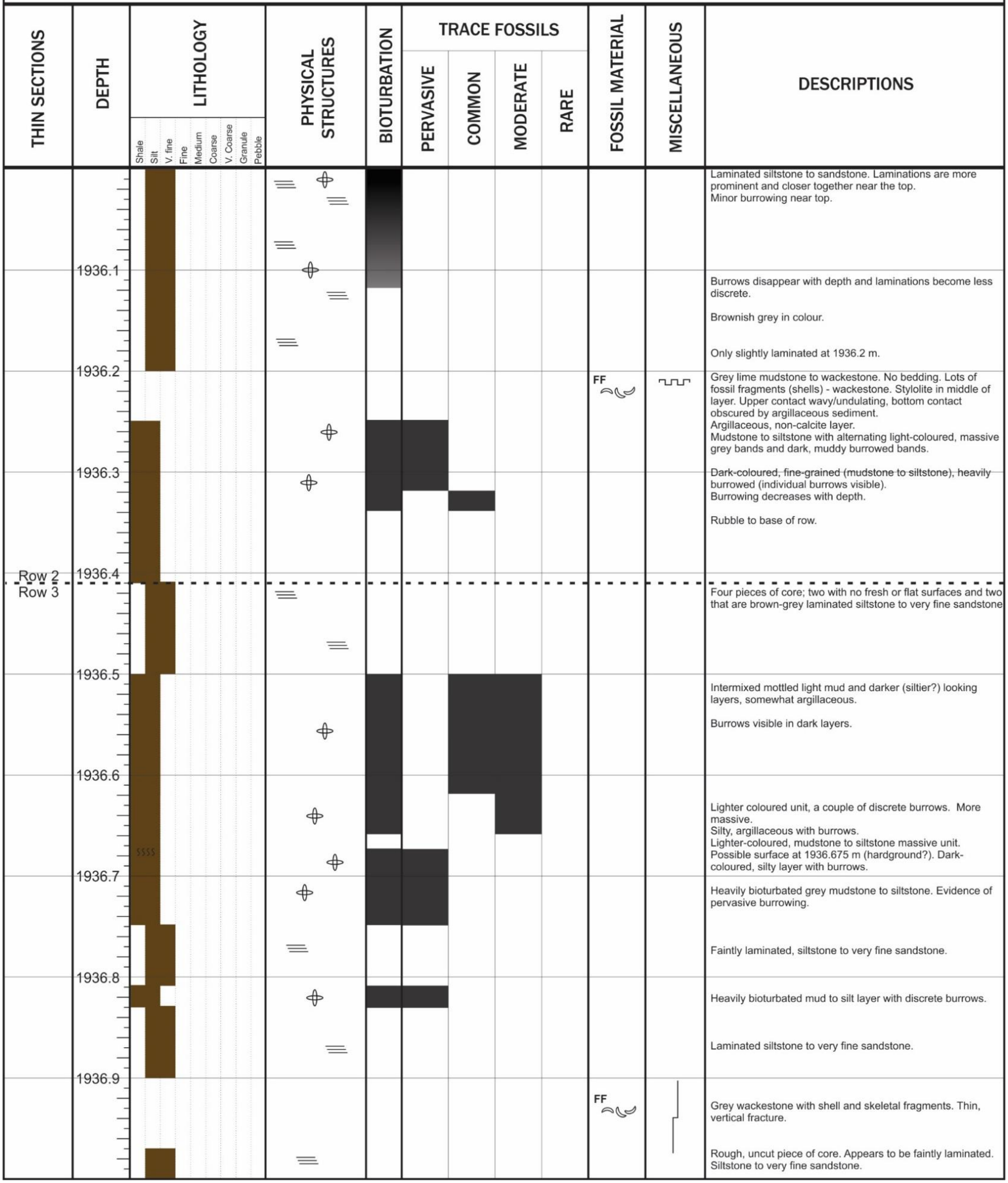
Underlain by a centimetre of argillaceous dark sediment with burrows.

Rough core. No fresh or flat surface. Appears massive, silt to very fine sand.
Possible pyrite.

Figure A6 continued: Core description for Freydis B-87, Core #1.

Well Location: Labrador Margin (Hopedale Basin) Fm/Strat. Unit: Paleozoic Page: 3

Well Name: Freydis B-87 Core interval: 1934.87 - 1941.29 m; Core #1



Laminated siltstone to sandstone. Laminations are more prominent and closer together near the top.
Minor burrowing near top.

Burrows disappear with depth and laminations become less discrete.

Brownish grey in colour.

Only slightly laminated at 1936.2 m.

Grey lime mudstone to wackestone. No bedding. Lots of fossil fragments (shells) - wackestone. Stylolite in middle of layer. Upper contact wavy/undulating, bottom contact obscured by argillaceous sediment.
Argillaceous, non-calcite layer.
Mudstone to siltstone with alternating light-coloured, massive grey bands and dark, muddy burrowed bands.

Dark-coloured, fine-grained (mudstone to siltstone), heavily burrowed (individual burrows visible).
Burrowing decreases with depth.

Rubble to base of row.

Four pieces of core; two with no fresh or flat surfaces and two that are brown-grey laminated siltstone to very fine sandstone

Intermixed mottled light mud and darker (siltier?) looking layers, somewhat argillaceous.

Burrows visible in dark layers.

Lighter coloured unit, a couple of discrete burrows. More massive.
Silty, argillaceous with burrows.
Lighter-coloured, mudstone to siltstone massive unit.
Possible surface at 1936.675 m (hardground?). Dark-coloured, silty layer with burrows.

Heavily bioturbated grey mudstone to siltstone. Evidence of pervasive burrowing.

Faintly laminated, siltstone to very fine sandstone.

Heavily bioturbated mud to silt layer with discrete burrows.

Laminated siltstone to very fine sandstone.

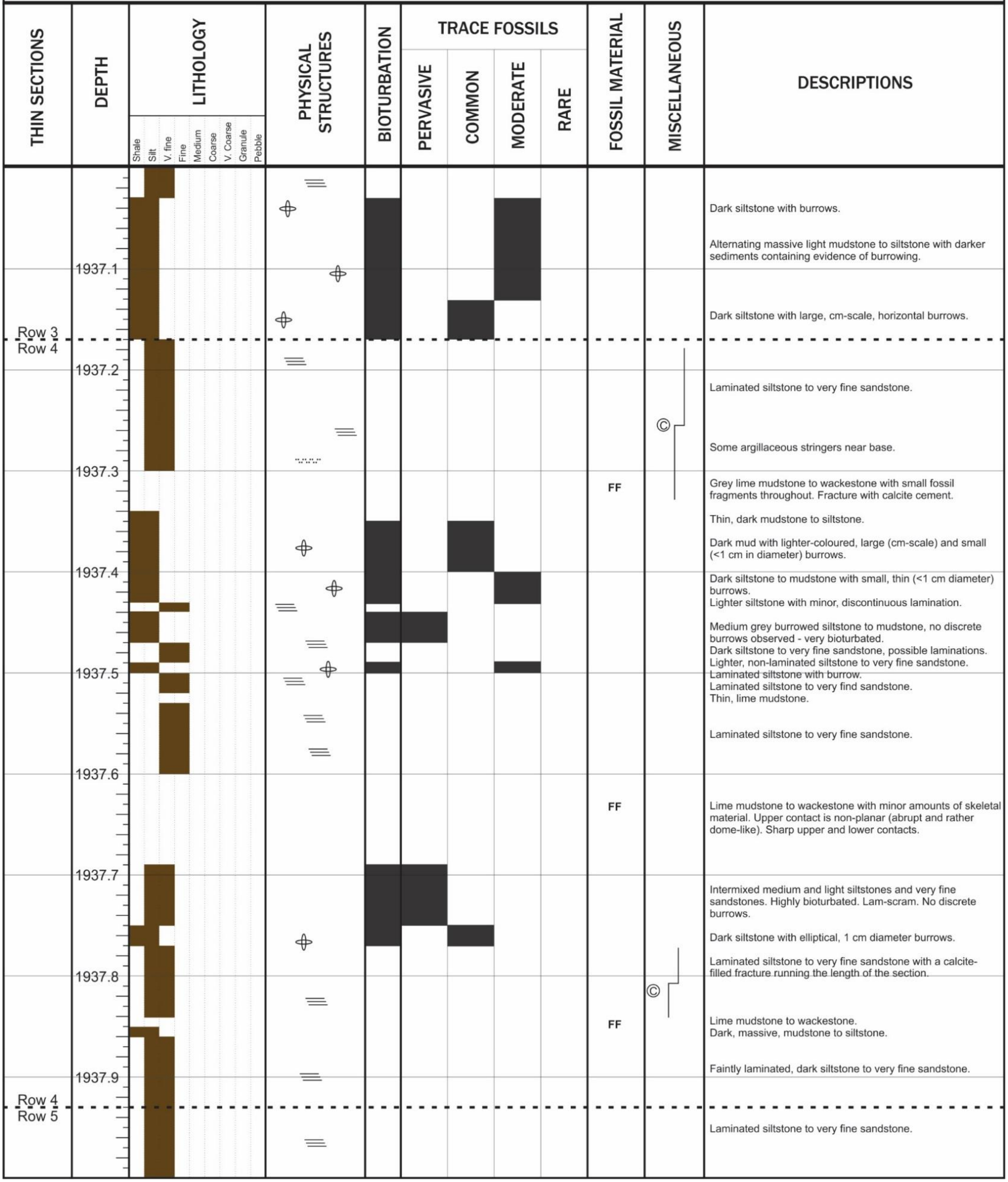
Grey wackestone with shell and skeletal fragments. Thin, vertical fracture.

Rough, uncut piece of core. Appears to be faintly laminated. Siltstone to very fine sandstone.

Figure A6 continued: Core description for Freydis B-87, Core #1.

Well Location: Labrador Margin (Hopedale Basin)
Fm/Strat. Unit: Paleozoic
Page: 4

Well Name: Freydis B-87
Core interval: 1934.87 - 1941.29 m; Core #1



Dark siltstone with burrows.

Alternating massive light mudstone to siltstone with darker sediments containing evidence of burrowing.

Dark siltstone with large, cm-scale, horizontal burrows.

Laminated siltstone to very fine sandstone.

Some argillaceous stringers near base.

Grey lime mudstone to wackestone with small fossil fragments throughout. Fracture with calcite cement.

Thin, dark mudstone to siltstone.

Dark mud with lighter-coloured, large (cm-scale) and small (<1 cm in diameter) burrows.

Dark siltstone to mudstone with small, thin (<1 cm diameter) burrows.
Lighter siltstone with minor, discontinuous lamination.

Medium grey burrowed siltstone to mudstone, no discrete burrows observed - very bioturbated.
Dark siltstone to very fine sandstone, possible laminations.
Lighter, non-laminated siltstone to very fine sandstone.
Laminated siltstone with burrow.
Laminated siltstone to very find sandstone.
Thin, lime mudstone.

Laminated siltstone to very fine sandstone.

Lime mudstone to wackestone with minor amounts of skeletal material. Upper contact is non-planar (abrupt and rather dome-like). Sharp upper and lower contacts.

Intermixed medium and light siltstones and very fine sandstones. Highly bioturbated. Lam-scram. No discrete burrows.

Dark siltstone with elliptical, 1 cm diameter burrows.

Laminated siltstone to very fine sandstone with a calcite-filled fracture running the length of the section.

Lime mudstone to wackestone.
Dark, massive, mudstone to siltstone.

Faintly laminated, dark siltstone to very fine sandstone.

Laminated siltstone to very fine sandstone.

Figure A6 continued: Core description for Freydis B-87, Core #1.

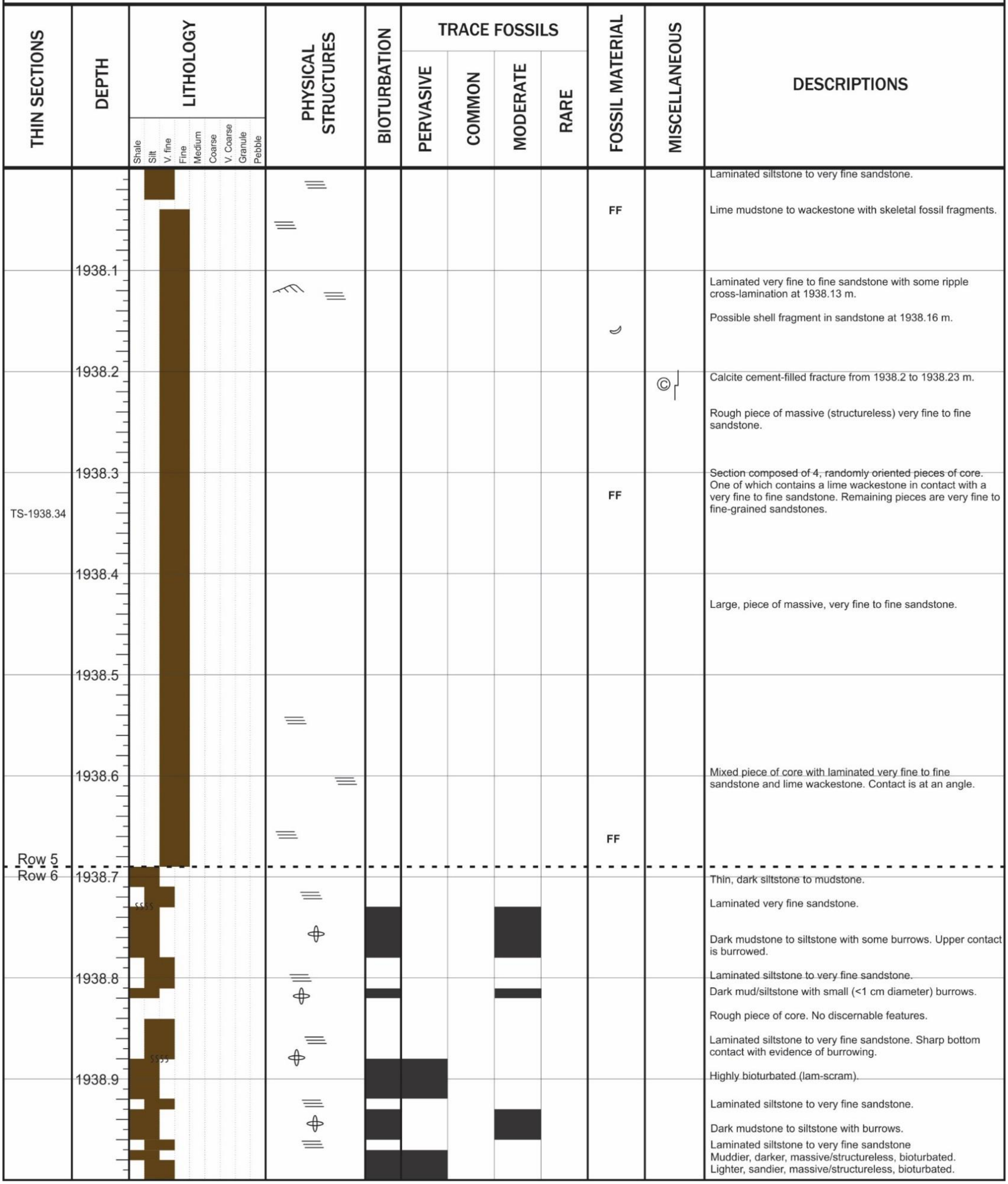
Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 5

Well Name: Freydis B-87

Core interval: 1934.87 - 1941.29 m; Core #1



Laminated siltstone to very fine sandstone.

Lime mudstone to wackestone with skeletal fossil fragments.

Laminated very fine to fine sandstone with some ripple cross-lamination at 1938.13 m.

Possible shell fragment in sandstone at 1938.16 m.

Calcite cement-filled fracture from 1938.2 to 1938.23 m.

Rough piece of massive (structureless) very fine to fine sandstone.

Section composed of 4, randomly oriented pieces of core. One of which contains a lime wackestone in contact with a very fine to fine sandstone. Remaining pieces are very fine to fine-grained sandstones.

Large, piece of massive, very fine to fine sandstone.

Mixed piece of core with laminated very fine to fine sandstone and lime wackestone. Contact is at an angle.

Thin, dark siltstone to mudstone.

Laminated very fine sandstone.

Dark mudstone to siltstone with some burrows. Upper contact is burrowed.

Laminated siltstone to very fine sandstone.

Dark mud/siltstone with small (<1 cm diameter) burrows.

Rough piece of core. No discernable features.

Laminated siltstone to very fine sandstone. Sharp bottom contact with evidence of burrowing.

Highly bioturbated (lam-scram).

Laminated siltstone to very fine sandstone.

Dark mudstone to siltstone with burrows.

Laminated siltstone to very fine sandstone

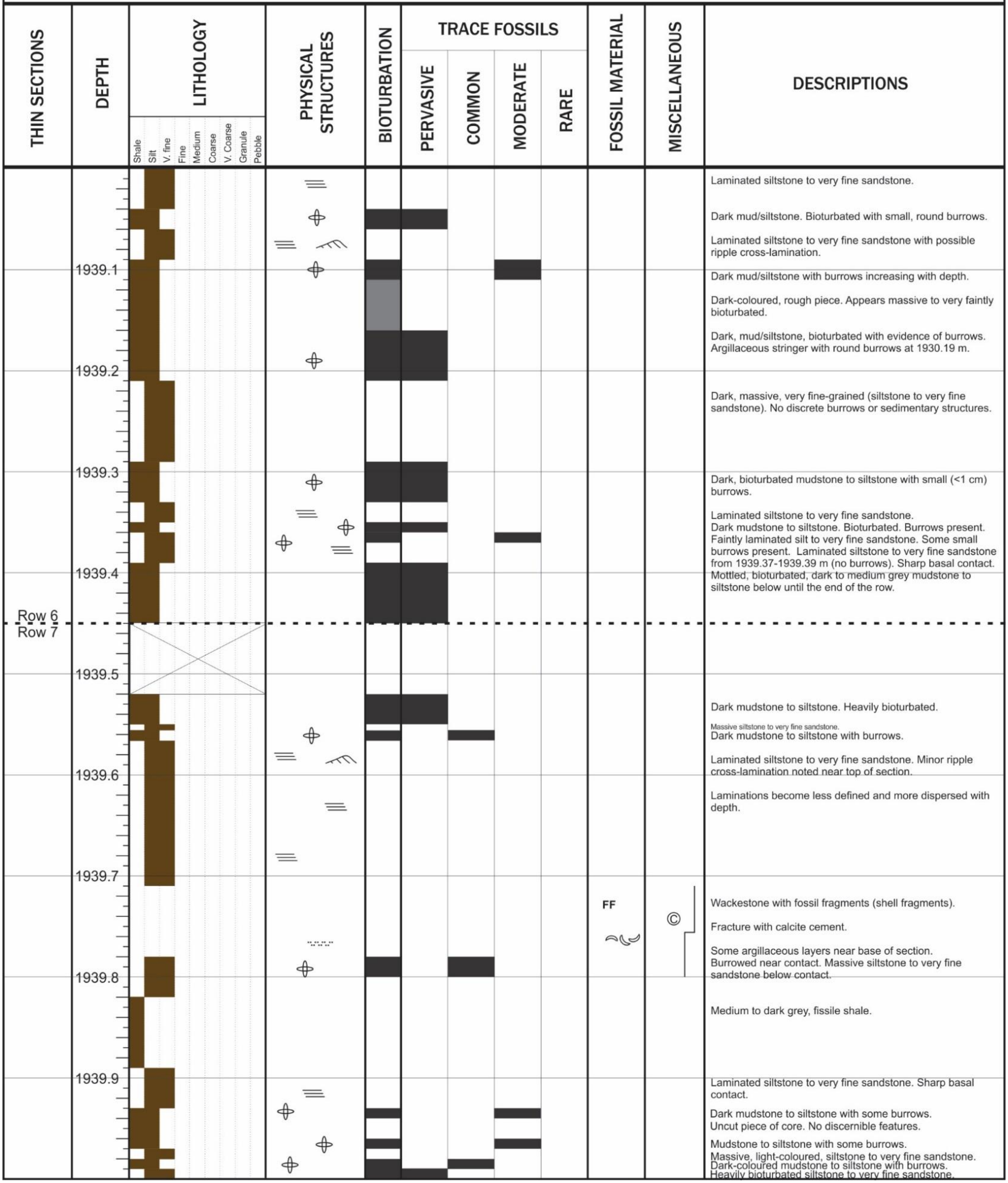
Muddier, darker, massive/structureless, bioturbated.

Lighter, sandier, massive/structureless, bioturbated.

Figure A6 continued: Core description for Freydis B-87, Core #1.

Well Location: Labrador Margin (Hopedale Basin)
Fm/Strat. Unit: Paleozoic
Page: 6

Well Name: Freydis B-87
Core interval: 1934.87 - 1941.29 m; Core #1



Laminated siltstone to very fine sandstone.

Dark mud/siltstone. Bioturbated with small, round burrows.

Laminated siltstone to very fine sandstone with possible ripple cross-lamination.

Dark mud/siltstone with burrows increasing with depth.

Dark-coloured, rough piece. Appears massive to very faintly bioturbated.

Dark, mud/siltstone, bioturbated with evidence of burrows. Argillaceous stringer with round burrows at 1930.19 m.

Dark, massive, very fine-grained (siltstone to very fine sandstone). No discrete burrows or sedimentary structures.

Dark, bioturbated mudstone to siltstone with small (<1 cm) burrows.

Laminated siltstone to very fine sandstone.
Dark mudstone to siltstone. Bioturbated. Burrows present.
Faintly laminated silt to very fine sandstone. Some small burrows present. Laminated siltstone to very fine sandstone from 1939.37-1939.39 m (no burrows). Sharp basal contact.
Mottled, bioturbated, dark to medium grey mudstone to siltstone below until the end of the row.

Dark mudstone to siltstone. Heavily bioturbated.

Massive siltstone to very fine sandstone.
Dark mudstone to siltstone with burrows.

Laminated siltstone to very fine sandstone. Minor ripple cross-lamination noted near top of section.

Laminations become less defined and more dispersed with depth.

Wackestone with fossil fragments (shell fragments).

Fracture with calcite cement.

Some argillaceous layers near base of section.
Burrowed near contact. Massive siltstone to very fine sandstone below contact.

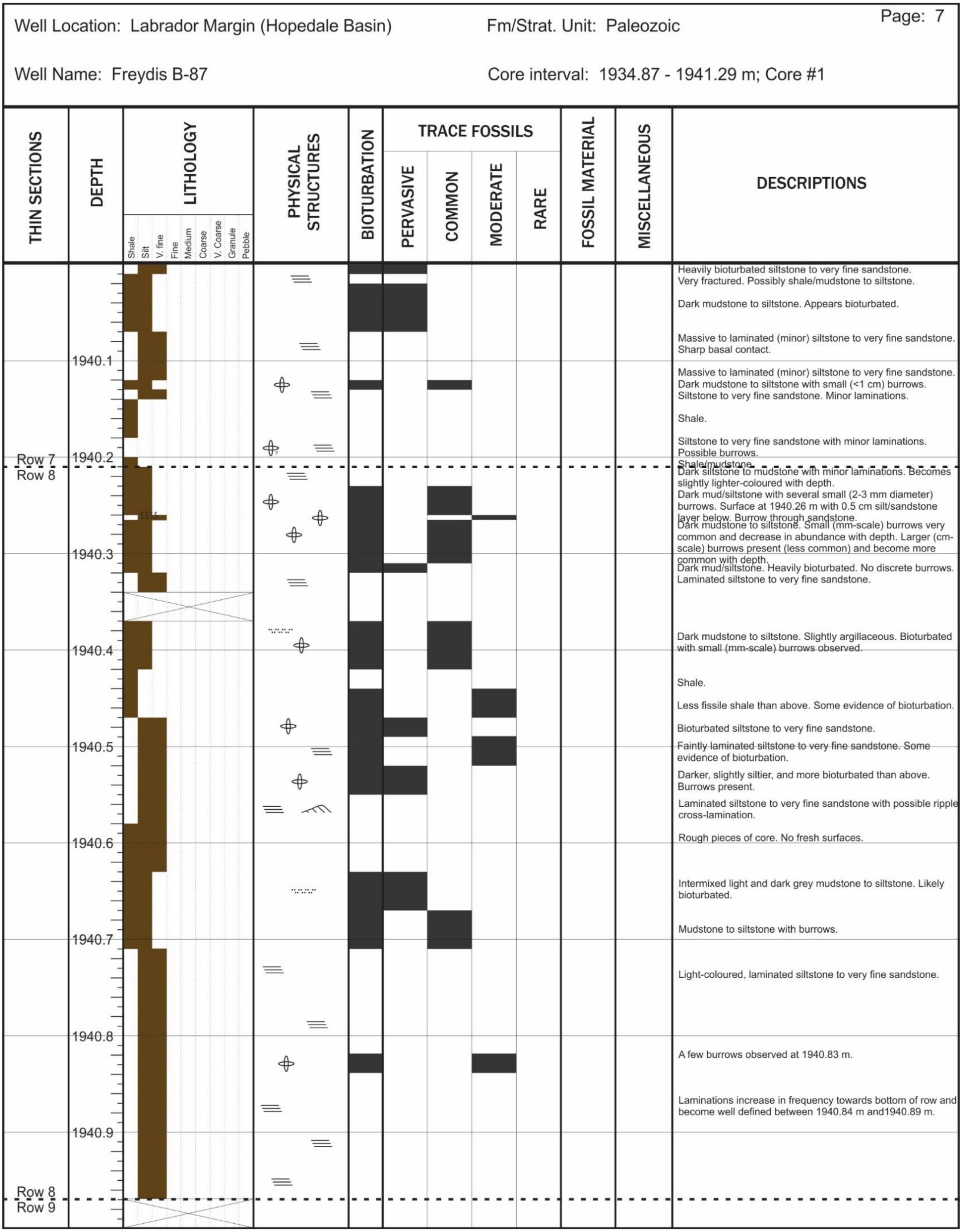
Medium to dark grey, fissile shale.

Laminated siltstone to very fine sandstone. Sharp basal contact.

Dark mudstone to siltstone with some burrows.
Uncut piece of core. No discernible features.

Mudstone to siltstone with some burrows.
Massive, light-coloured, siltstone to very fine sandstone.
Dark-coloured mudstone to siltstone with burrows.
Heavily bioturbated siltstone to very fine sandstone.

Figure A6 continued: Core description for Freydis B-87, Core #1.



Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 7

Well Name: Freydis B-87

Core interval: 1934.87 - 1941.29 m; Core #1

Heavily bioturbated siltstone to very fine sandstone.
Very fractured. Possibly shale/mudstone to siltstone.

Dark mudstone to siltstone. Appears bioturbated.

Massive to laminated (minor) siltstone to very fine sandstone.
Sharp basal contact.

Massive to laminated (minor) siltstone to very fine sandstone.
Dark mudstone to siltstone with small (<1 cm) burrows.
Siltstone to very fine sandstone. Minor laminations.

Shale.

Siltstone to very fine sandstone with minor laminations.
Possible burrows.
Shale/mudstone.
Dark siltstone to mudstone with minor laminations. Becomes slightly lighter-coloured with depth.
Dark mud/siltstone with several small (2-3 mm diameter) burrows. Surface at 1940.26 m with 0.5 cm silt/sandstone layer below. Burrow through sandstone.
Dark mudstone to siltstone. Small (mm-scale) burrows very common and decrease in abundance with depth. Larger (cm-scale) burrows present (less common) and become more common with depth.
Dark mud/siltstone. Heavily bioturbated. No discrete burrows.
Laminated siltstone to very fine sandstone.

Dark mudstone to siltstone. Slightly argillaceous. Bioturbated with small (mm-scale) burrows observed.

Shale.

Less fissile shale than above. Some evidence of bioturbation.

Bioturbated siltstone to very fine sandstone.

Faintly laminated siltstone to very fine sandstone. Some evidence of bioturbation.

Darker, slightly siltier, and more bioturbated than above.
Burrows present.

Laminated siltstone to very fine sandstone with possible ripple cross-lamination.

Rough pieces of core. No fresh surfaces.

Intermixed light and dark grey mudstone to siltstone. Likely bioturbated.

Mudstone to siltstone with burrows.

Light-coloured, laminated siltstone to very fine sandstone.

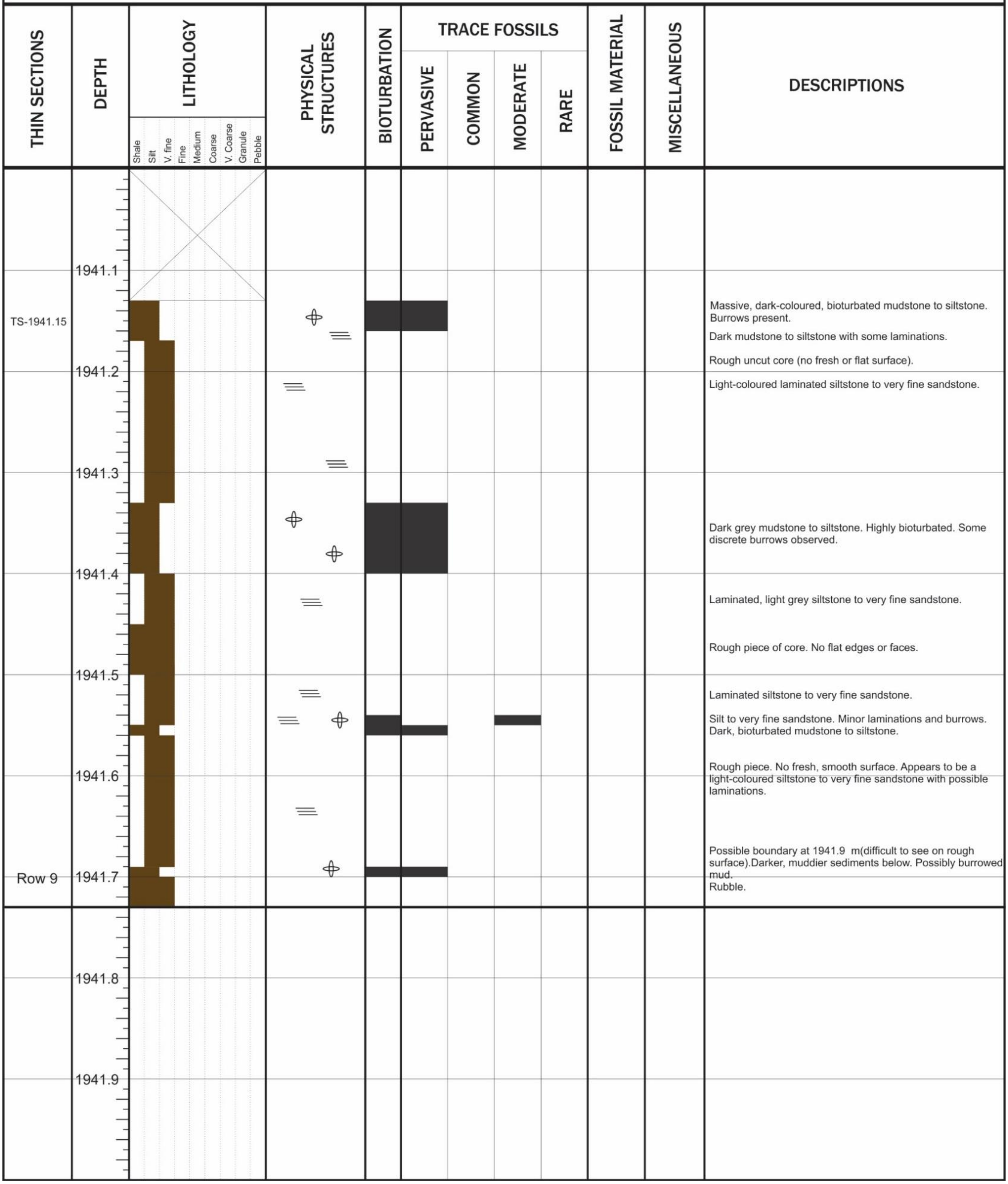
A few burrows observed at 1940.83 m.

Laminations increase in frequency towards bottom of row and become well defined between 1940.84 m and1940.89 m.

Figure A6 continued: Core description for Freydis B-87, Core #1.

Well Location: Labrador Margin (Hopedale Basin) Fm/Strat. Unit: Paleozoic

Well Name: Freydis B-87 Core interval: 1934.87 - 1941.29 m; Core #1



Massive, dark-coloured, bioturbated mudstone to siltstone. Burrows present.

Dark mudstone to siltstone with some laminations.

Rough uncut core (no fresh or flat surface).

Light-coloured laminated siltstone to very fine sandstone.

Dark grey mudstone to siltstone. Highly bioturbated. Some discrete burrows observed.

Laminated, light grey siltstone to very fine sandstone.

Rough piece of core. No flat edges or faces.

Laminated siltstone to very fine sandstone.

Silt to very fine sandstone. Minor laminations and burrows.

Dark, bioturbated mudstone to siltstone.

Rough piece. No fresh, smooth surface. Appears to be a light-coloured siltstone to very fine sandstone with possible laminations.

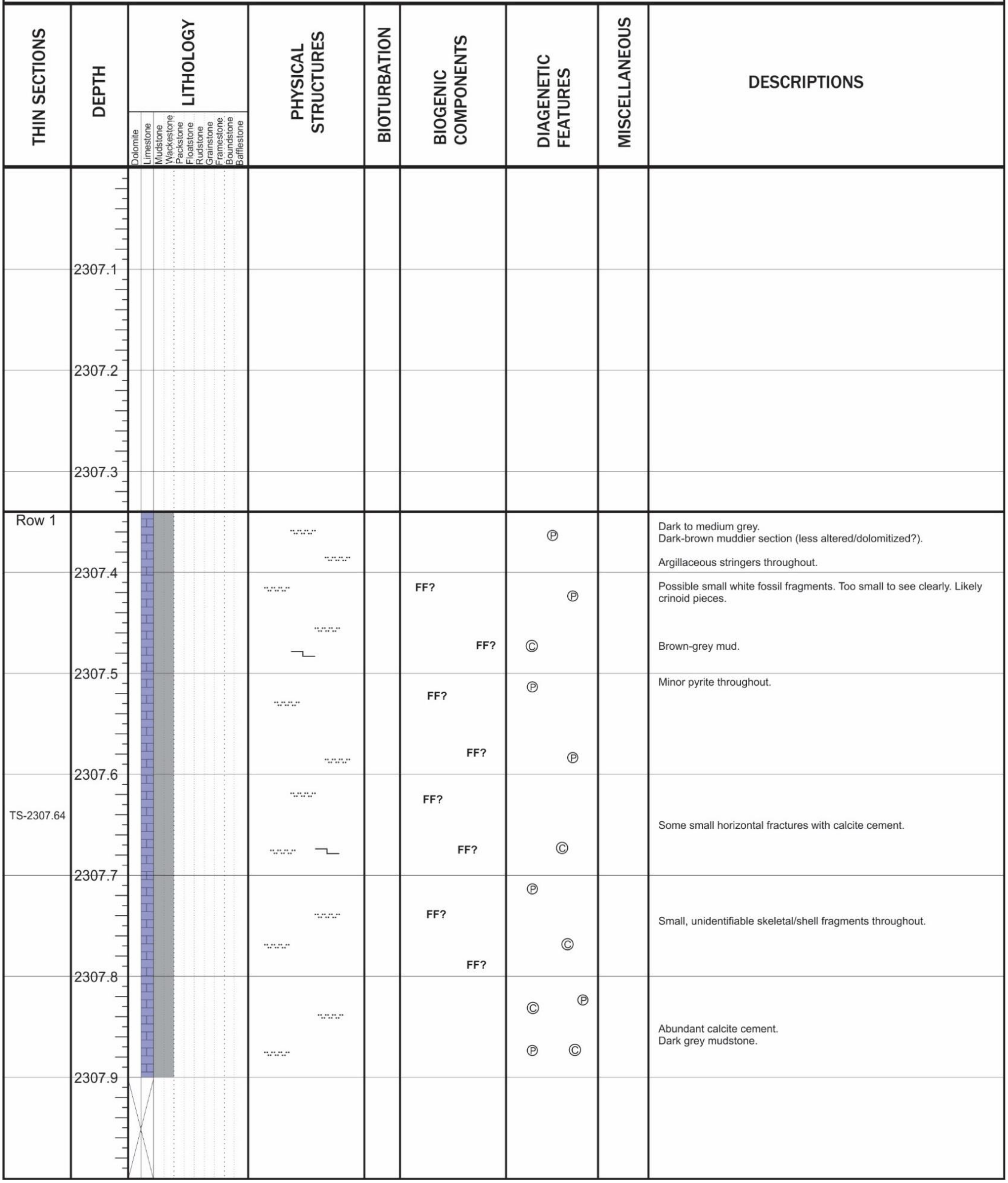
Possible boundary at 1941.9 m(difficult to see on rough surface).Darker, muddier sediments below. Possibly burrowed mud.

Rubble.

Figure A6 continued: Core description for Freydis B-87, Core #1.

Well Location: Labrador Margin (Hopedale Basin) Fm/Strat. Unit: Paleozoic Page: 1

Well Name: Freydis B-87 Core interval: 2307.34 - 2313.43 m; Core #2



Dark to medium grey.
Dark-brown muddier section (less altered/dolomitized?).

Argillaceous stringers throughout.

Possible small white fossil fragments. Too small to see clearly. Likely crinoid pieces.

Brown-grey mud.

Minor pyrite throughout.

Some small horizontal fractures with calcite cement.

Small, unidentifiable skeletal/shell fragments throughout.

Abundant calcite cement.
Dark grey mudstone.

Figure A7: Core description for Freydis B-87, Core #2.

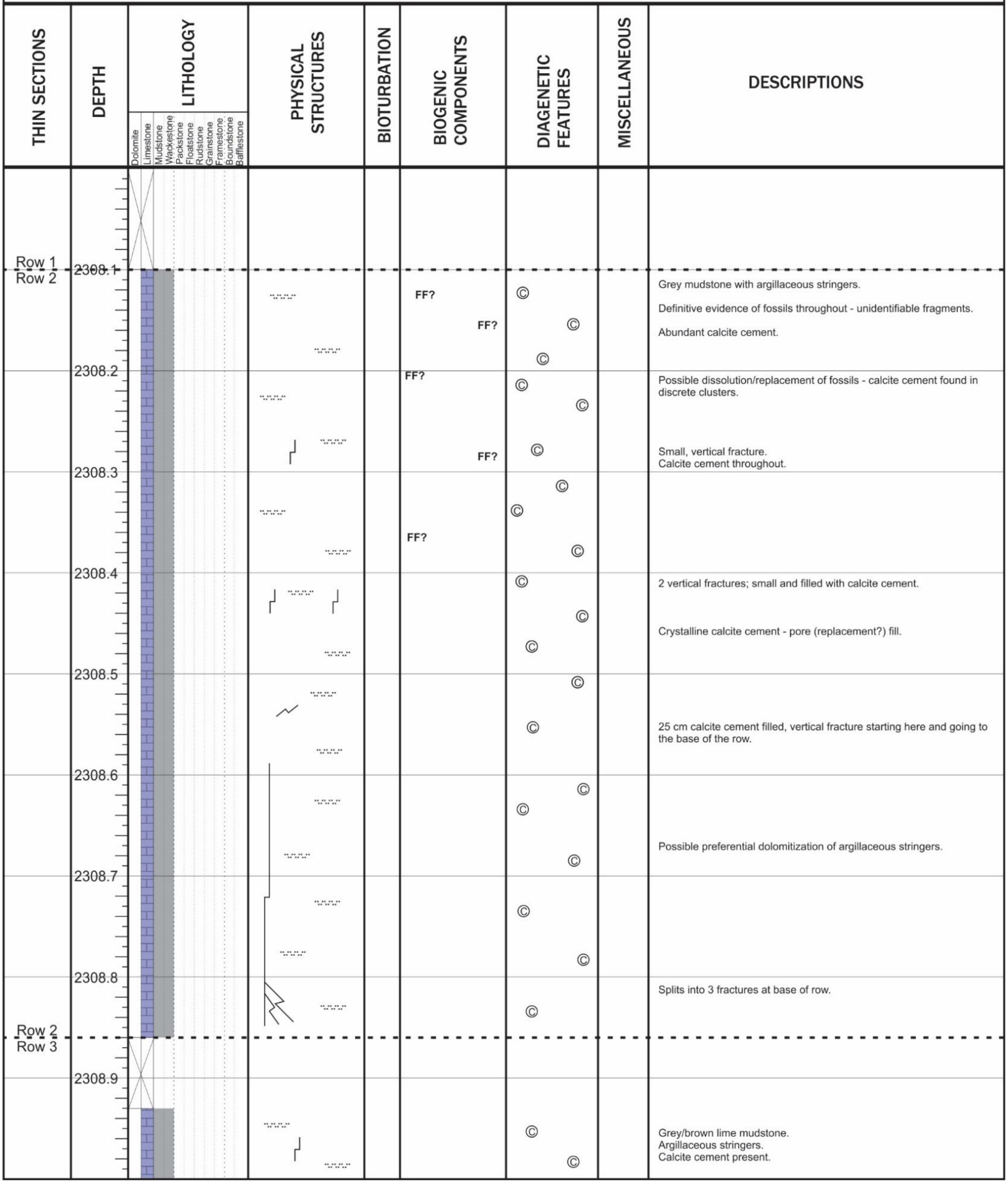
Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 2

Well Name: Freydis B-87

Core interval: 2307.34 - 2313.43 m; Core #2



Grey mudstone with argillaceous stringers.

Definitive evidence of fossils throughout - unidentifiable fragments.

Abundant calcite cement.

Possible dissolution/replacement of fossils - calcite cement found in discrete clusters.

Small, vertical fracture.
Calcite cement throughout.

2 vertical fractures; small and filled with calcite cement.

Crystalline calcite cement - pore (replacement?) fill.

25 cm calcite cement filled, vertical fracture starting here and going to the base of the row.

Possible preferential dolomitization of argillaceous stringers.

Splits into 3 fractures at base of row.

Grey/brown lime mudstone.
Argillaceous stringers.
Calcite cement present.

Figure A7 continued: Core description for Freydis B-87, Core #2.

Well Location: Labrador Margin (Hopedale Basin) Fm/Strat. Unit: Paleozoic Page: 3

Well Name: Freydis B-87 Core interval: 2307.34 - 2313.43 m; Core #2

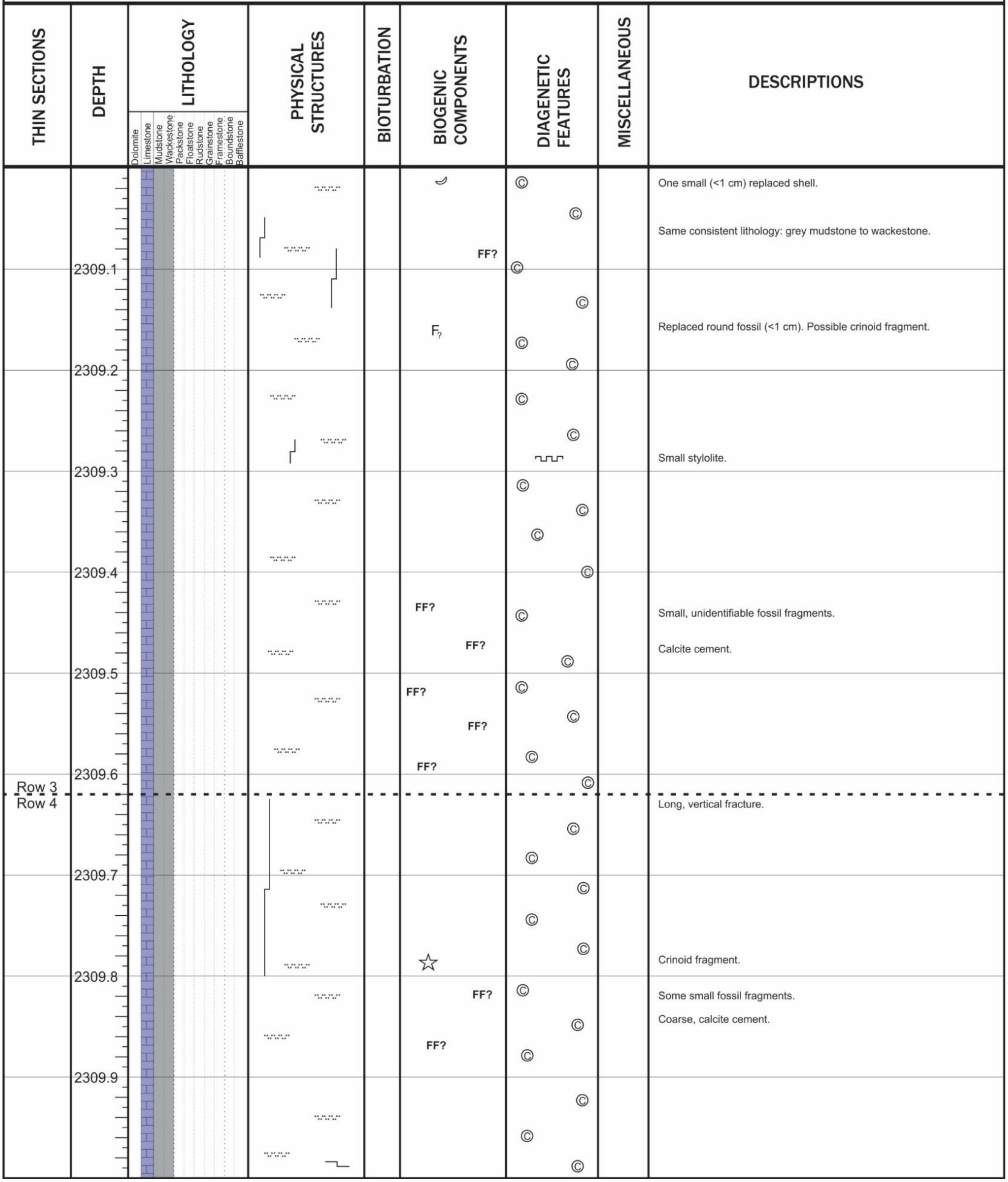
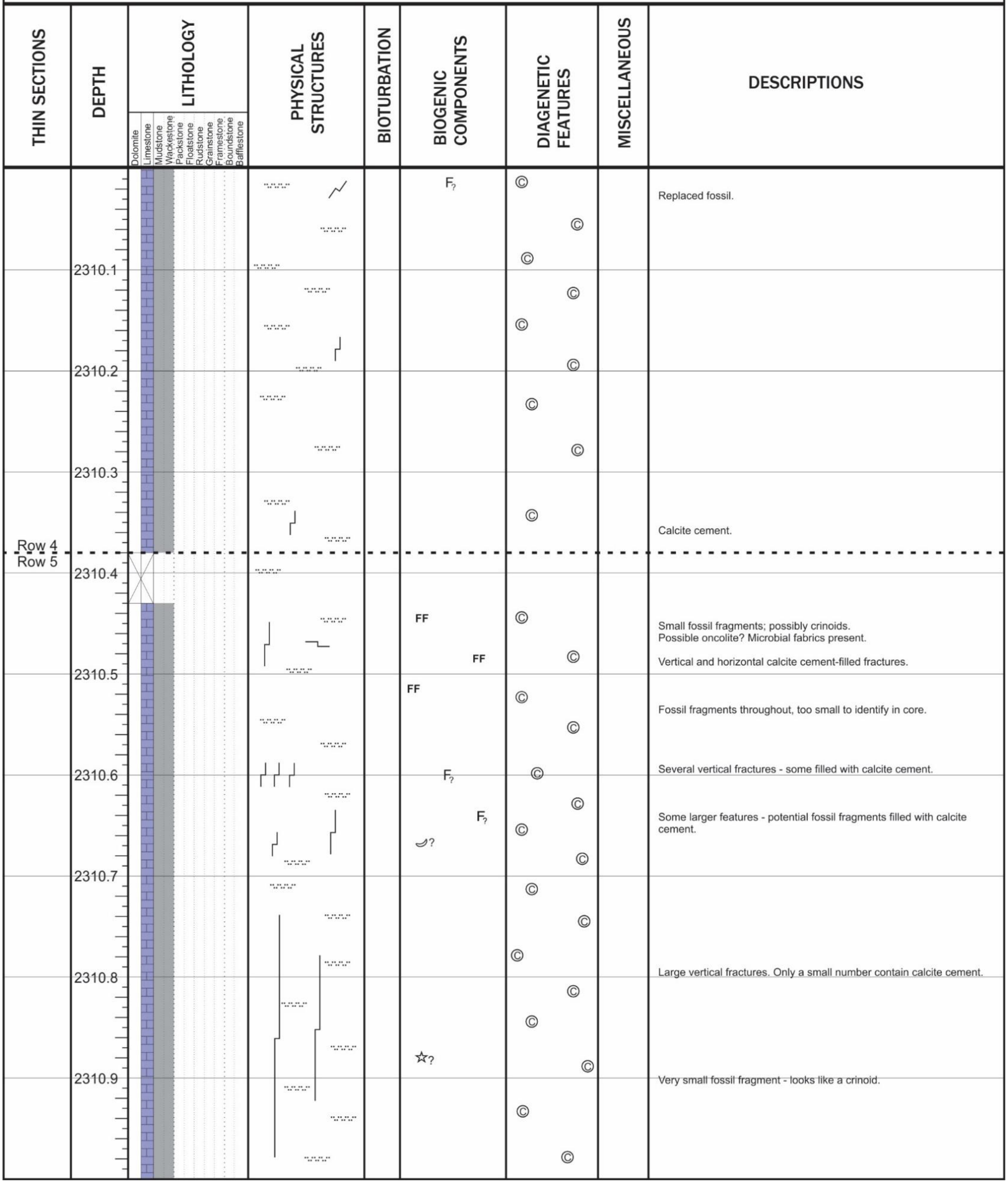


Figure A7 continued: Core description for Freydis B-87, Core #2.

Well Location: Labrador Margin (Hopedale Basin) | Fm/Strat. Unit: Paleozoic | Page: 4

Well Name: Freydis B-87 | Core interval: 2307.34 - 2313.43 m; Core #2



Replaced fossil.

Calcite cement.

Small fossil fragments; possibly crinoids.
Possible oncolite? Microbial fabrics present.

Vertical and horizontal calcite cement-filled fractures.

Fossil fragments throughout, too small to identify in core.

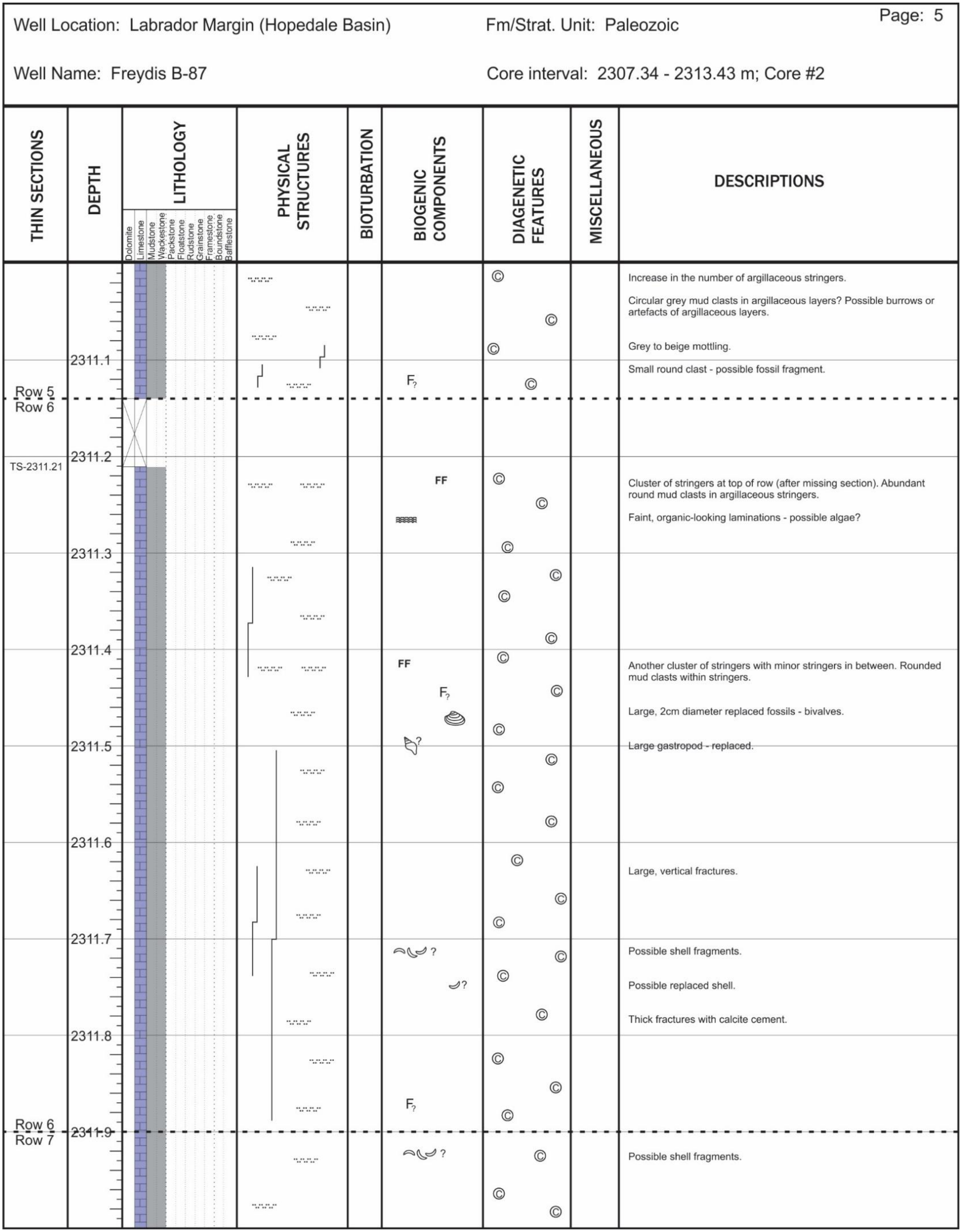
Several vertical fractures - some filled with calcite cement.

Some larger features - potential fossil fragments filled with calcite cement.

Large vertical fractures. Only a small number contain calcite cement.

Very small fossil fragment - looks like a crinoid.

Figure A7 continued: Core description for Freydis B-87, Core #2.



Increase in the number of argillaceous stringers.

Circular grey mud clasts in argillaceous layers? Possible burrows or artefacts of argillaceous layers.

Grey to beige mottling.

Small round clast - possible fossil fragment.

Cluster of stringers at top of row (after missing section). Abundant round mud clasts in argillaceous stringers.

Faint, organic-looking laminations - possible algae?

Another cluster of stringers with minor stringers in between. Rounded mud clasts within stringers.

Large, 2cm diameter replaced fossils - bivalves.

~~Large gastropod - replaced.~~

Large, vertical fractures.

Possible shell fragments.

Possible replaced shell.

Thick fractures with calcite cement.

Possible shell fragments.

Figure A7 continued: Core description for Freydis B-87, Core #2.

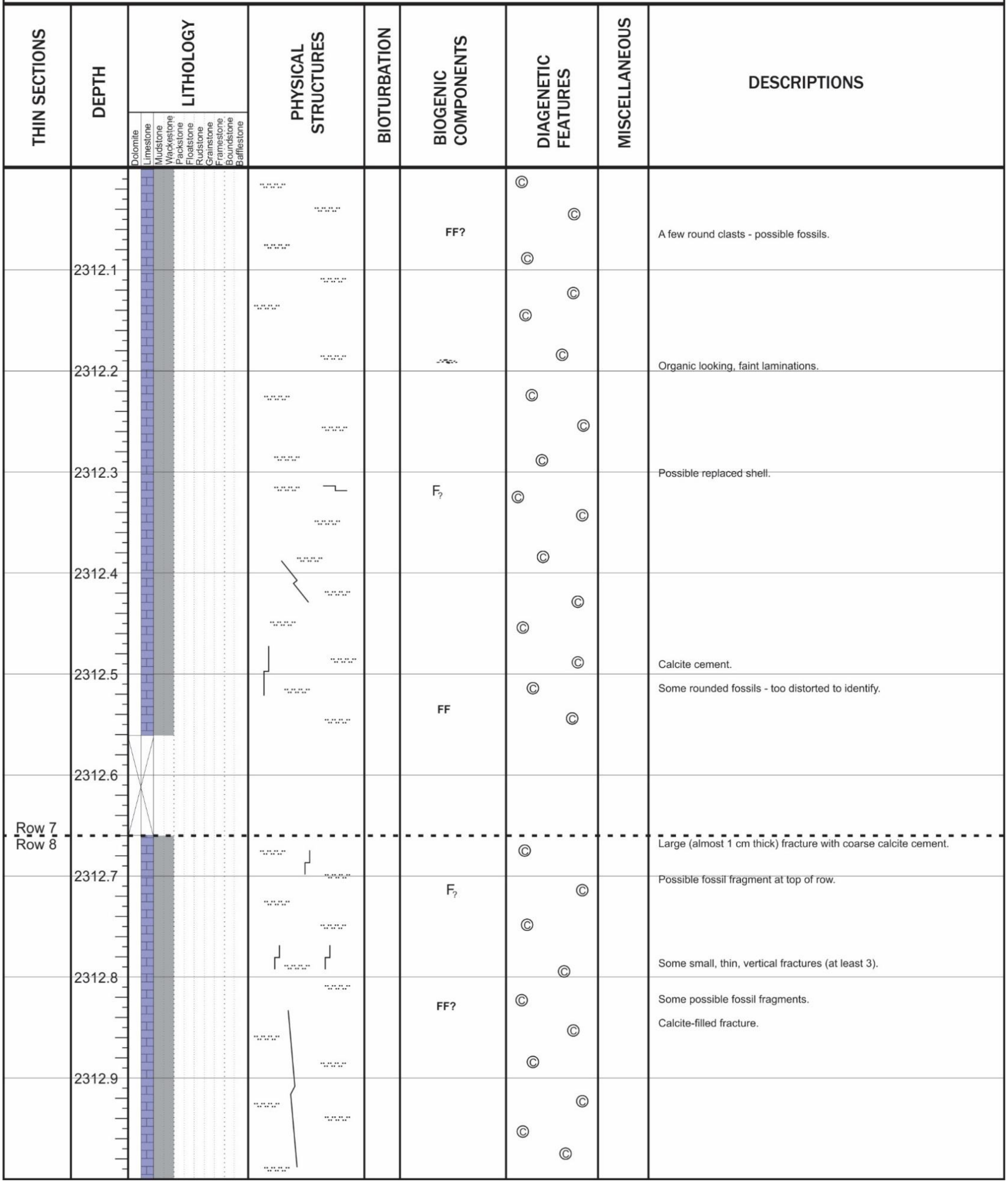
Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Page: 6

Well Name: Freydis B-87

Core interval: 2307.34 - 2313.43 m; Core #2



A few round clasts - possible fossils.

Organic looking, faint laminations.

Possible replaced shell.

Calcite cement.

Some rounded fossils - too distorted to identify.

Large (almost 1 cm thick) fracture with coarse calcite cement.

Possible fossil fragment at top of row.

Some small, thin, vertical fractures (at least 3).

Some possible fossil fragments.

Calcite-filled fracture.

Figure A7 continued: Core description for Freydis B-87, Core #2.

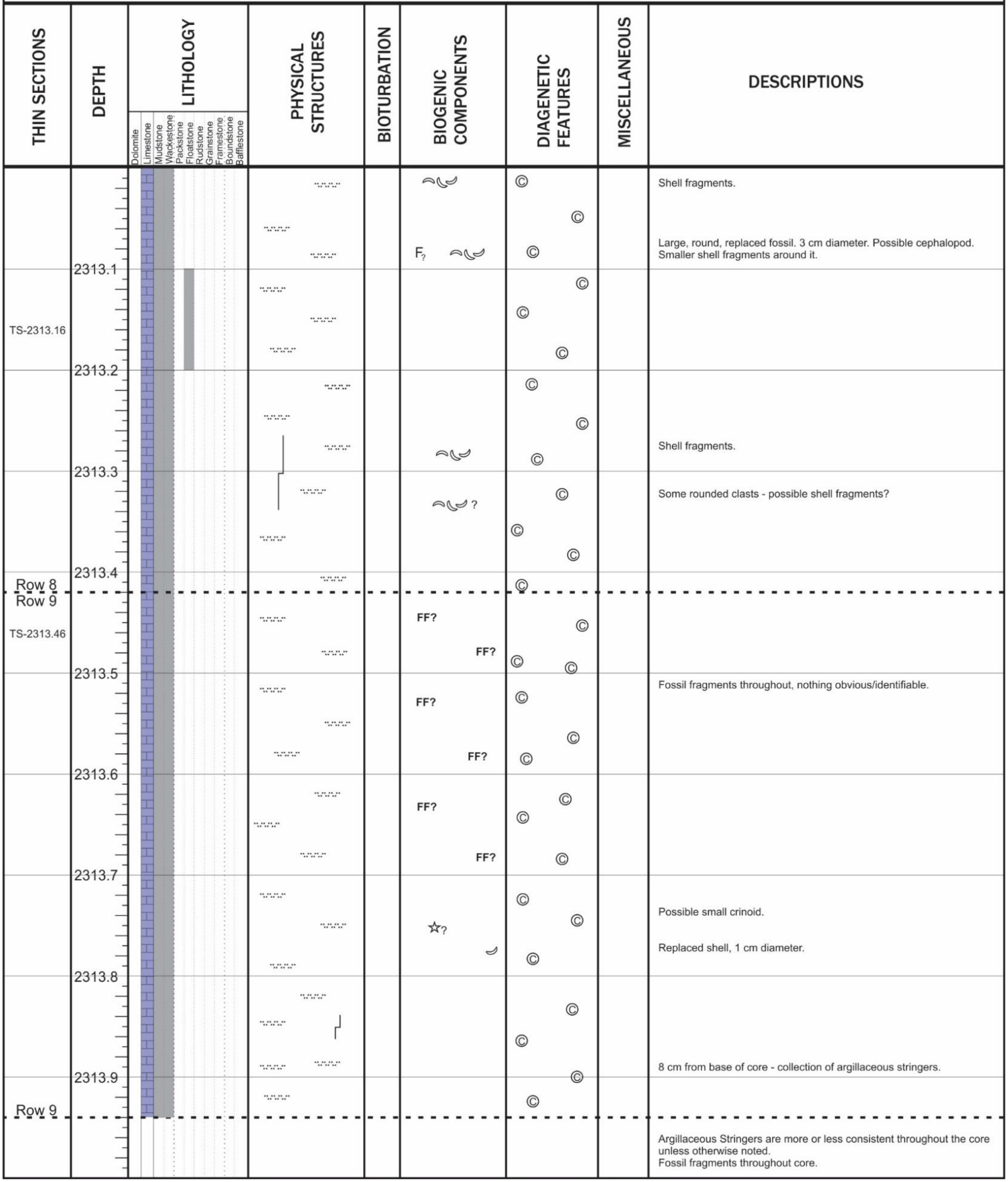
Page: 7

Well Location: Labrador Margin (Hopedale Basin)

Fm/Strat. Unit: Paleozoic

Well Name: Freydis B-87

Core interval: 2307.34 - 2313.43 m; Core #2



Shell fragments.

Large, round, replaced fossil. 3 cm diameter. Possible cephalopod. Smaller shell fragments around it.

Shell fragments.

Some rounded clasts - possible shell fragments?

Fossil fragments throughout, nothing obvious/identifiable.

Possible small crinoid.

Replaced shell, 1 cm diameter.

8 cm from base of core - collection of argillaceous stringers.

Argillaceous Stringers are more or less consistent throughout the core unless otherwise noted.
Fossil fragments throughout core.

Figure A7 continued: Core description for Freydis B-87, Core #2.

Appendix B - Thin section descriptions

Table B1: Thin sections

Well	Core #	Depth of thin section (m)	Vintage
Gudrid H-55	1	2676.44	2017
	1	2677.78	2017
	1	2677.85	Archived
	1	2678.06	2017
	1	2678.98	2017
	1	2679.43	2017
Roberval K-92	6	3578.06	Archived
	6	3578.38	Archived
	6	3578.69	2017
	6	3578.78	2017
	6	3578.96	2017
	6	3579.1	Archived
	6	3580	Archived
	6	3581	Archived
	7	3870	Archived
	7	3870.5	Archived
	7	3870.85	2017
	7	3870.9	Archived
	7	3871.45	2017
	7	3872	Archived
	7	3872.34	Archived
	7	3872.8	2017
	7	3873.3	Archived
Indian harbour M-52	1	3952.48	Archived
	1	3952.54	Archived
	1	3952.69	Archived
	1	3952.91	Archived
	1	3952.94	Archived
	1	3953.09	Archived
	1	3953.73	Archived
	1	3954.22	Archived
	1	3954.49	Archived
	1	3955.35	Archived
	1	3956.2	Archived
	1	3956.47	Archived
Freydis B-87	1	1935.6	2017
	1	1935.79	2017
	1	1938.34	2017
	1	1941.15	2017
	2	2307.64	2017
	2	2311.21	2017
	2	2313.16	2017
	2	2313.46	Archived

Gudrid H-55

2676.44 m

Gudrid H-55
2676.44 m

Well: Gudrid H-55
Core #: 1
Depth: 2676.44 m
Vintage: 2017
Lithology:

- Carbonate
  - Dolostone

Composition:

- Pervasive dolomitization
  - Subhedral to euhedral dolomite common
  - Euhedral limpid dolomite rhombs in some areas
  - Varying sizes of dolomite crystals
    - Smaller, finer crystals in some areas – perhaps a secondary phase
      - Occurs as possible fracture and/or pore fill
  - Zoning present in some crystals (more common in euhedral crystals)
    - Limpid to multilayered
  - Fabric-destructive
  - Subhedral dolomite crystals tend to be un-zoned and have a relatively dirty, buff-coloured appearance
  - Colour intensity varies possibly indicating some ghost textures (bioturbation?)
- Calcite cement in areas
- Minor opaque minerals disseminated throughout

Paleontology:

- No obvious fossil content

Sedimentary structures:

- Fractures present
  - Some contain euhedral dolomite along edges

2677.78 m

Gudrid H-55
2677.78 m

Well: Gudrid H-55
Core #: 1
Depth: 2676.78 m
Vintage: 2017
Lithology:

- Carbonate
    - Dolostone

Composition:

- Pervasively dolomitized
    - Subhedral to euhedral dolomite crystals
        - Dolomite tends to be zoned (euhedral dolomite) and is more common in less dense areas
        - Anhedral to subhedral crystals tend to be un-zoned and have a relatively dirty/cloudy, buff-coloured appearance
    - Fabric-destructive dolomite
    - Areas with zoned dolomite
        - Limpid to multilayered
        - Zoning and limpid dolomite tend to occur as euhedral dolomite
    - Size of dolomite crystals varies
        - Areas with higher concentrations of smaller, finer dolomite crystals
- Opaque minerals scattered throughout
    - Some occur in small clusters
    - Likely pyrite
- Some background and pore-filling calcite cement

Paleontology:

- No obvious fossil content
- Possible ghost fossils and textures

Sedimentary structures:

- Fractures present
    - Some contain calcite cement
    - One with a high concentration of pyrite

2677.85 m

Well: Gudrid H-55
Core #: 1
Depth: 2676.85 m
Vintage: Archived
Lithology:

- Carbonate
    - Dolostone

Composition:

- Pervasive, fabric-destructive dolomitization
    - Much of the slide is composed of anhedral to subhedral, dirty/cloudy (not clear), buff to grey dolomite crystals. Appears mottled
    - Some distinct pockets of limpid dolomite present especially in less dense areas such as around pore and fracture edges
    - Limpid and non-limpid dolomite intermixed in other areas
- No calcite cement
- Opaque minerals present (likely pyrite)
    - Occur in good-sized, inter-crystalline clusters (do not tend to occur in pores and fractures but rather in between crystals)
    - Also occur disseminated throughout slide

Paleontology:

- No obvious fossil content
- Mottled appearance may be indication of previous bioturbation

Sedimentary structures:

- Pores and fractures common

2678.06 m

Well: Gudrid H-55
Core #: 1
Depth: 2678.06 m

Vintage: 2017
Lithology:

- Carbonate
  - Dolostone

Composition:

- Predominantly fabric-destructive dolomite
  - Dolomite consists of intermixed larger and smaller crystals
  - Majority of crystals are cloudy/dirty in appearance (anhedral to subhedral)
  - Some limpid dolomite present, especially near edges of fractures or pores
  - Dolomite occurs largely as subhedral crystals. Euhedral dolomite rhombs occur in the less dense areas such as pores and fractures and is associated with limpid dolomite
- Opaque minerals (pyrite) present
- Calcite cement noted in some fractures
- Evidence of a pre-diagenetic argillaceous layer/texture

Paleontology:

- One possible altered and replaced shell fragment

Sedimentary structures:

- Pores and fractures

2678.98 m

Gudrid H-55
2678.98 m

Well: Gudrid H-55
Core #: 1
Depth: 2678.98 m
Vintage: 2017
Lithology:

- Carbonate
  - Dolostone

Composition:

- Subhedral to euhedral, fabric-destructive dolomite
  - Intermixed smaller and larger crystal fractions
  - Increase in euhedral crystals in less dense areas
  - Clarity of dolomite varies from almost clear to dirty/cloudy
  - Some limpid dolomite observed
  - Multilayered zoning observed in some euhedral crystals
- Calcite cement in some pores
- Opaque minerals present. Occur disseminated throughout as well as in clusters
  - Also occur in between dolomite crystals

Paleontology:

- No obvious fossil content
- There are some patches where the dolomite appears less cloudy. These tend to be circular in shape and may indicate the presence of previous burrows

Sedimentary structures:

- Fractures

2679.43 m

Well: Gudrid H-55
Core #: 1
Depth: 2679.43 m
Vintage: 2017
Lithology:

- Carbonate
    - Dolostone

Composition:

- Pervasive, subhedral to euhedral, fabric-destructive dolomite
    - The number of euhedral crystals and the degree of zonation appears greatest in this thin section when compared to the rest of the Gudrid H-55 slides
    - Intermixed small and large dolomite crystal fractions
    - Zoning evident in some of the euhedral dolomite
    - Clarity of dolomite ranges from dirty/cloudy to limpid to clean
    - Dissolution of dolomite cores noted in some limpid crystals (tend to be more euhedral)
- Opaque minerals occur throughout
    - Can be disseminated or occur in clusters
    - Clusters/aggregations of opaque minerals are more common in voids/pores
- Calcite cement present. Can occur as isolated crystals or in patches

Paleontology:

- No obvious fossil content

Roberval K-92

3578.06 m

Well: Roberval K-92
Core #: 6
Depth: 3578.06 m
Vintage: Archived
Lithology:

- Carbonate
    - Dolostone

Composition:

- Pervasive dolomitization
    - Fabric-destructive
    - Appears to be two primary types of dolomite that are intermixed with one another
        - Smaller, granular, subhedral crystals that are clearer and appear somewhat grey
        - Subhedral to anhedral, dirtier/cloudier, larger crystals that are a buff colour
    - Subhedral to euhedral crystals near the edges of pores
        - Some zoning evident
- Opaque minerals are present
    - Tend to be scattered throughout, no major accumulations
- Hydrocarbons present
    - In some pores and fractures
- Very minor calcite cement (in pores and fractures)
- Possible dark grey micritic texture in some areas behind dolomite (gives dolomite a cloudy appearance)

Paleontology:

- Ghost textures and fossils visible – slight changes in the density, cloudiness, and colour of dolomite crystals

Sedimentary structures:

- Some vertical fractures – some are lined with hydrocarbon

3578.38 m

Well: Roberval K-92
Core #: 6
Depth: 3578.38 m
Vintage: Archived
Lithology:

- Carbonate
    - Dolostone

Composition:

- Pervasive, fabric-destructive dolomitization
- Two primary types of dolomite noted:
    - Smaller, subhedral to euhedral, grey-coloured, cleaner, granular looking dolomite
    - Slightly larger, buff-coloured, subhedral to anhedral, cloudier/dirtier
    - Abrupt transitions between the two types
    - Euhedral dolomite crystals observed near edges of pores
- Patches of calcite cement – possible replacement of ghost fossils
- Grey, micrite texture in some pores
- Hydrocarbon in some pores and fractures – some visible without magnification
- Ghost textures evident by variations in dolomite colour and clarity (mottled appearance)
- Very minor amount of opaque minerals scattered throughout thin section

Paleontology:

- Dissolved fossil shell

Sedimentary structures:

- Minor fractures

3578.69 m

Well: Roberval K-92

Core #: 6
Depth: 3578.69 m
Vintage: 2017
Lithology:

- Igneous
  - Mafic
  - Thin section created from large, dark grey/black-coloured piece of core

Composition:

- Several minerals present in various abundances
  - Plagioclase
    - High abundance
    - Bladed to rectangular crystals
  - Amphibole
  - Pyroxene
  - Larger, rounded mineral grains (unknown)
  - 10-15% are opaque minerals; primarily a cubic mineral (sulphide of some sort)
- Relatively coarse grained
- Mafic igneous mineral assemblage
  - Possible gabbro?

Paleontology:

- Igneous (no fossil content)

Sedimentary structures:

- Small fracture

3578.78 m

Well: Roberval K-92
Core #: 6
Depth: 3578.78 m
Vintage: 2017
Lithology:

- Carbonate
  - Dolostone

Composition:

- Fine-grained, fabric-destructive dolomite
  - Density of dolomite varies throughout the thin section
  - Anhedral to subhedral dolomite
    - Crystal boundaries not that well defined
    - Cloudy/dirty dolomite – no defined rims or zonation

        - In higher density areas
    - Subhedral to euhedral dolomite
        - Majority is limpid dolomite – cloudy cores and clear rims
        - In less dense regions
- Evidence of some original textures possible
    - Possible peloidal texture
    - Thin section appears mottled possibly indicating bioturbation
    - Denser, buff-coloured sections appear to occur in rounded to square patches
- Patch of calcite cement - may represent original placement of a fossil
- Very minor amount of opaque minerals

Paleontology:
- 2 possible echinoderm fragments

Sedimentary structures:
- Somewhat vuggy texture – small cavities throughout

3578.96 m

Roberval K-92
3578.96 m

Well: Roberval K-92
Core #: 6
Depth: 3578.96 m
Vintage: 2017
Lithology:
- Carbonate
    - Dolostone

Composition:
- Pervasive, fabric-destructive dolomite
    - Dolomite is very fine – smallest crystals observed in Roberval K-92
    - Sucrosic nature to dolomite
    - Subhedral to anhedral dolomite
    - Predominantly cloudy/dirty dolomite
    - Some crystals seem to have better defined edges and may show some evidence of zoning (limpid dolomite), however crystals are too small to definitively classify the dolomite
- Opaque minerals present
    - Tend to occur in inter-crystalline pores, along the edges between crystals
- Hydrocarbons present
    - Lining pores and fractures
    - Pores and fractures are very small making it difficult to describe the hydrocarbon content

    - The amount of hydrocarbon is not consistent throughout the thin section
        - Higher concentration in upper right section of thin section
        - The left bottom portion of the slide is rather clean with respect to hydrocarbons
- No mottling noted
- Rare to absent opaque minerals

Paleontology:
- No obvious fossil content

Sedimentary structures:
- Several small fractures
    - Only some fractures contain evidence of hydrocarbons
    - Hydrocarbon along edges, lining fractures
- Small pores common to abundant

3579.1 m

Well: Roberval K-92
Core #: 6
Depth: 3579.1 m
Vintage: Archived
Lithology:
- Carbonate
    - Dolostone

Composition:
- Pervasive, fabric-destructive dolomite
    - Small, granular (sucrosic), subhedral to anhedral (predominantly anhedral) dolomite crystals
    - Minor colour variation noted in dolomite throughout slide (grey to buff coloured) – possibly related to original textures/lithology
- Hydrocarbons in some fractures and in the stylolite
- Minor amount of opaque minerals disseminated throughout the thin section
- A grey, micritic texture in one section
- Calcite cement in possible ghost fossil

Paleontology:
- Colour variation and ghost textures may be indicative of bioturbation
- Possible ghost fossils

Sedimentary structures:
- Fractures
    - Some of which contain hydrocarbons
- Stylolite

3580 m

Well: Roberval K-92
Core #: 6
Depth: 3580 m
Vintage: Archived
Lithology:

- Carbonate
    - Dolostone

Composition:

- Pervasive, fabric-destructive dolomitization
    - Sucrosic, small-granular, anhedral to euhedral dolomite
    - Subhedral to euhedral limpid dolomite near pore and fracture edges
    - Minor amounts of larger, buff-coloured, anhedral to subhedral dolomite
- Organic material present in some of the pores and fractures as well as in the stylolite

Paleontology:

- No obvious fossil content (no ghost fossils or textures)

Sedimentary structures:

- Minor, small fractures
- Small stylolite

3581 m

Well: Roberval K-92
Core #: 6
Depth: 3581 m
Vintage: Archived
Lithology:

- An altered carbonate of some type
    - Thin section belongs to GSC archives and as such, the original sample is not known

    - The depth is recorded as 3581 m. However there was no core described at this depth likely due to the core shifting in the boxes over the years
    - The last almost meter of Core #6 from Roberval K-92 is composed of rubble that includes buff-coloured limestone pieces as well as blue-green mudstones. It is possible that this thin section was made from one of these pieces of rubble

Composition:

- Large patches of an orange-coloured mineral.
    - Fibrous appearance
    - May be a product of alteration
    - Possibly siderite or sphalerite or some other diagenetic mineral
    - Very abundant in pores and in inter-crystalline spaces
    - Exhibits fracturing
- Opaque minerals abundant
    - Do not occur in clusters but are rather small and scattered throughout the matrix
    - Appear cubic; most likely pyrite
- Subhedral to euhedral dolomite rhombs common
    - Clarity ranges from cloudy/dirty to almost clear
    - Grey-coloured
    - Orange mineral appears to be a type of cement in the background to these rhombs

Paleontology:

- Not obvious fossil content

Sedimentary structures:

- Highly fractured

3870 m

Well: Roberval K-92
Core #: 7
Depth: 3870 m
Vintage: Archived
Lithology:

- Carbonate
    - Dolostone

Composition:

- Pervasively dolomitized
    - Fabric-destructive dolomite
    - Cloudy/dirty, anhedral to subhedral dolomite crystals
    - Limpid dolomite crystals around edges of pores and fractures

        - One sizeable patch in the top right corner of the slide
            - No fracture or pore present
            - Abrupt transition from surrounding anhedral-to subhedral, un-zoned dolomite crystals
    - Some smaller dolomite crystals intermixed near edges of pores and fractures
        - Similar characteristics of the larger dolomite crystals, just significantly smaller in size
- Calcite cement in some of the fractures
- Opaque minerals are minor to non-existent
- Some hydrocarbons in small, inter-crystalline pore spaces as well as in the stylolite
    - Particularly in the lower portion of the thin section

Paleontology:
- Possible replaced shell

Sedimentary structures:
- Quite porous
    - Pores are relatively small
- Some fractures present
- A small, thin stylolite with hydrocarbon in it

3870.5 m

Well: Roberval K-92
Core #: 7
Depth: 3870.5 m
Vintage: Archived
Lithology:
- Carbonate
    - Dolostone

Composition:
- Pervasive, fabric-destructive dolomite
    - Subhedral to anhedral, buff-coloured, dirty/cloudy dolomite
    - Euhedral to subhedral limpid dolomite
- Some minor calcite cement in fractures
- Minor amount of hydrocarbons present
    - Inter-crystalline, typically occurs in the pores between limpid dolomite crystals
- Minor amount of opaque minerals disseminated throughout thin section

Paleontology:
- No obvious fossil content

Sedimentary structures:
- Relatively porous (small-pores)
- Stylolites
- Fractures

3870.85 m

Roberval K-92
3870.85 m

Well: Roberval K-92
Core #: 7
Depth: 3870.85 m
Vintage: 2017
Lithology:
- Carbonate
    - Dolostone

Composition:
- Fabric-destructive dolomite (3 variations noted)
    - Anhedral to subhedral, cloudy/dirty dolomite crystals
    - Zoned subhedral to euhedral dolomite crystals
        - Tend to occur in areas between the anhedral to subhedral dolomite crystals
        - Some limpid dolomite noted
    - Some smaller, subhedral to anhedral dolomite present
- Some evidence of possible original argillaceous texture
    - Some areas appear darker and dirtier. Tend to consist of smaller dolomite crystals
- Hydrocarbon present
    - Lining pores
- Possible altered phosphate grain
    - Orange in appearance and largely isotropic under cross polar light
    - Appears to be a composite grain or was altered during diagenesis
    - Some quartz grains located in close proximity to potential phosphate grain
- Minor amounts of opaque minerals disseminated throughout thin section

Paleontology:
- No obvious fossil content

Sedimentary structures:
- Stylolites

3870.9 m

Well: Roberval K-92
Core #: 7
Depth: 3870.9 m
Vintage: Archived
Lithology:

- Carbonate
    - Dolostone

Composition:

- Pervasive, fabric-destructive dolomite
    - Anhedral to subhedral, dirty/cloudy dolomite present
    - Subhedral to euhedral, limpid dolomite crystals observed in fractures and pore spaces
        - Occurs in two sizes
            - One is comparable to the anhedral to subhedral, dirty/cloudy dolomite
            - The other is relatively smaller limpid dolomite that can be found throughout the thin section
    - All variations of dolomite appear to be intermixed: different types of dolomite with varying sizes, shapes, and colours etc.
- Minor amount of hydrocarbon
    - Occurs in fractures that tend to be filled with limpid dolomite - occurs within inter-crystalline pores (between limpid dolomite crystals)

Paleontology:

- No obvious fossil content

Sedimentary structures:

- Relatively porous
- Fractures
    - Typically filled with limpid dolomite
    - Minor amounts of calcite cement in fracture fills

3871.45 m

Roberval K-92
3871.45 m

Well: Roberval K-92
Core #: 7
Depth: 3871.45 m
Vintage: 2017
Lithology:

- Carbonate
    - Dolomite

Composition:

- Fabric-destructive dolomite
    - Large, anhedral to subhedral, dirty/cloudy dolomite crystals
    - Some sections of subhedral to euhedral dolomite rhombs exhibiting zoning
        - Limpid dolomite common
            - Typically occurs in less dense areas such as around the edges or pores and fractures
        - Limpid dolomite can also be found intermixed with the anhedral to subhedral non-zoned dolomite
    - Minor amount of a smaller-sized fraction of dolomite
- A minor amount of organic material
    - Found along one, tight fracture
- Minor amount of opaque minerals – tend to be quite small in size

Paleontology:

- No obvious fossil content

Sedimentary structures:

- Fractures

3872 m

Roberval K-92
3872 m

Well: Roberval K-92
Core #: 7
Depth: 3872 m
Vintage: Archived

Lithology:

- Carbonate
    - Dolostone

Composition:

- Pervasive, fabric-destructive dolomite
    - Anhedral to subhedral, buff dirty/cloudy dolomite
    - Subhedral to euhedral limpid dolomite
    - Some smaller-sized dolomite intermixed with limpid dolomite
- Minor amounts of calcite cement in fractures
- Minor amounts of hydrocarbon in small tight fractures and in the stylolites

Paleontology:

- No obvious fossil content

Sedimentary structures:

- Fractures
    - Some of which are visible without the aid of magnification
- Stylolites
- Pores – not as porous as other Roberval K-92 thin sections but appears to be more fractured than most

3872.34 m

Well: Roberval K-92
Core #: 7
Depth: 3872.34 m
Vintage: Archived

Lithology:

- Carbonate
    - Dolostone

Composition:

- Pervasive, fabric-destructive dolomite
    - Buff-coloured, dirty/cloudy, anhedral to subhedral dolomite
    - Subhedral to euhedral limpid dolomite also present in varying sizes
        - The majority of the limpid dolomite are close in size to the anhedral to subhedral dolomite
- Calcite cement in some fractures
- Some hydrocarbon in fractures (lining pores within the fractures) as well as in stylolites
- Opaque minerals are minor to non-existent

Paleontology:

- No obvious fossil content
- Some variation in dolomite type may be indicative of an original biological texture
    - Rounded patches of limpid dolomite

Sedimentary structures:

- Not very porous; only cavities occur within fractures
- Fractures
    - Some fractures are visible without magnification
- Stylolites

3872.8 m

Well: Roberval K-92
Core #: 7
Depth: 3872.8 m
Vintage: 2017
Lithology:

- Carbonate
    - Dolostone

Composition:

- Fabric-destructive dolomite
    - Primarily composed of larger anhedral to subhedral, dirty/cloudy dolomite
    - Clearer, subhedral to euhedral dolomite crystals in pores and along fractures
    - Some minor, smaller, anhedral to subhedral crystals
        - Occur grouped along a fracture (predominantly)
        - Minor amounts intermixed with larger-sized crystals
- No hydrocarbon observed
- A section that appears as if composed of caving material or perhaps a later-stage fracture fill
    - Contains smaller dolomite rhombs
- Little to no opaque minerals observed

Paleontology:

- No obvious fossil content

Sedimentary structures:

- A few small/tight fractures

3873.3 m

Roberval K-92
3873.3 m

Well: Roberval K-92
Core #: 7
Depth: 3873.3 m
Vintage: Archived
Lithology:

- Carbonate
    - Dolostone

Composition:

- Fabric-destructive dolomite
    - Dolomite appears mottled: grey and buff coloured sections
        - Grey dolomite appears to occur in rounded patches – possibly related to an original organic texture such as burrows?
    - Size of dolomite crystals varies from small and granular to large, distinct rhombs
    - Anhedral to subhedral, larger-sized, dirty/cloudy dolomite crystals are dominant
    - Large, euhedral dolomite rhombs in fractures (appear limited to fractures)
    - Very rare limpid dolomite crystals
- Calcite cement in fractures
- Hydrocarbon present in pores
    - Occurs inter-crystalline between the calcite or dolomite crystals that fill the pore
- Minor amount of opaque minerals that occur disseminated throughout thin section

Paleontology:

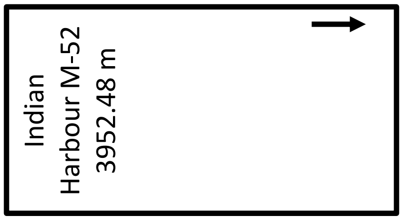
- Mottled appearance of slide may be indicative of an original bioturbated sediment
- No skeletal fossils

Sedimentary structures:

- Pores common
    - Typically filled with calcite cement or dolomite
    - May be due to dissolution or recrystallization of fossils?
- Fractures common
- Possible stylolite

Indian Harbour M-52

3952.48 m



Well: Indian Harbour M-52
Core #: 1
Depth: 3952.48 m
Vintage: Archived
Lithology:

- Carbonate
    - Limestone with dolomite

Composition:

- Dark-coloured lime mudstone matrix
    - Has a bit of a crystalline appearance in areas (degree of crystallization varies as some areas are still quite muddy)
    - Peloidal texture recognized in some areas of the thin section
- Dolomite present
    - Replacement of some fossil components by dolomite
    - Occurs as anhedral or subhedral to euhedral dolomite
        - Subhedral to euhedral crystals common in argillaceous layers
            - Limpid dolomite crystals present
        - Occur in isolated patches of anhedral dolomite crystals and distinct rhombs in matrix
    - Hydrothermal dolomite present in fractures
- Minor amount of opaque minerals disseminated throughout thin section
- Calcite cement present
    - Blocky calcite cement in some fractures and voids
    - Some isopachous calcite cement lining large fractures

Paleontology:

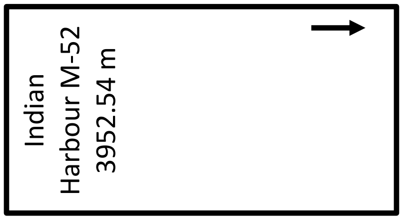
- Small, indeterminate fossil fragments are common
- Some fossils have been replaced by dolomite others have been slightly altered
- Crinoids
- Bivalve shell fragments
    - Some articulated bivalves present
        - Recrystallized shells
        - Some in-filled with dolomite
- Sponge spicules
- Possible radiolarians
- Bryozoans

- Dasycladacean green algae
- Possible trilobite fragment
- Shell fragments

Sedimentary structures:

- Stylolites
    - Do not cut across fractures
    - Some euhedral dolomite rhombs present along stylolites
- Fractures
- Argillaceous stringers that have been preferentially dolomitized
- Order: Stylolites then dolomitization of argillaceous stringers, then fractures followed by hydrothermal dolomite

3952.54 m



Well: Indian Harbour M-52
Core #: 1
Depth: 3952.54 m
Vintage: Archived
Lithology:

- Carbonate
    - Limestone with dolomite

Composition:

- Dark, lime mudstone matrix
    - Matrix has a microbial texture to it in some regions
    - Matrix becomes more crystalline towards center of thin section
        - Increase in calcite cement, resulting in a peloidal appearance
    - Variations in degree of crystallization from a muddy to crystalline matrix
- Dolomite present
    - Patches of buff, finely crystalline dolomite in matrix
    - Some isolated, floating dolomite rhombs in matrix
    - A large patch of anhedral dolomite that is bounded by a stylolite and expands out from it
        - Some limpid dolomite also present
    - Another large patch of dolomite in the top left corner of slide
        - Predominantly anhedral dolomite with minor amounts of limpid dolomite
    - No obvious reason for dolomite distribution
    - Small, possible hydrothermal dolomite along edges of the larger patches of dolomite
- Opaque minerals present

- Calcite cement present
    - Occurs in fractures

Paleontology:

- Small, indeterminate fossil fragments present throughout thin section
    - Possible shell fragments and sponge spicules
- Possible radiolarians

Sedimentary structures:

- Stylolites and fractures are common
    - Calcite cement in fractures
        - Smaller cement crystals around edges with larger, anhedral, blocky crystals in the middle of the fracture

3952.69 m

Well: Indian Harbour M-52
Core #: 1
Depth: 3952.69 m
Vintage: Archived
Lithology:

- Carbonate
    - Limestone with dolomite

Composition:

- Dark, microbial-looking lime mud matrix that is also slightly crystalline
- Peloidal section within crystalline matrix
- Several small grains in matrix
    - Either quartz grains or very small fragments of shells
- Dolomite present
    - Patches of buff-coloured anhedral dolomite
        - Can be bounded by stylolites
    - Floating, isolated dolomite rhombs in the matrix (cloudy, some are limpid)
    - Dolomite rhombs along stylolites
    - Hydrothermal dolomite present
        - Pores occur within the hydrothermal dolomite
        - Some smaller patches of hydrothermal dolomite along stylolites
        - Large patch of hydrothermal along the bottom left of thin section
            - Bounded by a stylolite on the bottom and surrounded by non-hydrothermal dolomite
- Opaque minerals present

Paleontology:

- Small, indeterminate fossil fragments are common

- Dasycladacean algae
- Possible shell fragments and sponge spicules
- Definitive bivalve fragments
- Articulated bivalve shell
- Echinoderm fragments

Sedimentary structures:

- Highly fractured
    - Calcite cement in fractures
- Stylolites common

3952.91 m

Indian
Harbour M-52
3952.91 m

Well: Indian Harbour M-52
Core #: 1
Depth: 3952.91 m
Vintage: Archived
Lithology:

- Carbonate
    - Limestone and dolomite

Composition:

- Lime mudstone matrix
    - Clotted, microbial texture
        - Possible *Girvanella* patches
    - Some areas exhibit signs of crystallization
- Fabric-destructive dolomite
    - Large accumulation of dolomite
        - Smaller, subhedral to euhedral crystals around the edges
        - Larger, anhedral crystals in middle
    - Some dolomite rhombs in matrix
        - Can be floating or can form clumps
        - Aggregate in patches especially in argillaceous stringers
    - A minor amount of hydrothermal dolomite near the top of the thin section
- Opaque minerals present
- Calcite cement
    - In fractures and replacing some fossils

Paleontology:

- Small, indeterminate fossil fragments are common
- Replaced (calcite)/recrystallized fossils
- Sponge spicules
- Gastropod

- Trilobite fragment
- Circular fossils
    - Possible calcispheres
- Possible radiolarians
- Crinoid fragments
- Dasycladacean green algae

Sedimentary structures:

- Fractures
- Stylolites

3952.94 m

Indian
Harbour M-52
3952.94 m

Well: Indian Harbour M-52
Core #: 1
Depth: 3952.94 m
Vintage: Archived
Lithology:

- Carbonate
    - Limestone with dolomite

Composition:

- Dark, lime mudstone matrix
    - Microbial texture
    - Possible stromatactis texture
    - Patches of altered/crystalline texture
- Dolomite present
    - Large patches of anhedral dolomite
    - Floating dolomite rhombs in matrix
        - Can be isolated or occur in patches
    - Some subhedral to euhedral dolomite in fractures
    - Large fracture with small dolomite rhombs along edges and hydrothermal dolomite in the middle
    - Small patches of very finely crystalline dolomite
- Calcite cement
    - Replacing fossils and in fractures

Paleontology:

- Small, indeterminate fossil fragments are common
- Shell fragments
- Sponge spicules
- Bivalve shells
- Calcite replaced skeletal fragments

- Possible foraminifera
- Trilobite fragments
- Crinoid fragments

Sedimentary structures:

- Calcite cement filled fractures
- Stylolites
  - Pyrite along stylolite

3953.09 m

Indian
Harbour M-52
3953.09 m

Well: Indian Harbour M-52
Core #: 1
Depth: 3953.09 m
Vintage: Archived
Lithology:

- Carbonate
  - Limestone with dolomite

Composition:

- Lime mudstone matrix
  - Contains areas of recrystallization and dolomite patches
  - Microbial appearance in areas
  - Replaced fossil fragments (predominantly shells) floating in matrix
  - Several small, round grains in matrix (possible quartz grains)
- Dolomite present
  - Patches of anhedral dolomite
    - Some ghost textures/fabrics present in larger dolomite patches
      - Rounded – possible burrows?
    - Some patches bounded by stylolites
  - A large, circular dolomite patch
    - Possible burrow?
  - Finely crystalline patches of dolomite in matrix
  - Dolomite rhombs floating in matrix, can occur in clusters
  - Hydrothermal dolomite in fractures
- Calcite cement in fractures
- Minor amounts of opaque minerals
- One isotropic grain noted
  - Clear/colourless in plain polarized light
  - Angular, 6-sided

Paleontology:

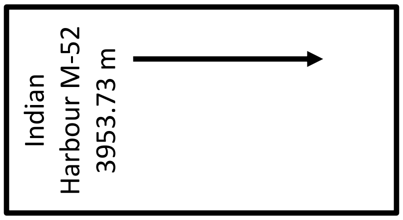
- Majority of fossil fragments show evidence of alteration/partial replacement

- Small, indeterminate fossil fragments are common
- Possible radiolarians
- Trilobite fragments
- Bivalve fragments
- Gastropod
- Crinoid fragments
- Shell fragments
- Sponge spicules
- Possible bivalve or ostracod within a dolomite patch
- Possible dasycladacean green algae
- Possible replaced small articulated bivalve
- Rounded, replaced fossil?

Sedimentary structures:

- Stylolites
- Fractures
    - Can contain calcite cement and/or dolomite including hydrothermal dolomite

3953.73 m



Well: Indian Harbour M-52
Core #: 1
Depth: 3953.73 m
Vintage: Archived
Lithology:

- Carbonate
    - Limestone with dolomite

Composition:

- Lime mud matrix
    - Some sections have a dark, microbial look to them
    - Crystallization has occurred to varying degrees
- Dolomite present
    - Accounts for 60-70% of the slide
    - Large sections of anhedral to subhedral dolomite
        - Buff-coloured, dirty/cloudy dolomite
        - Can be bounded by stylolites
    - Some subhedral to euhedral dolomite rhombs in matrix
    - Smaller, anhedral crystalline dolomite present along edges of larger, anhedral to subhedral dolomite sections as well as occurs in the matrix as patches

  - Dolomite rhombs along stylolites
  - Hydrothermal dolomite
    - Primarily within the anhedral to subhedral dolomite patches
    - Section along edge of thin section
    - Areas of hydrothermal dolomite appear to be interconnected
- Large calcite cement-filled fracture along the top of the thin section
  - Calcite cement also noted in aggregations in the matrix as well as in some fossil cavities
- A minor amount of opaque minerals

Paleontology:
- Small, unidentifiable fossil fragments are common
- Sponge spicules
- Echinoderm (crinoid) fragments
- Bivalve shells
  - Including ghosts of shells in heavily dolomitized patches
- Gastropods
- Trilobite fragments
- Dasycladacean green algae
- Possible radiolarians

Sedimentary structures:
- Stylolites
  - Some cut through anhedral to subhedral dolomite patches
  - Some appear to be the boundary for a few of the anhedral to subhedral dolomite patches
- Fractures
  - Some of which contain calcite cement
  - Fracture at top of thin section cuts through anhedral to subhedral dolomite patches as well as areas of crystallization

3954.22 m

Well: Indian Harbour M-52
Core #: 1
Depth: 3954.22 m
Vintage: Archived

Lithology:
- Carbonate
  - Limestone with dolomite

Composition:
- Overall crystalline appearance

- Lime mud matrix
    - Some sections appear dark and microbial
    - Some areas have been crystallized
    - Peloidal texture in some areas
- Dolomite present
    - Anhedral to subhedral dolomite sections
        - Buff-coloured, cloudy/dirty dolomite
    - Aggregations of euhedral dolomite rhombs
    - Hydrothermal dolomite
        - Bottom left corner of thin section
- Calcite cement
    - Within fossils
    - Within fractures
    - As crystalline areas within matrix
- A minor amount of opaque minerals

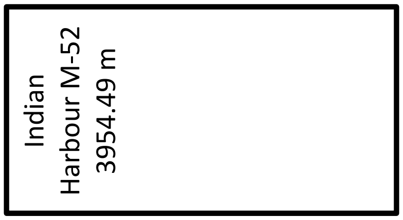
Paleontology:

- Small, unidentifiable fossil fragments are common
- Large (~3-4 mm in diameter) brachiopod (atrypide or rhynchonellide; Sproat, pers. comm.)
- Shell fragments common (both brachiopod and bivalve)
- Trilobite fragments
- Sponge spicules
- Echinoderm (crinoid) fragments
- Dasycladacean green algae
- Possible radiolarians
- Some fossils have been recrystallized to beyond recognition
    - Possible gastropod or cephalopod or foraminifera

Sedimentary structures:

- Stylolites
    - Can be associated with the edges of dolomite patches
- Fractures

3954.49 m



Well: Indian Harbour M-52
Core #: 1
Depth: 3954.49 m
Vintage: Archived
Lithology:

- Carbonate

    - Limestone with dolomite

Composition:
- Lime mudstone matrix
    - Some areas appear to have been crystallized
- Dolomite present
    - Large to moderate sized dolomite patches
        - Some are interconnected
        - Anhedral to subhedral, buff-coloured, cloudy/dirty dolomite
        - Some limpid dolomite observed
    - Dolomite rhombs in matrix (can occur in patches)
    - Fine crystalline anhedral dolomite occurs in patches
        - Can be rounded or may occur along outskirts of larger, anhedral to subhedral dolomite sections
    - Minor hydrothermal dolomite
- Calcite cement
    - In fractures
- Opaque minerals present
    - Increase in abundance from previously described thin sections
    - Occur in association with dolomite (inter-crystalline and along edges)
    - Also occurs in stylolites that transverse dolomite sections

Paleontology:
- Small, unidentifiable fossils fragments common throughout thin section
- Echinoderm (crinoid) fragments
- Possible radiolarians
- Shell fragments
- Trilobite fragments

Sedimentary structures:
- Fractures
    - Larger fractures contain a smaller and larger calcite crystal size-fraction
        - Small calcite crystals along edge of fracture with larger, blocky calcite cement in middle
    - Cross-cut dolomite sections
- Stylolites
    - Cross-cur dolomite patches

3955.35 m

Indian
Harbour M-52
3955.35 m

Well: Indian Harbour M-52
Core #: 1
Depth: 3955.35 m

Vintage: Archived
Lithology:

- Carbonate
    - Limestone with dolomite

Composition:

- Lime mudstone matrix
    - Varying degrees of crystallization
    - Microbial texture
- Dolomite present
    - Anhedral to subhedral, cloudy/dirty dolomite
    - Subhedral to euhedral dolomite
        - Occur within larger sections as well as floating in matrix
    - Minor amount of hydrothermal dolomite (bottom right section of thin section)
- Minor amount of opaque minerals throughout thin section
    - Concentrated along dolomite edges and along stylolites
- Calcite cement
    - Occurs within fractures
- Finely crystalline rounded patches – calcite and/or dolomite

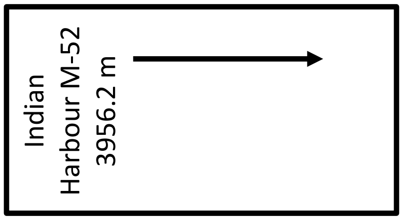
Paleontology:

- Small, unidentifiable fossil fragments common
- Possible gastropod
- Echinoderm (crinoid) fragments
- Possible radiolarians
- Sponge spicules
- Shell fragments
- Dasycladacean green algae
- Trilobite fragments

Sedimentary structures:

- Fractures
    - Cross-cut dolomite sections
- Stylolites

3956.2 m



Well: Indian Harbour M-52
Core #: 1
Depth: 3956.2 m
Vintage: Archived
Lithology:

- Carbonate
    - Primarily dolostone

Composition:

- Pervasively dolomitized
    - Fabric-destructive
    - Predominantly subhedral to euhedral
        - Some anhedral dolomite crystals within pores
    - Range in crystal size
    - Granular, sucrosic appearance
    - Larger crystals filling in pores
        - Several of the pores are circular and may represent dissolved fossils
    - Buff-coloured
    - Limpid dolomite present
        - Especially in the less dense areas such as within pores
    - No evidence of hydrothermal dolomite
- Calcite cement
    - Minor
    - Occurs as background cement in a few of the larger open areas (pores)
- Opaque minerals present
    - Common throughout
    - Can occur in aggregations
- Ghost textures
    - Apparent in dolomite based on variations in size, shape, colour, and density of dolomite
    - Rounded features could be possible burrows or fossils

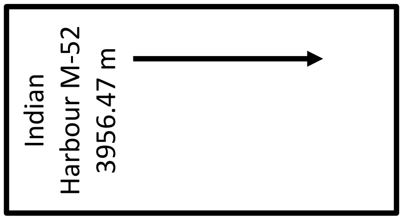
Paleontology:

- Ghost fossils present
- Several round features in the dolomite (areas of larger, less dense dolomite); not sure of origin
- Possible echinoderm fragments

Sedimentary structures:

- Argillaceous stringers
- No fractures noted

3956.47 m



Well: Indian Harbour M-52
Core #: 1
Depth: 3956.47 m
Vintage: Archived

Lithology:

- Carbonate
    - Limestone with dolomite

Composition:

- Lime mudstone matrix
    - Dark-coloured
    - Microbial (*Girvanella*)
    - Varying degrees of crystallization
- Dolomite present
    - Primarily subhedral to euhedral
    - Areas of very finely crystalline, anhedral to subhedral dolomite
    - A minor amount of hydrothermal dolomite
        - Possible dissolved shell in-filled with hydrothermal dolomite
    - Some fossil fragments in dolomite (shell and echinoderm fragments)
- Calcite cement
    - Occurs within fractures and in small, round patches within matrix (possible fossil replacement/recrystallization)
- Opaque minerals
    - Primarily scattered throughout but may occur in small clusters

Paleontology:

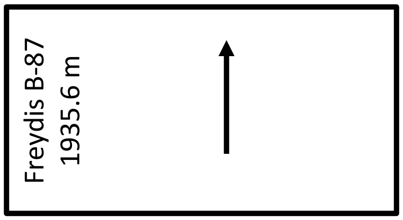
- Small, unidentifiable fossil fragments
- Sponge spicules
- Possible dasycladacean algae
- Shell fragments
- Echinoderm (crinoid) fragments
- Possible radiolarians
- Trilobite fragments
- *Girvanella*
- Ring-shaped fossils (possible algae)

Sedimentary structures:

- Fractures
- Stylolites
- Argillaceous stringers

Freydis B-87

1935.6 m



Well: Freydis B-87
Core #: 1
Depth: 1935.6 m
Vintage: 2017
Lithology:

- Siliciclastic? Carbonate?
    - Thin section was created from a section of core that appeared to be a carbonate unit within a primarily siliciclastic core

Composition:

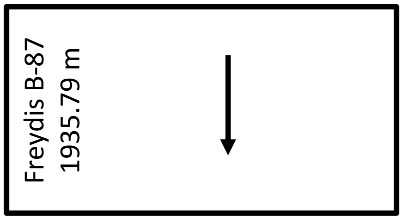
- Angular quartz grains dominate
    - Some finer, dirtier grains present but overall a relatively clean look
- Opaque minerals scattered throughout
    - Can occur in clusters, some of which are spherical in shape
    - Also occur in elongated clusters (likely replacement of a fossil shell?)
- Calcite cement
    - Within large recrystallized shells
    - In cavities created by shells
- A minor amount of dolomite (anhedral) adjacent to calcite cement
- Darker, muddier sections
    - Possibly organic (microbial mat fragment? Possible rip up clast?)
    - Thin and elongated

Paleontology:

- Several fossil fragments within thin section
- Large bivalve shell filled with recrystallized calcite
    - Smaller, elongated calcite crystals along inner edges of shell with larger, blocky calcite cement in the middle
    - Aggregation of calcite cement under a bivalve shell
    - Shell does not appear to be replaced/recrystallized
- Echinoderm (crinoid) fragments
- Shell fragments
    - Several bivalve pieces
- Brachiopod fragments

- Large coral (something similar to *Thamnopora*) or bryozoan fragment (cut obliquely)
- Bryozoans
- Several dense, fossil fragments
    - May be large fragments of shells
    - Not replaced/recrystallized
    - Contains parallel, laminar features
    - Typically elongated but some square fossils with circular centers that appear to be of the same composition are observed
    - Buff in colour (possible mimetic dolomite?)

1935.79 m



Well: Freydis B-87
Core #: 1
Depth: 1935.79 m
Vintage: 2017
Lithology:
- Siliciclastic
    - Sandstone

Composition:
- Very fine to fine-grained laminated sandstone
- Dominated by angular quartz grains
- Some finer-grained lithic fragments in between sand grains
- Laminations are characterized by a higher percentage of finer-grained components (mud)
- Opaque minerals present scattered throughout and also occurring in small clusters
- Poorly sorted, dirty (not clean), laminated sandstone

Paleontology:
- A few, possible, small shell fragments

Sedimentary structures:
- Laminations defined by higher mud content

1938.34 m

Freydis B-87
1938.34 m

Well: Freydis B-87
Core #: 1
Depth: 1938.34 m
Vintage: 2017
Lithology:

- Siliciclastic
    - Sandstone

Composition:

- Very fine, massive sandstone
- Predominantly composed of angular to sub-rounded quartz grains
- Some lithic fragments present
    - Overall cleaner than previous sandstones
- No mud observed
- No laminations
- Minor amount of opaque minerals scattered throughout
- Rounded green-coloured grain

Paleontology:

- Possible thin shell fragments

1941.15 m

Freydis B-87
1941.15 m

Well: Freydis B-87
Core #: 1
Depth: 1941.15 m
Vintage: 2017
Lithology:

- Siliciclastic
    - Burrowed mudstone to siltstone

Composition:

- Dark coloured, mudstone to siltstone
    - Opaques common
        - Can occur as clusters
    - Thin, needle like minerals present
- Burrows

    - Infilled with sand
    - Angular quartz grains and other lithic components
    - Very fine sand
    - Minor amounts of opaques
    - Elongated horizontally due to compaction
        - Large burrows are approximately 4.5 mm wide and 2.8 mm tall
    - Possible evidence of internal architecture in larger burrows

Paleontology:

- Burrows
    - *Chondrites*
        - Small burrows (on the order of a millimeter)
    - Larger burrows (*Glossifungites* Ichnofacies)
        - Evidence of internal structure
        - Both cross sections and longitudinal sections of burrows visible

Sedimentary structures:

- Burrows

2307.64 m

Freydis B-87
2307.64 m

Well: Freydis B-87
Core #: 2
Depth: 2307.64 m
Vintage: 2017
Lithology:

- Carbonate
    - Limestone

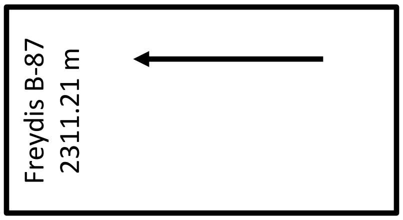
Composition:

- Fossiliferous wackestone
- Lime mudstone matrix
    - Dark-coloured, microbial
    - Some areas have been crystallized (crystallization of micritic mud)
        - Some of these patches are rather circular in nature – possible evidence of burrowing?
- Dolomite rhombs in argillaceous stringers
    - Preferential dolomitization of argillaceous stringers
    - Also in rounded, recrystallized areas
- Calcite cement
    - In fractures, pores and within recrystallized fossils
- Peloidal texture in areas
- Opaque minerals present scattered throughout and in aggregations

Paleontology:
- Small, unidentifiable fossil fragments
- Gastropods
- Bivalves
- Shell fragments
- Echinoderm (crinoid) fragments
- Dasycladacean green algae
- Bryozoan fragments
- Trilobite fragments
- Brachiopod shell fragments
- Sponge spicules
- Possible calcispheres
- Possible radiolarians
- *Girvanella*
- Possible cephalopod

Sedimentary structures:
- Argillaceous stringers
- Fractures
- Stylolites

2311.21 m



Well: Freydis B-87
Core #: 2
Depth: 2311.21 m
Vintage: 2017
Lithology:
- Carbonate
  - Limestone

Composition:
- Fossiliferous wackestone
- Lime mudstone matrix
  - Dark-coloured, microbial
  - Some areas have been recrystallized (crystallization of micritic mud)
- Dolomite rhombs in argillaceous stringers
  - Preferential dolomitization of argillaceous stringers
- Calcite cement
  - In fractures, pores and within recrystallized fossils
- Peloidal texture in several areas
- Opaque minerals present scattered throughout and in aggregations

    - More common in argillaceous stringers

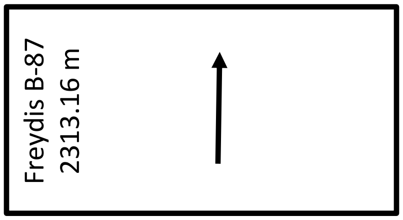
Paleontology:

- Small, unidentifiable fossil fragments
- Shell fragments
- Bivalves
- Brachiopods
- Gastropods
- Echinoderm (crinoid) fragments
- Trilobite fragments
- Sponge spicules
- Bryozoans
- Ostracods
- *Girvanella*
- Dasycladacean green algae
- Possible radiolarians
- Unknown round fossils in dolomitized argillaceous layers
    - Buff coloured (mimetic dolomite?)
    - Quite dense looking
    - Internal layering
    - *Nuia* (problematicum)?

Sedimentary structures:

- Argillaceous stringers
    - Preferentially dolomitized
- Fractures
- No stylolites

2313.16 m



Well: Freydis B-87
Core #: 2
Depth: 2313.16 m
Vintage: 2017
Lithology:

- Carbonate
    - Limestone

Composition:

- Fossiliferous wackestone to packstone
- Lime mudstone matrix
    - Dark-coloured, microbial
    - Some areas have been recrystallized (crystallization of micritic mud)

        - Some of these appear rounded/spherical
- Dolomite rhombs in argillaceous stringers
    - Preferential dolomitization of argillaceous stringers
- Calcite cement
    - In fractures and within recrystallized fossils
    - Bladed cement adjacent to some argillaceous stringers
- Opaque minerals present scattered throughout and in aggregations
- Limited peloidal textures

Paleontology:
- Small, unidentifiable fossil fragments
- Ostracods
- Shell fragments
- Echinoderm (crinoid fragments)
- Gastropods
- Bivalves
- Dasycladacean green algae
- Bryozoans
- Fenestrate bryozoans
- Cephalopod
- Trilobites
- *Girvanella*
- Sponge spicules
- Brachiopods
- Possible radiolarians
- Unknown round to hexagonal fossils
    - In mud matrix
    - Buff coloured
    - Has a radial pattern
    - Appears somewhat altered/damaged
    - *Nuia* (problematicum)?

Sedimentary structures:
- Argillaceous stringers
- Fractures

2313.46 m

Freydis B-87
2313.46 m

Well: Freydis B-87
Core #: 2
Depth: 2313.46 m
Vintage: Archived

Lithology:

- Carbonate
  - Limestone

Composition:

- Fossiliferous wackestone
- Lime mudstone matrix
  - Dark-coloured, microbial
  - Some areas have been recrystallized (crystallization of micritic mud)
- Dolomite rhombs in argillaceous stringers
  - Preferential dolomitization of argillaceous stringers
    - Some fossils within dolomitized argillaceous stringers
      - Crinoids
  - Rounded to irregular dolomitized patches
- Calcite cement
  - In fractures, pores and within recrystallized fossils
- Peloidal texture in several areas
- Opaque minerals present scattered throughout and in aggregations
- More mud and less fossils compared to the rest of the thin sections from Freydis B-87 Core #2

Paleontology:

- Small, unidentifiable fossil fragments
- *Girvanella*
- Shell fragments
- Bivalves
- Sponge spicules
- Dasycladacean green algae
- Possible radiolarians
- Gastropods
- Bryozoans
- Articulated bivalve shells
- Calcispheres
- Echinoderm (crinoids) fragments

Sedimentary structures:

- Argillaceous stringers
- Stylolites
- Fractures

Appendix C - Thin section Photographs

PPL = Plane polarized light

XPL = Cross polarized light

Scale bar units = micrometres (µm)

Thin sections were photographed with an Axiocam 12 Mb camera and captured digitally using the Zeiss ZEN software

Table C1: Thin section figures

Well	Core #	Depth of thin section (m)	Vintage	Figure #
Gudrid H-55	1	2676.44	2017	C1
	1	2677.78	2017	C2
	1	2677.85	Archived	C3
	1	2678.06	2017	C4
	1	2678.98	2017	C5
	1	2679.43	2017	C6
Roberval K-92	6	3578.06	Archived	C7
	6	3578.38	Archived	C8
	6	3578.69	2017	C9
	6	3578.78	2017	C10
	6	3578.96	2017	C11
	6	3579.1	Archived	C12
	6	3580	Archived	C13
	6	3581	Archived	C14
	7	3870	Archived	C15
	7	3870.5	Archived	C16
	7	3870.85	2017	C17
	7	3870.9	Archived	C18
	7	3871.45	2017	C19
	7	3872	Archived	C20
	7	3872.34	Archived	C21
	7	3872.8	2017	C22
	7	3873.3	Archived	C23
Indian harbour M-52	1	3952.48	Archived	C24
	1	3952.54	Archived	C25
	1	3952.69	Archived	C26
	1	3952.91	Archived	C27
	1	3952.94	Archived	C28
	1	3953.09	Archived	C29
	1	3953.73	Archived	C30
	1	3954.22	Archived	C31
	1	3954.49	Archived	C32
	1	3955.35	Archived	C33
	1	3956.2	Archived	C34

	1	3956.47	Archived	C35
Freydis B-87	1	1935.6	2017	C36
	1	1935.79	2017	C37
	1	1938.34	2017	C38
	1	1941.15	2017	C39
	2	2307.64	2017	C40
	2	2311.21	2017	C41
	2	2313.16	2017	C42
	2	2313.46	Archived	C43

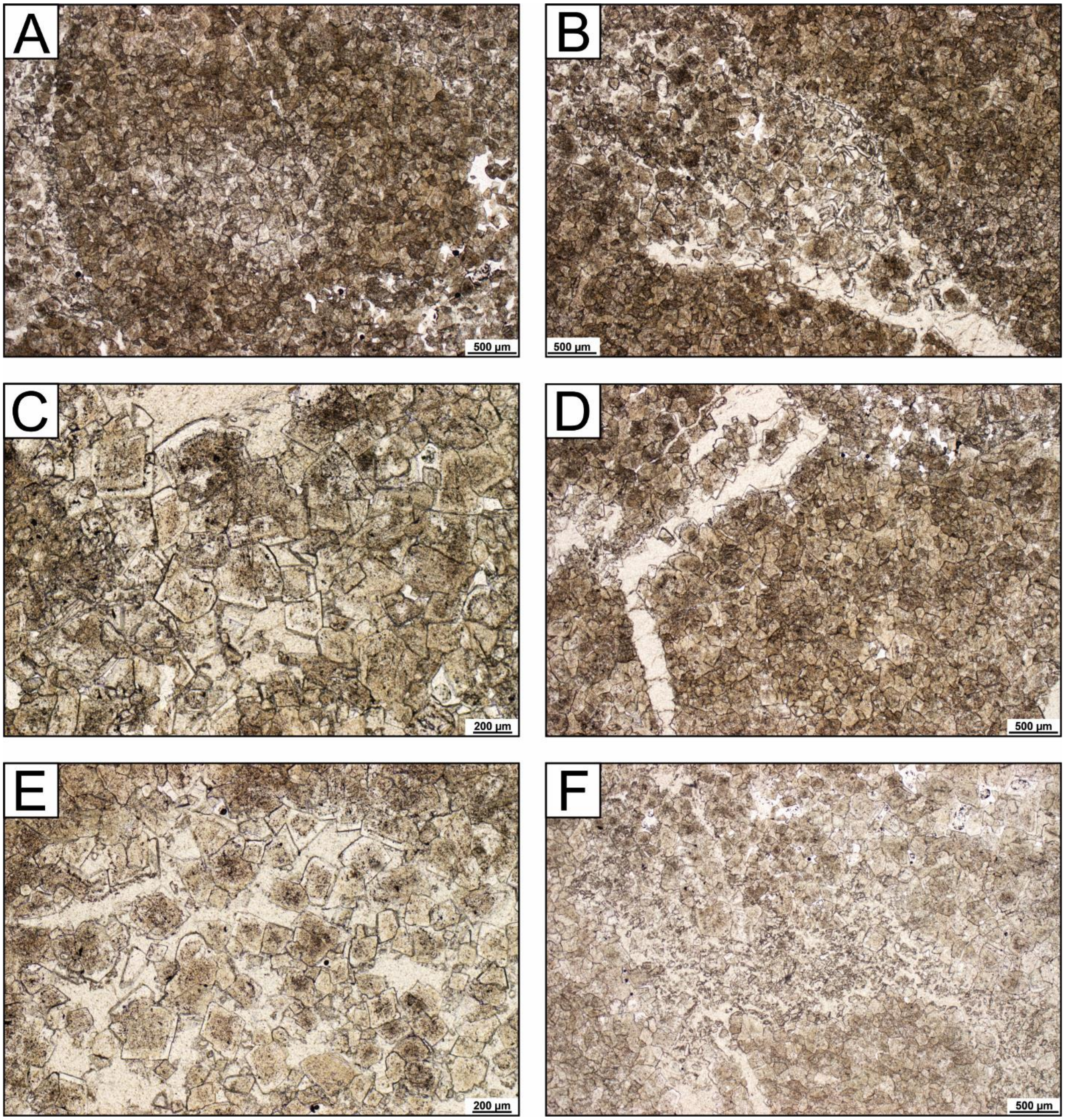


Figure C1: Gudrid H-55, Core #1, 2676.44 m, all photos are in PPL. (A) Lighter and darker buff-coloured anhedral to subhedral dolomite result in a mottled texture. (B) Anhedral to subhedral buff-coloured dolomite surrounding a fracture filled with subhedral to euhedral dolomite (limpid dolomite visible). (C) Subhedral to euhedral limpid dolomite. (D) Anhedral to subhedral buff-coloured dolomite with some subhedral to euhedral, limpid dolomite near fracture edges. (E) Primarily subhedral to euhedral dolomite (limpid crystals present). (F) Smaller dolomite crystals intermixed with larger, primarily anhedral to subhedral dolomite.

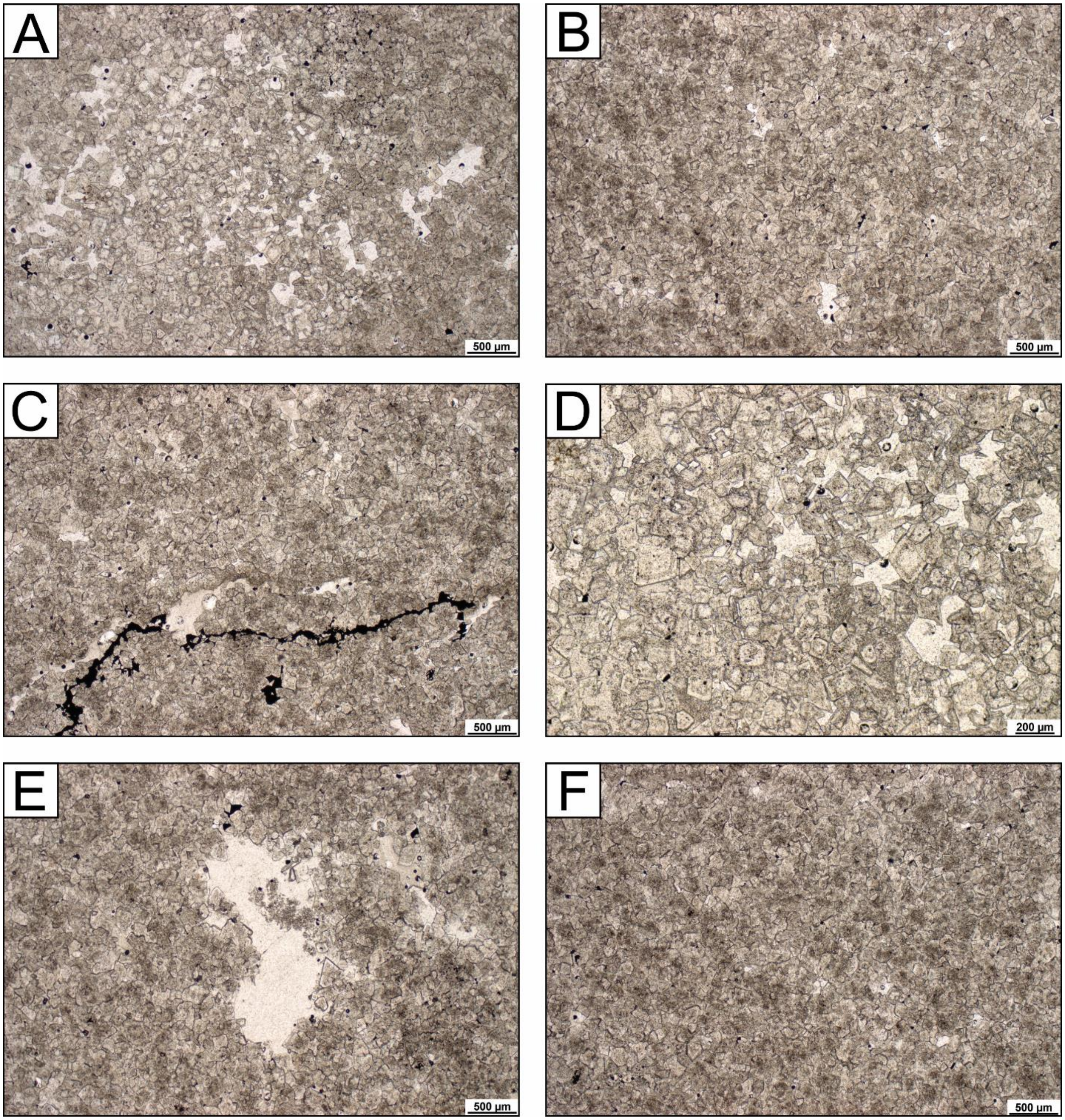


Figure C2: Gudrid H-55, Core #1, 2677.78 m, all photos are in PPL. (A) Intermixed anhedral to subhedral and subhedral to euhedral dolomite. (B) Anhedral to subhedral buff-coloured dolomite displaying some mottling. (C) Anhedral to subhedral dolomite with opaque mineral (pyrite) aggregations along fractures and in pores. (D) Primarily subhedral to euhedral zoned dolomite. (E) Intermixed anhedral to subhedral and subhedral to euhedral dolomite. Subhedral to euhedral dolomite is more common around the pore edges and exhibits some evidences of zoning (limpid dolomite). Note the presence of opaque minerals (pyrite) within inter-crystalline pore spaces. (F) Primarily anhedral to subhedral buff-coloured dolomite displaying some mottling.

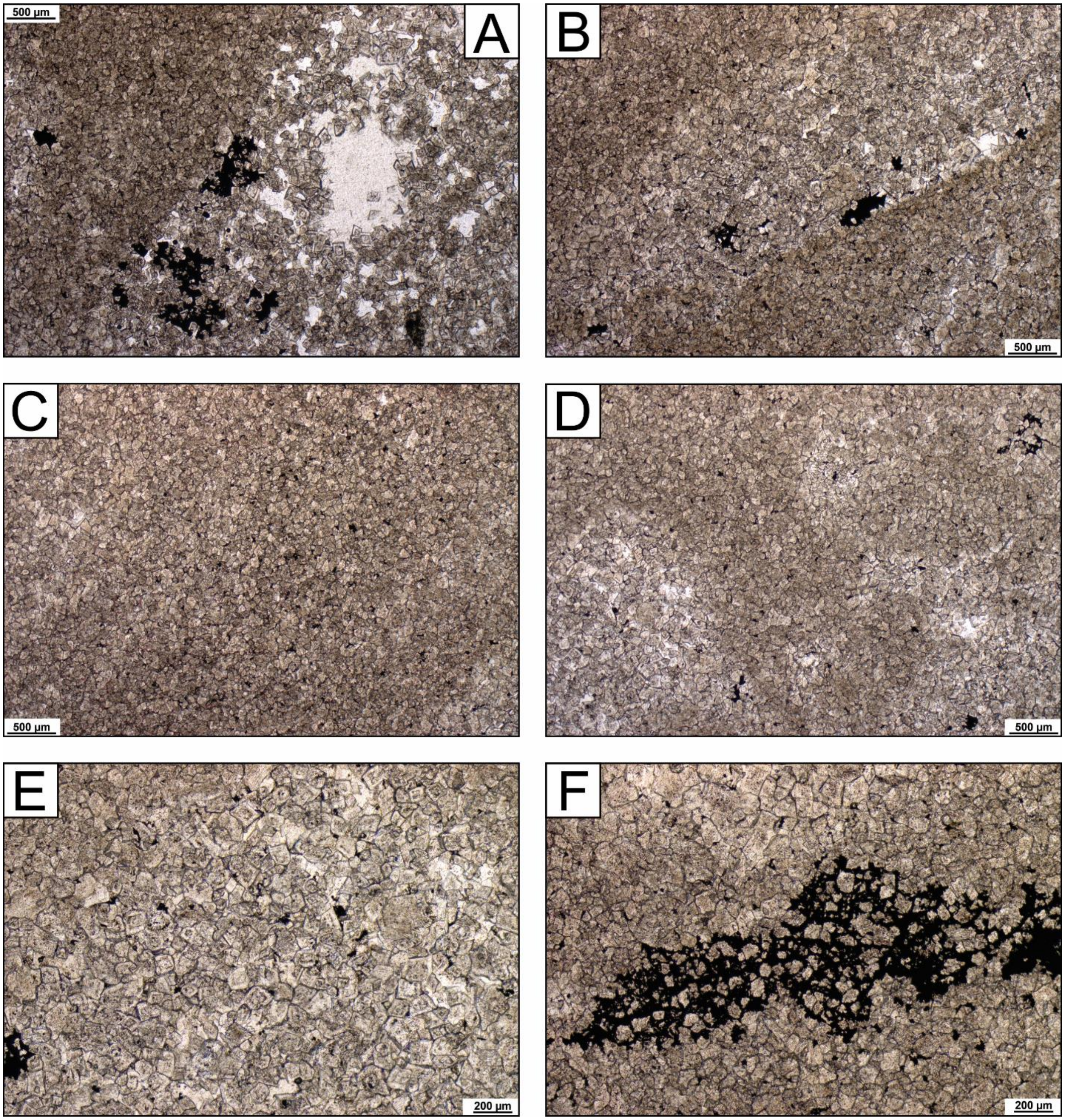


Figure C3: Gudrid H-55, Core #1, 2677.85 m, all photos are in PPL. (A) Anhedral to subhedral dolomite with subhedral to euhedral zoned dolomite in open pore areas. Note opaque mineral (pyrite) aggregations in inter-crystalline pore spaces. (B) Anhedral to subhedral dolomite exhibiting mottling. Note opaque mineral (pyrite) aggregations in inter-crystalline pore spaces. (C) Anhedral to subhedral dolomite. (D) Anhedral to subhedral dolomite exhibiting mottling with some subhedral to euhedral, zone dolomite in less dense areas (pores). (E) Subhedral to euhedral zoned dolomite (including limpid dolomite). (F) Anhedral to subhedral dolomite with opaque mineral (pyrite) aggregations in inter-crystalline spaces.

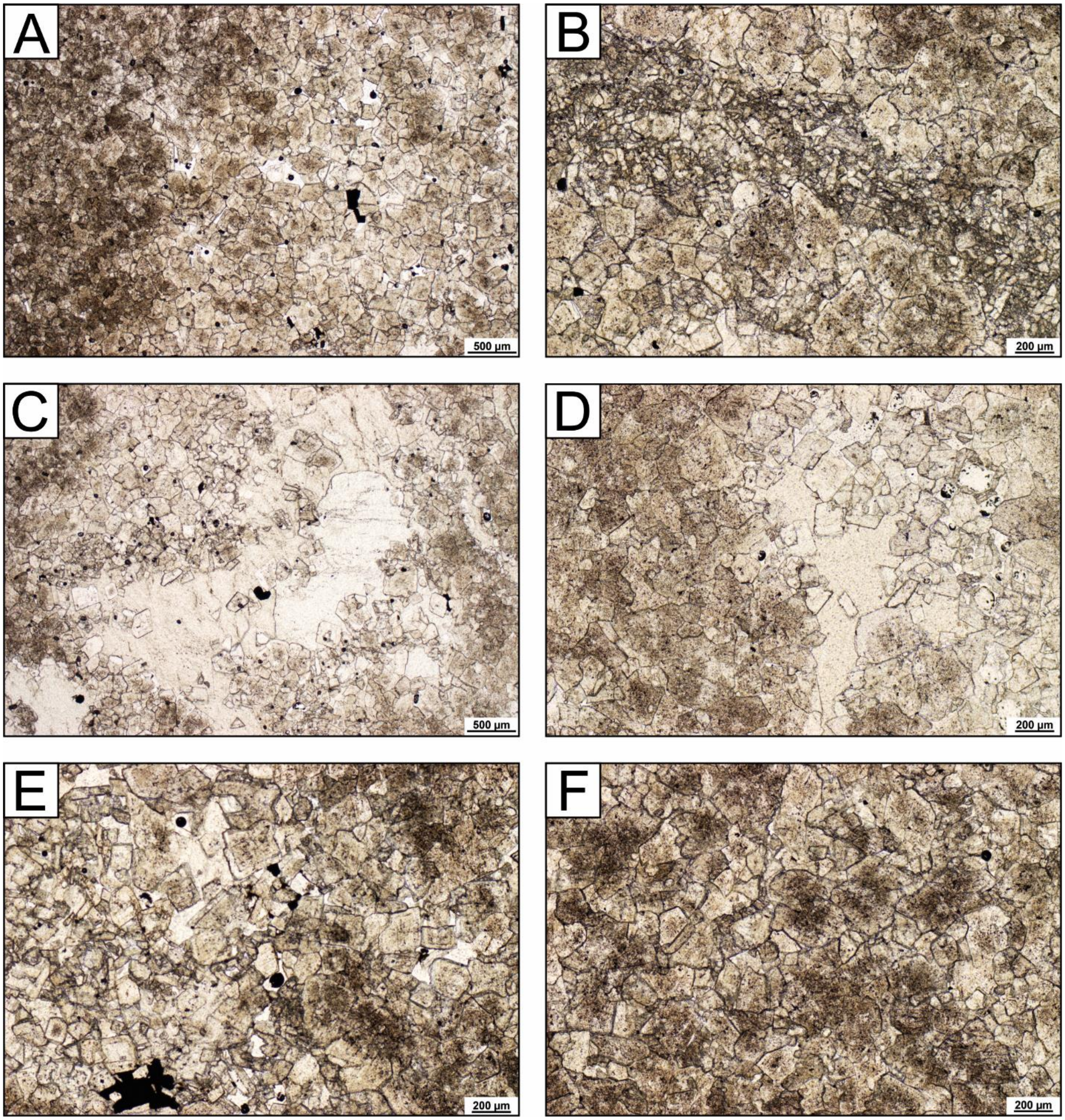


Figure C4: Gudrid H-55, Core #1, 2678.06 m, all photos are in PPL. (A) Anhedral to subhedral dolomite exhibiting mottling based on colour differences dominates the left section of the slide. Subhedral to euhedral dolomite prevalent on the right side of the image. (B) Anhedral to subhedral dolomite with smaller dolomite crystals within an argillaceous stringer. (C) Anhedral to subhedral dolomite around edges with anhedral to euhedral zoned dolomite towards the middle of the pore space. (D) Anhedral to subhedral dolomite alongside subhedral to euhedral, zoned dolomite. (E) Intermixed anhedral to subhedral and subhedral to euhedral dolomite. Note inter-crystalline opaque mineral (pyrite) aggregations. (F) Anhedral to subhedral dolomite exhibiting mottling.

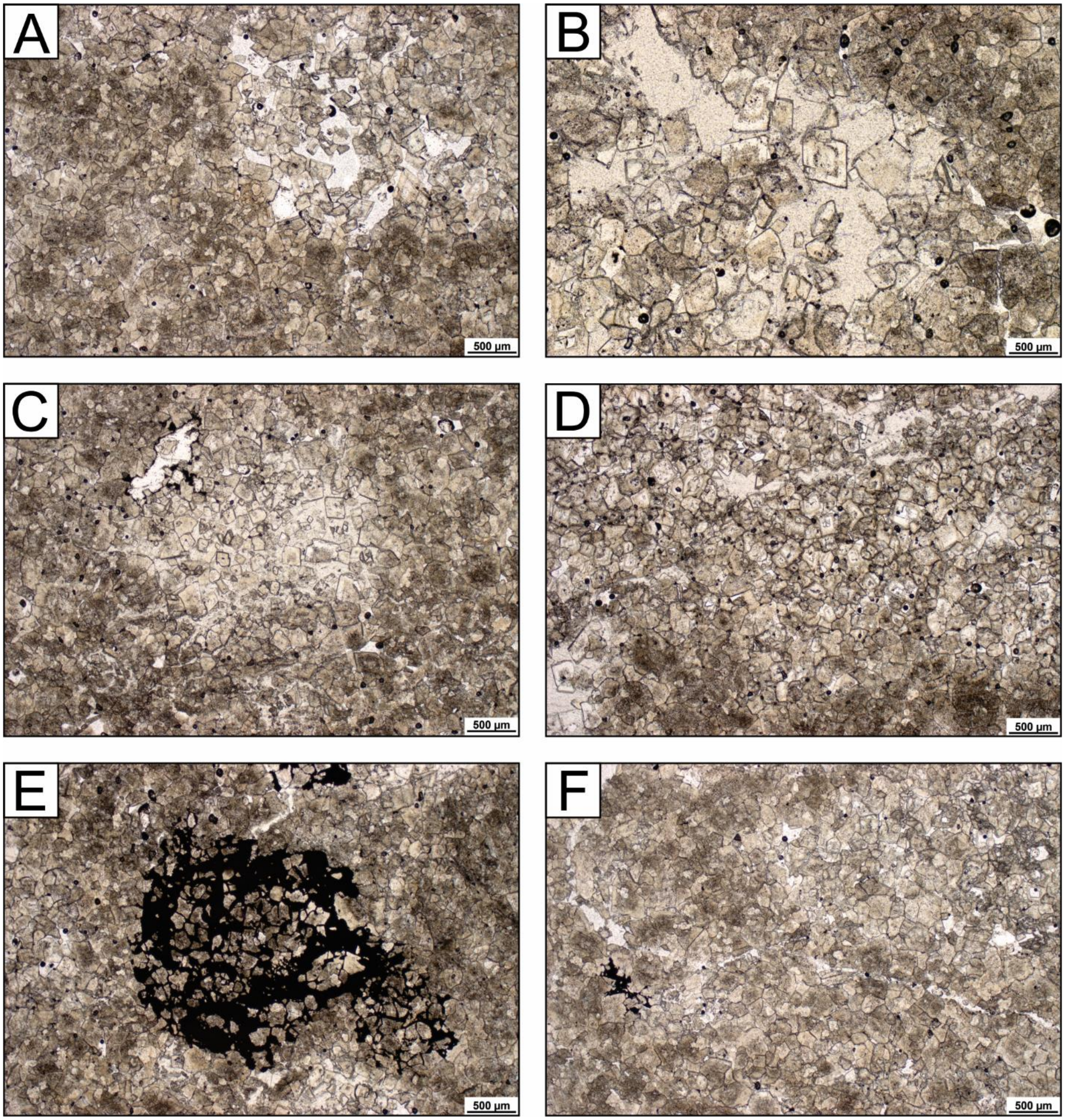


Figure C5: Gudrid H-55, Core #1, 2678.98 m, all photos are in PPL. (A) Anhedral to subhedral dolomite exhibiting mottling. Zoning of dolomite crystals occurs within the pore. (B) Anhedral to subhedral dolomite around edges with subhedral to euhedral, zoned dolomite within pore. (C) Anhedral to subhedral dolomite exhibiting mottling surrounding a rounded area of subhedral to euhedral, zoned dolomite. (D) Intermixed anhedral to subhedral and subhedral to euhedral dolomite. (E) Primarily anhedral to subhedral dolomite with high concentrations of opaque minerals (pyrite) in inter-crystalline spaces. (F) Primarily anhedral to subhedral dolomite with some smaller dolomite crystals intermixed.

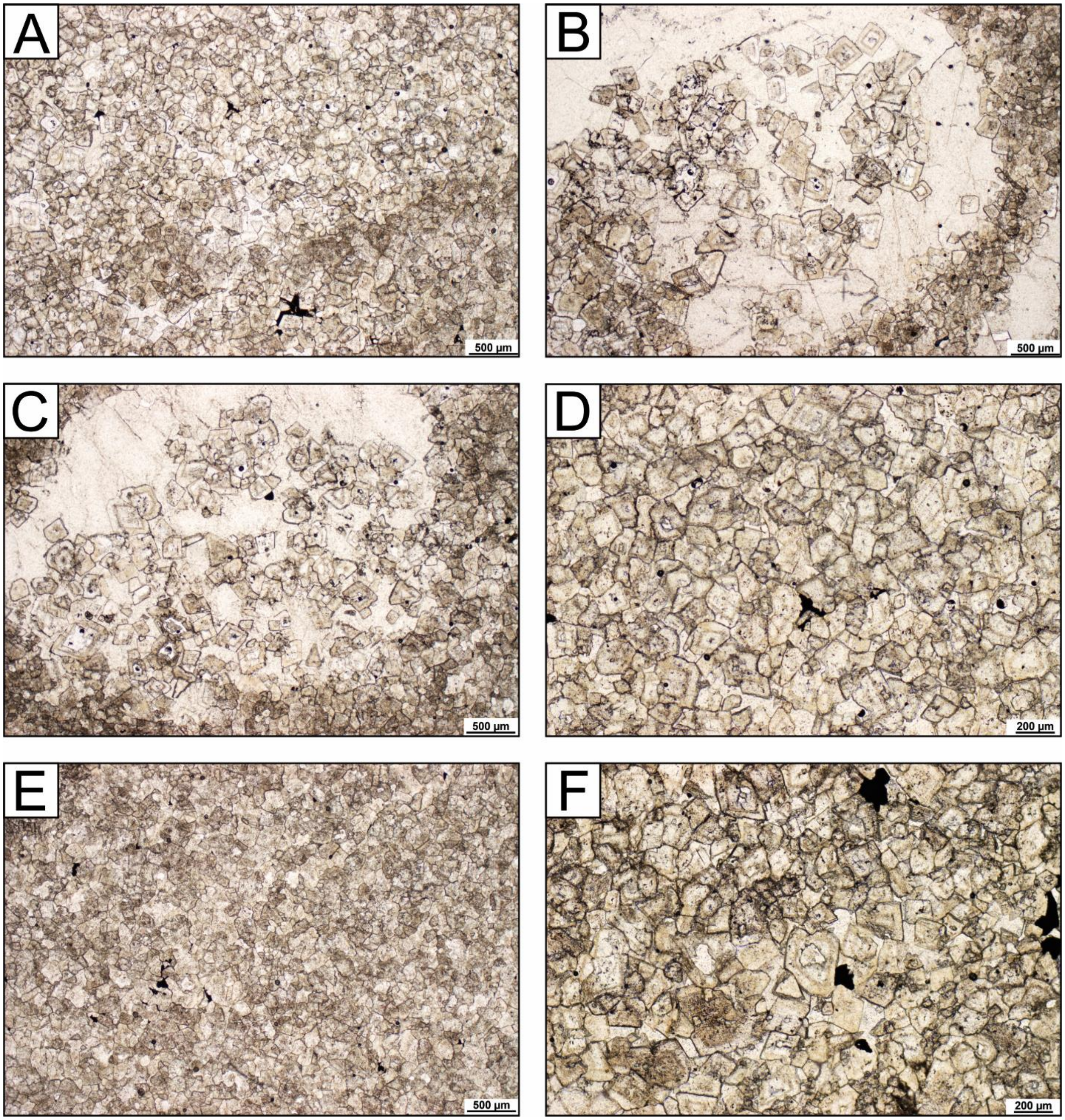


Figure C6: Gudrid H-55, Core #1, 2679.43 m, all photos are in PPL. (A) Intermixed anhedral to subhedral and subhedral to euhedral dolomite. (B) Subhedral to euhedral zoned dolomite in pore space surrounded by anhedral to subhedral dolomite. (C) Subhedral to euhedral zoned dolomite in pore space surrounded by anhedral to subhedral dolomite. (D) Subhedral to euhedral, zoned dolomite. (E) Primarily anhedral to subhedral dolomite. (F) Subhedral to euhedral dolomite with opaque mineral (pyrite) aggregations in inter-crystalline pore spaces.

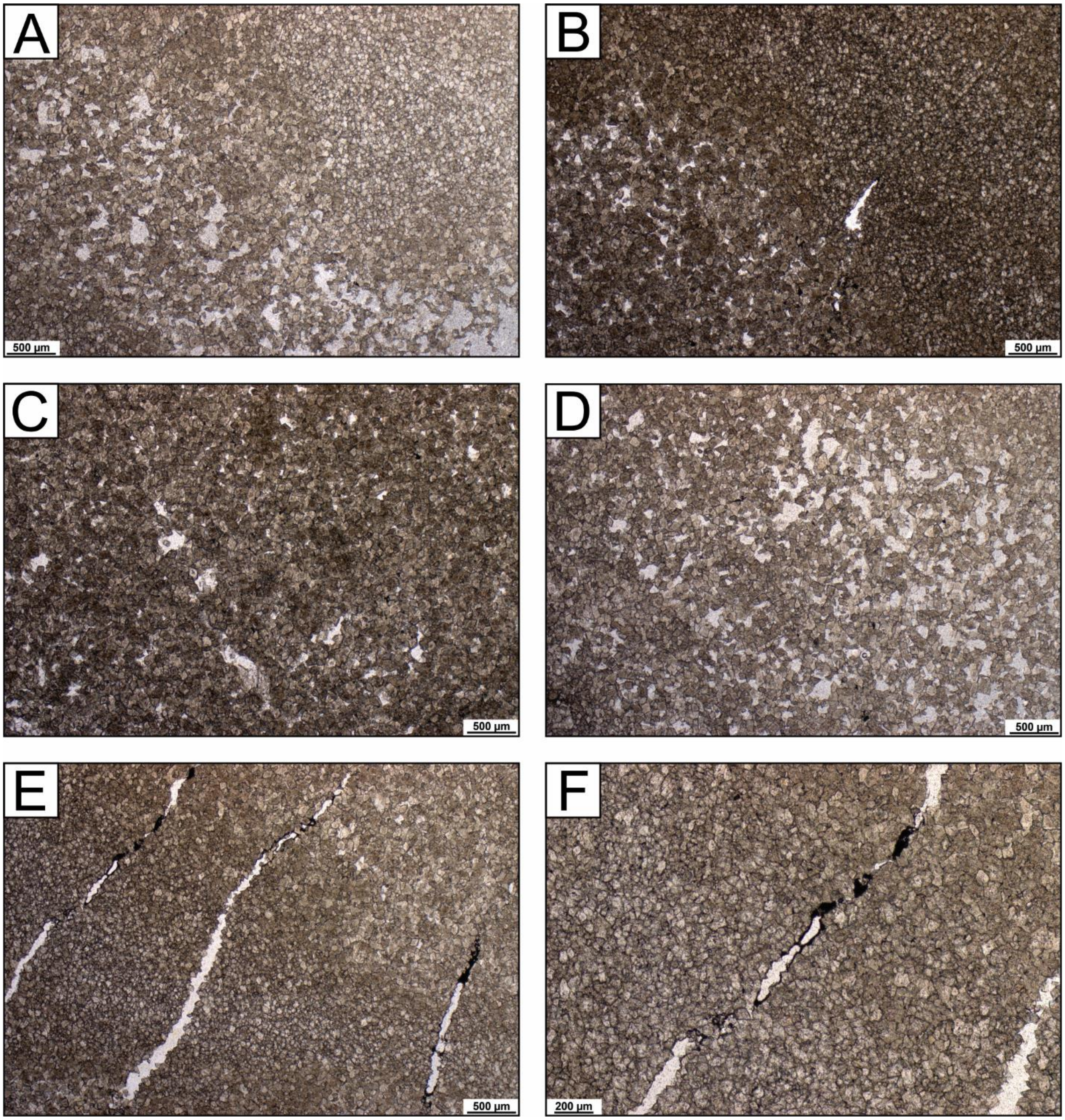


Figure C7: Roberval K-92, Core #6, 3578.06 m, all photos are in PPL. (A) Varying, intermixed sizes of anhedral to euhedral dolomite. Variations in size and colour of dolomite result in mottled appearance. (B) Smaller (right side) and larger-sized (left side), anhedral to euhedral dolomite. (C) Primarily anhedral to subhedral dolomite. (D) Anhedral to euhedral dolomite. (E) Intermixed smaller to larger-sized, anhedral to euhedral dolomite. Note mottled appearance of dolomite as well as the presence of hydrocarbons of unknown nature in the fractures. (F) Unknown hydrocarbons in fracture surrounded by anhedral to subhedral dolomite.

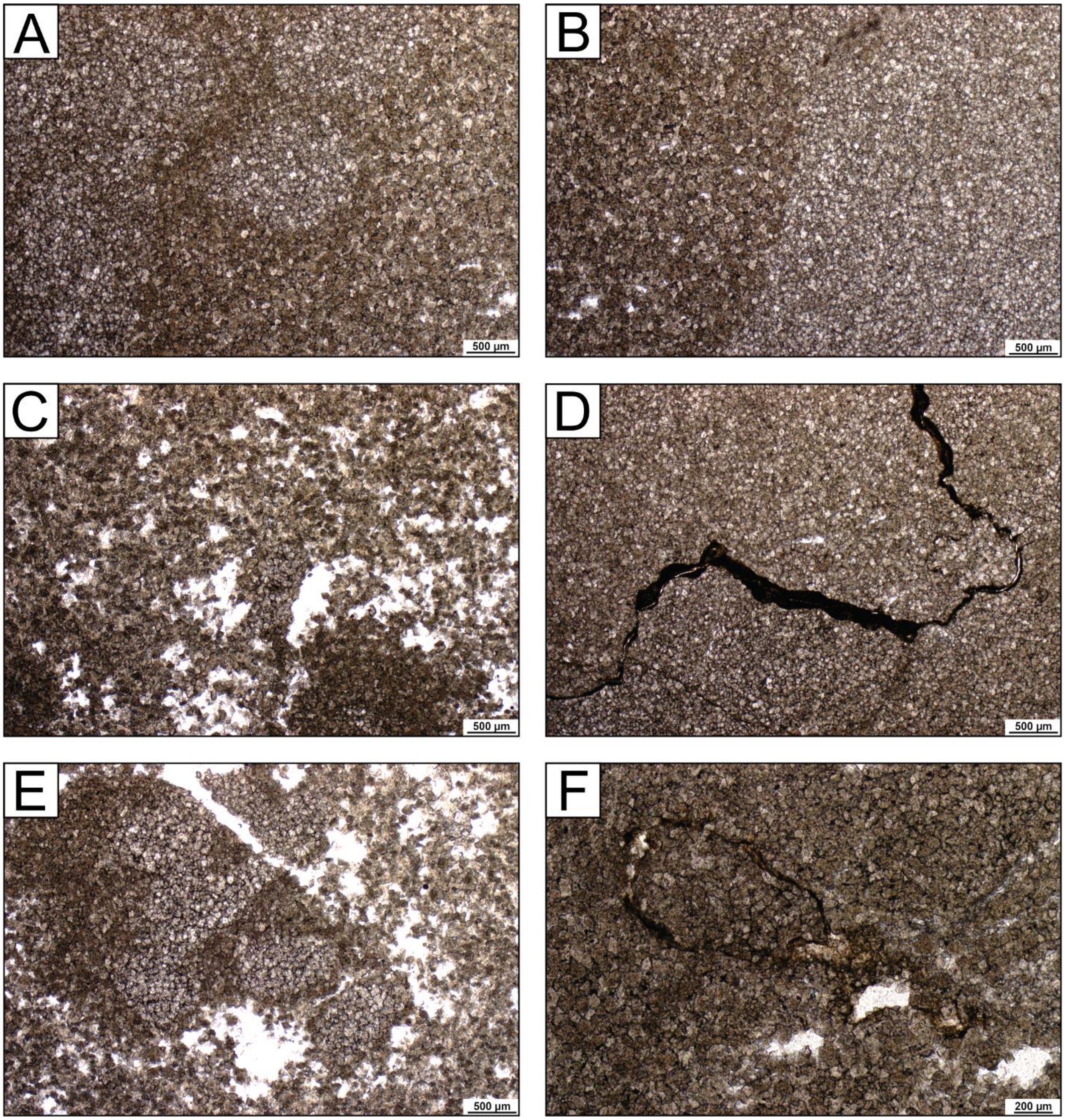


Figure C8: Roberval K-92, Core #6, 3578.38 m, all photos are in PPL. (A) Intermixed anhedral to subhedral dolomite. Subhedral dolomite tends to be clearer and occurs in rounded to spherical patches, producing a mottled appearance. (B) Darker, buffer anhedral to subhedral dolomite abutting clearer and lighter-coloured, subhedral to euhedral dolomite. (C) Varying colours and shades of anhedral to euhedral dolomite. (D) Stylolite containing unknown hydrocarbons surrounded by anhedral to subhedral dolomite. (E) Clearer subhedral dolomite intermixed with darker, cloudier anhedral dolomite producing a mottled appearance. (F) Unknown hydrocarbons in fractures surrounded by anhedral to subhedral dolomite.

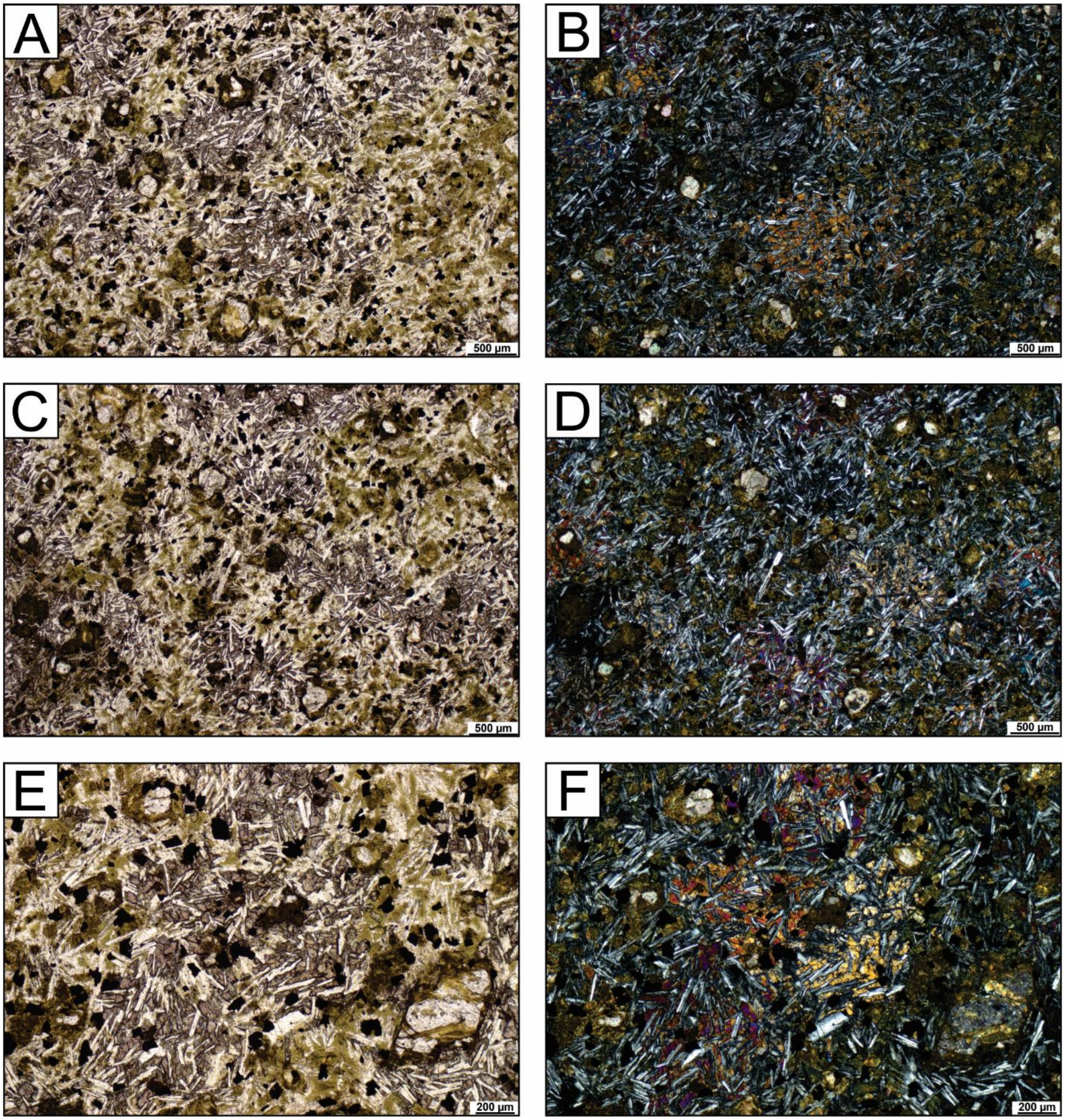


Figure C9: Roberval K-92, Core #6, 3578.69 m. PPL (A, C, and E) and XPL (B, D, and F) photomicrographs of a mafic igneous mineral suite that is dominated by plagioclase (thin, blade-like crystals). Amphiboles and pyroxenes are also present as are opaque minerals that are likely a type of sulphide mineral.

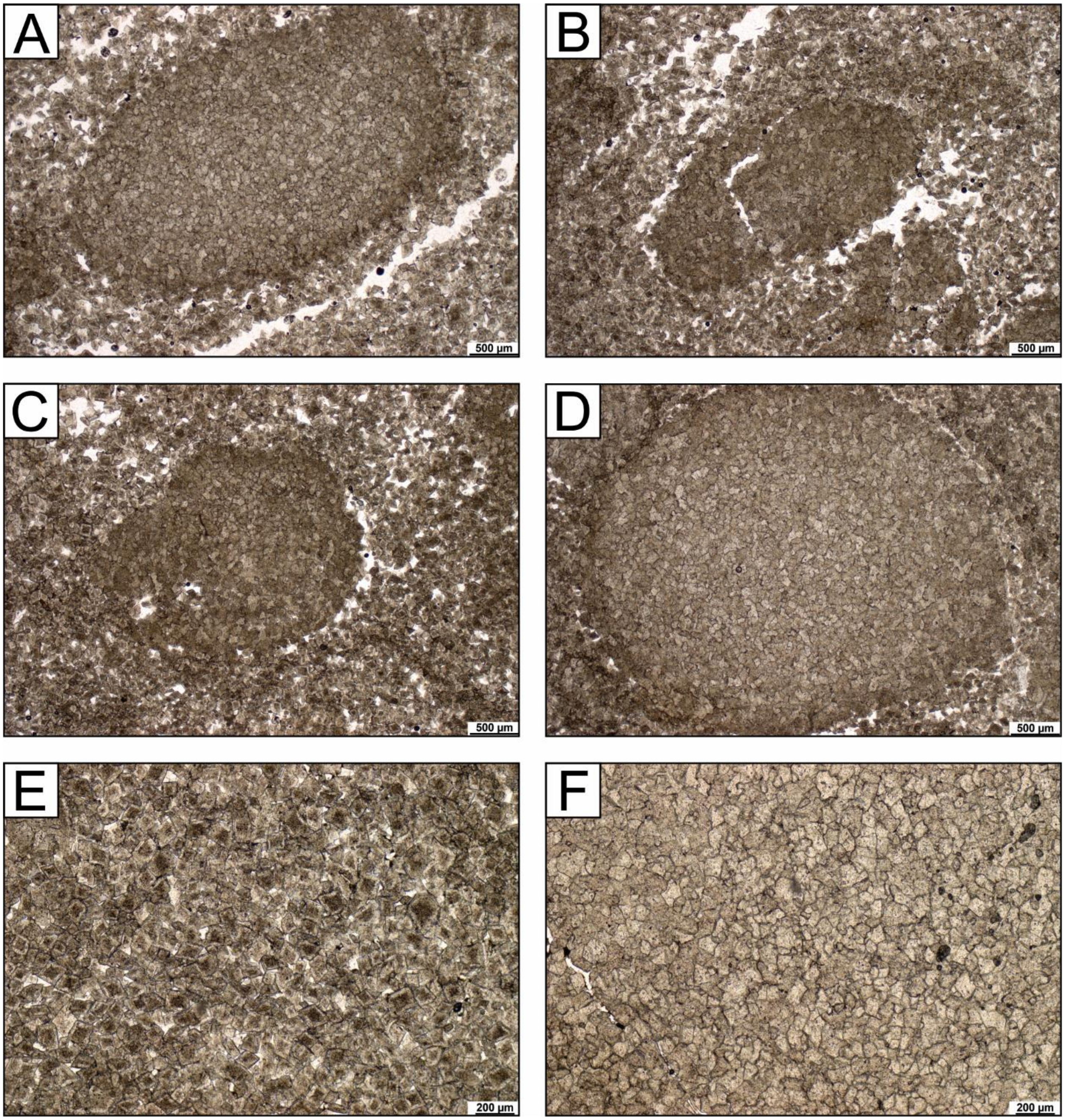


Figure C10: Roberval K-92, Core #6, 3578.78 m, all photos are in PPL. (A) A rounded patch (possible burrow) of anhedral to subhedral, buff-coloured dolomite, surrounded by subhedral to euhedral, zoned dolomite. (B) Anhedral to subhedral, buff-coloured dolomite occurs in an oval-shaped patch (possible burrow) surrounded by subhedral to euhedral dolomite that tends to exhibit zoning. (C) Another rounded patch of anhedral to subhedral dolomite (possible burrow) surrounded by subhedral to euhedral, zoned dolomite. (D) A spherical occurrence of anhedral to subhedral dolomite, surrounded by subhedral to euhedral, primarily zoned dolomite. These rounded, spherical sections may be indicative of original bioturbatic fabrics, such as burrows. (E) Close up of the subhedral to euhedral dolomite. Zoning is prevalent with limpid dolomite dominating. (F) Close up of the anhedral to subhedral, buff-coloured dolomite that occurs in rounded features throughout the thin section (possible burrows) and is typically surrounded by the subhedral to euhedral dolomite.

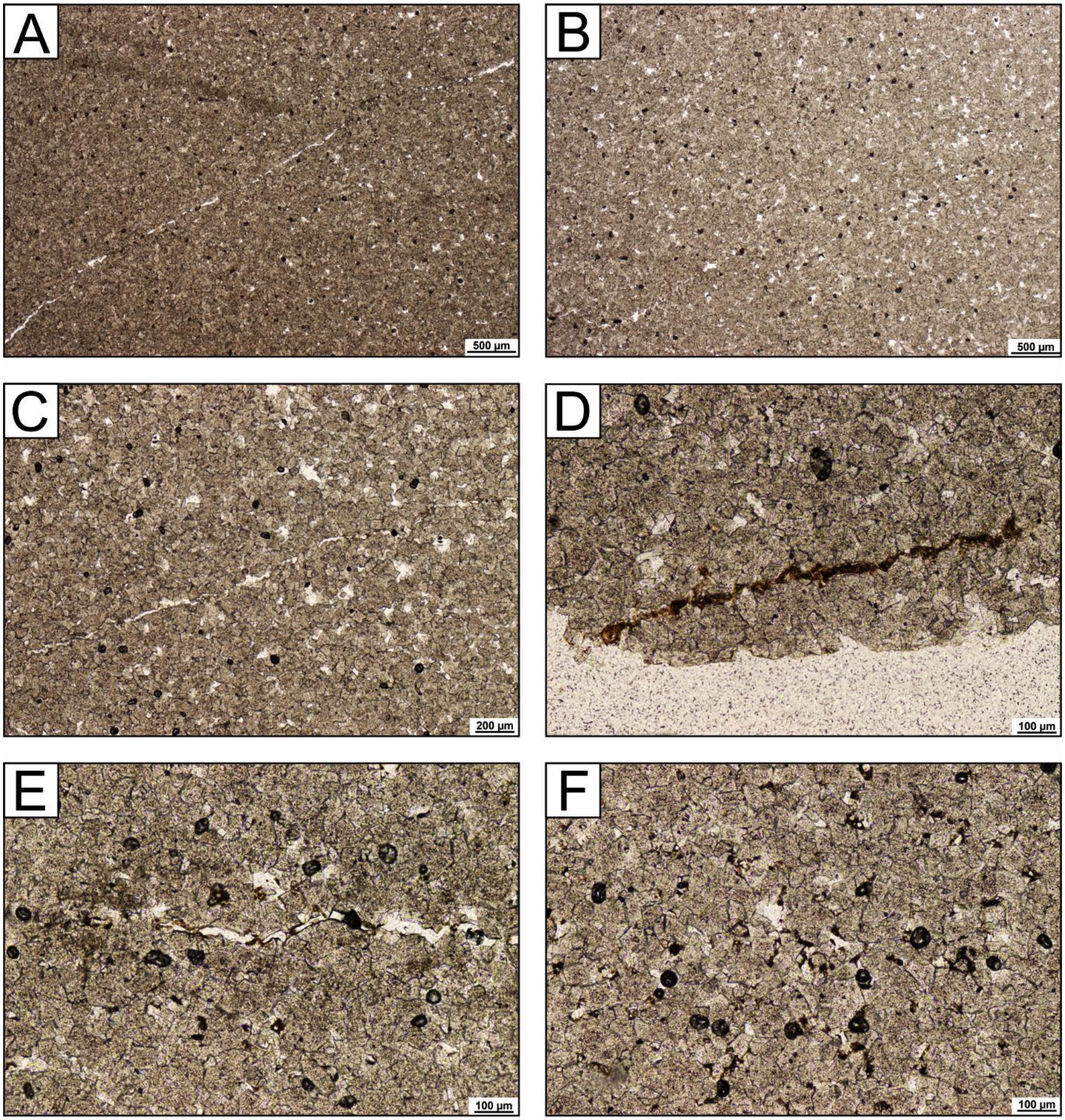


Figure C11: Roberval K-92, Core #6, 3578.96 m, all photos are in PPL. (A) Fine, anhedral to subhedral sucrosic dolomite. (B) Fine, anhedral to subhedral sucrosic dolomite. Note that several of the dark spots on the slide are air bubbles in the thin section. (C) Fine, anhedral to subhedral sucrosic dolomite. Note the micro-porous nature of the dolomite. (D) Unknown hydrocarbons in a small, thin fracture within the fine, anhedral to subhedral dolomite. (E) Unknown hydrocarbons lining a small fracture within anhedral to subhedral dolomite. (F) Hydrocarbon of unknown origin occurs lining several pores of the anhedral to subhedral sucrosic dolomite.

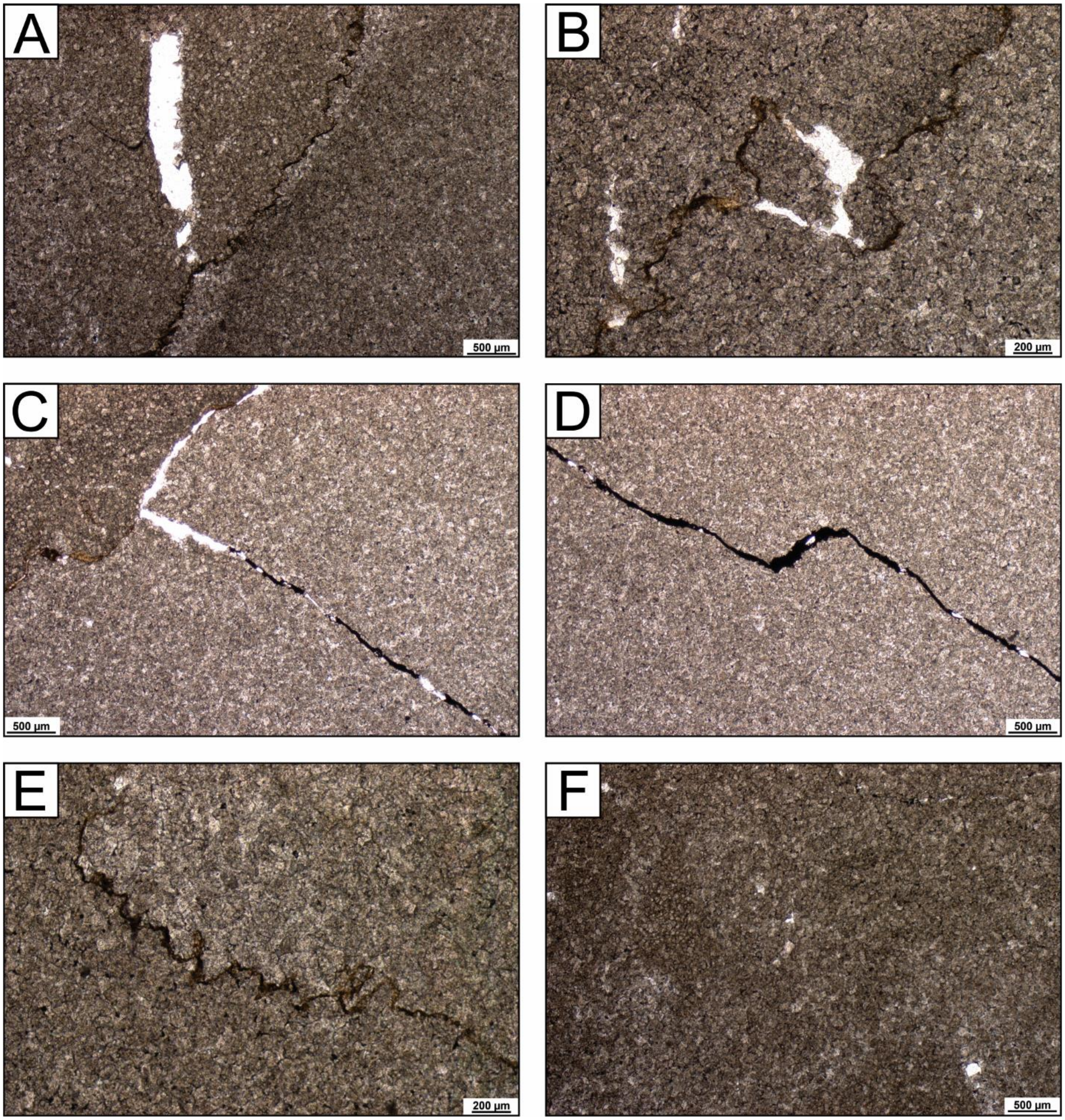


Figure C12: Roberval K-92, Core #6, 3579.1 m, all photos are in PPL. (A) A hydrocarbon-filled stylolite in fine, anhedral to subhedral dolomite. (B) Unknown hydrocarbon in a stylolite cutting through anhedral to subhedral, sucrosic dolomite. (C) Anhedral to subhedral dolomite with a stylolite and a fracture containing unknown hydrocarbons. (D) Unknown hydrocarbon in a fracture surrounded by anhedral to subhedral, sucrosic dolomite. (E) Stylolite containing hydrocarbons of unknown origin in anhedral to subhedral, sucrosic dolomite. (F) Mottling apparent in fine, anhedral to subhedral sucrosic dolomite.

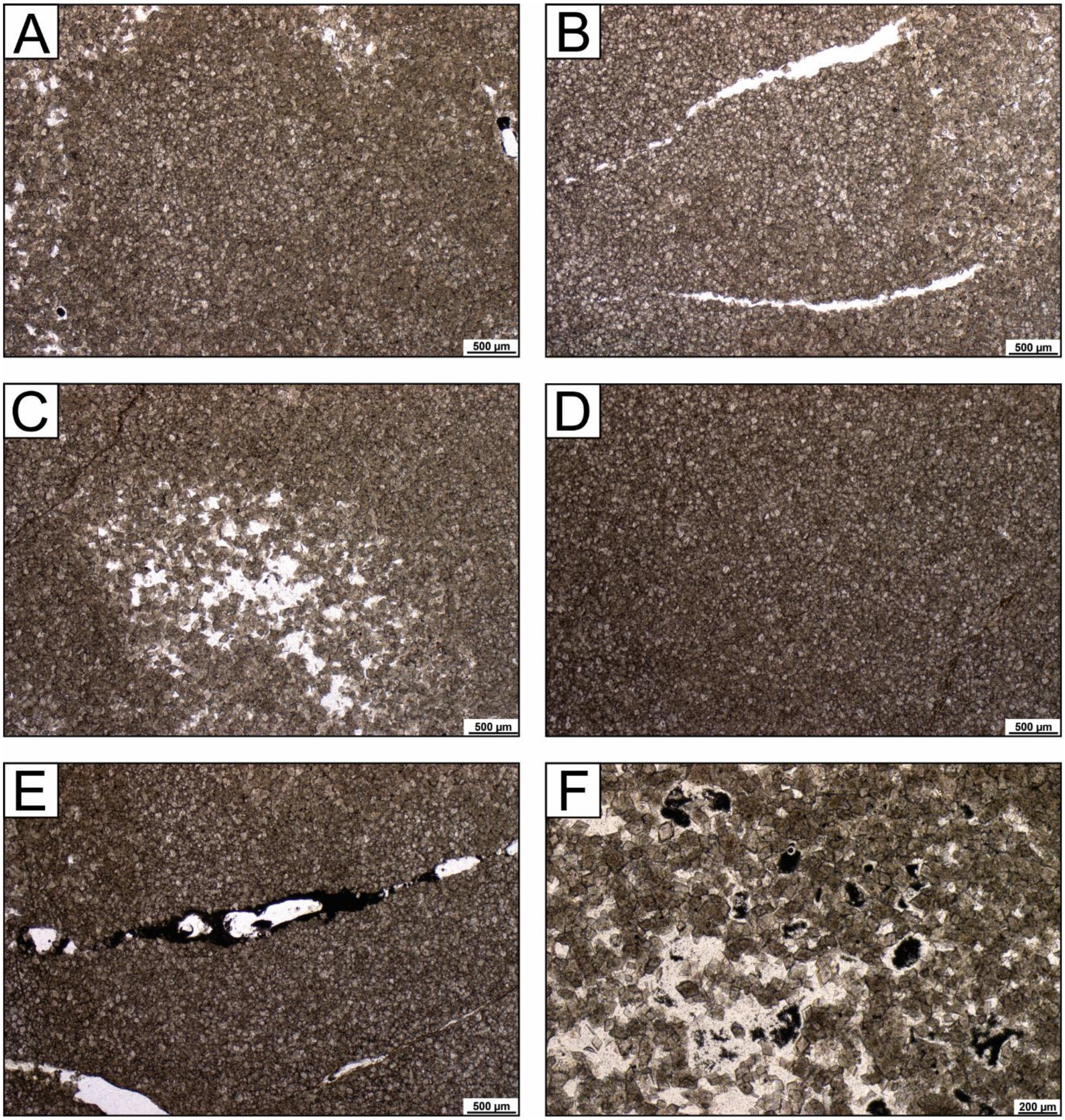


Figure C13: Roberval K-92, Core #6, 3580 m, all photos are in PPL. (A) A mixture of anhedral to subhedral and subhedral to euhedral dolomite with zoning evident in some of the subhedral to euhedral crystals. Note a small amount of hydrocarbon present in the pore spaces. (B) Fractures in anhedral to subhedral dolomite (primarily on left-side of image) and subhedral to euhedral, zoned (limpid) dolomite (on right-side). (C) Anhedral to subhedral dolomite along edges with subhedral to euhedral, zoned dolomite in and around pore. (D) Anhedral to subhedral dolomite with some hydrocarbon in argillaceous stringer (bottom right). (E) Unknown hydrocarbon in fracture surrounded by anhedral to subhedral dolomite. (F) Subhedral to euhedral dolomite with unknown hydrocarbons in pore spaces.

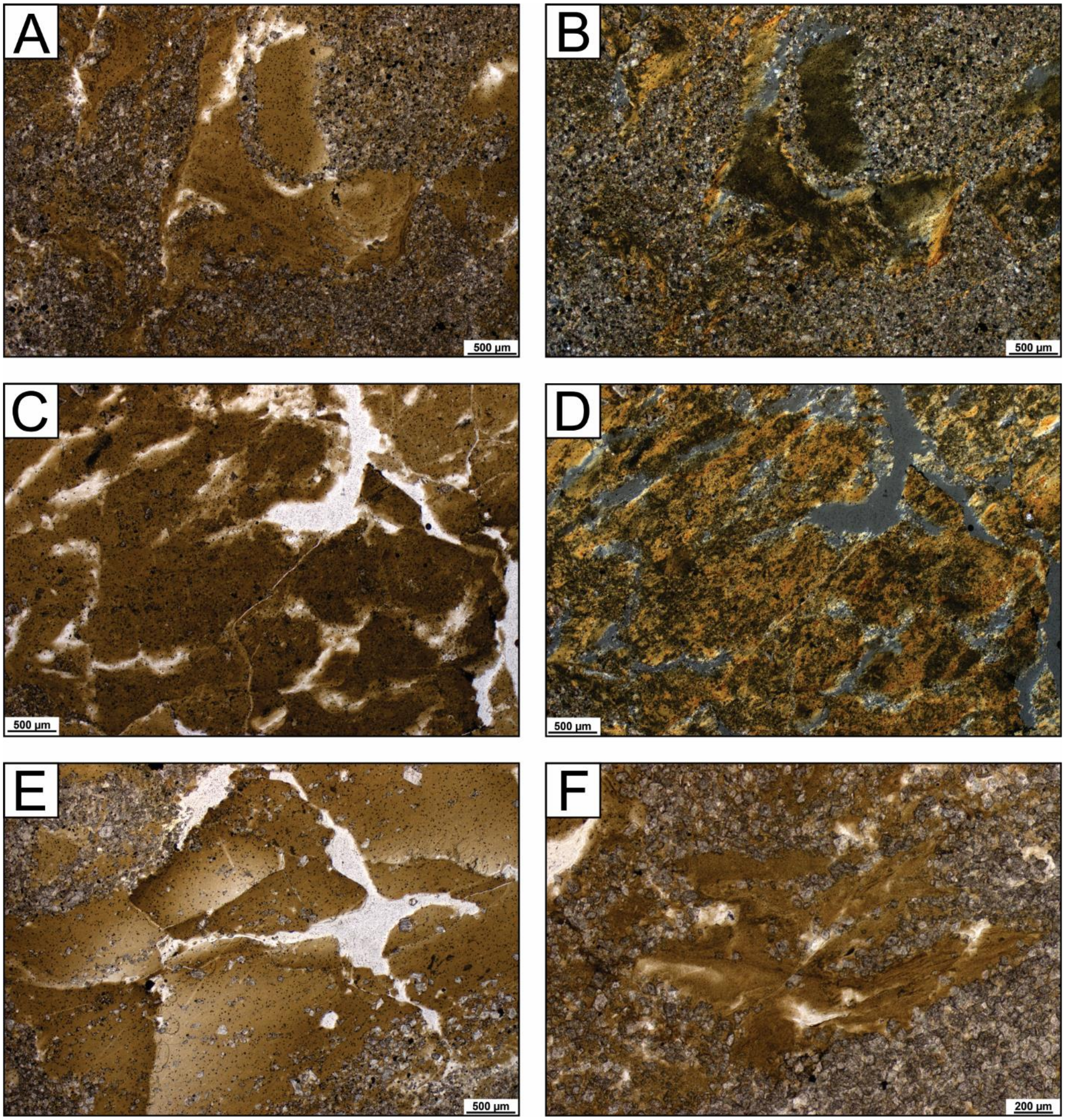


Figure C14: Roberval K-92, Core #6, 3581 m. (A) Unknown orange-coloured mineral with anhedral to euhedral dolomite and opaque minerals (PPL). (B) Unknown orange-coloured mineral with anhedral to euhedral dolomite and opaque minerals (XPL). (C) Unknown orange-coloured mineral (PPL). (D) Unknown orange-coloured mineral (XPL). (E) Orange-coloured mineral and anhedral to euhedral dolomite. (F) Textures within unknown orange-coloured mineral along with anhedral to euhedral dolomite.

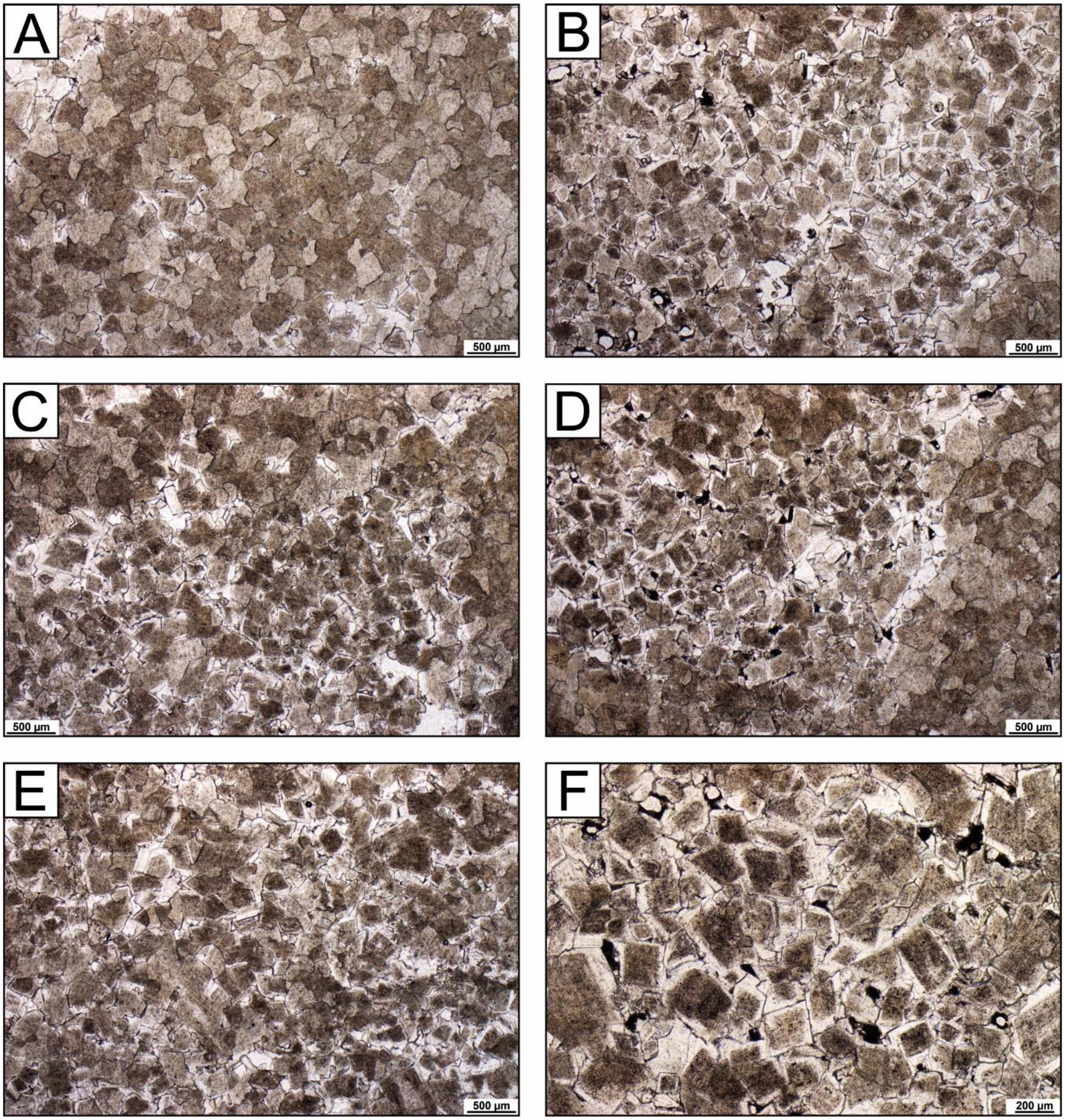


Figure C15: Roberval K-92, Core #7, 3870 m, all photos are in PPL. (A) Anhedral to subhedral dolomite. (B) Subhedral to euhedral, zoned (limpid) dolomite with hydrocarbons lining pore spaces. (C) A mixture of anhedral to subhedral (along top) and subhedral to euhedral, zoned (limpid) dolomite. (D) Anhedral to subhedral dolomite surrounding a section of subhedral to euhedral, zoned (limpid) dolomite with hydrocarbons observed in inter-crystalline spaces. (E) Intermixed subhedral to euhedral, zoned (dominant) and anhedral to subhedral dolomite. (F) Subhedral to euhedral, zoned (limpid) dolomite with unknown hydrocarbons in some inter-crystalline pores.

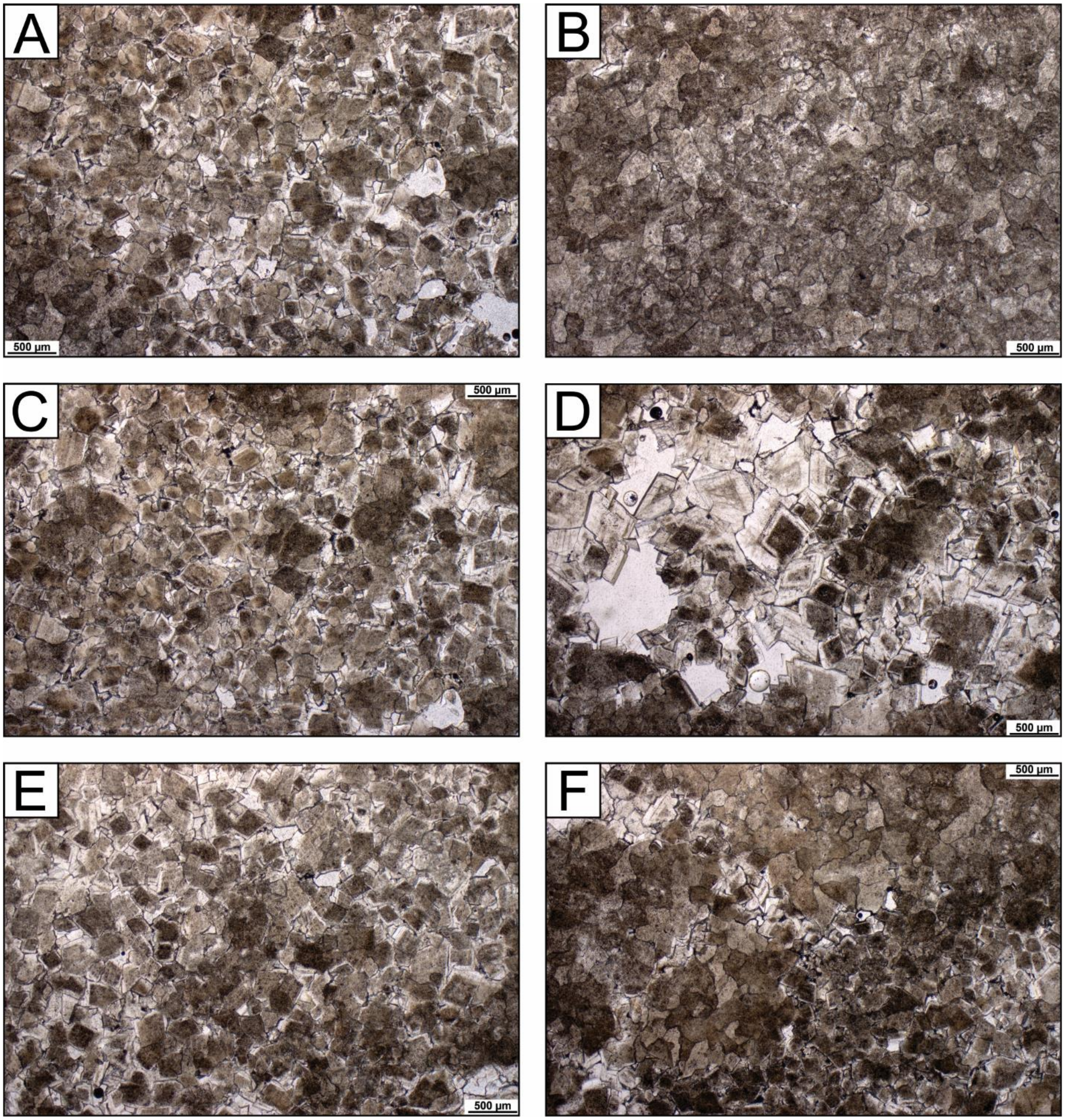


Figure C16: Roberval K-92, Core #7, 3870.5 m, all photos are in PPL. (A) Anhedral to subhedral dolomite along edges with subhedral to euhedral zoned (primarily limpid) dolomite in the middle. (B) Varying crystal sizes of anhedral to subhedral dolomite. (C) Primarily subhedral to euhedral, zoned (limpid) dolomite with minor amounts of hydrocarbons in pores. (D) Subhedral to euhedral, zoned (limpid and multilayered zoning) dolomite with minor films of an unknown hydrocarbon in some pores. (E) Subhedral to euhedral, zoned (primarily limpid) dolomite. (F) A combination of anhedral to subhedral and subhedral to euhedral, zoned dolomite.

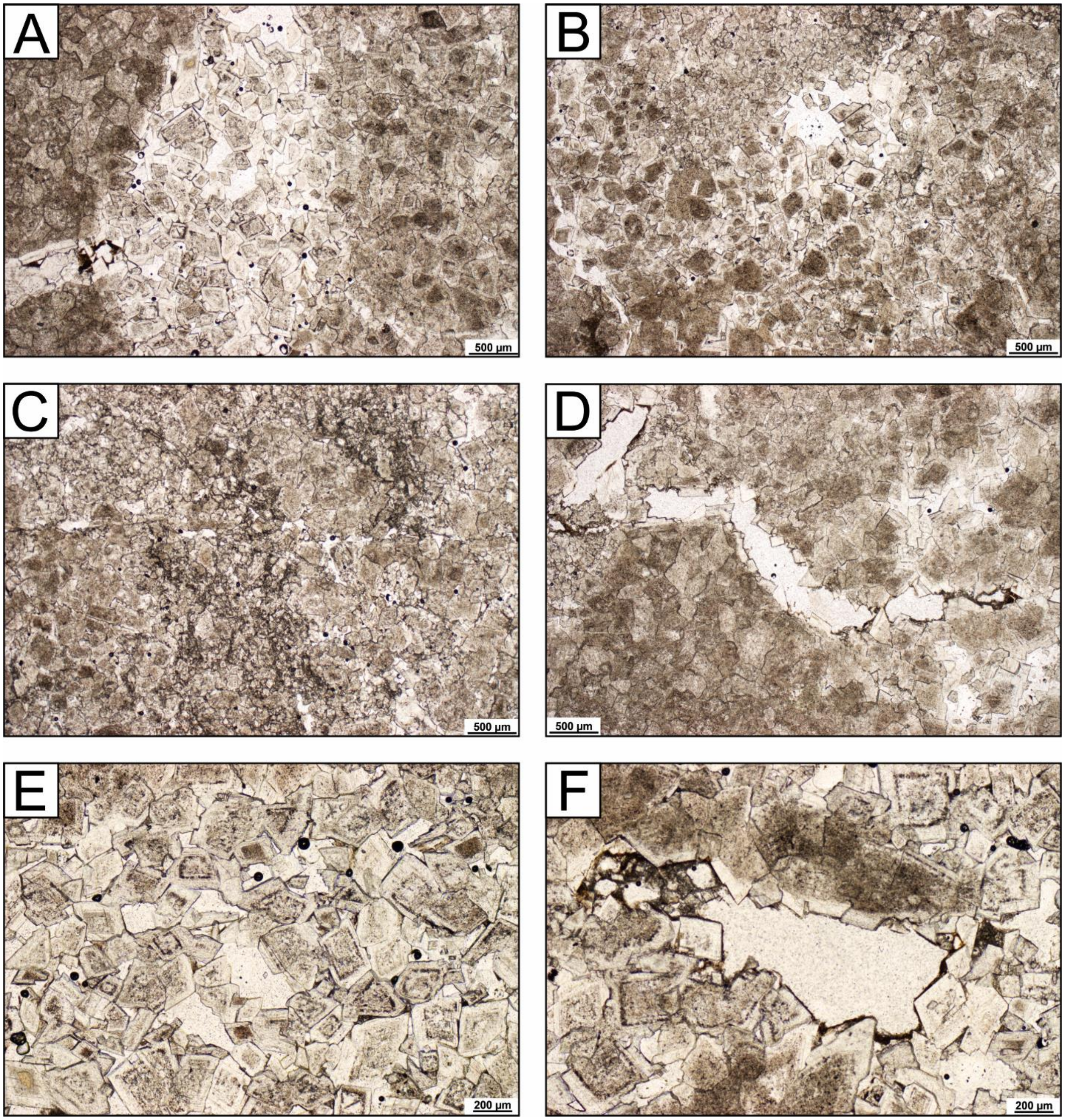


Figure C17: Roberval K-92, Core #7, 3870.85 m, all photos are in PPL. (A) Anhedral to subhedral dolomite along left edge of image. Subhedral to euhedral, zoned dolomite in, less dense pore region, and subhedral dolomite along the right side of image. Note minor hydrocarbon material in a few pore spaces. (B) Varying sizes of anhedral to subhedral and subhedral to euhedral, zoned dolomite. (C) A smaller and larger crystal-size fraction of anhedral to subhedral dolomite. (D) Anhedral to subhedral dolomite with an unknown hydrocarbon lining fracture. (E) Subhedral to euhedral, zoned (limpid and multilayered zoning) dolomite with minor amounts of hydrocarbons lining pore spaces. (F) Anhedral to euhedral dolomite with euhedral crystals displaying zonation. Note unknown hydrocarbon material lining pore.

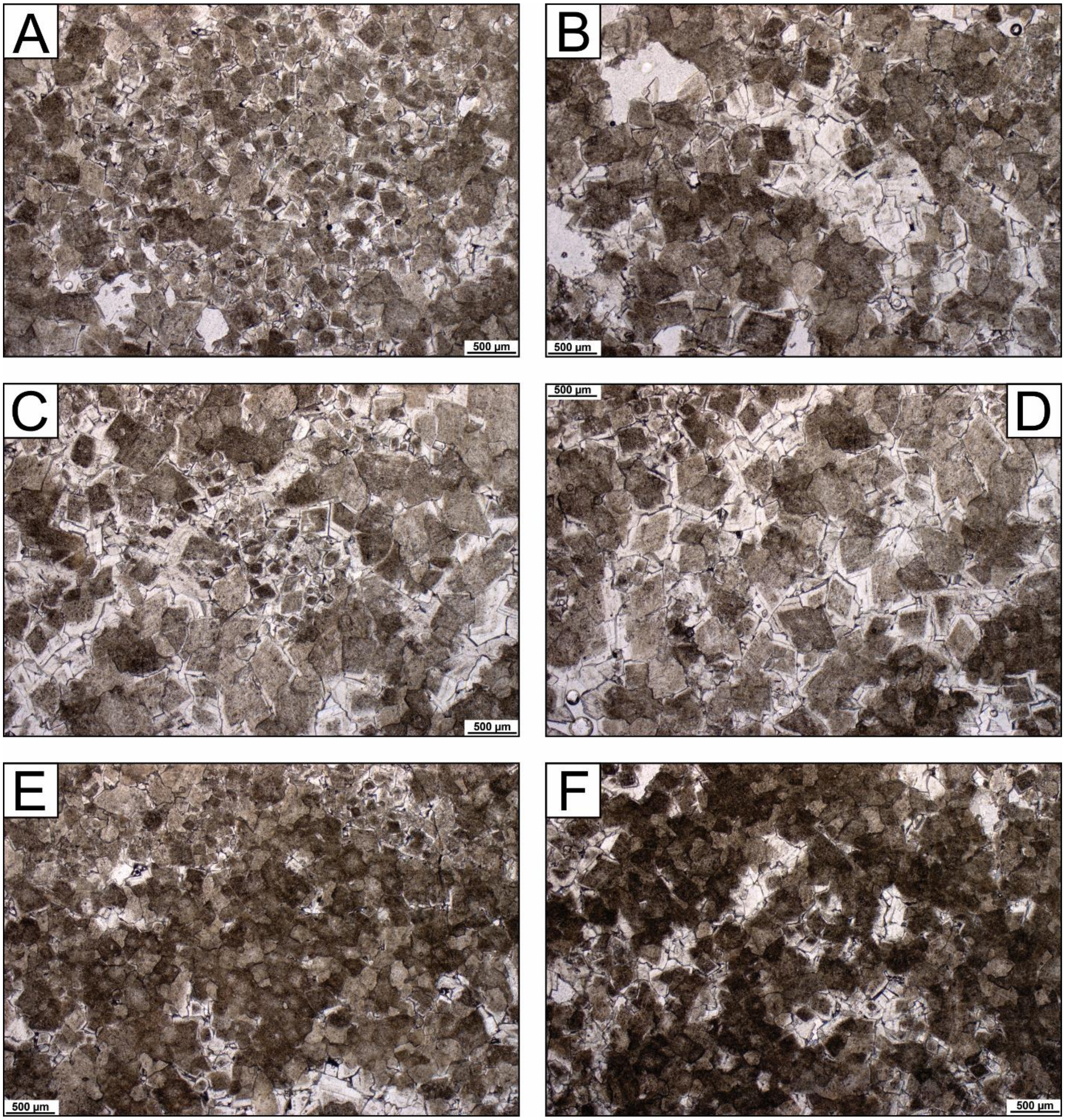


Figure C18: Roberval K-92, Core #7, 3870.9 m, all photos are in PPL. (A) Subhedral to euhedral, zoned (limpid) dolomite with anhedral to subhedral dolomite along edges of image. (B) Intermixed anhedral to subhedral and subhedral to euhedral, zoned dolomite. (C) Intermixed anhedral to subhedral and subhedral to euhedral, zoned (limpid) dolomite. Note varying sizes of crystals. (D) Primarily subhedral to euhedral, zoned (limpid) dolomite with some anhedral to subhedral dolomite, particularly around the edges of the image. (E) Primarily anhedral to subhedral dolomite with subhedral to euhedral dolomite (minor zoning) along the edges of the image. (F) Predominantly anhedral to subhedral dolomite with minor subhedral to euhedral, zoned (limpid) dolomite in pores.

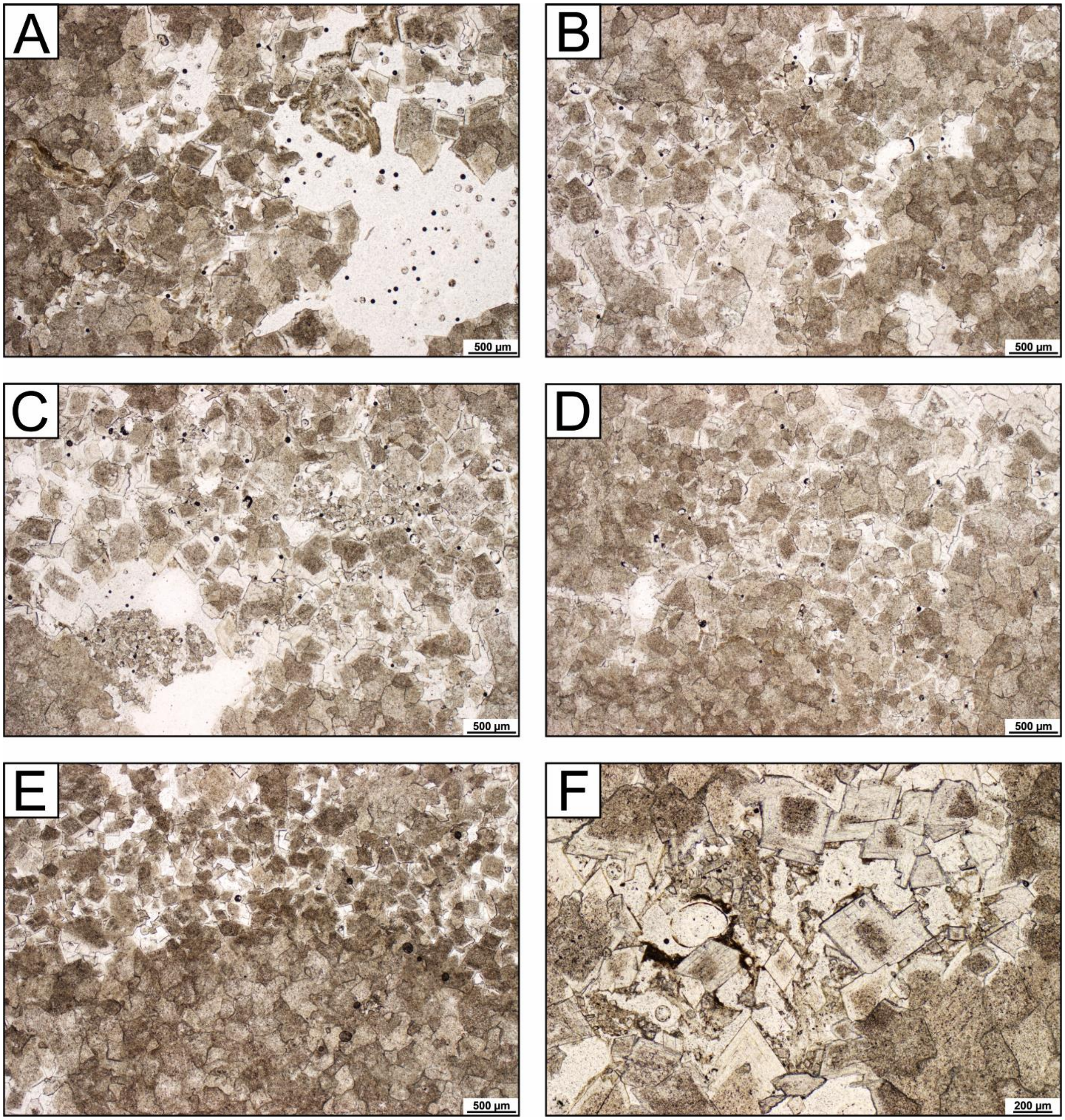


Figure C19: Roberval K-92, Core #7, 3871.45 m, all photos are in PPL. (A) Intermixed anhedral to subhedral and subhedral to euhedral (limpid) dolomite. Note hydrocarbon in argillaceous stringer along left side of image. (B) Anhedral to subhedral and subhedral to euhedral, zoned (limpid) dolomite. (C) Subhedral to euhedral, zoned (limpid) dolomite with some anhedral to subhedral dolomite along the edges of the image. Note the presence of a smaller crystal-size fraction intermixed with the subhedral to euhedral dolomite. (D) Intermixed anhedral to subhedral and subhedral to euhedral, zoned (limpid) dolomite. (E) Subhedral to euhedral, zoned (limpid) dolomite along top of image. Anhedral to subhedral dolomite predominantly in bottom half of slide. Note rounded appearance of anhedral to subhedral dolomite section. (F) Subhedral to euhedral, zoned (primarily limpid) dolomite with anhedral to subhedral dolomite along edge of image. Note unknown hydrocarbon lining pores as well as the presence of a smaller dolomite crystal-size fraction.

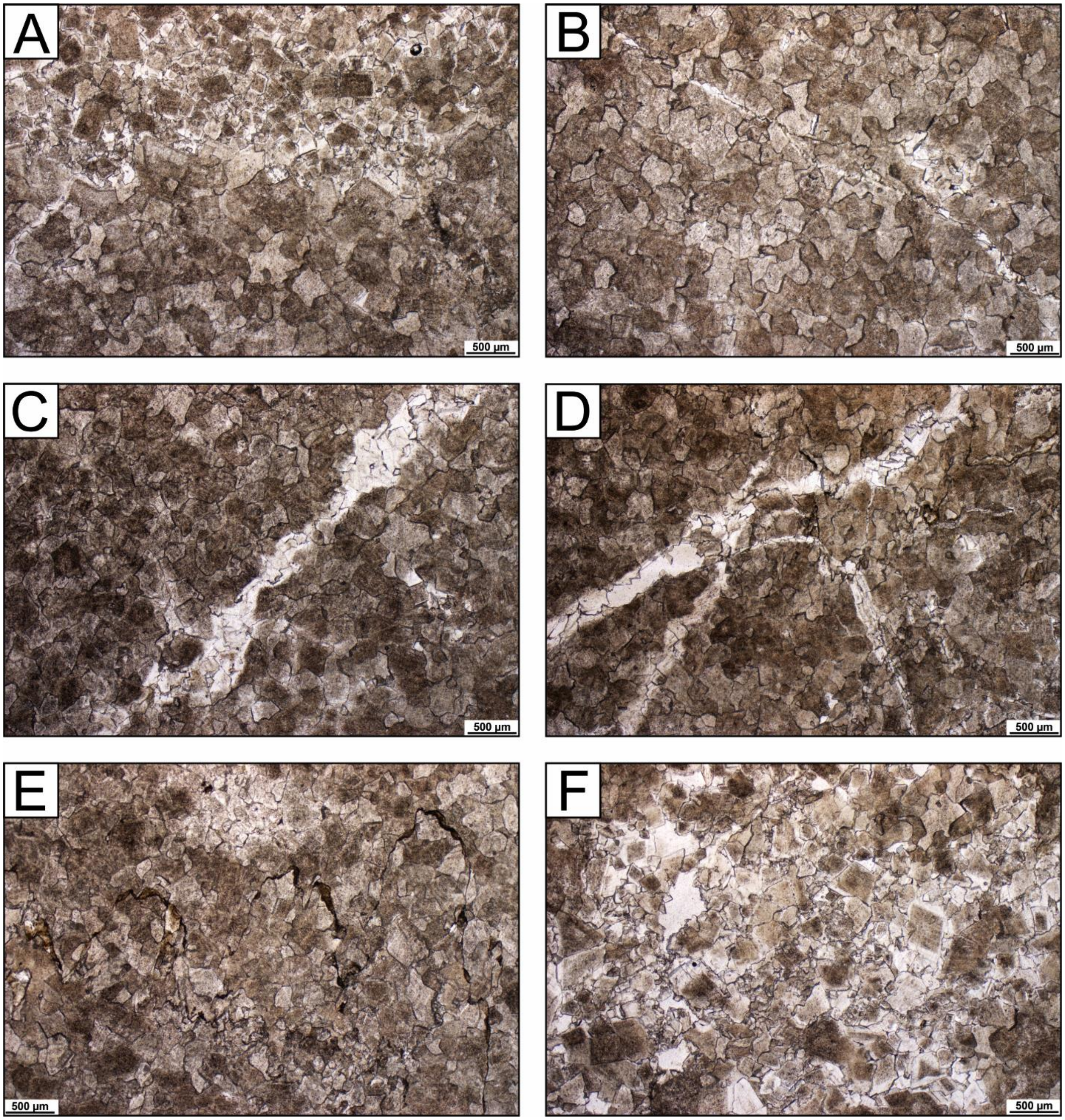


Figure C20: Roberval K-92, Core #7, 3872 m, all photos are in PPL. (A) Predominantly anhedral to subhedral dolomite with subhedral to euhedral dolomite towards the top of image. (B) Anhedral to subhedral dolomite. (C) Fracture in anhedral to subhedral dolomite. Note mottled appearance to dolomite. (D) Fractures and a stylolite in anhedral to subhedral dolomite. (E) Stylolite containing hydrocarbon material in anhedral to subhedral dolomite. (F) Anhedral to euhedral dolomite with euhedral crystals exhibiting zoning (limpid dolomite). Note varying size fractions of dolomite.

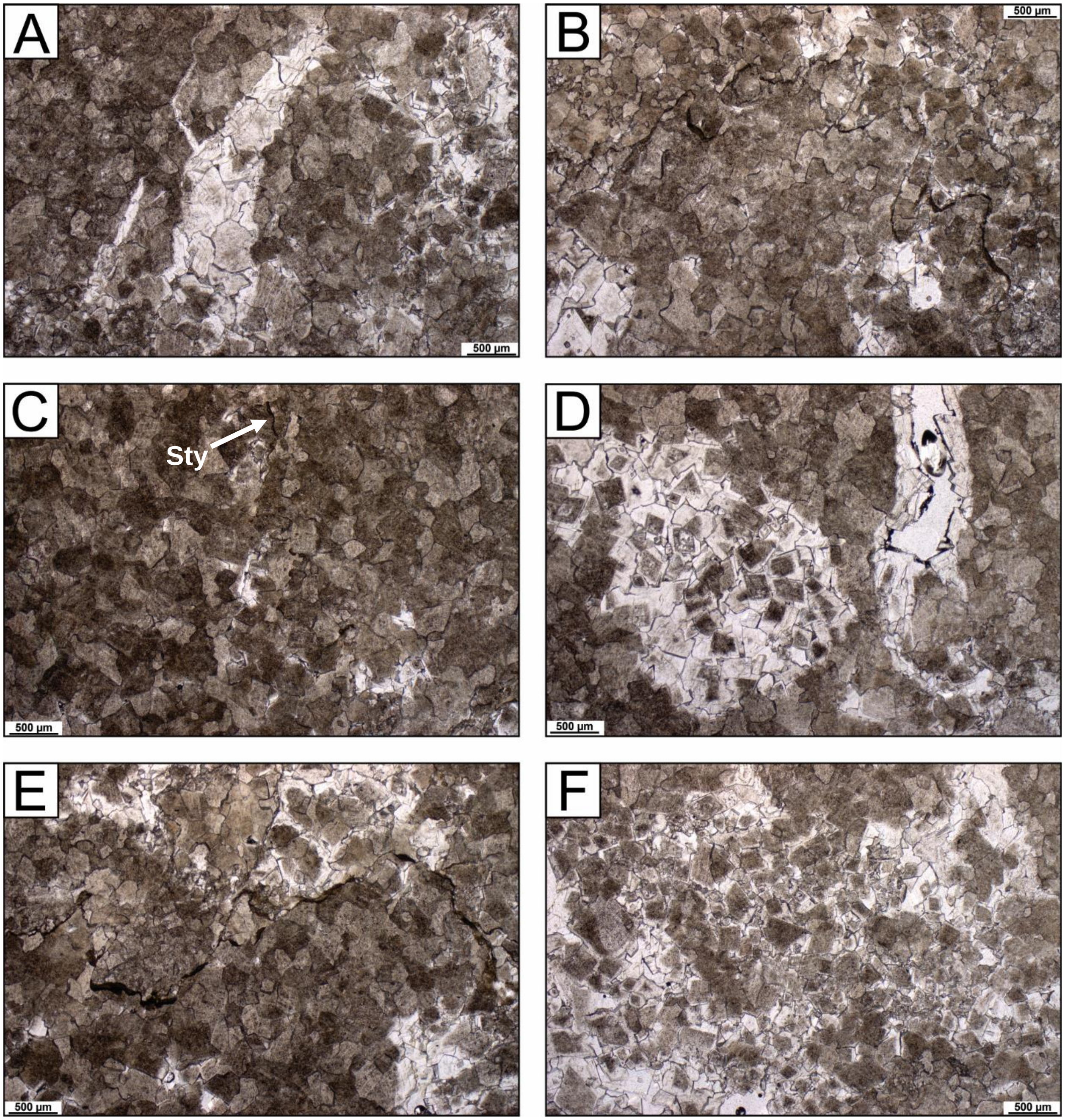


Figure C21: Roberval K-92, Core #7, 3872.34 m, all photos are in PPL. (A) Anhedral to subhedral dolomite with a minor amount of subhedral to euhedral, zoned (primarily zoned) dolomite on the right-hand margin of image. (B) Stylolite containing hydrocarbons in anhedral to subhedral dolomite. (C) Anhedral to subhedral dolomite with a minor amount of unknown hydrocarbon material within a very thin stylolite (Sty). (D) Primarily anhedral to subhedral dolomite with subhedral to euhedral, zoned (primarily limpid) dolomite in a rounded pore space. Note fracture lined with cement and hydrocarbon. (E) Hydrocarbon of unknown origin in a stylolite cross-cutting primarily anhedral to subhedral dolomite. Some subhedral limpid dolomite towards the top of the image. (F) Primarily subhedral to euhedral, zoned (limpid) dolomite with anhedral to subhedral dolomite around the edges of the image.

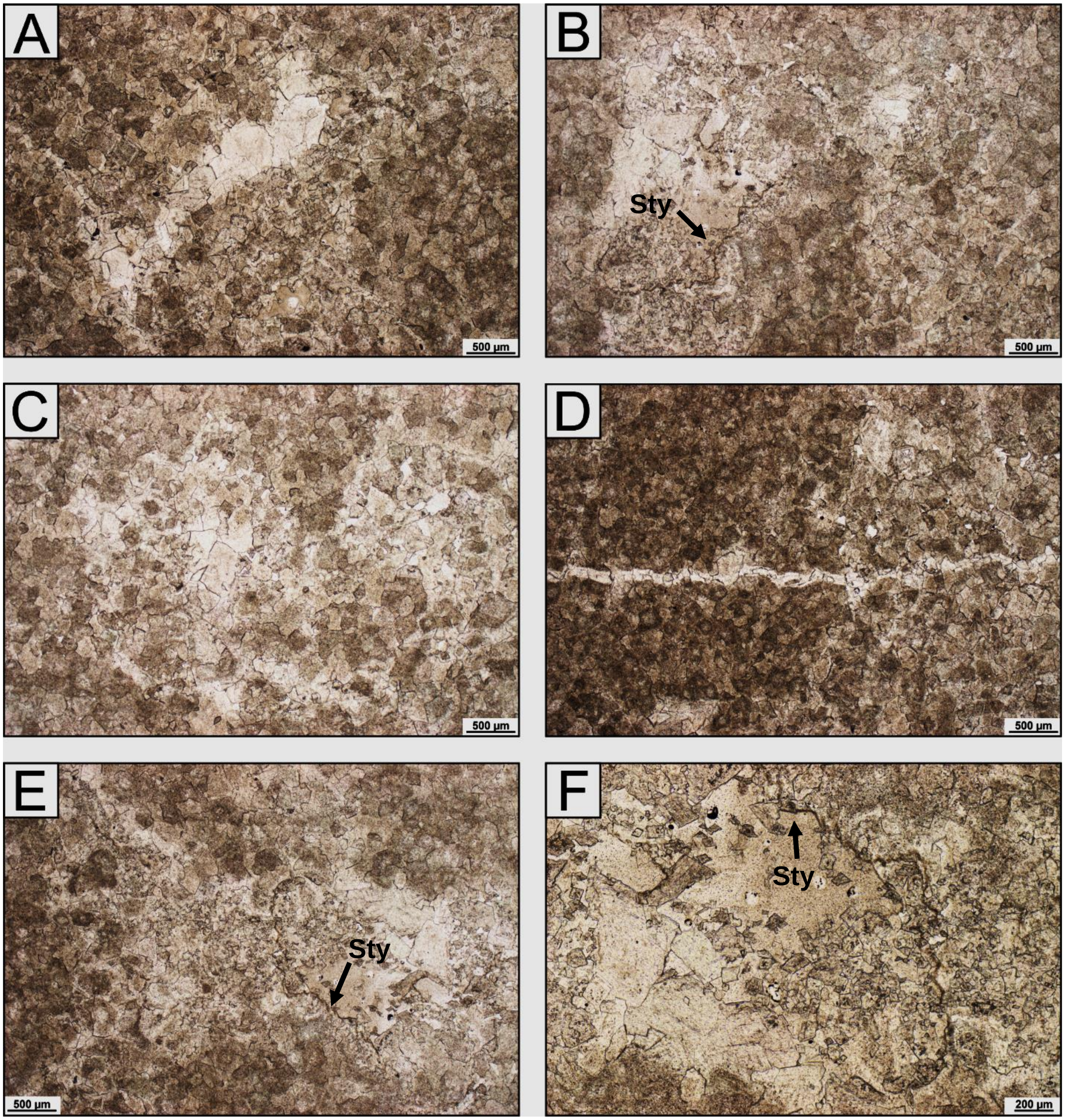


Figure C22: Roberval K-92, Core #7, 3872.8 m, all photos are in PPL. (A) Anhedral to subhedral dolomite. (B) Anhedral to subhedral dolomite of various crystal-size fractions all intermixed. Note mottled appearance of dolomite as well as small stylolite (Sty) with hydrocarbon content. (C) Anhedral to subhedral dolomite primarily around image edges with subhedral to euhedral dolomite (some evidence of zoning) in less dense areas. (D) Anhedral to subhedral dolomite where the dolomite on the left appears darker than the dolomite on the right. These colour variations result in the dolostone having a mottled appearance. (E) Anhedral to subhedral dolomite of various crystal sizes. Note small stylolite (Sty) containing unknown hydrocarbon material. (F) Hydrocarbon-filled stylolite (Sty) amongst dolomite of varying crystal shapes and sizes.

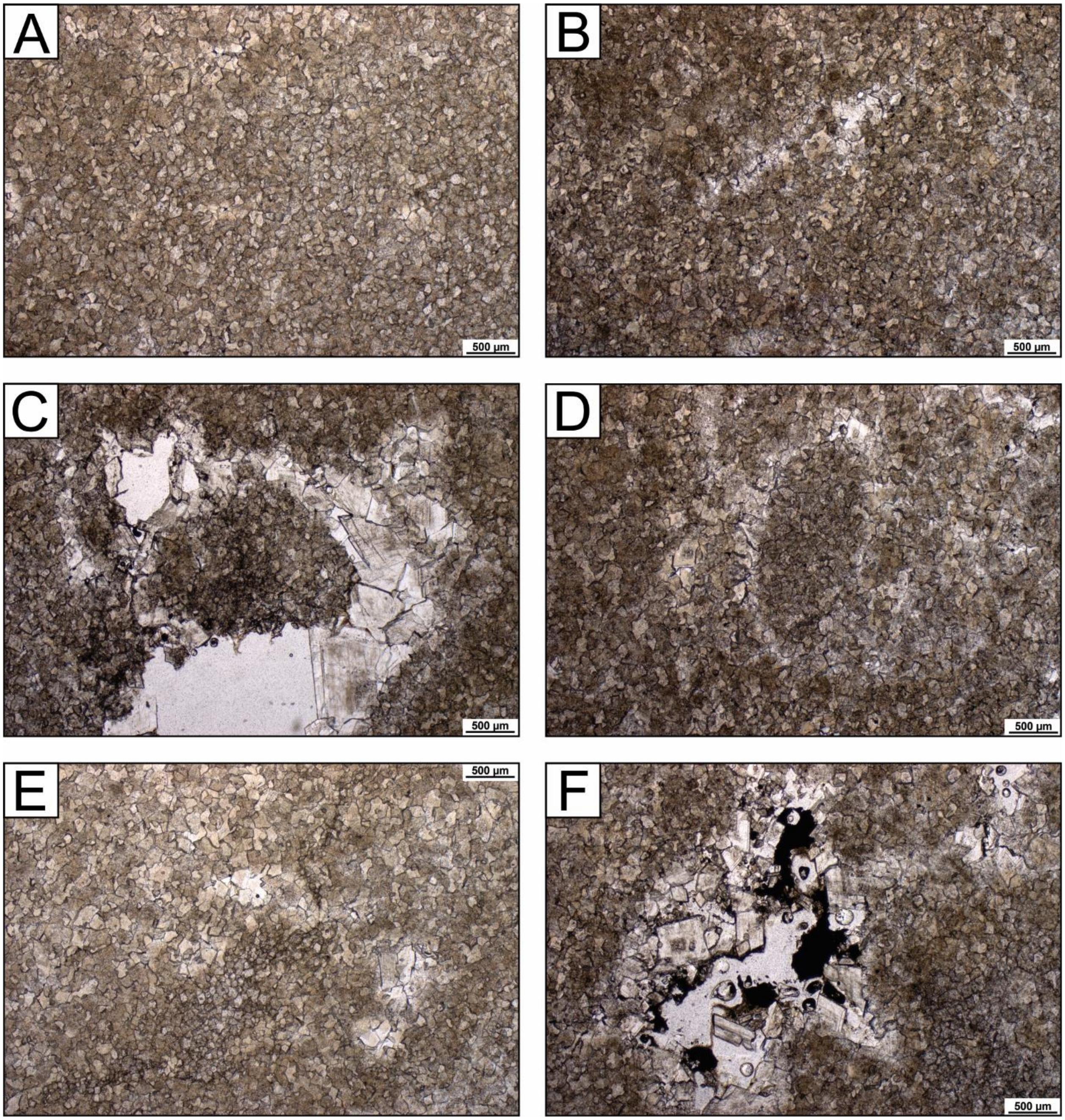


Figure C23: Roberval K-92, Core #7, 3873.3 m, all photos are in PPL. (A) Subhedral to euhedral dolomite. (B) Anhedral to subhedral dolomite with a mottled appearance. (C) Anhedral to subhedral dolomite. Pore space contains dolomite cement. Note rounded shape of anhedral to subhedral dolomite section within the larger pore body. (D) Anhedral to subhedral dolomite. Note rounded features and mottled appearance which may be indicative of pre-diagenesis bioturbation activity. (E) Subhedral to euhedral dolomite of varying crystal- size fractions. (F) Mottled anhedral to subhedral dolomite surrounding a pore containing subhedral to euhedral dolomite and hydrocarbon material of unknown origin.

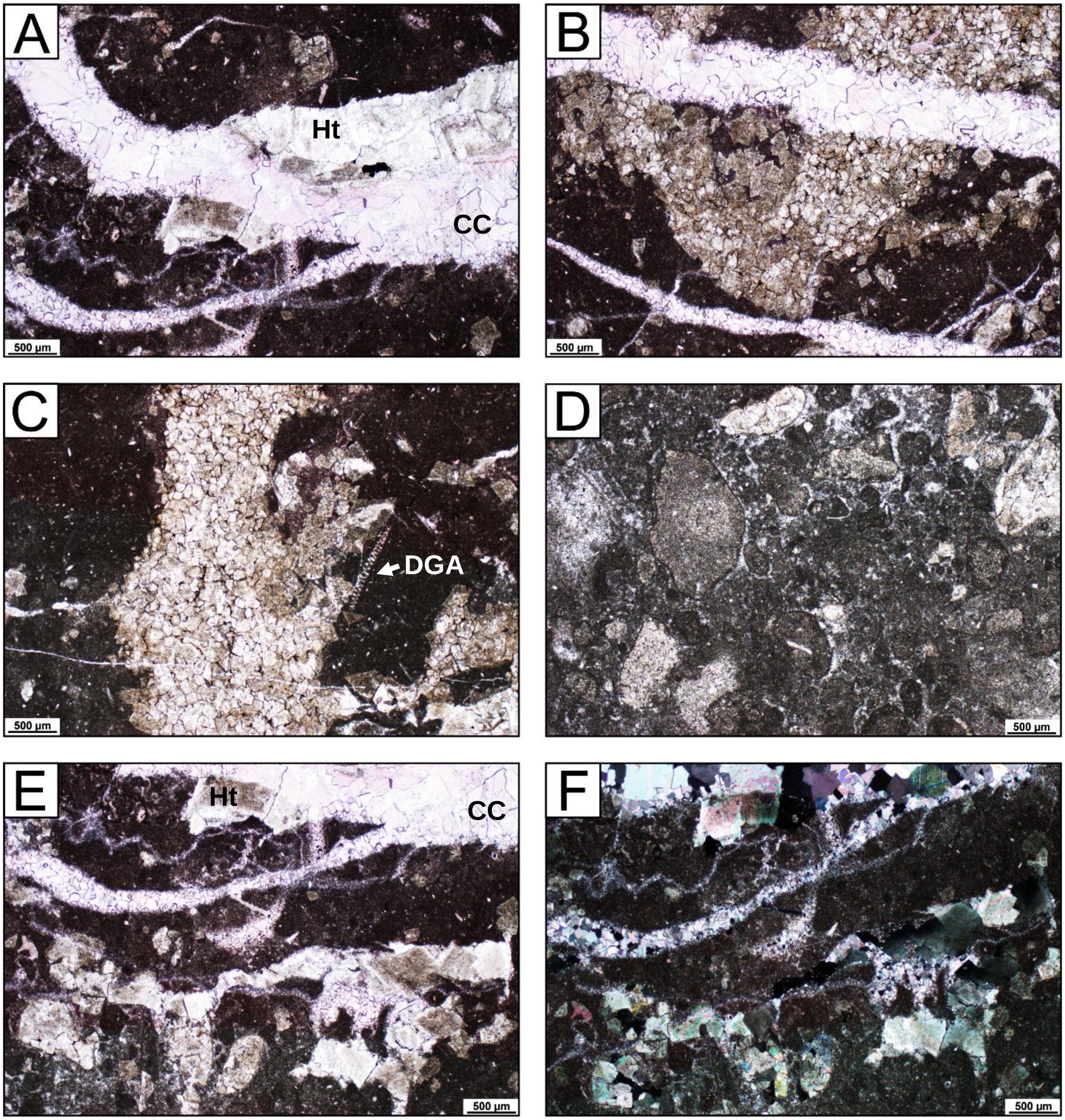


Figure C24: Indian Harbour M-52, Core #1, 3952.48 m. (A) Large fracture with calcite cement (CC) and hydrothermal dolomite (Ht) cutting across a microbial-looking, fossiliferous wackestone (PPL). (B) Calcite cement-filled fracture cutting across a patch of subhedral to euhedral dolomite within a fossiliferous wackestone with a microbial-looking mud matrix (PPL). (B) A patch of subhedral to euhedral dolomite within a fossiliferous wackestone containing a fragment of dasycladacean green algae (DGA) (PPL). (D) Peloidal texture emphasized by the crystallization of the mud matrix (PPL). (E) Microbial-looking mudstone to fossiliferous wackestone with dolomite patches and fractures containing calcite cement (CC) and hydrothermal dolomite (Ht) (PPL). (F) Microbial-looking mudstone to fossiliferous wackestone with dolomite patches and fractures containing calcite cement and hydrothermal dolomite (XPL).

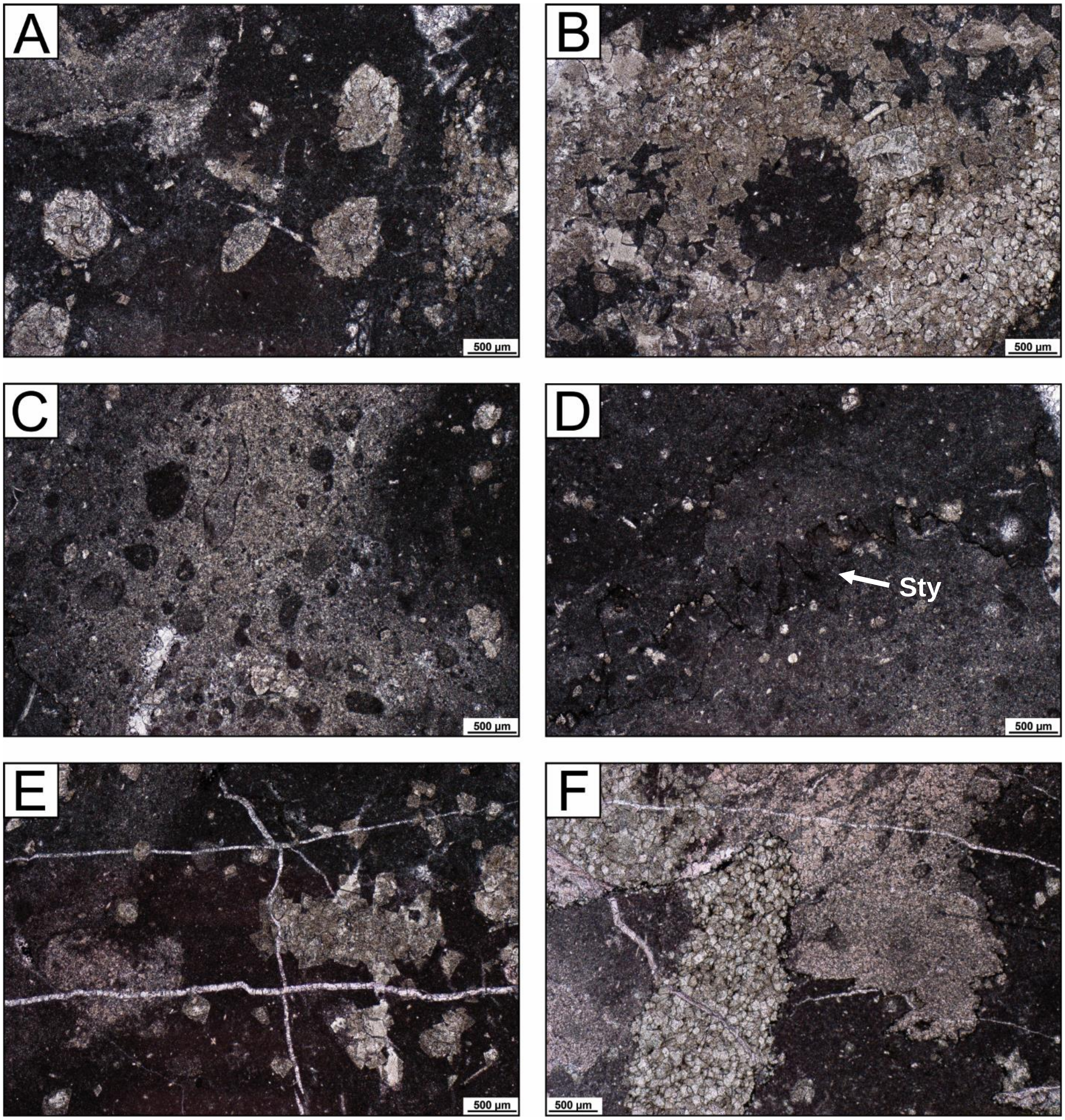


Figure C25: Indian Harbour M-52, Core #1, 3952.54 m, all photos are in PPL. (A) Dolomite patches in a microbial-looking fossiliferous wackestone. Note rounded appearance of dolomite sections. (B) Large dolomite (subhedral to euhedral) section within a mudstone to fossiliferous wackestone. (C) Peloidal texture emphasized by crystallization of the mud matrix. (D) A stylolite (Sty) through a fossiliferous wackestone where the mud has undergone varying degrees of crystallization. (E) A fossiliferous wackestone with fractures and dolomite patches. (F) Microbial-looking mud containing subhedral to euhedral dolomite sections (preferential dolomitization of argillaceous stringers), fractures, and small, unidentifiable fossil fragments. Sections of the mud matrix have also been crystallized.

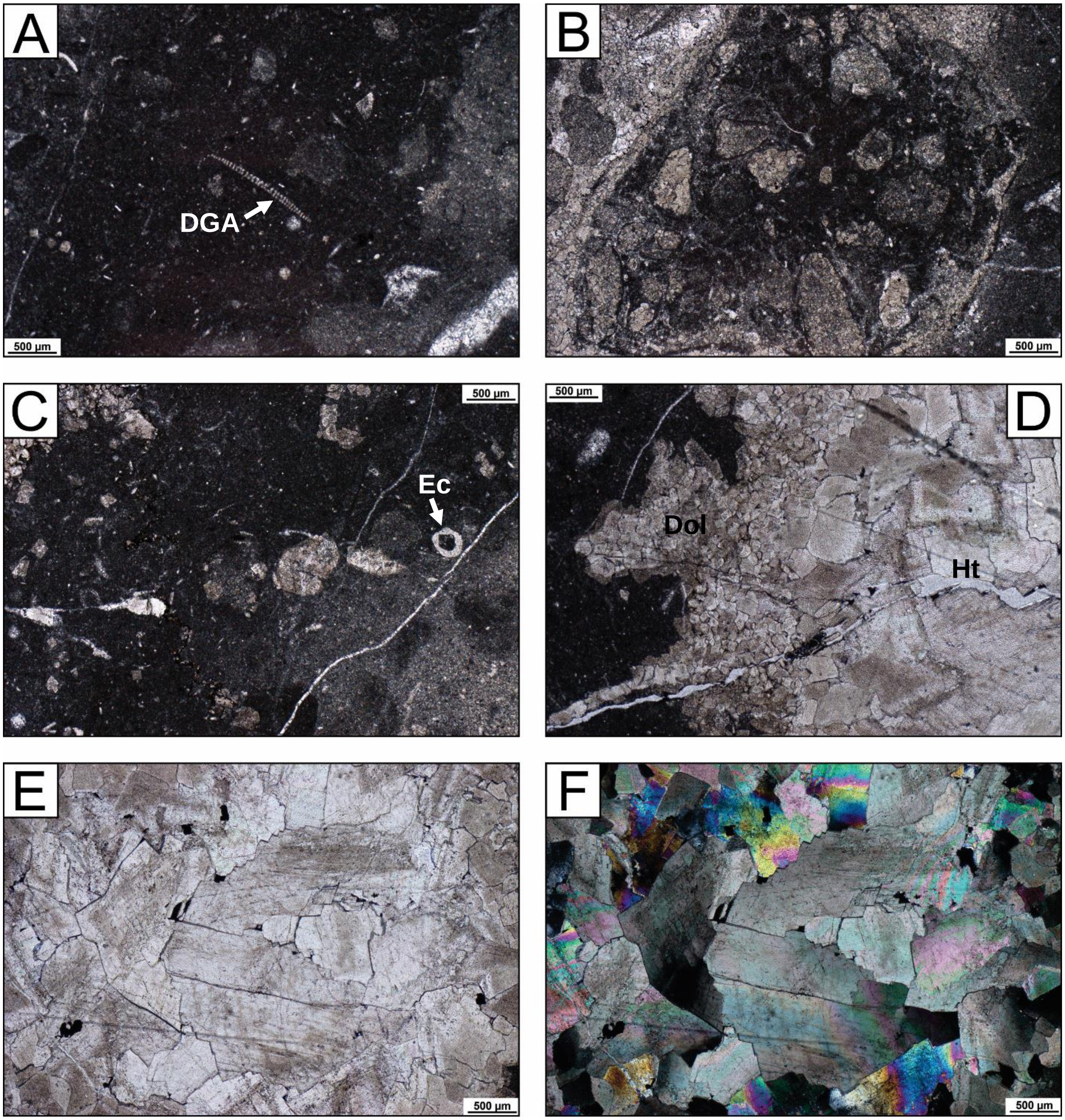


Figure C26: Indian Harbour M-52, Core #1, 3952.69 m. (A) A fossiliferous wackestone with a fragment of dasycladacean green algae (DGA) and small, unidentifiable fossil fragments. Note section of crystallized mud on left of image (PPL). (B) Peloidal texture (left-side of image) and sections of dolomite within a microbial-looking mud matrix (PPL). (C) A fossiliferous wackestone with dolomite patches, fractures, a piece of an echinoderm (crinoid; Ec), and small, unidentifiable fossil fragments. Note that a section of the mud matrix in the bottom right of the image has been crystallized (PPL). (D) A sizeable section of dolomite containing anhedral to subhedral dolomite (Dol) along the edges and hydrothermal dolomite (Ht) in the center of the section (PPL). (E) Hydrothermal dolomite (PPL). (F) Hydrothermal dolomite (XPL).

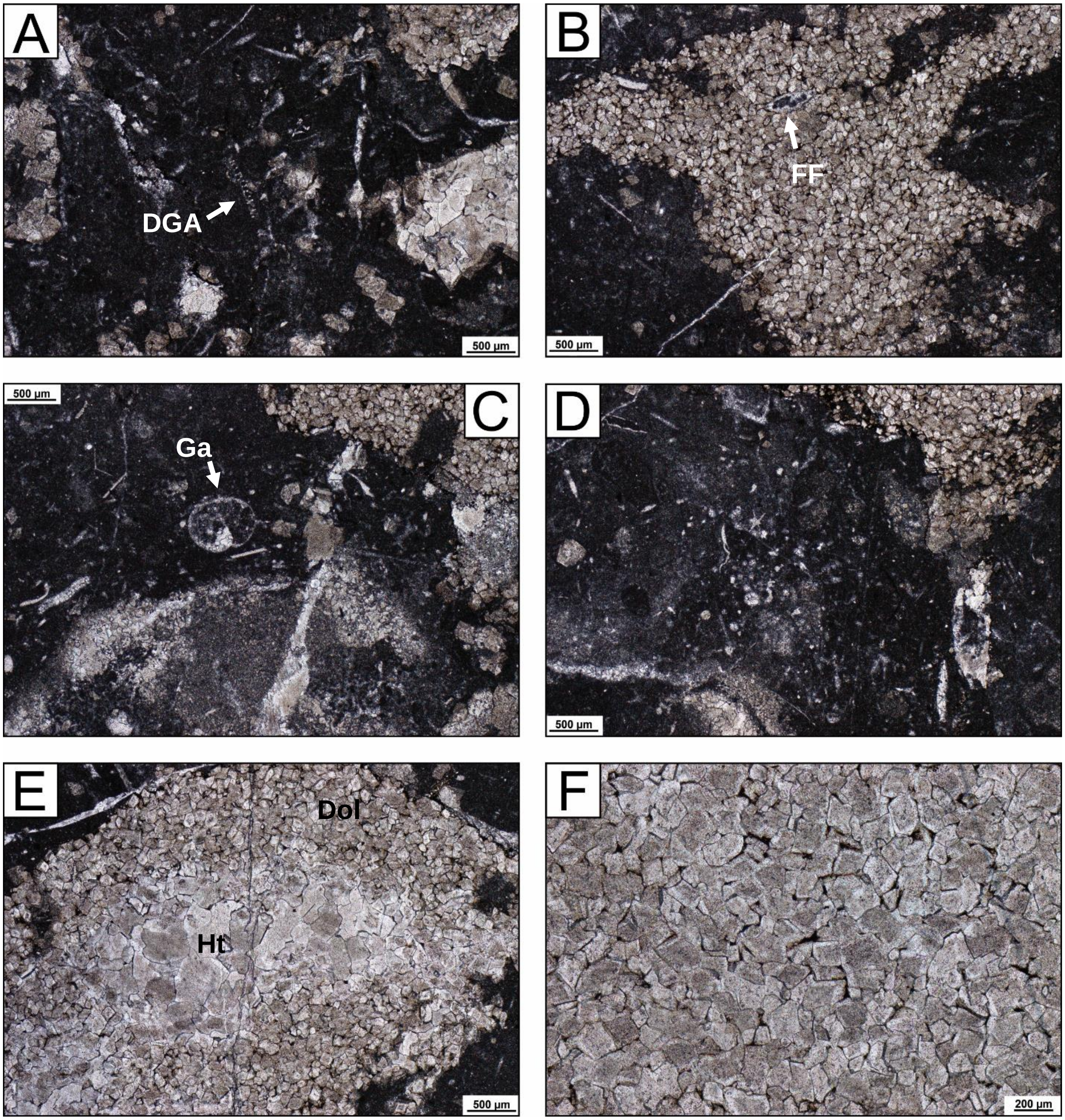


Figure C27: Indian Harbour M-52, Core #1, 3952.91 m, all photos are in PPL. (A) A fossiliferous wackestone with dasycladacean green algae (DGA), unidentifiable fossil fragments, as well as dolomitized sections of the matrix. (B) A dolomitized section within a fossiliferous wackestone. Dolomite is composed of subhedral to euhedral crystals and contains an unknown fossil fragment (FF). (C) A fossiliferous wackestone with a gastropod (Ga) and small, unidentifiable fossil fragments. Sections of the matrix have been dolomitized and/or crystallized. (D) A fossiliferous wackestone with dolomitized sections. (E) A dolomitized region containing hydrothermal dolomite (Ht) surrounded by subhedral to euhedral dolomite (Dol). (F) Subhedral to euhedral dolomite exhibiting zoning (limpid). Note the presence of possible hydrocarbon material in inter-crystalline pores.

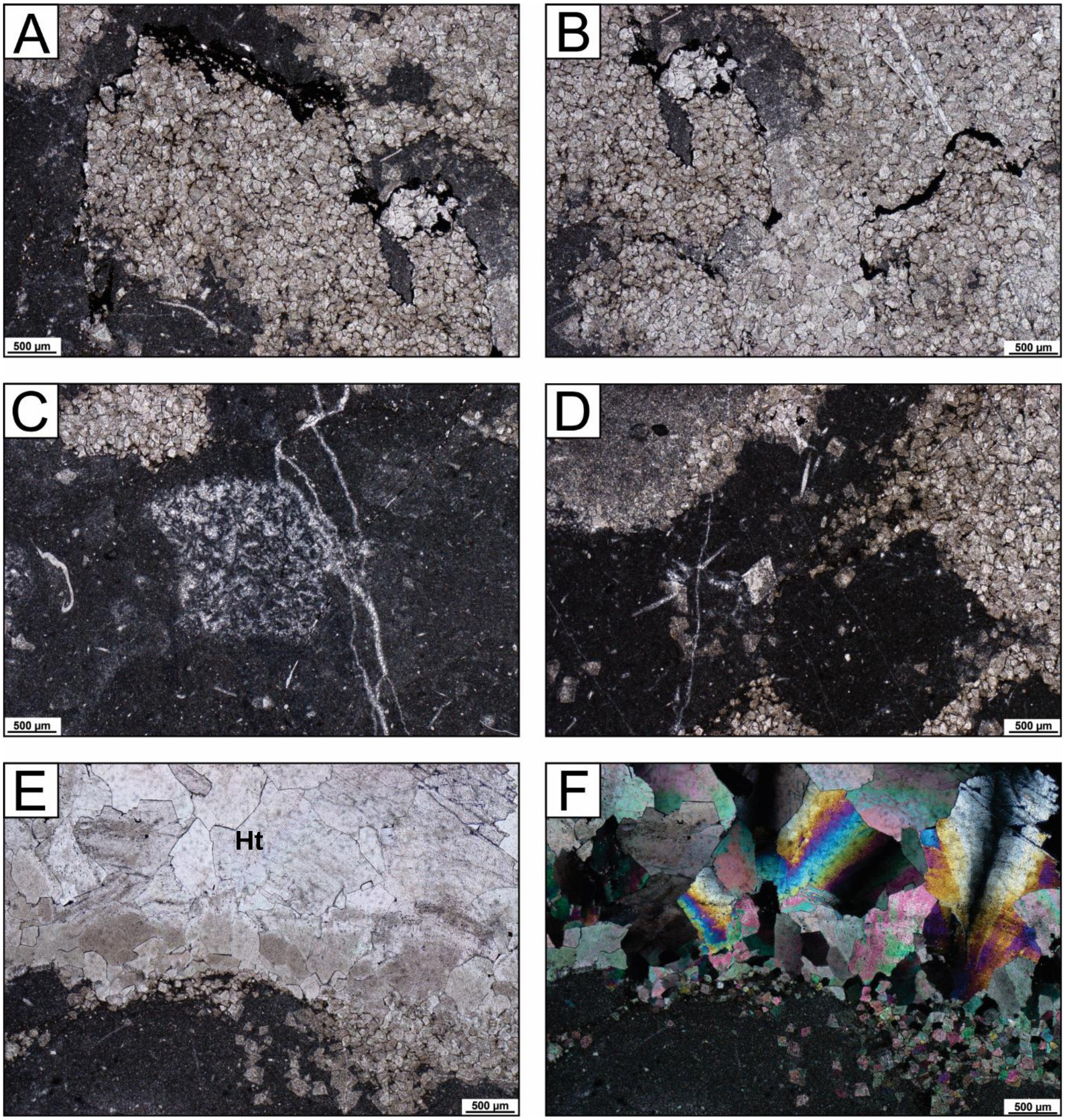


Figure C28: Indian Harbour M-52, Core #1, 3952.94 m. (A) Dolomitized sections bounded by stylolites in an otherwise fossiliferous wackestone. High concentrations of opaque minerals (pyrite) along stylolite (PPL). (B) Anhedral to subhedral dolomite. Note high concentration of pyrite (opaque) mineral along stylolite (PPL). (C) Fossiliferous wackestone with fractures and small patches of dolomite. The lack of mud in the middle of the image has revealed the presence of the calcimicrobe *Girvanella* (PPL). (D) A fossiliferous wackestone with sections that have been dolomitized (PPL). (E) A fossiliferous wackestone with sections that have been dolomitized including areas of hydrothermal dolomite (Ht) (PPL). (F) A fossiliferous wackestone with sections that have been dolomitized including areas of hydrothermal dolomite (Ht) (XPL).

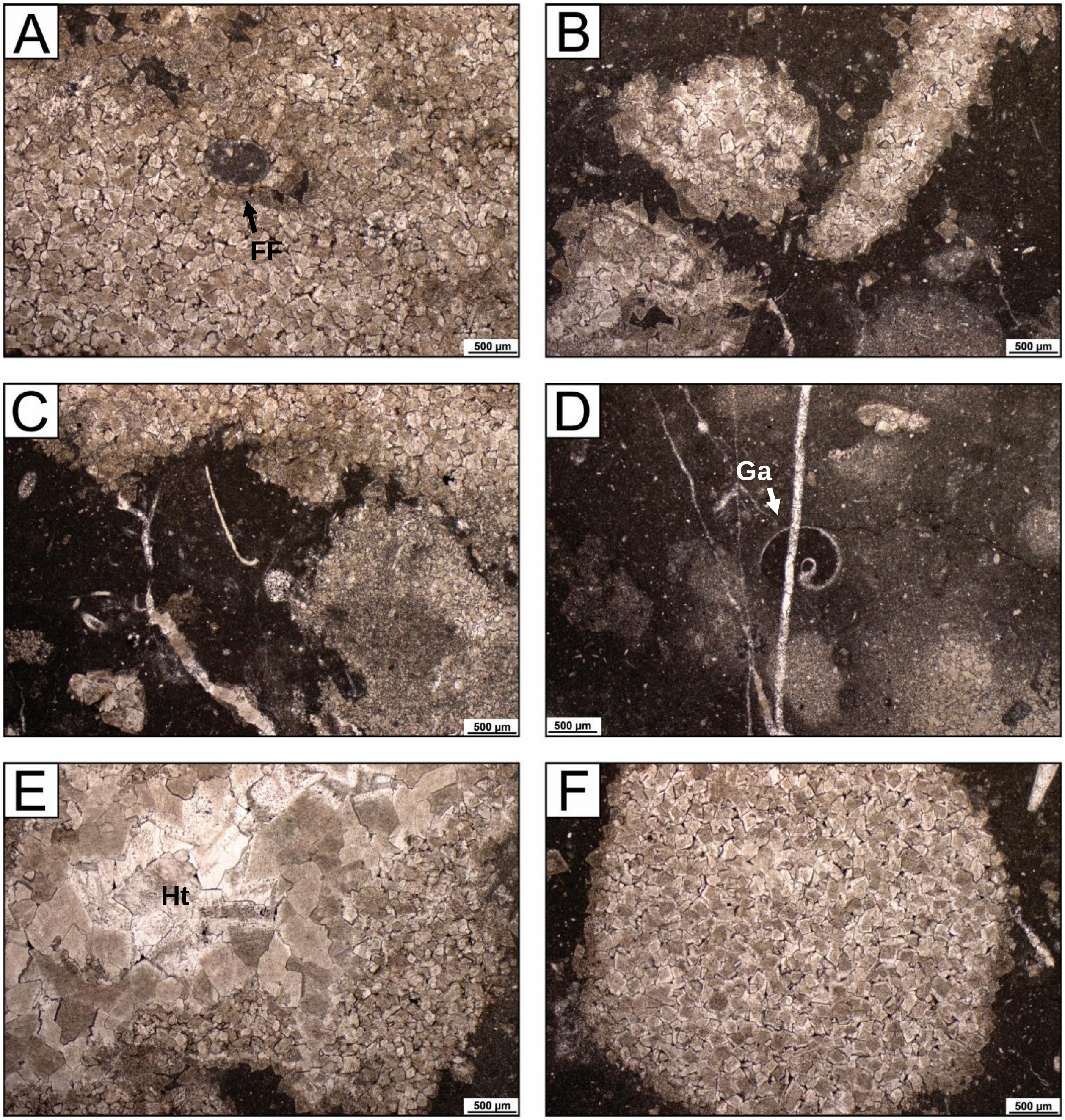


Figure C29: Indian Harbour M-52, Core #1, 3953.09 m, all photos are in PPL. (A) An unknown fossil fragment (FF) in a dolomitized section dominated by subhedral to euhedral dolomite. (B) A fossiliferous wackestone with dolomitized sections. (C) A fossiliferous wackestone with a trilobite fragment and small, unidentifiable fossil fragments. Parts of the matrix have been dolomitized and/or crystallized. (D) A fossiliferous wackestone with a gastropod (Ga) fossil. (E) A dolomitized section of the thin section containing subhedral to euhedral dolomite along the edges and hydrothermal dolomite (Ht) towards the interior. (F) A rounded dolomitized section containing subhedral to euhedral dolomite with some evidence of zoning (limpid dolomite) apparent.

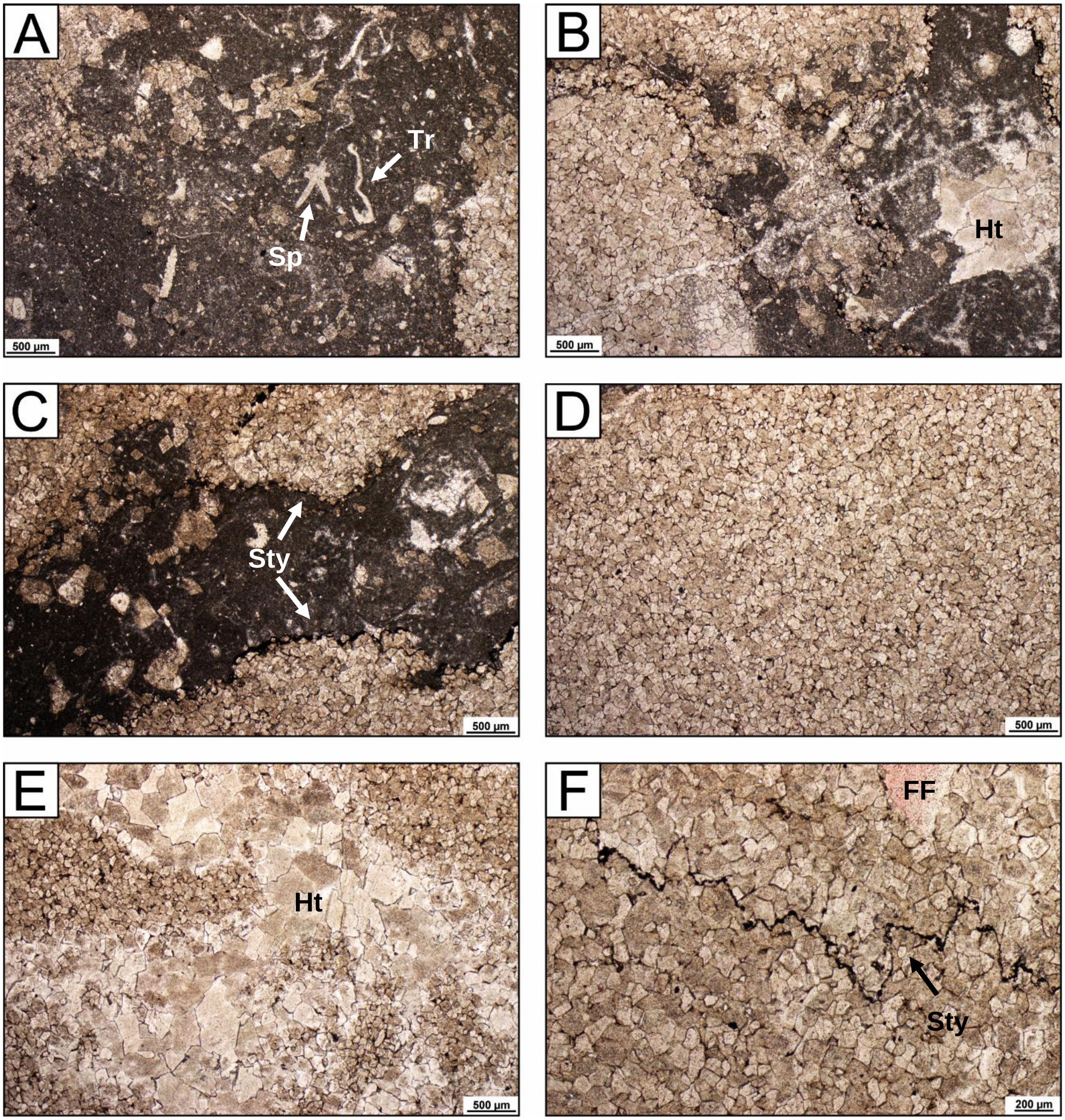


Figure C30: Indian Harbour M-52, Core #1, 3953.73 m, all photos are in PPL. (A) A fossiliferous wackestone with unidentifiable fossil fragments, sponge spicules (Sp), and trilobites (Tr). Note that dolomitization has occurred in some areas of the matrix. (B) A fossiliferous wackestone with areas of the matrix having undergone substantial dolomitization. Hydrothermal dolomite (Ht) is also present. (C) A fossiliferous wackestone with dolomitized regions that are bounded by stylolites (Sty). (D) Subhedral to euhedral dolomite. (E) Subhedral to euhedral dolomite surrounding a section of hydrothermal dolomite (Ht). (F) A stylolite (Sty) through a region of subhedral to euhedral dolomite. There is also an unknown fossil fragment (FF) in the dolomite (likely a fragment of an echinoderm).

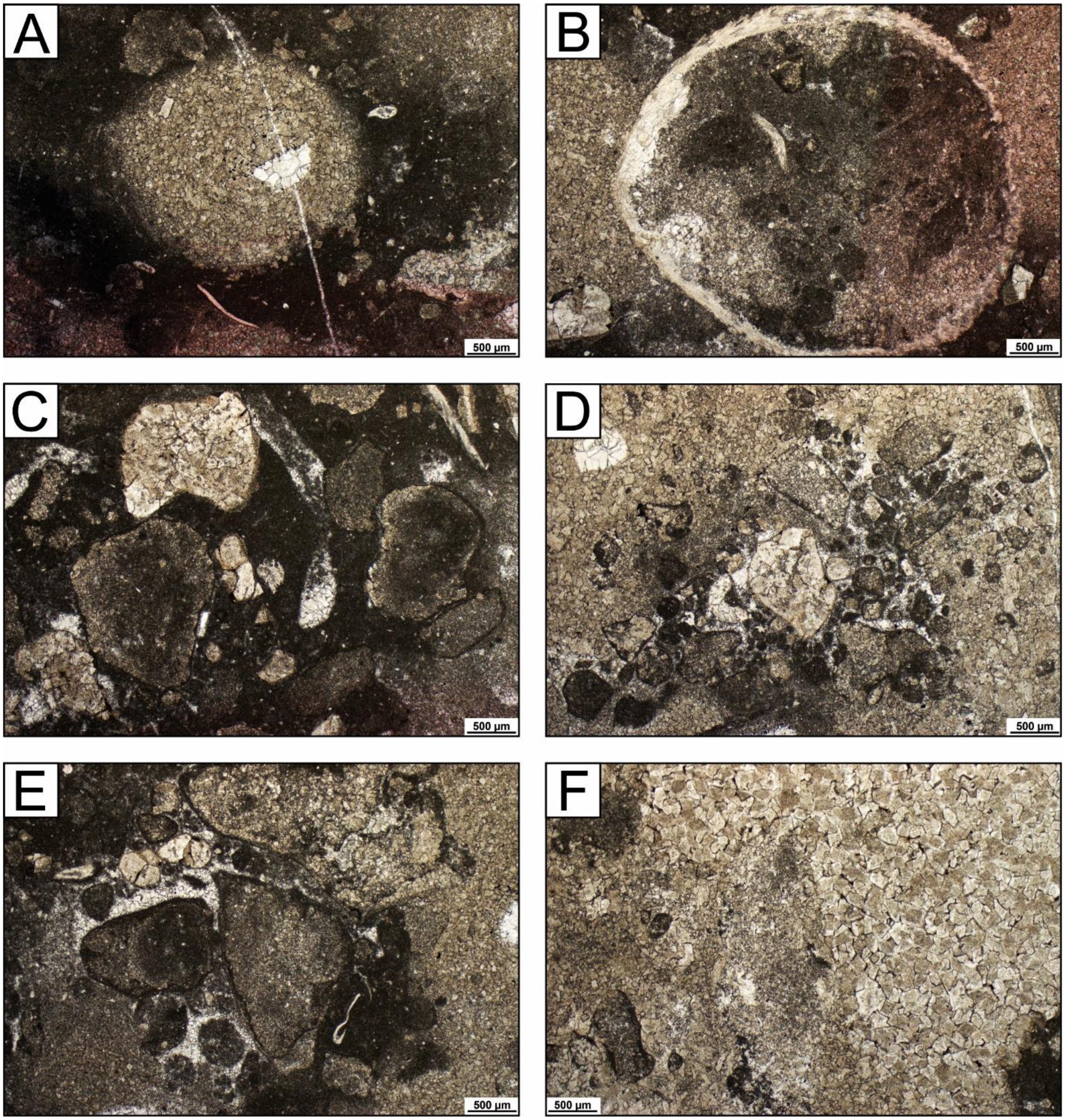


Figure C31: Indian Harbour M-52, Core #1, 3954.22 m, all photos are in PPL. (A) A fossiliferous wackestone in which areas of the matrix have been dolomitized and/or crystallized. (B) A fossiliferous wackestone with a large, articulated brachiopod (atrypide or rhynchonellide; Sproat, pers. comm.). Note that significant regions of the matrix have been crystallized. (C) A fossiliferous wackestone with sections that have been crystallized. (D) A peloidal texture encased by anhedral to subhedral dolomite. (E) A peloidal area with varying degrees of matrix crystallization. (F) Finer and coarser dolomite. The coarser dolomite is subhedral to euhedral and exhibits evidence of zoning (limpid).

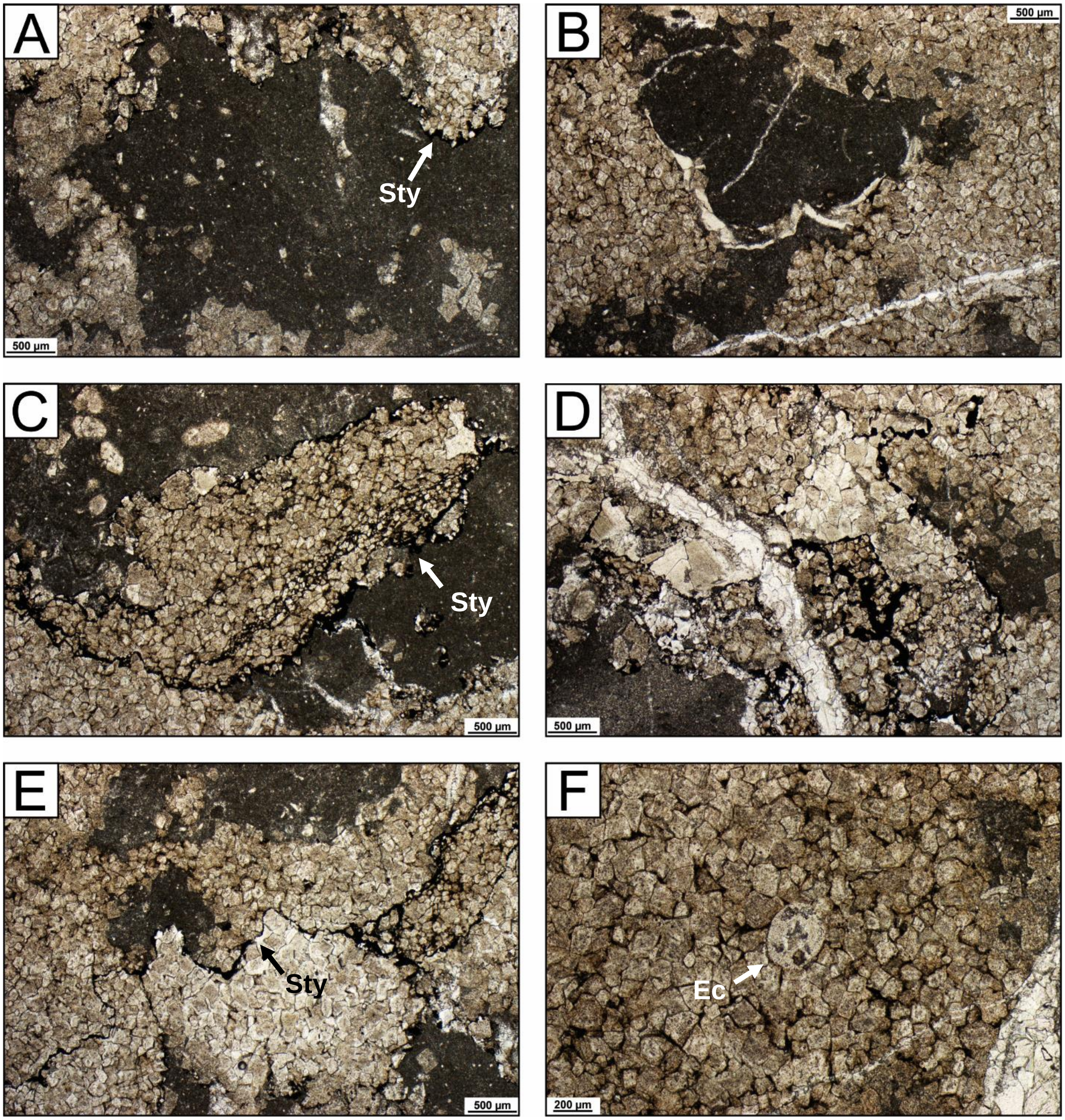


Figure C32: Indian Harbour M-52, Core #1, 3954.49 m, all photos are in PPL. (A) Fossiliferous wackestone where areas of the matrix have been dolomitized. Some of these dolomite sections are bounded by stylolites (Sty) highlighted by high concentrations of opaque minerals (pyrite). (B) Fossiliferous wackestone with subhedral to euhedral dolomite. (C) Fossiliferous wackestone where dolomitization has occurred. Some dolomitized regions are bounded by stylolites (Sty) highlighted by an abundance of pyrite. (D) Multi-phased dolomitization of regions of a fossiliferous wackestone. Note abundance of opaque minerals (pyrite) which occur along stylolites. (E) Fossiliferous wackestone with subhedral to euhedral dolomite. Note high concentrations of pyrite along stylolites. (F) Subhedral to euhedral dolomite containing an echinoderm (crinoid; Ec) fragment.

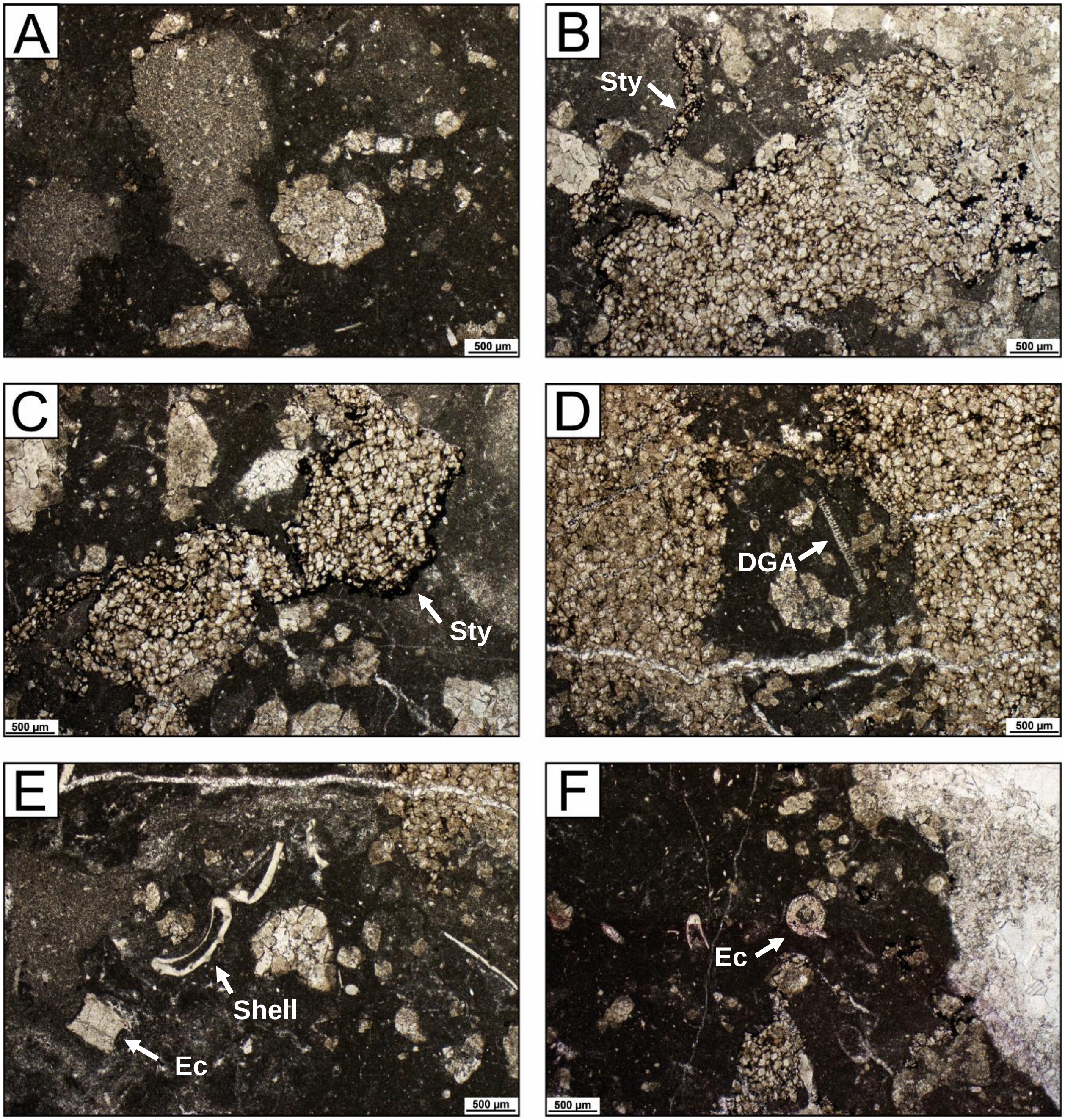


Figure C33: Indian Harbour M-52, Core #1, 3955.35 m, all photos are in PPL. (A) A fossiliferous wackestone where sections of the matrix have been dolomitized/crystallized. (B) A fossiliferous wackestone and subhedral to euhedral dolomite. Areas of the dolomite are bounded by stylolites (Sty) that are highlighted by a high concentration of pyrite. (C) A fossiliferous wackestone with patches of subhedral to anhedral dolomite bounded by stylolites (Sty) containing pyrite. (D) A fossiliferous wackestone with dasycladacean green algae (DGA) and subhedral to euhedral dolomite. (E) A fossiliferous wackestone containing shells, echinoderm (crinoid; Ec) fragments, and small, unidentifiable fossils. Note that sections of the matrix have been altered (dolomitized and/or crystalized). (F) A fossiliferous wackestone with pieces of crinoids (Ec) and small, unidentifiable fossil fragments.

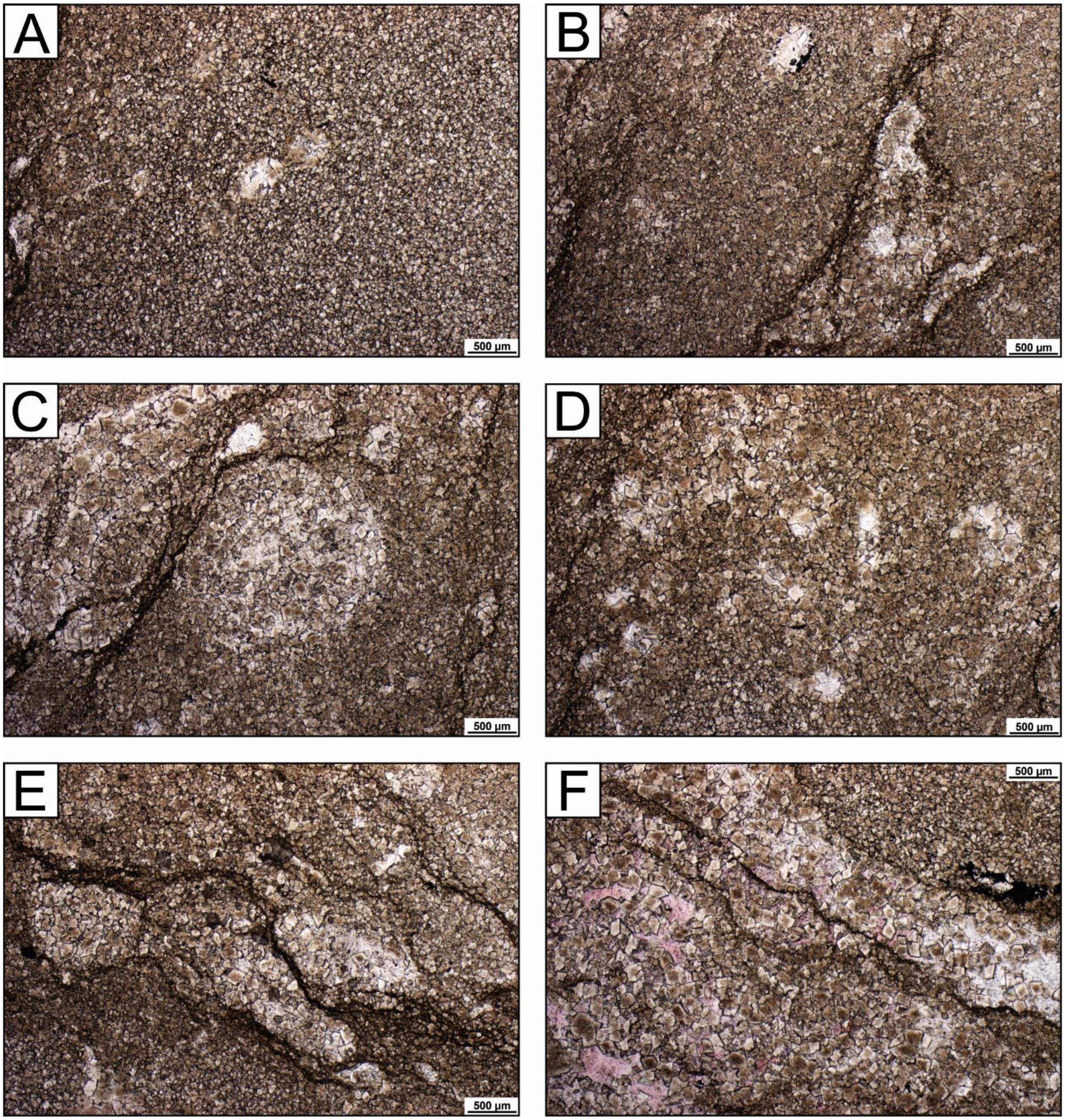


Figure C34: Indian Harbour M-52, Core #1, 3956.2 m, all photos are in PPL. (A) Primarily sucrosic subhedral to euhedral dolomite with, larger anhedral dolomite cement in pore spaces. (B) Anhedral to euhedral dolomite with dolomite cement infilling pore spaces. Note the presence of argillaceous stringers. (C) Anhedral to subhedral dolomite with subhedral to euhedral dolomite (including limpid dolomite) in less dense regions. Note circular shape to patch of limpid dolomite in center of image as well as the presence of argillaceous stringers. (D) Anhedral to euhedral dolomite of varying crystal sizes. (E) Anhedral to euhedral dolomite with argillaceous stringers. (F) Subhedral to euhedral zoned (limpid) dolomite with sucrosic dolomite in the upper right corner of the image. Note the presence of an argillaceous stinger.

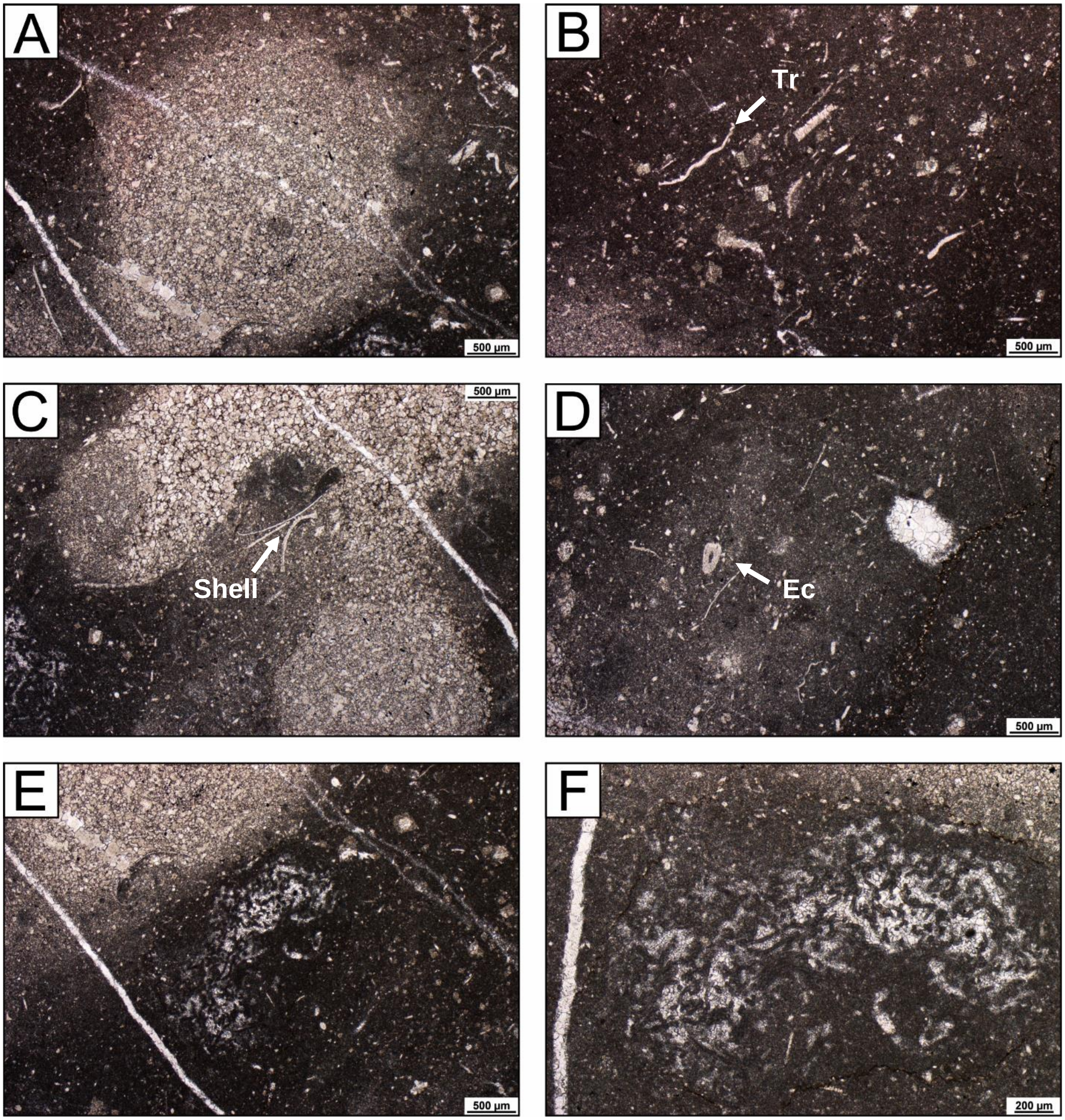


Figure C35: Indian Harbour M-52, Core #1, 3956.47 m, all photos are in PPL. (A) A rounded section of crystallized matrix in an otherwise fossiliferous wackestone. (B) A fossiliferous wackestone with small, unidentifiable fossil fragments as well as a trilobite fragment (Tr). (C) A fossiliferous wackestone in which parts of the matrix have been dolomitized. Small, unidentifiable fossils along with shell fragments are common. Note rounded appearance of crystallized/dolomitized matrix. (D) A fossiliferous wackestone with small, unidentifiable fossil fragments and echinoderms (crinoids; Ec). (E) A fossiliferous wackestone with microbial mud. Dolomitization has occurred to the matrix in the upper left corner of the image. (F) *Girvanella* (a calcimicrobe) is observed in less dense/partly crystalized areas of the matrix accounting for the microbial texture of the mud.

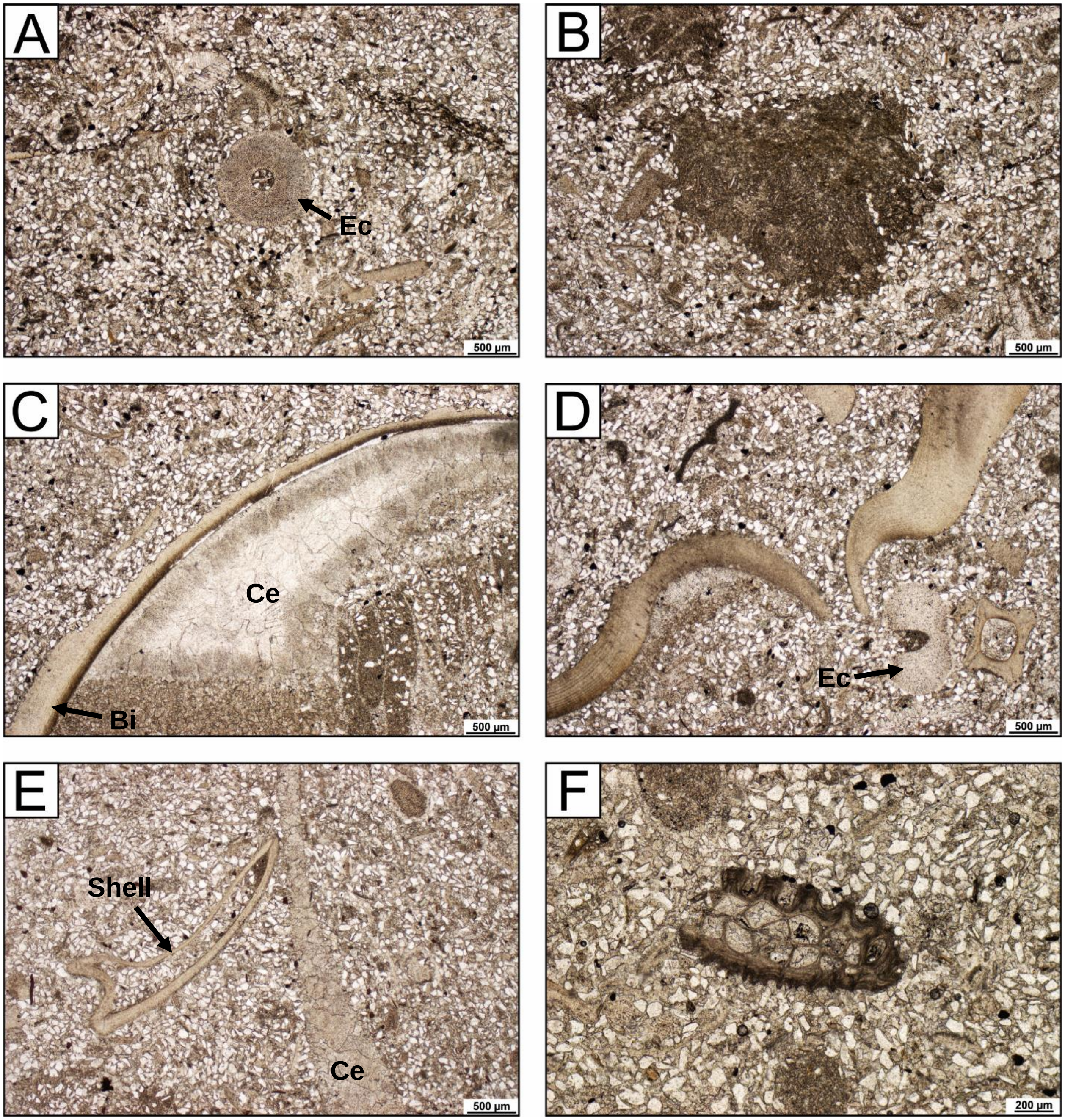


Figure C36: Freydis B-87, Core #1, 1935.6 m, all photos are in PPL. (A) A fossiliferous sandstone with numerous fossil fragments and echinoderms (crinoid; Ec). (B) The fossiliferous sandstone also contains clumps of microbial mud that appear to have been ripped up and incorporated. (C) A large bivalve shell (Bi) with cement (Ce) underneath. (D) Fossil fragments of unknown origin (interpreted to be shell fragments) as well as crinoid fragments (Ec). (E) A fossiliferous sandstone with shells, cement (Ce), and other small, unidentifiable fossil fragments. (F) A bryozoan fragment in the fossiliferous sandstone.

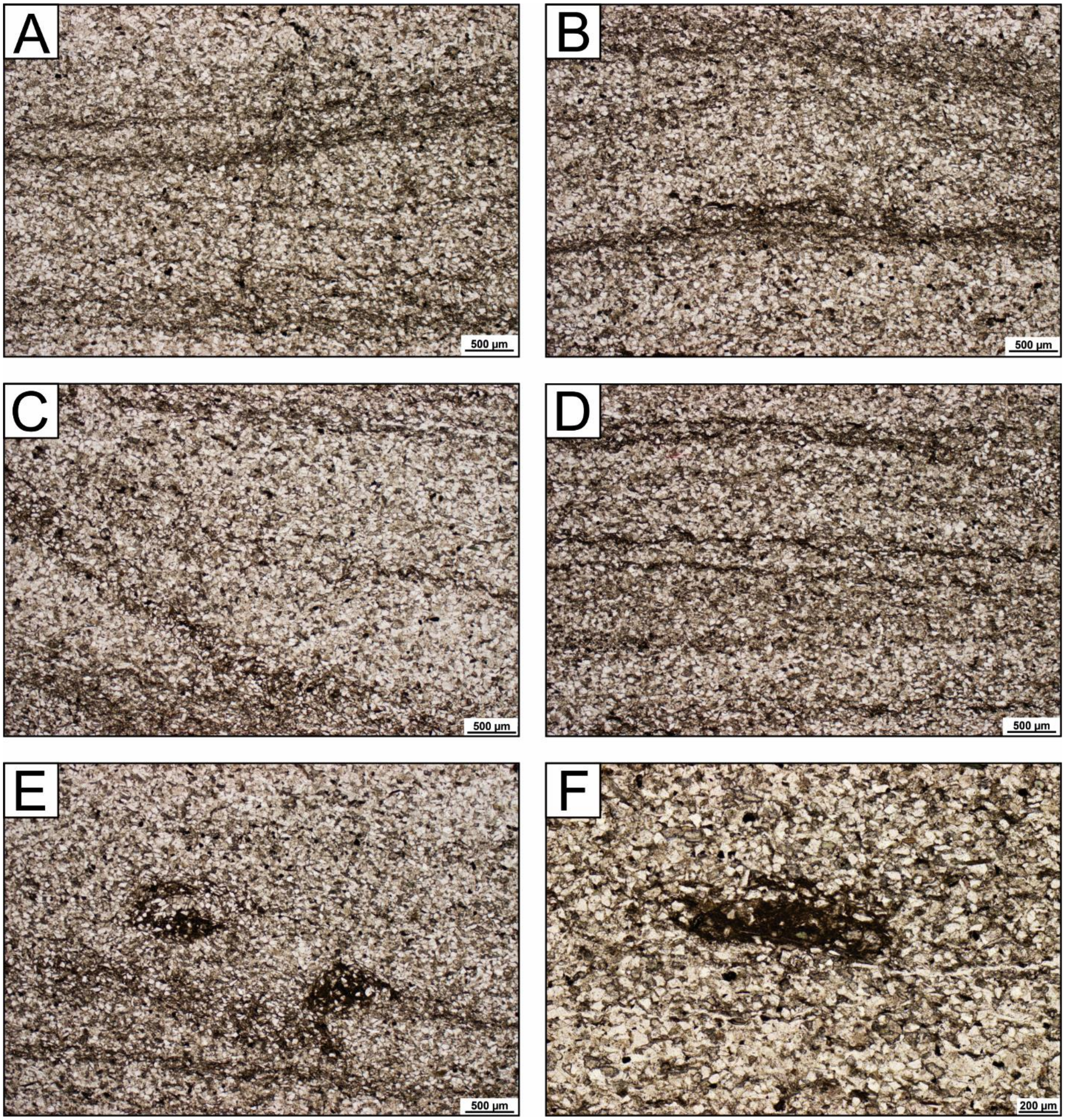


Figure C37: Freydis B-87, Core #1, 1935.79 m, all photos are in PPL. (A-D) A laminated sandstone where the laminations are defined by an increase in the silt/mud content. (E-F) dark, microbial-looking mud sections in an otherwise laminated mudstone.

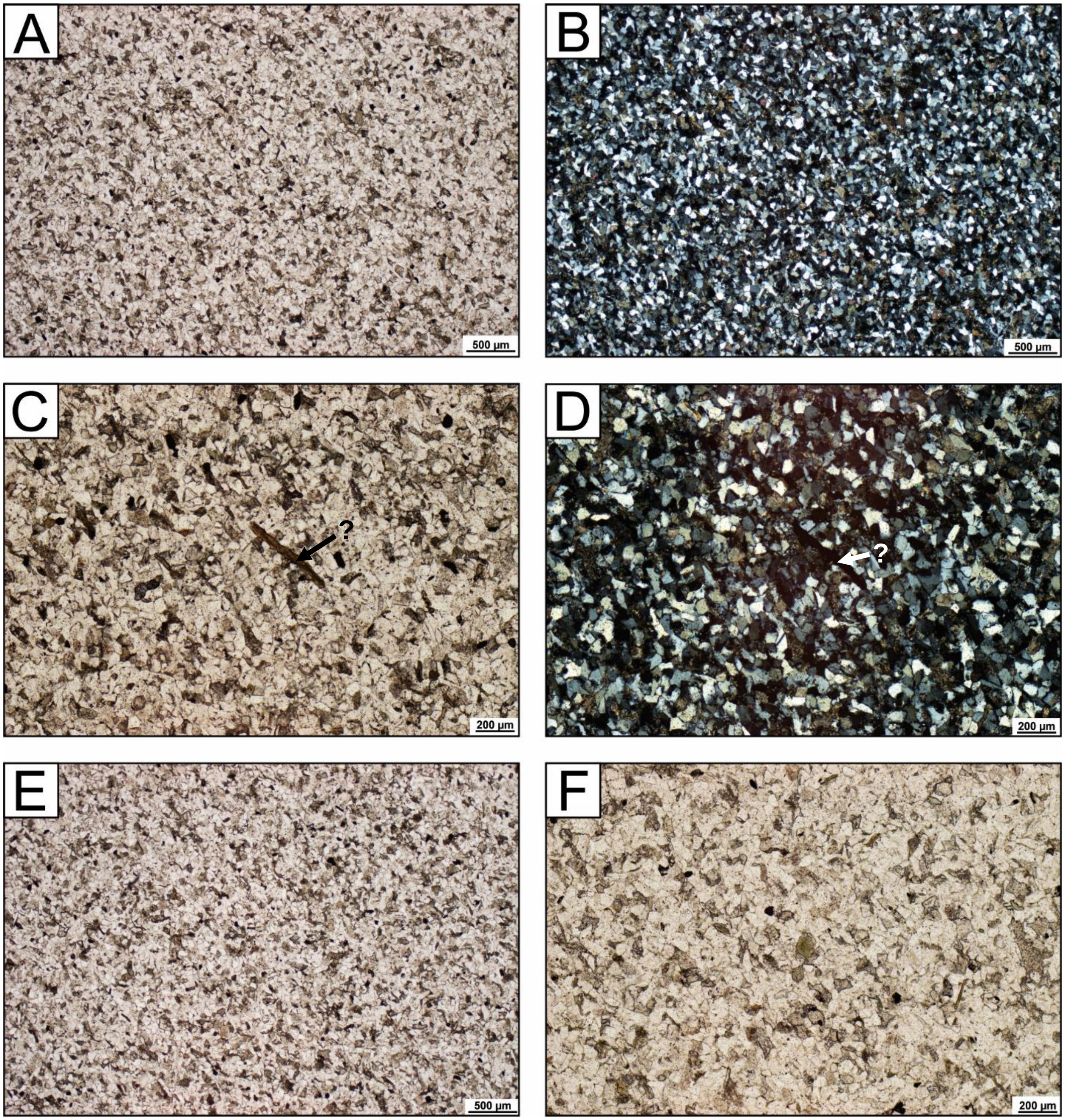


Figure C38: Freydis B-87, Core #1, 1938.34 m. (A) A massive sandstone with some lithic fragments. Little to no mud is present (PPL). (B) A massive sandstone with some lithic fragments. Little to no mud is present (XPL). (C) An unknown fragment (?) in a massive sandstone (PPL). (D) An unknown isotropic fragment (?) in a massive sandstone (XPL). (E) A massive sandstone (PPL). (F) A massive sandstone composed primarily of quartz with some lithic fragments present (PPL).

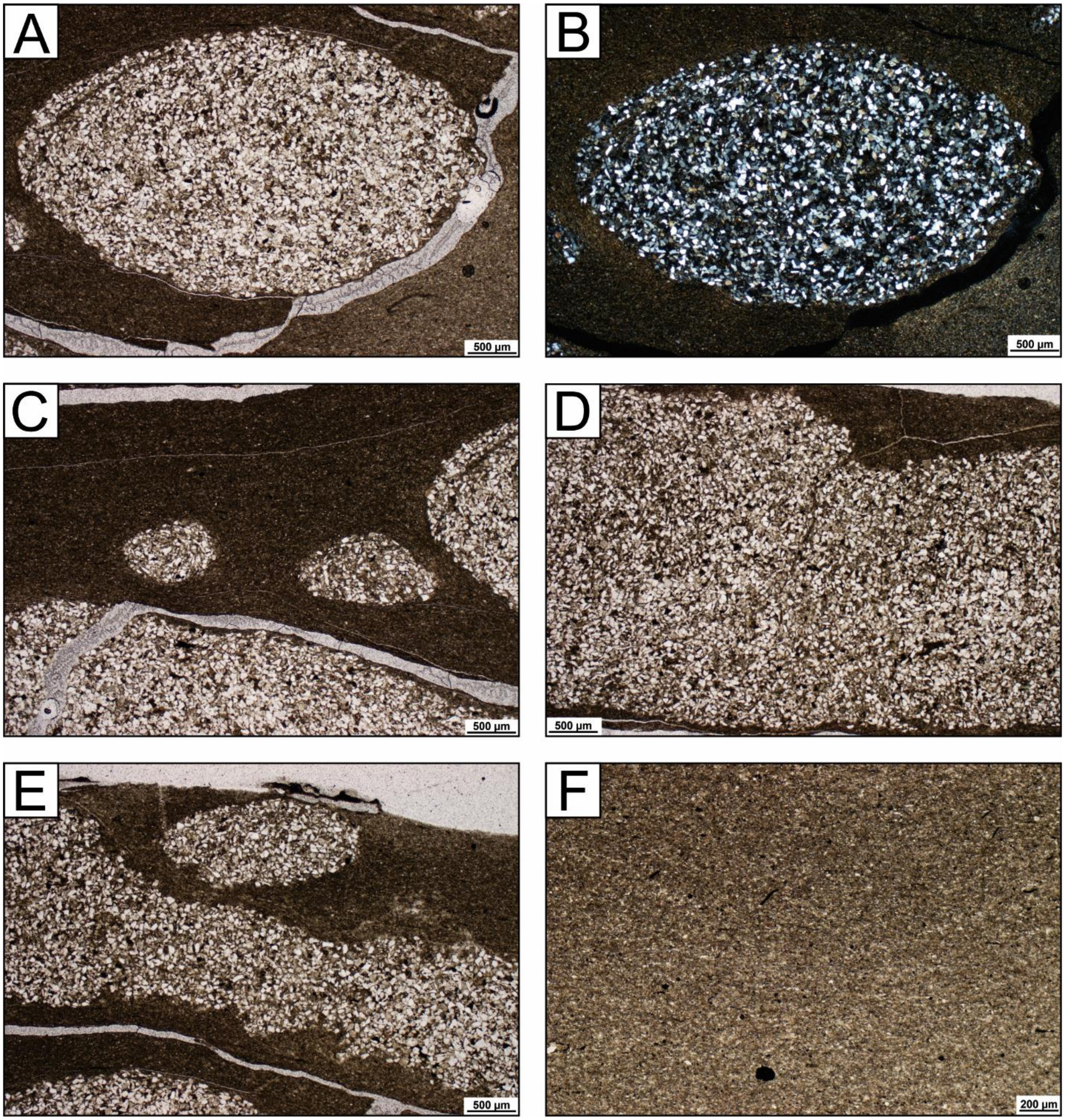


Figure C39: Freydis B-87, Core #1, 1941.15 m. (A) A cross-section through a sand-filled burrow of the *Glossifungites* Ichnofacies in an otherwise muddy (shale) interval (PPL). (B) A cross-section through a sand-filled burrow of the *Glossifungites* Ichnofacies in an otherwise muddy (shale) interval (XPL). (C) Cross-sections through two *Chondrites* sand-filled burrows in a mudrock unit (PPL). (D) A transverse view of a sand-filled *Glossifungites* burrow (PPL). (E) A dark-coloured mudrock unit with sand-filled burrows (PPL). (F) A dark, fine-grained mudstone to siltstone unit (PPL).

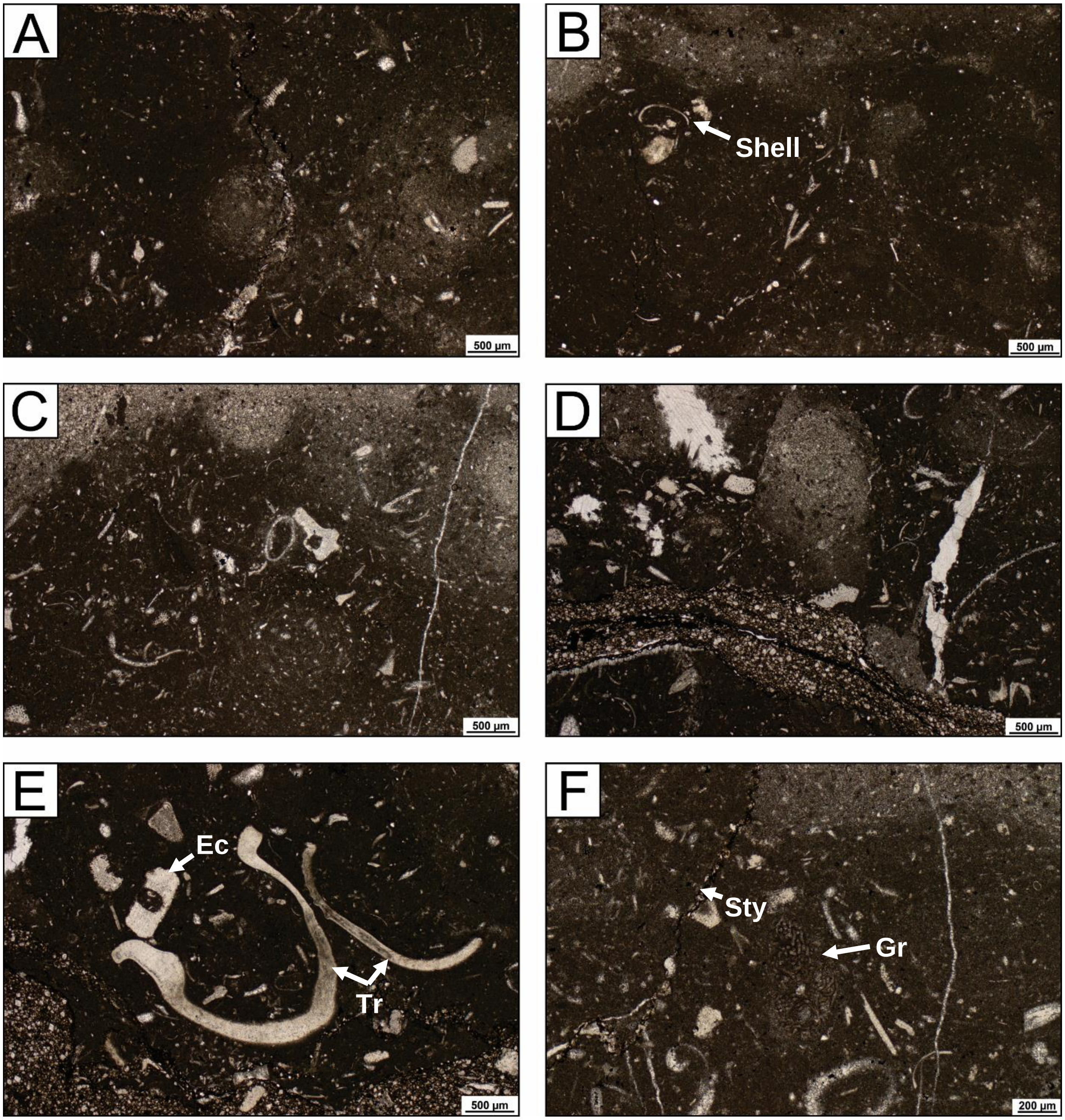


Figure C40: Freydis B-87, Core #2, 2307.64 m, all photos are in PPL. (A) A fossiliferous wackestone where sections of the matrix are partly crystallized. (B) A fossiliferous wackestone with small, unidentifiable fossil fragments including shells. (C) A fossiliferous wackestone with small, unidentifiable fossils. Note that areas of the matrix have been crystallized. (D) A fossiliferous wackestone where sections of the matrix have been crystallized. Note preferential dolomitization of argillaceous stringer. (E) A fossiliferous wackestone containing small, unidentifiable fossils along with echinoderms (crinoids; Ec), and trilobite fragments (Tr). Preferential dolomitization of the argillaceous stringers has occurred. (F) Fossiliferous wackestone with a microbial mud matrix. *Girvanella* (Gr), a calcimicrobe, is visible in a less dense region of the matrix. Note that a minor amount of dolomite is present along a stylolite (Sty).

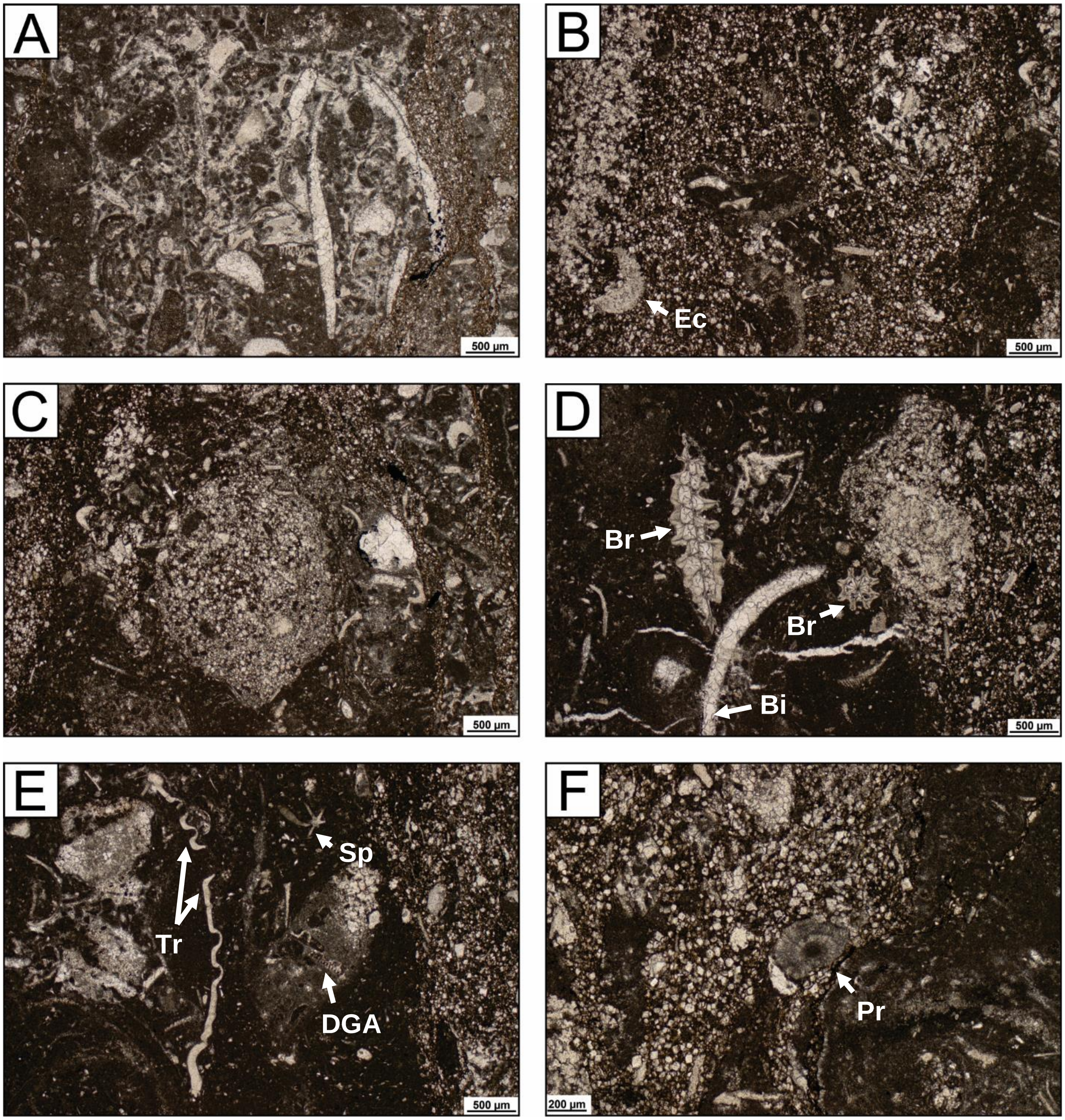


Figure C41: Freydis B-87, Core #2, 2311.21 m, all photos are in PPL. (A) Peloidal texture in an otherwise fossiliferous wackestone. Note preferential dolomitization of the argillaceous stringer along the right margin of the image. (B) Partial dolomitization of a fossiliferous wackestone containing small, unidentifiable fossils and echinoderm (crinoid; Ec) fragments. (C) A fossiliferous wackestone containing small, indeterminate fossil fragments including shell and echinoderm pieces. Argillaceous stringers have been preferentially dolomitized and rounded sections of the matrix have become crystallized. (D) A fossiliferous wackestone containing small, unidentifiable fossils, bryozoan fragments (Br), as well as remnants of dissolved bivalve shells (Bi). Note preferential dolomitization of argillaceous interval along the right side of the image. (E) A fossiliferous wackestone containing small, unidentifiable fossils, trilobite fragments (Tr), dasycladacean green algae (DGA), and sponge spicules (Sp). (F) A problematica fossil (Pr) is noted within a preferentially dolomitized argillaceous stringer.

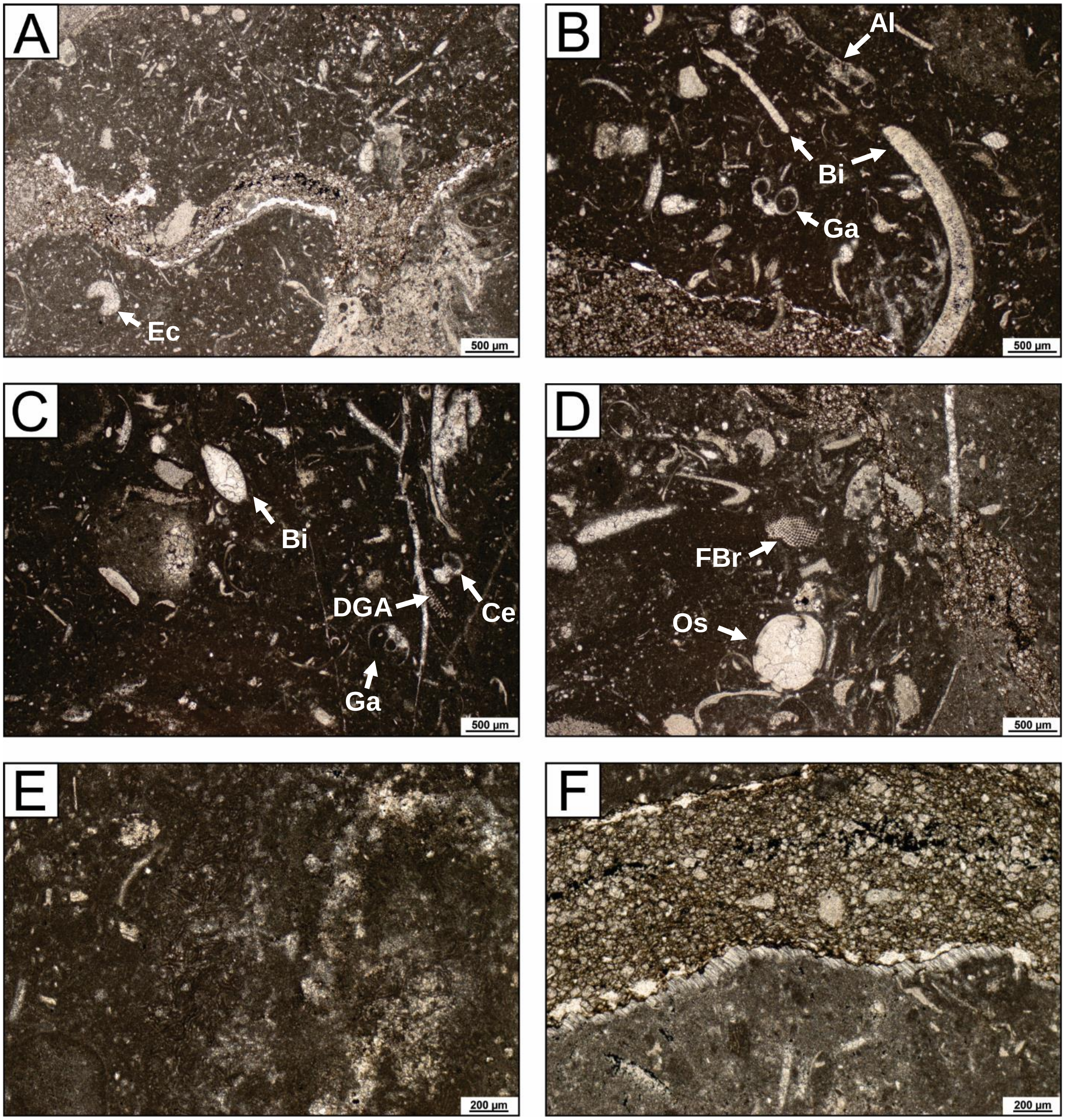


Figure C42: Freydis B-87, Core #2, 2313.16 m, all photos are in PPL. (A) A fossiliferous wackestone with small, unidentifiable fossils, shell bits, and echinoderms (Ec). Note preferential dolomitization of the argillaceous stringer. (B) Small, unidentifiable fossils, along with fragments of bivalves (bi), gastropods (Ga) and green algae (Al) in a mud matrix. Note preferential dolomitization of the argillaceous stringer. (C) A fossiliferous wackestone containing small fossil fragments as well as bivalves (Bi), gastropods (Ga), cephalopods (Ce), and dasycladacean green algae (DGA). (D) A fossiliferous wackestone with fossil fragments, shells bits, ostracods (Os), and fenestrate bryozoans (FBr) in a mud matrix. Note dolomitization of the argillaceous stringer. (E) A fossiliferous wackestone with a mud matrix containing the calcimicrobe *Girvanella*. (F) Preferential dolomitization of an argillaceous stringer in an otherwise fossiliferous wackestone.

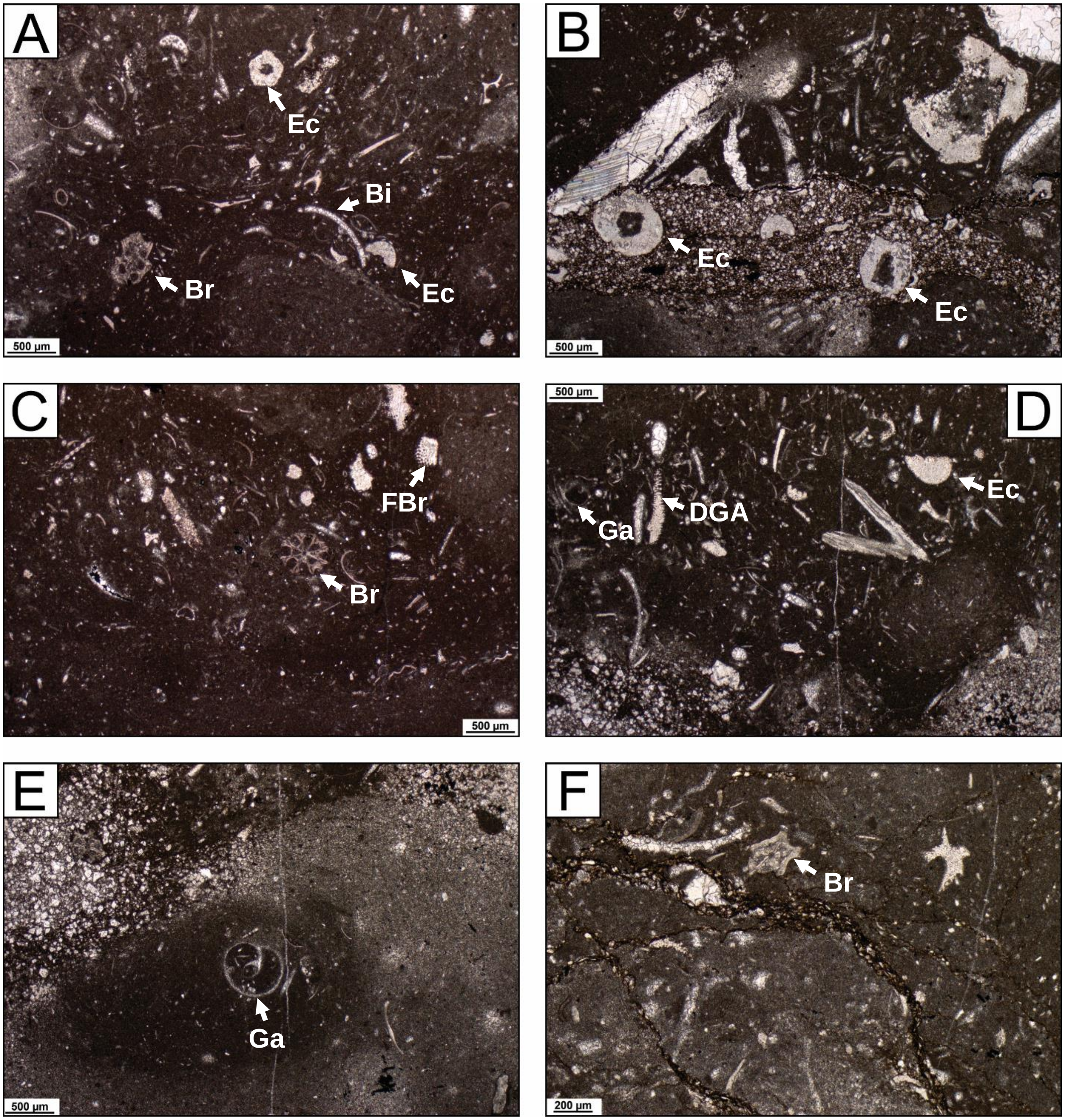


Figure C43: Freydis B-87, Core #2, 2313.46 m, all photos are in PPL. (A) A fossiliferous wackestone with small, unidentifiable fossils, as well as fragments of bryozoans (Br), bivalves (Bi), and echinoderms (crinoids; Ec). (B) A fossiliferous wackestone with echinoderm (crinoid) fragments (Ec). Note preferential dolomitization of the argillaceous stringer. (C) Fossil fragments including bryozoans (Br) and fenestrate bryozoans (FBr) in a mud matrix. (D) A fossiliferous wackestone with small, unidentifiable fossils, as well as fragments of gastropods (Ga), dasycladacean green algae (DGA), and echinoderms (Ec). (E) A gastropod (Ga) along with small fossil fragments in a mud matrix. Note preferential dolomitization of argillaceous stringer. (F) A fossiliferous wackestone with small, unidentifiable fossils and fragments of bryozoans (Br). Note minor dolomitization along argillaceous stringers.