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2010

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Recommended citation
Gould, K.M., Karim, A., Piper, D.J.W., and Pe-Piper, G., 2010. A standard lithofacies scheme for the Missisauga and Logan Canyon formations of the Scotian Basin and its application to long sections of conventional core; Geological Survey of Canada, Open File 6745, 119 p.

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Preface

This Open File is one of a series on the Lower Cretaceous rocks of the Scotian Basin resulting from a collaborative program initiated in 2001 between Saint Mary's University and the Geological Survey of Canada. This report presents a consistent lithofacies nomenclature and applies this nomenclature to long sections of conventional core in 17 wells.

Acknowledgments

We thank numerous students who have assisted with core logging over the years, including James Foley, Stephen Ingram, Nabeel Khan, Heidi MacKee, Ryan Noftall and Ann Okwese. Manuscript reviewed by D. Calvin Campbell.

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ABSTRACT

This report proposes a hierarchical scheme of sedimentary facies applicable to the Lower Cretaceous rocks of the Missisauga and Logan Canyon formations in the Scotian Basin. This succession hosts the major gas discoveries in the basin. The eleven facies, each of which is divided into several subfacies, are: 0 – delta front sandstone-mudstone turbidites; 1 – open shelf fossiliferous shales; 2 – shoreface sandstones and mudstones; 3 – intervals of condensed sedimentation (principally during transgressions); 4 - tidal estuary to fluvial sandstones; 5 - intertidal to subtidal sandy to mixed flats; 6 - intertidal muddy to mixed flats; 7- tidal marsh lignite or carbon-rich mud; 8 - lagoonal muds; 9 - river mouth to prodelta sandstone turbidites; 10 – highly deformed sediments.

These facies have been applied to long logged sections of conventional core in the following wells: Alma K-85, Alma F-67, Cohasset A-52, Como P-21, Glenelg E-58, Glenelg E-58A, Glenelg H-59, Glenelg N-49, Kegeshook G-67, North Triumph G-43; Panuke B-90, Tantallon M-41, Thebaud C-74, Thebaud I-93, Venture B-13, Venture B-52, and Venture H-22.

Three characteristic vertical successions of facies are recognized: prodelta, shoreface, and tidal parasequences. The prodelta parasequence is found in both inboard and outboard wells, however it is the dominant parasequence in outboard wells (e.g., Alma and Glenelg fields). Tidal parasequences are common in inboard wells (Cohassett A-52, Como P-21, Kegeshook G-67, and Panuke B-90) but are also found in wells farther outboard (North Triumph G-43, Thebaud I-93, Venture B-52, and Glenelg N-49). Shoreface parasequences are generally found within more inboard wells including Cohasset A-52, Panuke B-90, Thebaud I-93, and Venture B-13 and B-52.

This facies scheme is general enough to apply to both inboard and outboard wells in the Scotian Basin, while having enough subfacies to capture details within each depositional environment.

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Introduction and Purpose

The Scotian Basin is a Mesozoic-Cenozoic passive margin basin on the continental margin off Nova Scotia and southwestern Newfoundland (Wade and MacLean, 1990) (Figure 1). The latest Jurassic–early Cretaceous sand-prone Missisauga and Logan Canyon formations host all the gas reservoirs of the Sable Offshore Energy Project. Collaborative work by Saint Mary's University and the Geological Survey of Canada over the past decade on detrital petrology, diagenesis and thermal history of the Lower Cretaceous sedimentary rocks has involved systematic logging of conventional core by several different scientists and students. In order to present descriptive summaries of the sedimentary rocks in cores, a consistent lithofacies scheme has been developed.

The recognition of a set of common sedimentary facies representing different depositional environments is not new to the Scotian Basin. Work by Cummings and Arnott (2005), Karim et al. (2008), and Gould et al. (2010), and others, has shown that it is possible to devise a classification scheme using lithology, sedimentary and biogenic structures in core samples in order correlate between wells and interpret the paleoenvironment.

Because the Scotian Basin covers a wide range of sedimentary environments, and core samples are limited, studies focused in one area of the basin or on a select set of wells may not see the full array of sediment facies present in other wells, omit less common facies from their general scheme, or fail to recognize an environment, consequently lumping together lithologically similar but environmentally different facies.

The purpose of this document is to:

1. Provide a hierarchical and detailed classification scheme applicable throughout the Scotian Basin;
2. Apply the facies scheme to several wells throughout the Scotian Basin;
3. Re-evaluate sedimentary facies identified in previous publications.

Sedimentary facies in core

The facies scheme is hierarchical, with facies defined on the basis of the general environmental interpretation. They were further subdivided into a set of subfacies in order to discriminate between different rocks within the same depositional environment. The basic facies scheme is:

0 thin bedded sandstone and mudstone, prodelta turbidites

1 bioturbated fossiliferous mudstone, open shelf

2 sandstone and mudstone, shoreface

3 conglomerate, sandstone, mudstone, or limestone, open shelf transgressive

4 sandstone, tidal estuary to fluvial

5 sandy to mixed (sand>mud), tidal flats and channel, intertidal to subtidal

6 muddy to mixed (mud>sand), tidal flat, intertidal

7 lignite or carbon-rich mudstone, tidal marsh

8 mudstone, lagoon

9 thick bedded sandstones river mouth to prodelta turbidites

10 deformed sediments in which original facies cannot be recognized with confidence

This basic facies scheme is only slightly modified from the scheme originally proposed by MacRae and Jauer (2001) and published with minor modifications by Piper et al. (2004). This original scheme has been further modified based on the detailed interpretations of Cummings and Arnott (2005) and Cummings et al. (2006), presented in more detail by Cummings (2004). Cummings and Arnott (2005) interpreted many delta-front sandstones as strongly influenced by storms and thus likely to have shoreface architecture. These sandstones have been re-interpreted in the light of recent work by MacEachern et al. (2005), Pattison et al. (2007) and Myrow et al. (2008) as delta-front turbidites by Karim et al. (2008), Karim et al. (2010a,b), and Gould et al. (2010).

Table 1 defines sediment facies and subfacies using a format similar to Cummings and Arnott (2005) and Cummings et al. (2006). Each subfacies has: lithology and texture (with percentages given where known); primary sedimentary structures; biogenic structures; general environmental interpretation; and related facies. Additional information for the purposes of core logging is also given: diagnostic criteria, type example, and comparable facies in other published works. Figure 2 gives photo examples for each facies and subfacies.

In this report, we do not attempt a critical assessment of the sedimentological interpretation of the facies and sub-facies: in general, we follow the documented interpretations of Cummings and Arnott (2005) and Cummings et al. (2006), except for the recognition of delta-front turbidites as documented by Gould et al. (2010). In any classification scheme, rocks will be found that represent exceptions. Such exceptions may provide important evidence for sedimentological interpretations. However, our purpose here is to provide a consistent descriptive scheme that goes beyond simple lithology and has environmental significance.

Differences from previously published facies schemes

In general, the revised set of lithofacies was built upon one in Karim et al. (2010a,b), which itself is modeled after facies classification tables by Gould et al. (2010), Karim et al. (2008), Cummings et al. (2006), Cummings and Arnott (2005), and Piper et al. (2004). Following the detailed justification provided by Gould et al. (2010), facies previously interpreted as shoreface storm-dominated deposits by Cummings & Arnott (2005) and Cummings et al. (2006) have been reinterpreted as delta-front turbidite deposits. Thick-bedded prodelta turbidites were not recognized by MacRae and Jauer (2001) and Piper et al. (2004) and have been added to their basic scheme as facies 9. Highly deformed strata have been added as facies 10.

The facies schemes published by Piper et al. (2004) and Karim et al. (2008, 2010a,b) were strongly influenced by work on more outboard wells. In contrast, Cummings et al. (2006) and more recent logging by our group has focused on more inboard wells. In order to have a consistent level of detail in different facies, the number of subfacies recognized in more outboard wells has been simplified from Karim et al. (2008). General changes to the scheme of Karim et al. (2008) has involved the omission, addition, and merging several subfacies, with the main facies scheme remaining intact. This allowed for more equal spread of detail among the facies.

The most significant change to the scheme of Karim et al. (2008, 2010a,b) was the creation of several subfacies within tidal flat facies (5 and 6). These depositional environments were previously seen rarely in core, or were misinterpreted, with muddy tidal flat (facies 6) classified as a prodeltaic turbidites (facies 0); or sandy tidal flat (facies 5) classified as shoreface (facies 2). Recent logging of wells with continuous core through facies 5 and 6 (Panuke B-90 and Cohasset A-52, figures 5 and 13) allowed a more detailed analysis of the different lithology and sedimentary structures within each facies, resulting in the creation of several common subfacies.

Lagoonal facies (facies 8) are especially uncommon in cores reviewed for this study and previous workers have had difficulty recognizing this facies in core. For example, Piper et al. (2004) defined as lagoonal (facies 8) some grey-green highly bioturbated sandstones with oyster bioclasts, that we would now classify as facies 3. We have adopted the Cummings et al. (2006) definition of lagoonal facies, recognizing that this facies may have been overlooked during logging or locally mis-classified as facies 0, 3, and 6.

Some facies referenced within the Karim et al. (2008, 2010a,b) summary of lithofacies were similar in general lithology and therefore compared to facies in Cummings et al. (2005) and Cummings and Arnott (2006). However, with further work we now recognize that facies 6 (muddy tidal flat) cannot be equated to facies 3 (lagoon) in Cummings et al. (2005) and facies 11 (transgressive abandonment deposits) in Cummings and Arnott (2006).

Reclassification of previously described wells

The new facies scheme has been applied to a selection of wells previously published in peer-reviewed journals and open files by the joint Saint Mary's University - Geological Survey of Canada (Atlantic) group (Figure 1). These wells were chosen on the basis of having relatively long, continuous core and showing a good vertical facies succession. Interpretation of cores from the Louisbourg J-47 well, logged using the sediment facies scheme presented here, have been included in a different open file (Pe-Piper et al., 2010) and are not included here.

Previously published downcore plots showing facies picks were reinterpreted using operator's whole core photos, detailed close up photos, and core descriptions (Figures 3-19). In some cases, only minor changes were made, such as picking a different subfacies; or for subfacies that have been removed, changing to a new subfacies identification.

In other wells, entire new facies, and therefore depositional environments, were identified. This was the case for Alma F-67 and Alma K-85 (Piper et al., 2004), Glenelg N-49 (Karim et al., 2008), North Triumph G-43 (MacKee, 2008), Venture B-52, and Venture H-22 (Karim et al., 2010b). Commonly, tidal facies (5 and 6) had been included in outboard prodelta or shoreface facies (0 or 2). Other common misidentified facies included: Muddy facies 2 identified as 1, although lacking diagnostic thin shelled fossils and having over 5% sandstone; bioturbated shoreface deposits being classified as facies 0 because of the presence of minor preserved sandstone beds; and the lumping together of long successions of thickly bedded sandstones as facies 9, where in places mud drapes and cross-bedding identified parts as facies 4. Using the new, more rigorous classification table, boundaries within the most common facies association, 4 overlying 9 overlying 0, were more clearly and easily established. It was also possible to identify generally thin units of facies 3 that had previously been missed and grouped with other facies.

Facies associations

Much of the Missisauga and Logan Canyon formations is organized into prodeltaic parasequences (Gould et al., 2010). Prodelta parasequences (Fig. 20A) generally progress from shelf (facies 1) to shoreface (facies 2) to mixed river mouth to shoreface environments (facies 2 with 0 and 9). As the section shallows, thick bedded turbidites (facies 9) interbed with tidal estuary and/or fluvial sediments (facies 4), which become the dominant facies. The parasequence is usually capped by a condensed muddy, sandy or limey transgressive unit (facies 3), overlain by deeper water sediments, usually facies 1 or 2. This parasequence is found in both inboard and outboard wells, however it is the dominant parasequence in outboard wells (e.g., Alma and Glenelg fields).

Two modifications of this basic parasequence are recognized. Shoreface parasequences (Fig. 20B) consists of shelf and muddy shoreface sediments (facies 1 and 2); becoming dominated by sandy shoreface deposits up section. In some wells, facies 0 is present between muddy and sandier shoreface deposits. This parasequence differs from the typical prodeltaic parasequence in lacking facies 9 (thick bedded river mouth turbidites) and having only minor interbedded facies 0 (thin-bedded prodelta turbidites). The top of the parasequence is defined by a thin transgressive unit, usually carbonate cemented. This is the least common parasequence seen in core. It is present mainly within more inboard wells (Cohasset A-52, Panuke B-90, Thebaud I-93, and Venture B-13 and B-52).

Tidal parasequences (Fig. 20C) may also begin in a shoreface or prodelta environment (facies 1 or 2), but these facies are usually thin and not always preserved. The parasequence passes up into a tidal estuary or fluvial sediments (facies 4), with a commonly erosional base. Unlike the prodelta parasequence, these are overlain by muddy and sandy tidal flat sediments (facies 5 and 6), with the top of the section infrequently capped by supratidal coal or lagoon sediments (facies 7 or 8). These tidal sediments are overlain by a condensed transgressive unit (facies 3), and limestones or deep water shelf shales. This parasequence is most common in inboard wells (Cohassett A-52, Como P-21, Kegeshook G-67, and Panuke B-90) but is also found within in wells farther outboard (North Triumph G-43, Thebaud I-93, Venture B-52, and Glenelg N-49).

In most parasequences, not every facies in the succession is present and sediments representing shallow water and tidal facies interbed with each other, e.g., a prodelta parasequence may be overlain by a thin unit of tidal flat facies just below the transgressive sequence (e.g. core 1 and 2 of Cohasset A-52, Figure 5; and core 7 of Panuke B-90, Figure 13). Commonly in outboard wells, prodeltaic parasequences lack facies 4, with the transgressive unit overlying facies 0 and 9 (e.g. core 1 of Glenelg E-58; Figure 7). Cummings and Arnott (2005) recognized that erosional sequence boundaries defining incised valleys cut out underlying facies (for example at Glenelg E-58) and even in outboard wells were filled with a muddy tidal parasequence. Sandy facies 4 together with tidal flat facies 5 and 6 are more common in incised valleys in inboard wells, as illustrated in Figure 20C.

Conclusions

This paper presents a detailed assessment of the depositional facies of the Lower Cretaceous sandstones of the Scotian Basin. Through the review of previous facies schemes and depositional environments, the re-examination of previously interpreted wells and the interpretation of additional wells, we have presented a systematic facies scheme and organized facies into logical vertical associations according to parasequences. This facies scheme is general enough to apply to both inboard and outboard wells in the Scotian Basin, while having enough subfacies to capture details within each depositional environment.

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Table 1:Summary of sediment facies description and interpretation.

Facies	Subfacies	Lithology and texture	Primary sedimentary structures	Biogenic structures	General interpretation	Related facies	Notes on diagnostic criteria	Type example	Comparison with others
0	0g	sandstone, generally fine, rarely reach coarse	medium bedded; laminated or cross laminated, common erosional base; possible wave and current ripples	absent to sparse biot	River mouth to shoreface; prodeltaic turbidites	commonly overlies 1 and 2; may interbed with 9	lacks interbedded mudstone	2395	Gould (S4); Cummings and Arnott (6)
	0b	fine sandstone, siltstone, mudstone (sandstone > mudstone)	sharp, erosive based beds (<25 cm thick) with sltst laminae, interbedded with mst with sltst laminae; some lenticular bedding; parallel and cross laminae; variable sed structures as in Lamb et al, 2008; possible wave and current ripples	sparse to uncommon biot			sandstone:mudstone ratio	1150	Gould (S2b); Cummings and Arnott (3) and (5); Karim, 2008 (0t), (0s) and (0l)
	0m	mudstone, siltstone, very fine sandstone (mudstone >> sandstone)	some sltst or very fine sst laminae; parallel lam, x-lam, lenticular bedding; possible wave and current ripples	uncommon biot			sandstone:mudstone ratio; from 1 by sst; from 1 and 2b by lack of biot	2616	Gould (M1); Cummings et al. (4); Cummings and Arnott (4)
	0a	fine and coarse sandstone, mudstone (sandstone ><mudstone)	alternation of coarse and fine sst beds with interbedded mst; parallel lam, x-lam, lenticular bedding; possible wave and current ripples	absent to sparse biot			mudstone with coarse and fine grained sst	1146	
1		mudstone, <5% fine sandstone or siltstone	thin beds and laminae of parallel fine sst or sltst laminae	abundant to complete biot (*Chondrites* ichnofacies); uncommon thin shelled fossils - echinoderms, ammonites	Shelf	commonly overlies 3 and underlies 2 or 0	from 0 by biot; from 2b by sst; presence of marine shells	4246	
2	2b	mudstone, fine sandstone (10-60%)	destroyed by biot, possible remnants of storm beds with parallel lamination, wave ripples and wave dominated structures	generally moderate to common biot; possible shells, *Cruziana* ichnofacies; may have reworked shell frags at base of preserved beds	Shoreface	interbeds with 0; possibly grades into 3	from 0 by biot; from 1 by higher % of sand; less sst than 2c; diverse trace fossil assemblage; sst beds with possible shell hash at base, interbedded with biot sandy mst	1576	Gould (S4)
	2c	fine sandstone (60-95%), mudstone	destroyed by biot, possible remnants of storm beds with parallel lamination, wave ripples and wave dominated structures	common to complete biot, multiple species; possible shells; *Cruziana* ichnofacies; may have reworked shell frags at base of preserved beds			from 0s by biot; from 2b by sst; diverse trace fossil assemblage; primary structures rarely preserved; reworked shells, preserved structures are wave not current dominated	1383	Cummings and Arnott (14)
	2o	fine sandstone	generally thin to thick massive beds	sparse to moderate biot, horizontal *Ophiomorpha* burrows			like 4o but mud drapes absent	4338	
	2x	fine-rare medium sandstone	cross-bedding (mostly low angle), thin bed sets; rare mud drapes	sparse biot			from 4x because of biot, no mud drapes absent. Coal absent. Biot not *Skolithos* ichnofacies	4130	

Table 1:Summary of sediment facies description and interpretation.

Facies	Subfacies	Lithology and texture	Primary sedimentary structures	Biogenic structures	General interpretation	Related facies	Notes on diagnostic criteria	Type example	Comparison with others
3	3x	sandy mudstone (10-50% sand); granules; poorly sorted; common brown staining due to early siderite	may have intraclasts	moderate to complete biot; thick shells	Condensed unit on shelf, commonly transgressive	commonly overlies 3y	mudstone	4262	Gould (C1)
	3y	muddy sandstone (50-90% sand), granules; poorly sorted; common brown staining due to early siderite	may have intraclasts	moderate to complete biot; thick shells		commonly overlies 3l or an erosion surface	sandstone	4356	Gould (M2); Cummings and Arnott (13)
	3i	intraclast conglomerate; common brown staining due to early siderite	may have intraclasts	may include shells			intraclast cgl	1547	
	3c	lithic conglomerate; common brown staining due to early siderite	may have intraclasts	may include shells			lithic cgl; generally rare	4326	
	3f	firm ground	evidence of induration.; commonly associated intraclasts; erosion or incision of underlying sediment	some burrow penetrating firm ground, *Glossifungites*			evidence of firm ground; generally rare	1716	
	3l	bioclastic limestone	parallel lam	abundant shell fragments, possibly in place			bioclastic limestone	3956	Gould (L1); Cummings et al. (7)
	3o	oolitic limestone and sandstone	parallel lam	possible biot			oolitic limestone and sandstone	2572	
4	4o	principally fine sandstone	thin to medium bedded, may be cross-bedded; thin mud drapes	sparse to common biot, *Ophiomorpha* , *Skolithos* ichnofacies	Tidal estuary to fluvial	passes up into 5 or 2	from 5-4 by *Ophiomorpha* burrows; common mud drapes;	4297	Karim, 2008 (4o); Karim, 2008 (4u)
	4a	medium to coarse sandstone (>50%); mudstone	thin sharp-based sst beds (can be >30 cm thick, ave 5-10 cm), interbedded with thin to thick mst drapes. Mst drapes have m-cg lam (simular to 6) may have current ripples	biot absent; coal lam, intraclasts		may be interbedded with 4, 5, 6	from 4g by thick mud drapes with facies 6 character; from 6 by alternating cg sst beds and thick mst drapes	4913	
	4g	medium to coarse sandstone; may have coarse grained lag at base of unit; <5% mst	typically thin-bedded, parallel to low angle; mud drapes	absent to sparse biot			from 4x by presence of mud drapes and possible sparse biot	1098	Gould (S1); Cummings et al. (2); Cummings and Arnott (10, 12)
	4x	medium to coarse sandstone; mudstone intraclasts; may have coarse grained lag at base of unit	thin to thick cross-beds, med to high angle	biot absent; coal intraclasts			from 4g by coarser grainsize, high-angle cross-bedding, lack of mud drapes	2297	Cummings et al. (1)
	4n	mudstone, siltstone, very fine sandstone (sandstone>mudstone)	"tidal bundles" of poorly sorted sand and silt; or well-sorted fine sand, rarely with ripples; mud partings 1-2 mm	biot absent or sparse			more silt and sand than 0m; differs from 0a in lack of coarse sst beds	2622	Cumings and Arnott (2); Karim, 2008 (0n)
5	5m	>75% sandstone, predominantly fine may have medium or coarse grained beds, mudstone	thin bedded; variable mud drapes; mud, slt, and vf sst parallel & x-lam; mud on ripples	variable biot - sparse to moderate, or common to abundant, *Skolithos* ichnofacies; ?plant frags	Mixed flat - intertidal		from 6s by sandstone dominance; from 2 by less biot and dominant subvertical burrows, preservation of primary structures diagnostic of tidal environ.	Panuke B-90 core 8, box 24	Gould (S3); Cummings et al. (5); Cummings and Arnott (7)
	5s	>95% sandstone, generally fine may be medium or coarse grained, minor mudstone	possible thin to med bedded; some x-bedding	sparse to mod biot; shells	Sand flat - intertidal to subtidal	may pass up into 4o	mud drapes and *Ophiomorpha* rare compared to 4o; cross- bedding diagnostic; from 2 by less biot, subvertical burrows dominant, preservation of primary structures diagnostic of tidal environ.	4323	Karim, 2008 (4s)

Table 1:Summary of sediment facies description and interpretation.

Facies	Subfacies	Lithology and texture	Primary sedimentary structures	Biogenic structures	General interpretation	Related facies	Notes on diagnostic criteria	Type example	Comparison with others
5	5b	20-75% sandstone, predominantly fine may have medium or coarse grained beds	destroyed	abundant to complete biot - common large and long subvertical burrows; may have shells	Mixed flat - intertidal	transitional to 2	large subvertical burrows; from 2 by less biot, subvertical burrows dominant, preservation of primary structures some diagenetic of tidal environ.	4334	
	5c	medium sandstone	sharp based, thin beds	absent	Tidal channel - subtidal	within 5/6	thin beds within 5/6	4185	
6	6s	subequal fine sandstone,mudstone; or 60-75% mudstone, fine sandstone; may have minor medium-coarse sandstone, e.g. in burrows	mud dominant sections with wavy or current ripples and mud on ripple lam, interbedded with prominant parallel lam sst and mst (pinstripe-shaped)	small *Skolithos* ichnofacies burrows absent to common; possible plant frags	Mixed flat- intertidal	commonly interbedded with 4, 5, 7, 8	like 0 but with *Skolithos* burrows, current ripples	4299	Cummings et al. (3); Cummings and Arnott (11); Cummings (P4)
	6b	>80% mudstone, minor very fine to fine sandstonemay have minor medium-coarse sandstone, e.g. in burrows	destroyed; rare preserved parallel lam, current ripples	common to complete biot; may have whole or fragments of oyster shells	Mudflat- intertidal		from 5b by mud dominance; oyster shells	4169	
	6m	>95% mudstone, may have minor medium-coarse sandstone	rare discontinuous lam, broken by subvertical to vertical burrowing	biot absent to common, may have burrows (horizontal and subvertical) filled with m-c sst; ?oyster shells	Mudflat- intertidal		from other 5/6 by mudstone dominance	Panuke B-90 core 8 box 28	Cummings (P4)
7		lignite or carbon-rich mud		rootlets beneath	Tidal marsh	may overlie 6	lignite or carbon-rich mud	4188	
8		mudstone, rare siltstone	planar parallel to low angle cross siltstone lam	biot generally absent to sparse, with locally intense biot	Lagoon	interbeds with 5 & 6	1 has fossils and overlies 3, is more biot; 8 interbeds with 5 and 6	4053	Cummings (P3)
9	9g	very coarse to fine sandstone, some graded beds	sharp-based beds, some with erosive structures (sole marks); predominantly massive beds, generally >25cm thick, with minor parallel or cross laminae at top of some beds; possible mud intraclasts	absent to moderate biot at top of beds; plant detritus; possible reworked coastal deposits (shells, sid nodules)	River mouth to prodelta turbidite	commonly interbedded with 0, overlain by 4o	from facies 0 by bed thickness; from 9s by lack of interbedded mudstone	1688	Gould (S2c); Cummings and Arnott (8); Karim, 2008 (4b)
	9s	fine sandstone, minor mudstone, minor interbedded facies 0	sharp-based beds, some with erosive structures (sole marks); generally >25 thick, parallel lamination at base and cross lamination at top; some beds have mud intraclasts near base	moderate biot at top of beds; plant detritus; possible reworked coastal deposits (shells, sid nodules)			from facies 0 by bed thickness	4535	Gould (S2a), Karim 2008 (9m)
10	10f	mudstone to muddy sandstone	destroyed by deformation; secondary structures - massive texture, horizontal foliation	-	Deformed facies	commonly interbedded with 0		Alma K-85 core 3	
	10g	sandstone	destroyed by deformation; secondary structures - liquified beds	-				Alma K-85	
	10s	sandstone, siltstone, mudstone,	mostly destroyed by deformation; secondary structures - sheared and folded beds	variable biot				1466	

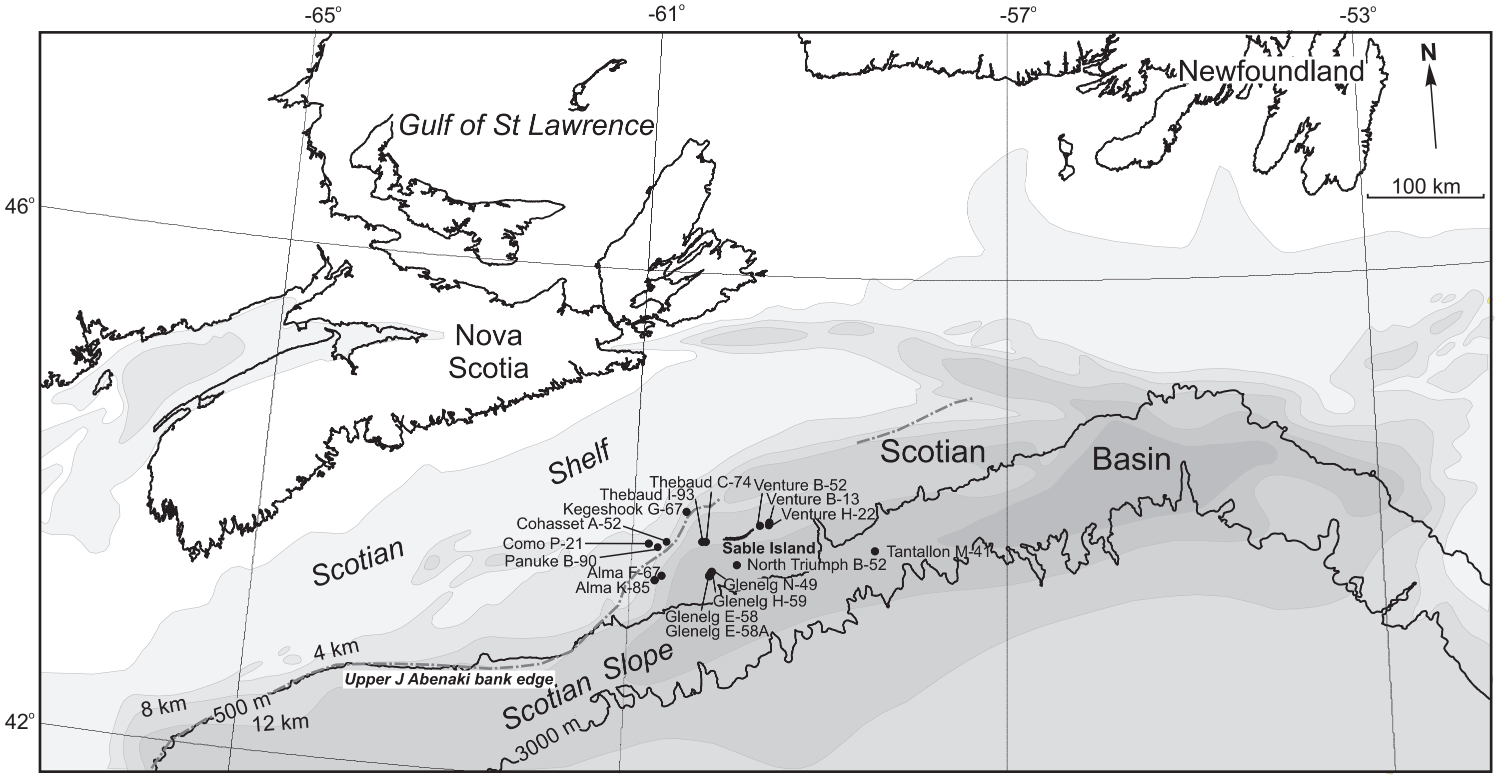


Figure 1: Map of the central Scotian Basin, showing the location of wells used in this study. Isopachs of Mesozoic to Cenozoic sediments in kilometres from MacLean & Wade (1992).

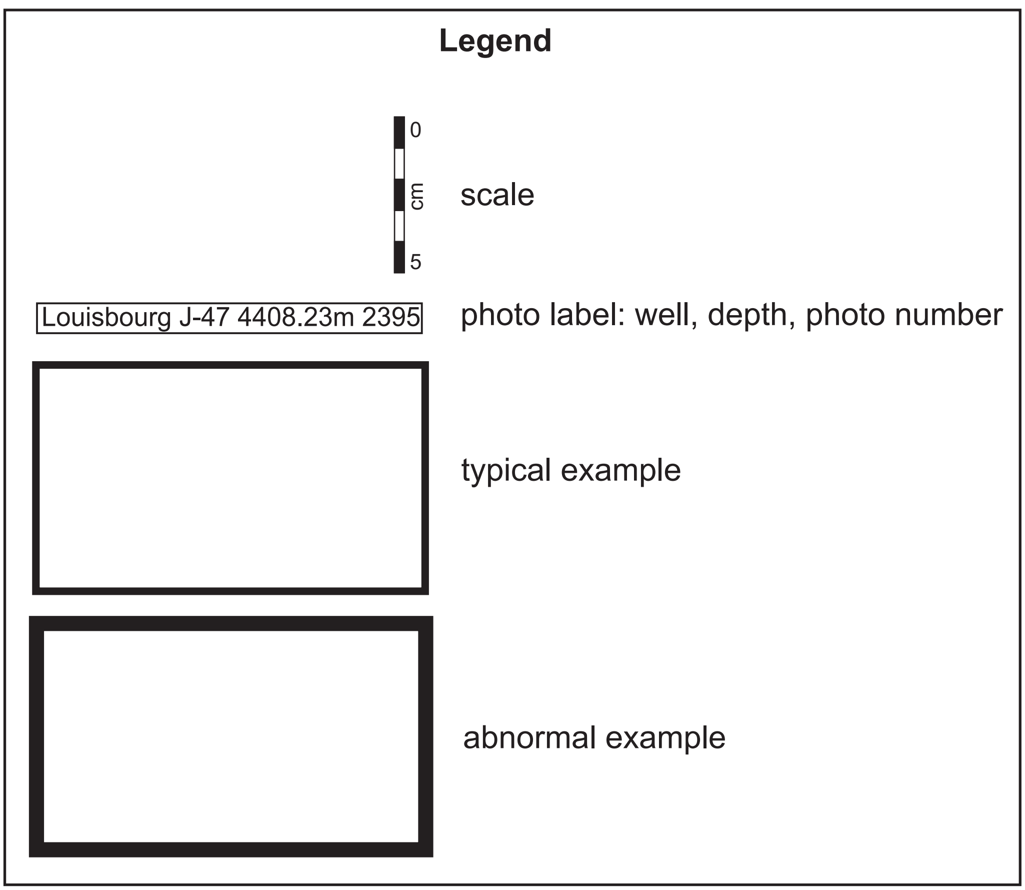
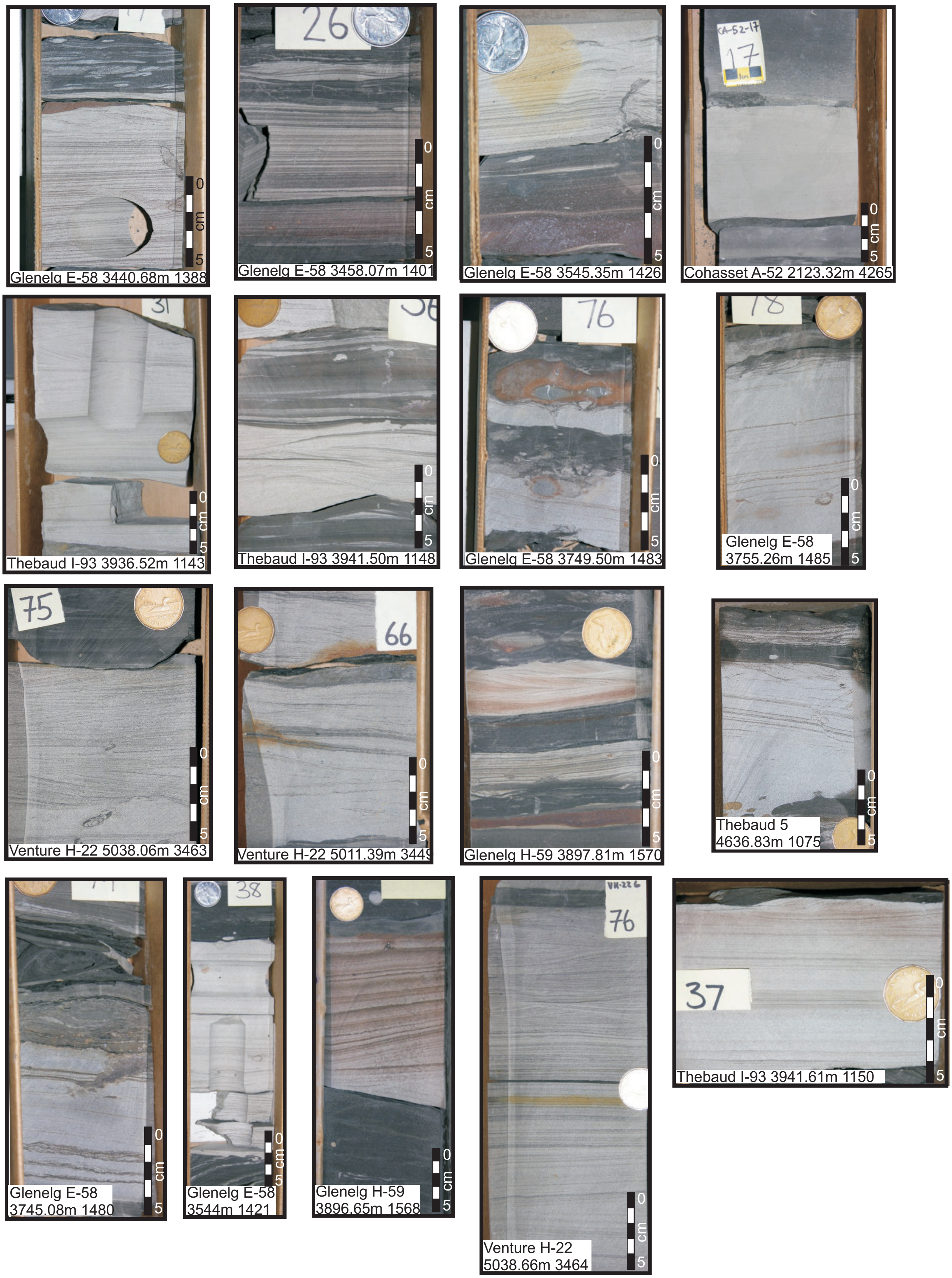


Figure 2: Photo examples of sedimentary facies in core.

Facies 0g

Louisbourg J-47 4408.23m 2395

Facies 0b


Glenelg E-58 3440.68m 1388
Glenelg E-58 3458.07m 1401
Glenelg E-58 3545.35m 1426
Cohasset A-52 2123.32m 4265
Thebaud I-93 3936.52m 1143
Thebaud I-93 3941.50m 1148
Glenelg E-58 3749.50m 1483
Glenelg E-58 3755.26m 1485
Venture H-22 5038.06m 3463
Venture H-22 5011.39m 3449
Glenelg H-59 3897.81m 1570
Thebaud 5 4636.83m 1075
Glenelg E-58 3745.08m 1480
Glenelg E-58 3544m 1421
Glenelg H-59 3896.65m 1568
Venture H-22 5038.66m 3464
Thebaud I-93 3941.61m 1150
0 cm 5

Facies 0m


33
0
cm
5
Glenelg N-49 3627.14m 2616


CA-52-11
11
0
cm
5
Cohasset A-52 2085.50m 4257

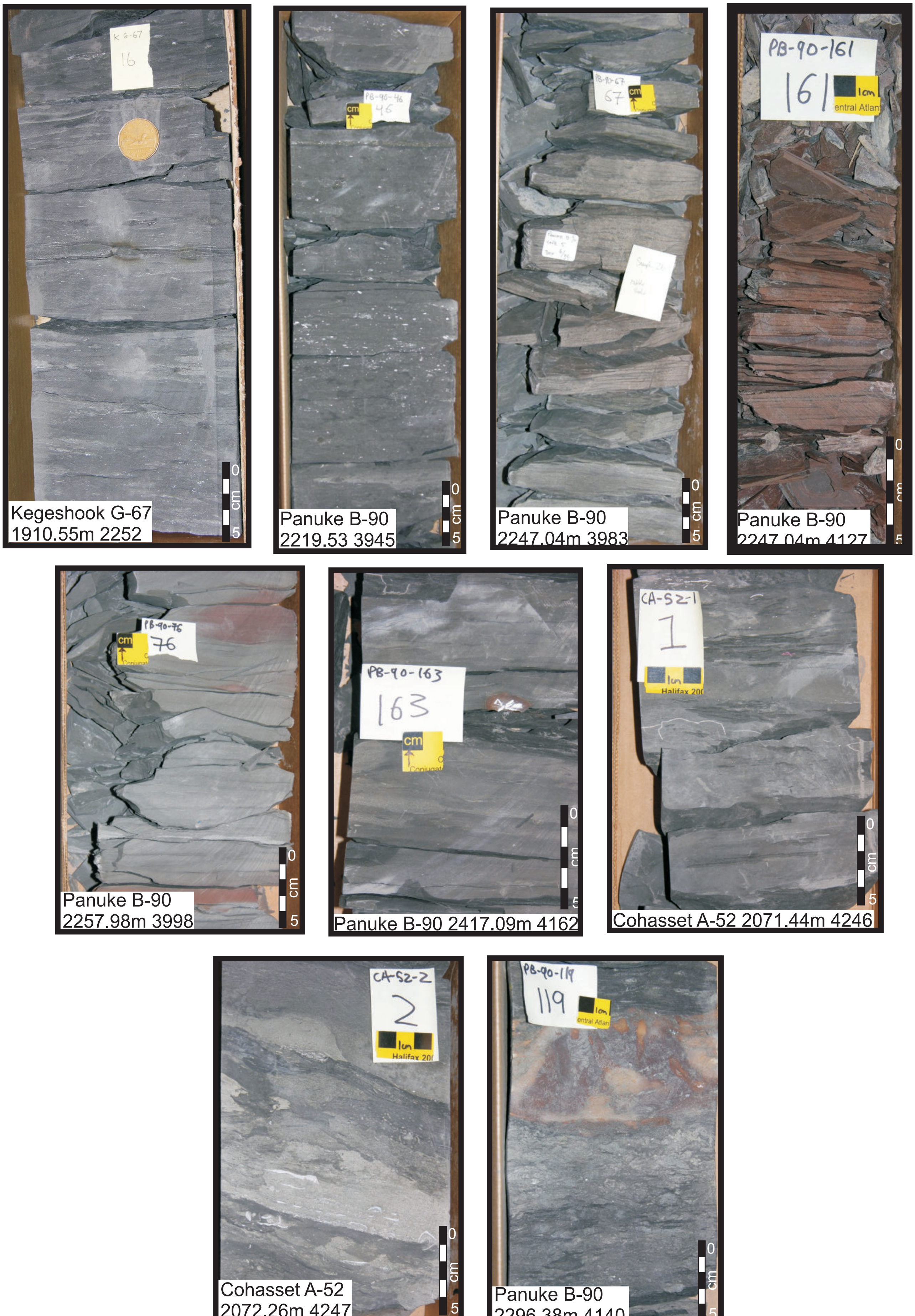

44
0
cm
5
Glenelg N-49 3658.41m 2631

Facies 0a

Thebaud I-93 3924.74m 1133

Thebaud I-93 3940.05m 1146

Facies 1


Kegeshook G-67
1910.55m 2252
Panuke B-90
2219.53 3945
Panuke B-90
2247.04m 3983
Panuke B-90
2247.04m 4127
Panuke B-90
2257.98m 3998
Panuke B-90 2417.09m 4162
Cohasset A-52 2071.44m 4246
Cohasset A-52
2072.26m 4247
Panuke B-90
2296.38m 4140

Facies 2b

Venture H-22 unknown depth 3039

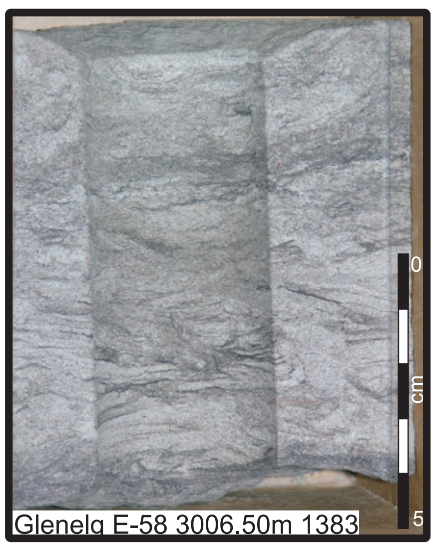
Glenelg H-59 3900.22m 1576

Cohasset A-52 2162.23m 4283

Facies 2c

Panuke B-90 2231.10m 3961

Panuke B-90
2405.00m 4085



Glenelg E-58 3006.50m 1383

Facies 2o

Cohasset A-52 2431.61m 4338

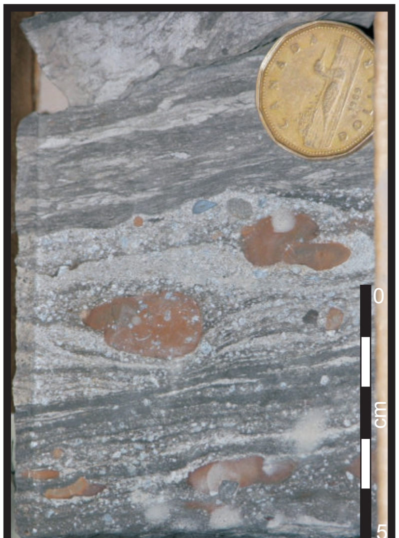
Facies 2x

Panuke B-90 2290.44m 4130

Facies 3x

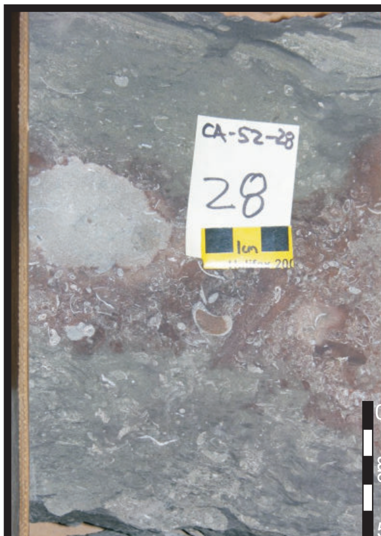
Glenelg E-58 3532.10m 1410

Cohasset A-52 2156.96m 4277



Glenelg E-58 3742.27m 1478

Cohasset A-52 2146.23m 4273



Cohasset A-52 2122.38m 4262

Facies 3y

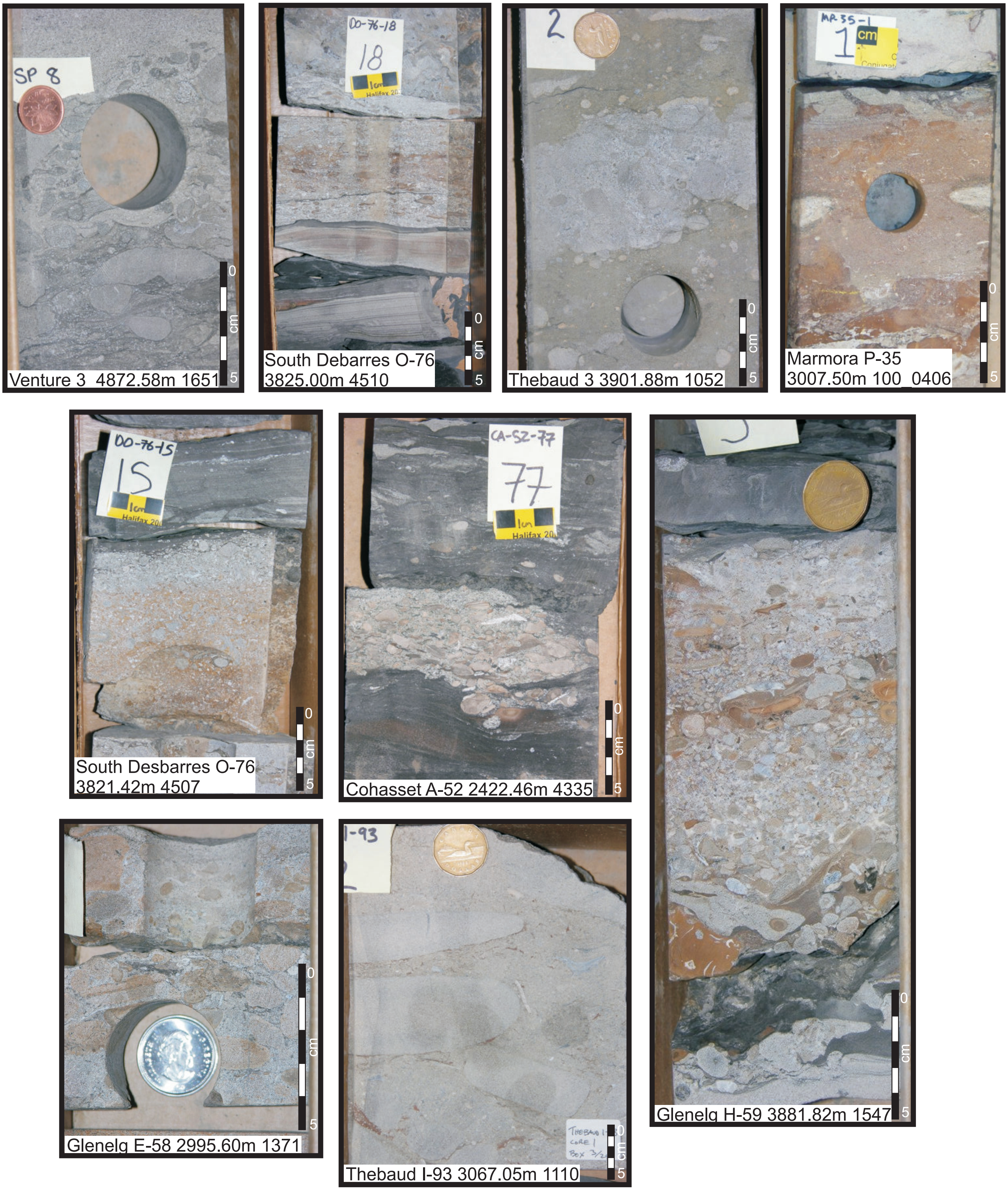

PB-90-123
123
0
cm
5
Panuke B-90 2302.57m 4145


CA-52-63
63
0
cm
5
Cohasset A-52 2345.38m 4319


CA-52-91
91
0
cm
5
Cohasset A-52 2445.54m 4356


0
cm
5
Glenelg E-58
3000.90m 1380

Facies 3i



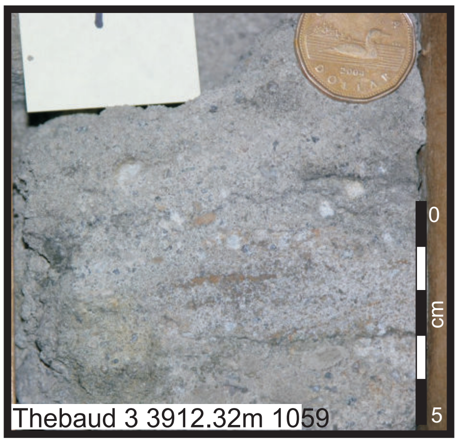
Venture 3 4872.58m 1651
South Debarres O-76 3825.00m 4510
Thebaud 3 3901.88m 1052
Marmora P-35 3007.50m 100_0406
South Desbarres O-76 3821.42m 4507
Cohasset A-52 2422.46m 4335
Glenelg H-59 3881.82m 1547
Glenelg E-58 2995.60m 1371
Thebaud I-93 3067.05m 1110

Facies 3c

Glenelg N-49 3593.50m 2591

Glenelg N-49 3593.72m 2592

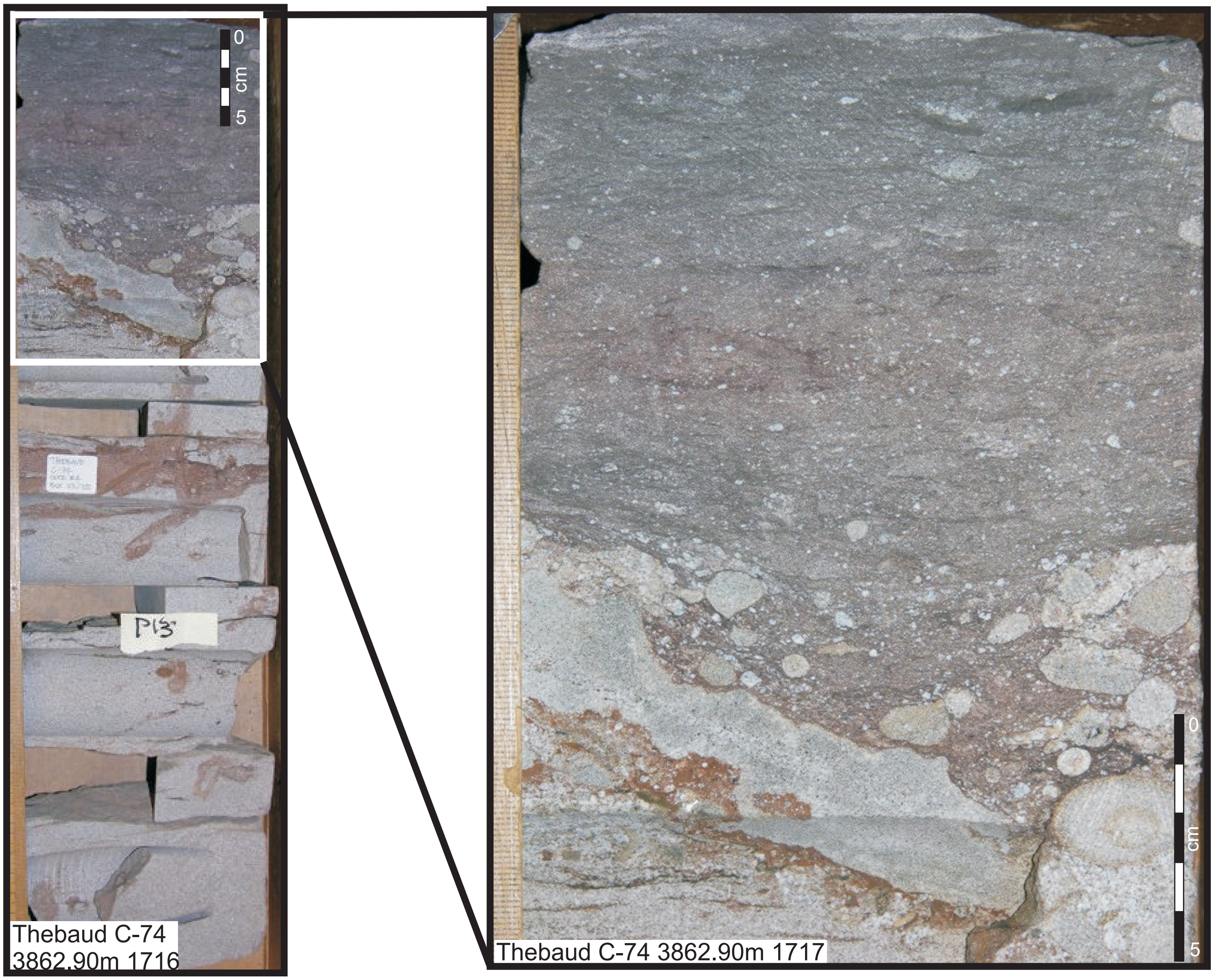
Cohasset A-52 2386.38m 4326



Thebaud 3 3912.32m 1059

Panuke B-90 2099.18m 3925

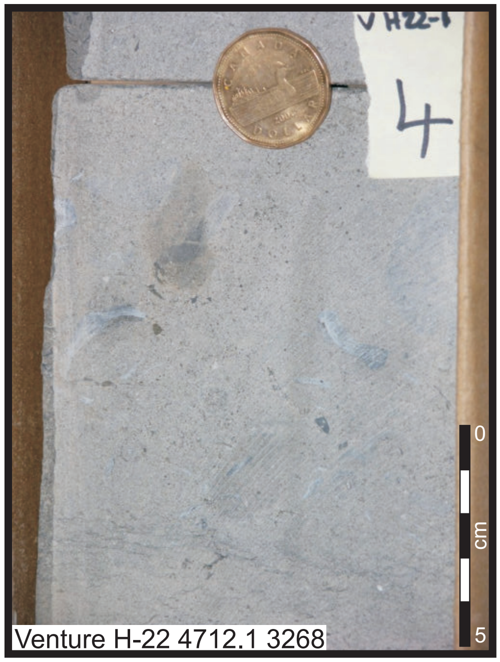
Facies 3f



0
cm
5
Thebaud C-74
3862.90m 1716
0
cm
5
Thebaud C-74 3862.90m 1717

Facies 3l

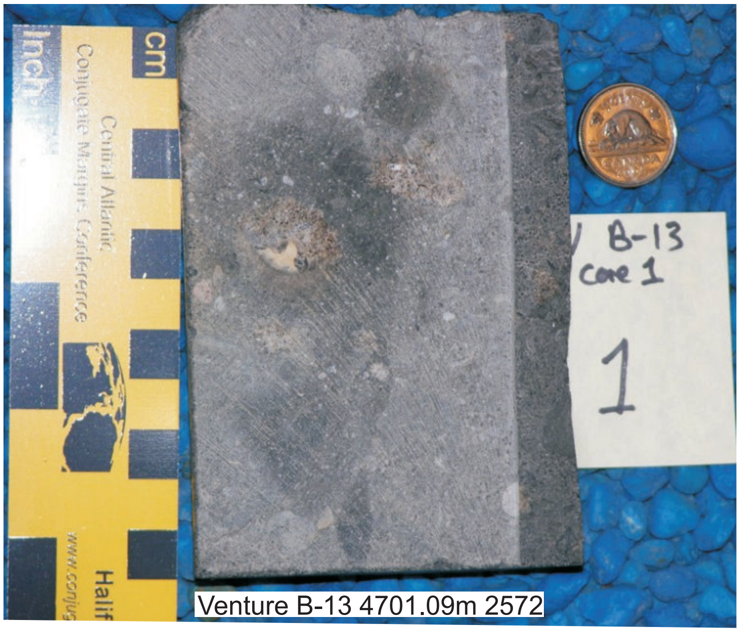
Panuke B-90 2224.84m 3956



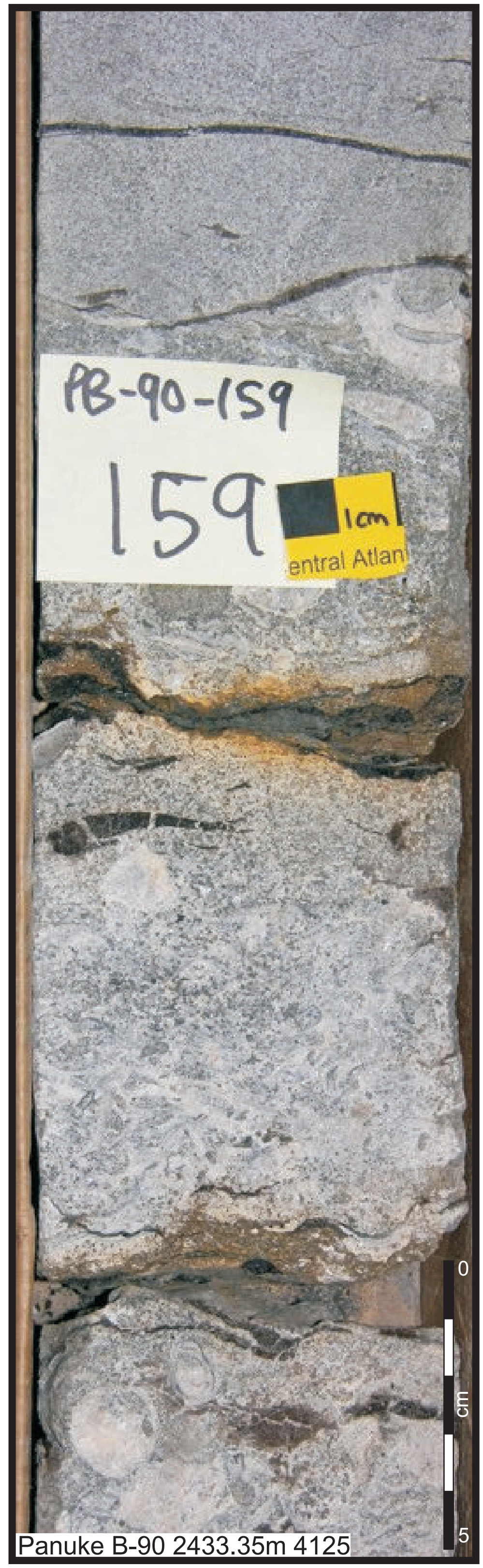
Venture H-22 4712.1 3268

Panuke B-90 2379.92m 4212

Facies 3o



Venture B-13 4701.09m 2572



Panuke B-90 2433.35m 4125

Facies 4o

Venture H-22 4963.5 3334

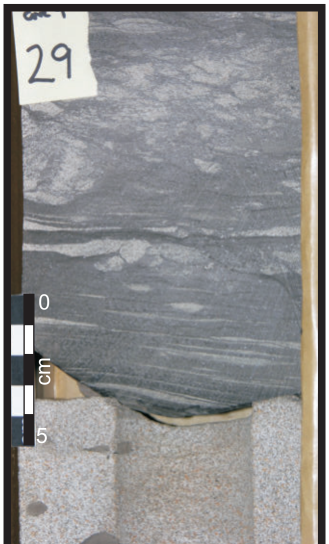
Cohasset A-52
2258.79m 4304

Venture H-22 5023.36m 3457

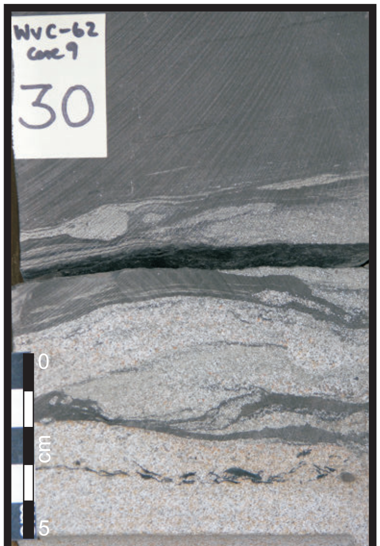
Cohasset A-52 2231.73m 4297

Como P-21 core 2
2962.72m

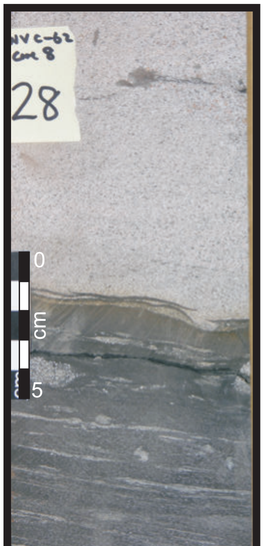
Facies 4a



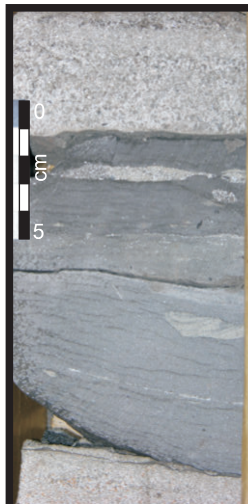
West Venture C-62
5165.55m 4858



West Venture C-62
5169.20m 4872



West Venture C-62
5164.15m 4857

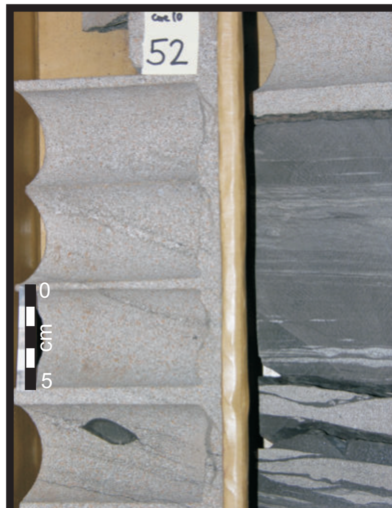


West Venture C-62
5097.67m 4810

West Venture C-62
m 4912

West Venture C-62
5214.72m 4913

Venture B-52
5119.39m 3030



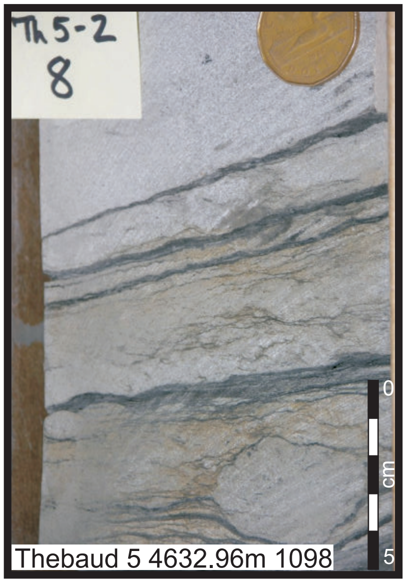
West Venture C-62
5217.62m 4914

Venture B-52
5121.96m 3034

Thebaud I-93 3362.68m 1120

Thebaud I-93 3363.70m 1118

Facies 4g



Thebaud 5 4632.96m 1098

Thebaud 5 ?4631.29m 1095

Thebaud 5 4632.32m 1096

Chebucto K-90 4279.9 m1537

Cohasset A-52 2427.14m 4336

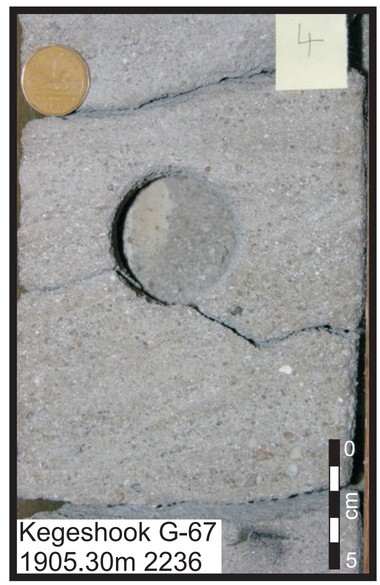
Thebaud 5 4632.69m 1097

Facies 4x

Kegeshook G-67 2414.60m 2297

Panuke B-90
2354.83m 4198

Panuke B-90
2367.05m 4205

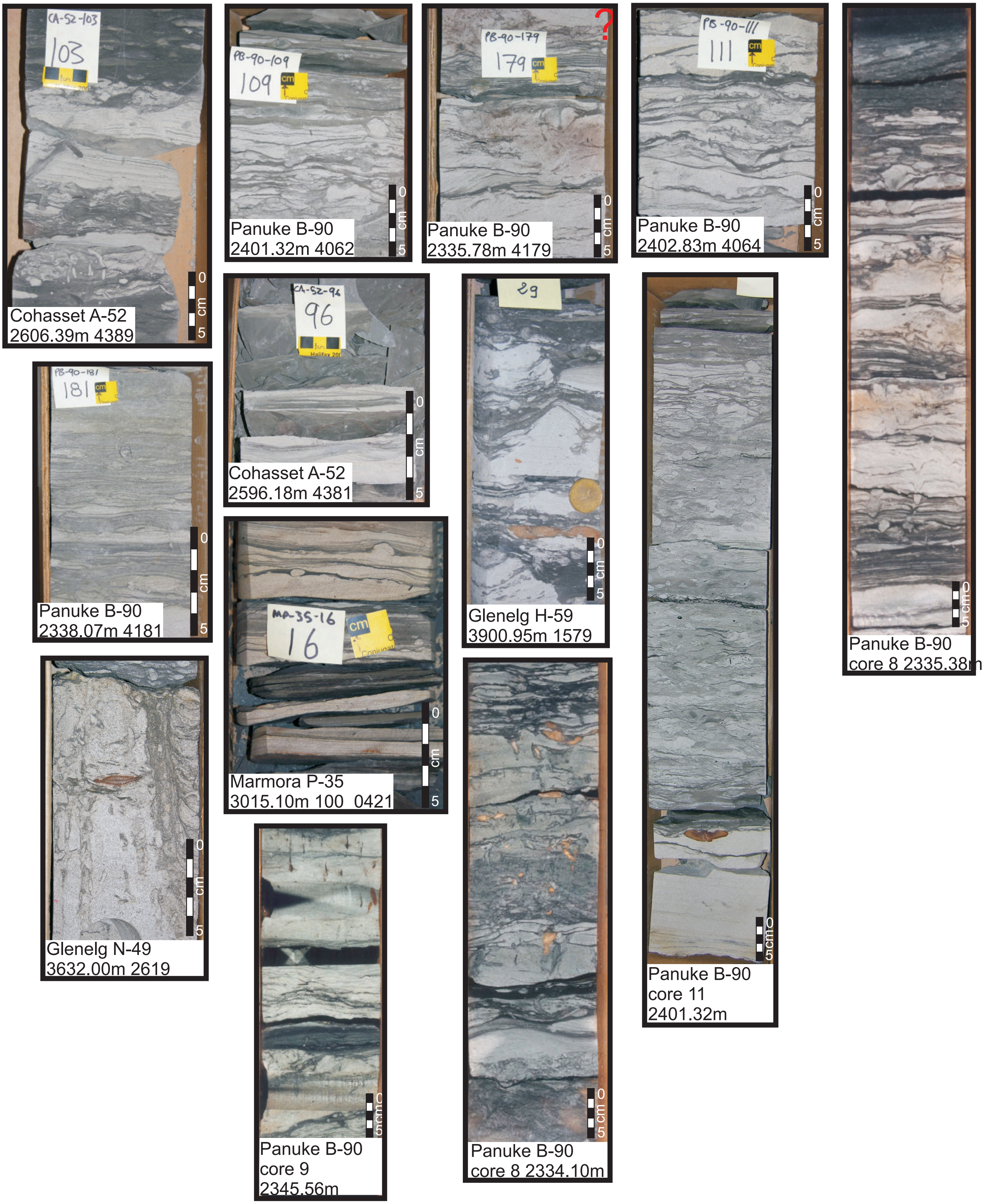


Kegeshook G-67
1905.30m 2236

Facies 4n


Glenelg N-49
3670.80m 2644
Glenelg E-58A
3736.58m 1508
Sable Island C-67
4085.35m 4446
Glenelg N-49
3671.86m 2652
Glenelg E-58A
3732.89m 1497
Glenelg N-49
3643.95m 2622
Glenelg N-49
3644.41m 2624
Glenelg E-58 3458.07m 1401
0
cm
5

Facies 5m



Cohasset A-52 2606.39m 4389

Panuke B-90 2338.07m 4181

Glenelg N-49 3632.00m 2619

Panuke B-90 2401.32m 4062

Cohasset A-52 2596.18m 4381

Marmora P-35 3015.10m 100 0421

Panuke B-90 core 9 2345.56m

Panuke B-90 2335.78m 4179

Glenelg H-59 3900.95m 1579

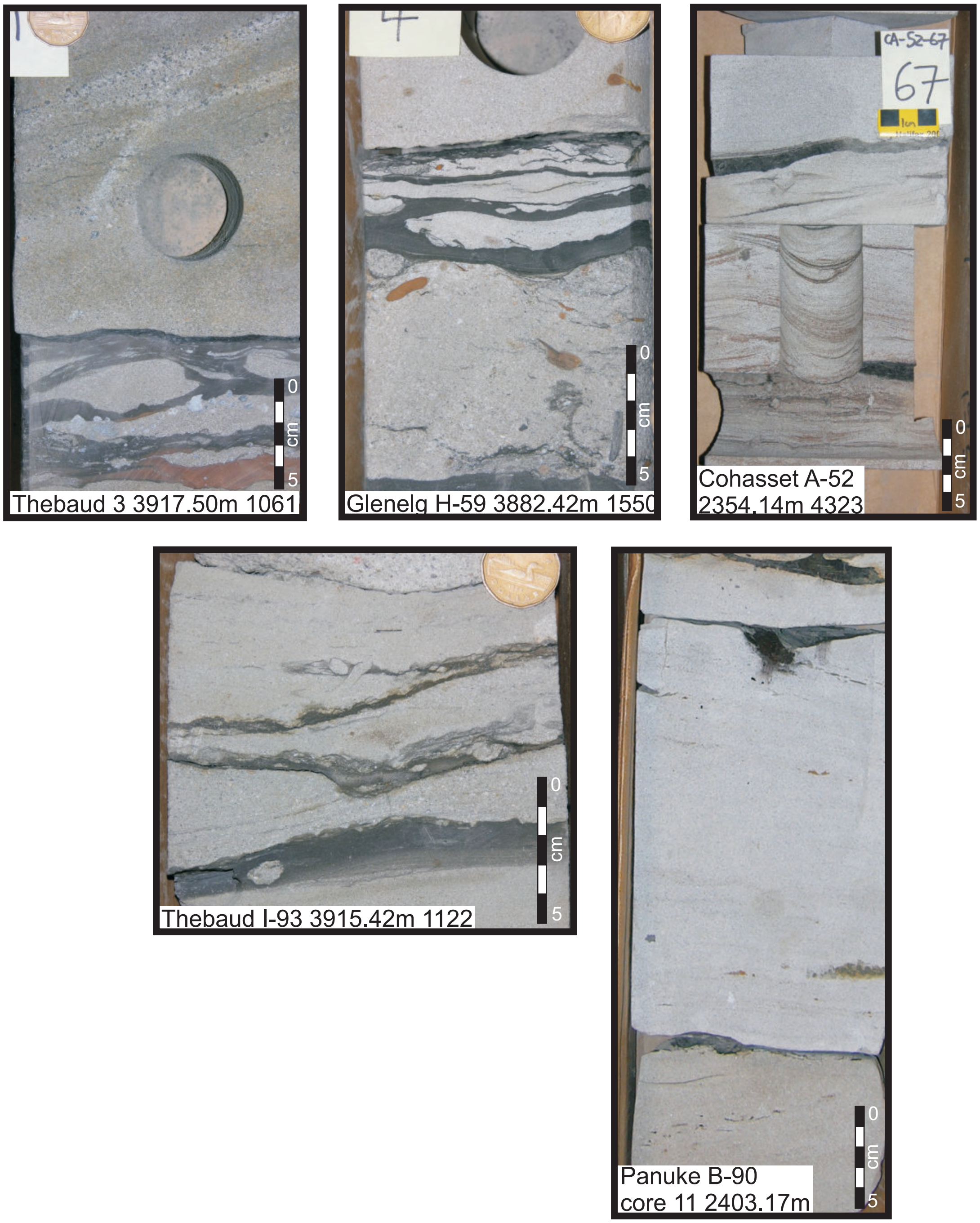
Panuke B-90 core 8 2334.10m

Panuke B-90 2402.83m 4064

Panuke B-90 core 11 2401.32m

Panuke B-90 core 8 2335.38m

Facies 5s


Thebaud 3 3917.50m 1061
Glenelg H-59 3882.42m 1550
Cohasset A-52
2354.14m 4323
CA-52-67
67
Thebaud I-93 3915.42m 1122
Panuke B-90
core 11 2403.17m
0
cm
5

Facies 5b

Como P-21
core 2
2961.49m
Como P-21
core 2
2962.13m
PB-90-194
194
Panuke B-90
2350.03m 4196
CA-52-76
76
Cohasset A-52
2421.67m 4334
SP85
Lawrence D-14
2279.79m 4417
5
Thebaud I-93 3075.25m 1113
0 cm 5

Facies 5c


184
cm
0
cm
5
Panuke B-90 2340.70m 4185


CA-52-48
48
1cm
entral Atlan
0
cm
5
Cohasset A-52 2258.79m 4302

Facies 6s

Como P-21 core 1 2191.05m

Panuke B-90 core 8 2331.65m

Panuke B-90 2307.00m 4151

Panuke B-90 2332.95m 4178

Panuke B-90 2332.83m 4177

Panuke B-90 2336.47m 4180

Panuke B-90 2338.37m 4183

Thebaud I-93 3942.65m 1138

Facies 6s (con't)

Cohasset A-52 2233.97m 4299

Cohasset A-52 2076.36m 4251

Panuke B-90
2339.48m 4184

Panuke B-90 2348.25m 4194

Cohasset A-52
2075.95m 4250

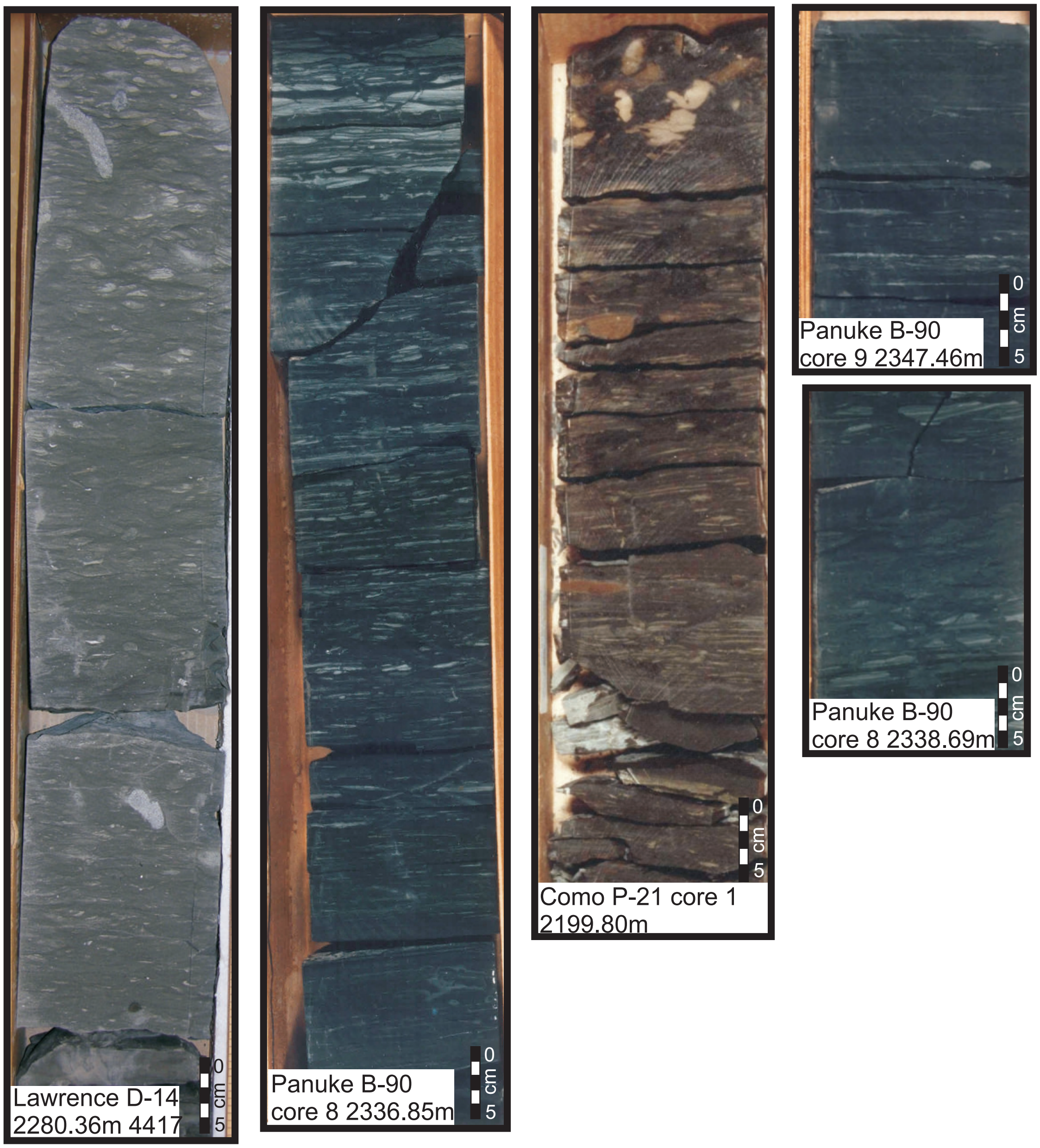
South Debarres O-76
5950.65m 4514

Thebaud I-93 3926.05m 1137

Facies 6b

PB-90-170
170
Panuke B-90
2325.07m 4169
PB-90-119
119
Panuke B-90
2296.38m 4140
PB-90-120
120
Panuke B-90
2297.08m 4141
2417.07m
TOP
Panuke B-90
2417.07m 4094
PB-90-118
118
Panuke B-90
2295.85m 4139
0
cm
5

Facies 6m



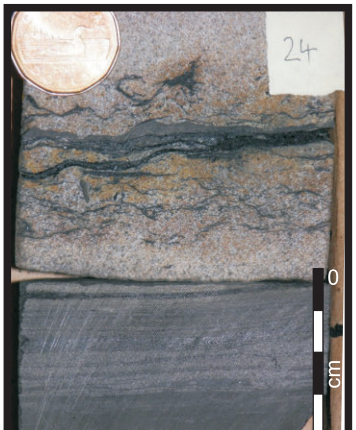
Lawrence D-14
2280.36m 4417
0 cm 5
Panuke B-90
core 8 2336.85m
0 cm 5
Como P-21 core 1
2199.80m
0 cm 5
Panuke B-90
core 9 2347.46m
0 cm 5
Panuke B-90
core 8 2338.69m
0 cm 5

Facies 7

Glenelg N-49
3592.00m 2590

Panuke B-90 2345.37m 4188

Venture B-52 5116.28m 3025



Venture B-52
unknown depth 3035

Venture H-22 4897.93m 3303

West Venture N-91
5115.27m 4890

West Venture N-91
5065.68m 4836

Facies 8

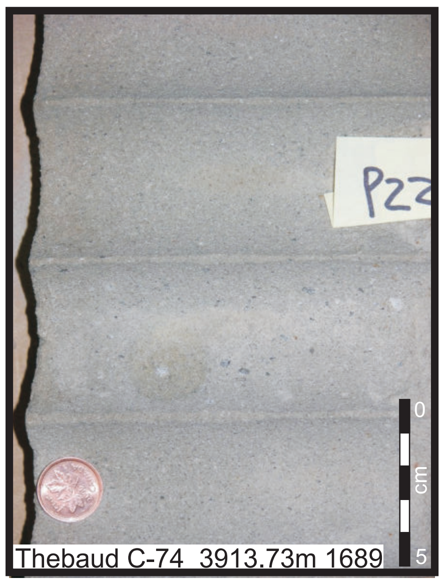
Facies 9g

Thebaud C-74 3915.74m 1687

Thebaud C-74 3918.64m 1685

Thebaud C-74 3917.06m1686

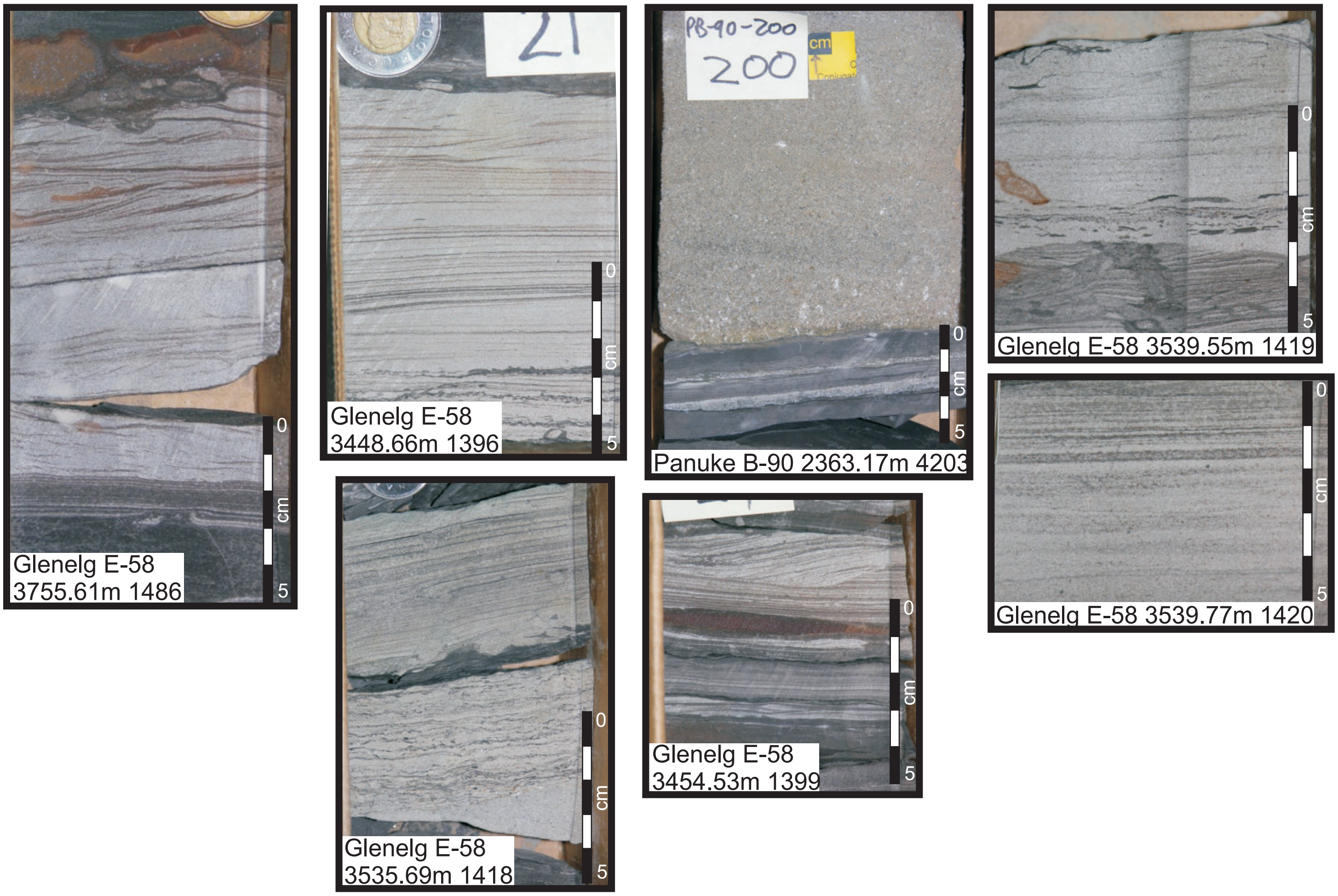
Thebaud C-74 3914.34m 1688



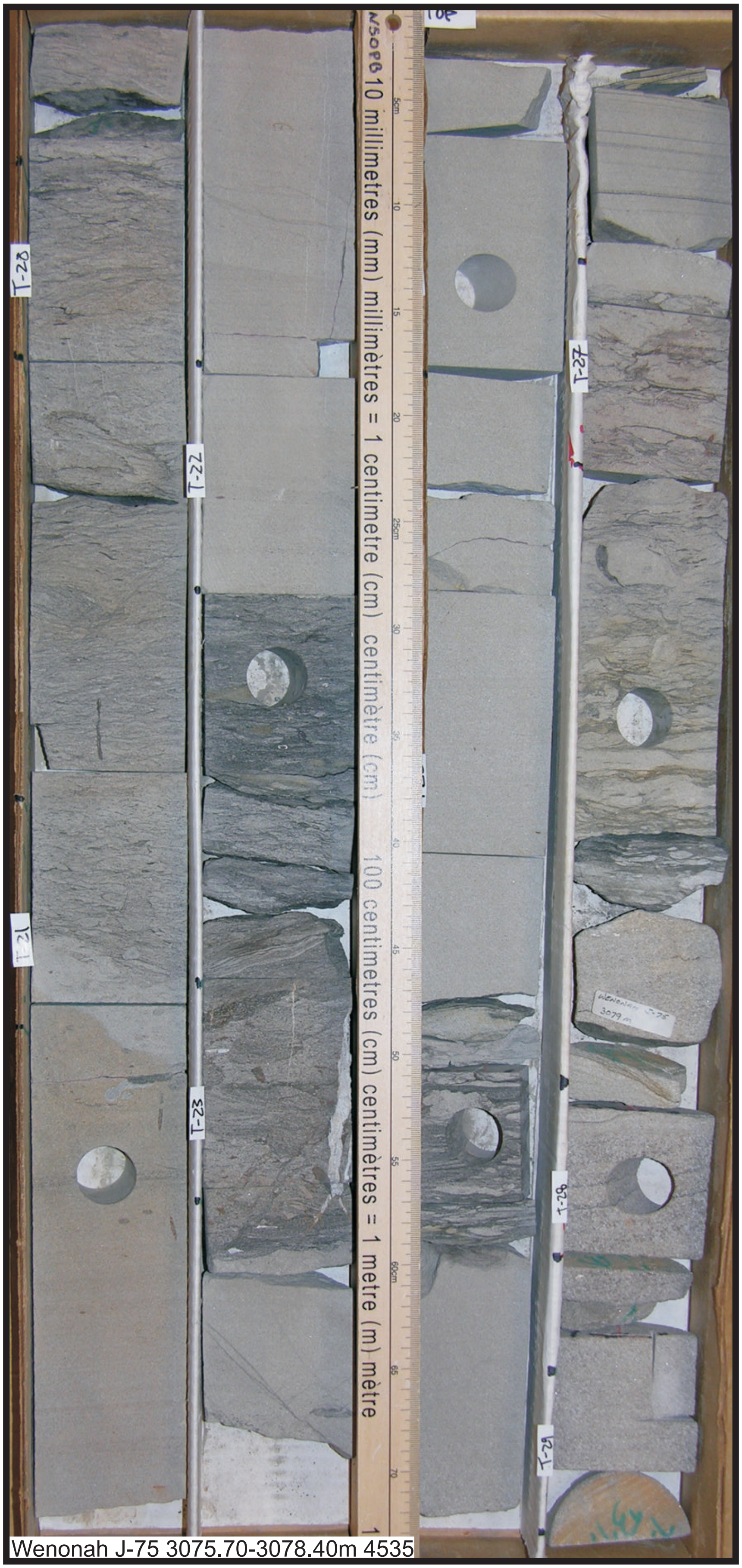
Thebaud C-74 3913.73m 1689

Panuke B-90 2385.55m 4032

Facies 9s


Glenelg E-58
3755.61m 1486
21
Glenelg E-58
3448.66m 1396
PB-90-200
200
Panuke B-90 2363.17m 4203
Glenelg E-58 3539.55m 1419
Glenelg E-58
3535.69m 1418
Glenelg E-58
3454.53m 1399
Glenelg E-58 3539.77m 1420
cm

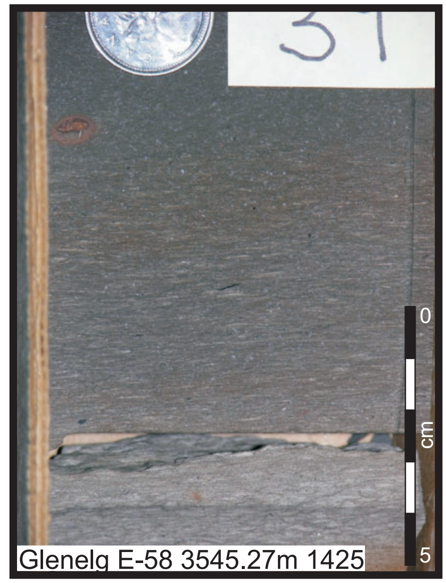
Facies 9s (con't)



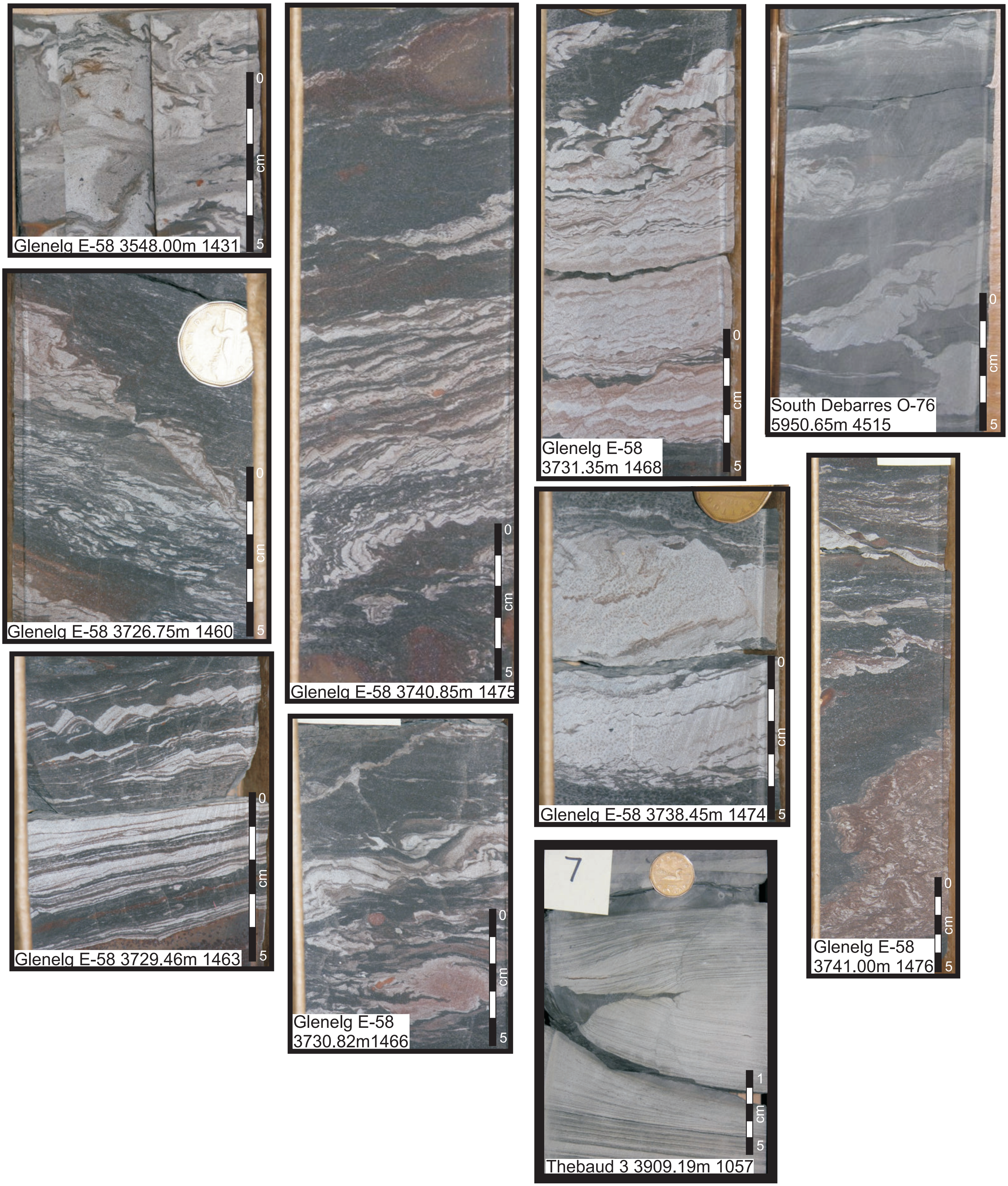
Facies 10f


0
cm
5
Glenelg E-58 3546.85m 1427


0
cm
5
Alma K-85 2869.94m


0
cm
5
Glenelg E-58 3545.27m 1425

Facies 10s


Glenelg E-58 3548.00m 1431
Glenelg E-58 3740.85m 1475
Glenelg E-58 3731.35m 1468
South Debarres O-76 5950.65m 4515
Glenelg E-58 3726.75m 1460
Glenelg E-58 3738.45m 1474
Glenelg E-58 3741.00m 1476
Glenelg E-58 3729.46m 1463
Glenelg E-58 3730.82m1466
Thebaud 3 3909.19m 1057

Facies 10g

Glenelg E-58 3451.10m

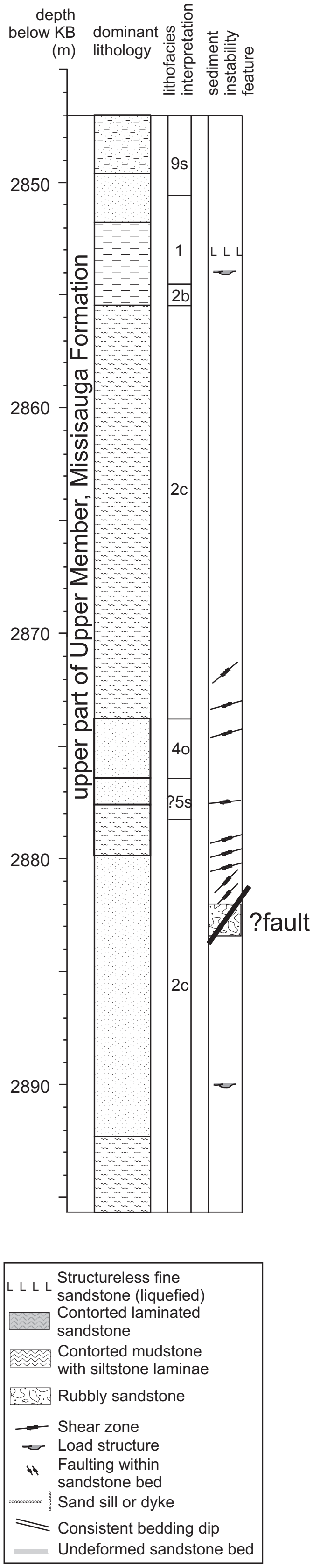


Figure 3: Summary log of conventional cores 1-3 from Alma F-67 well. Lithofacies have been reinterpreted from Piper et al., 2004.

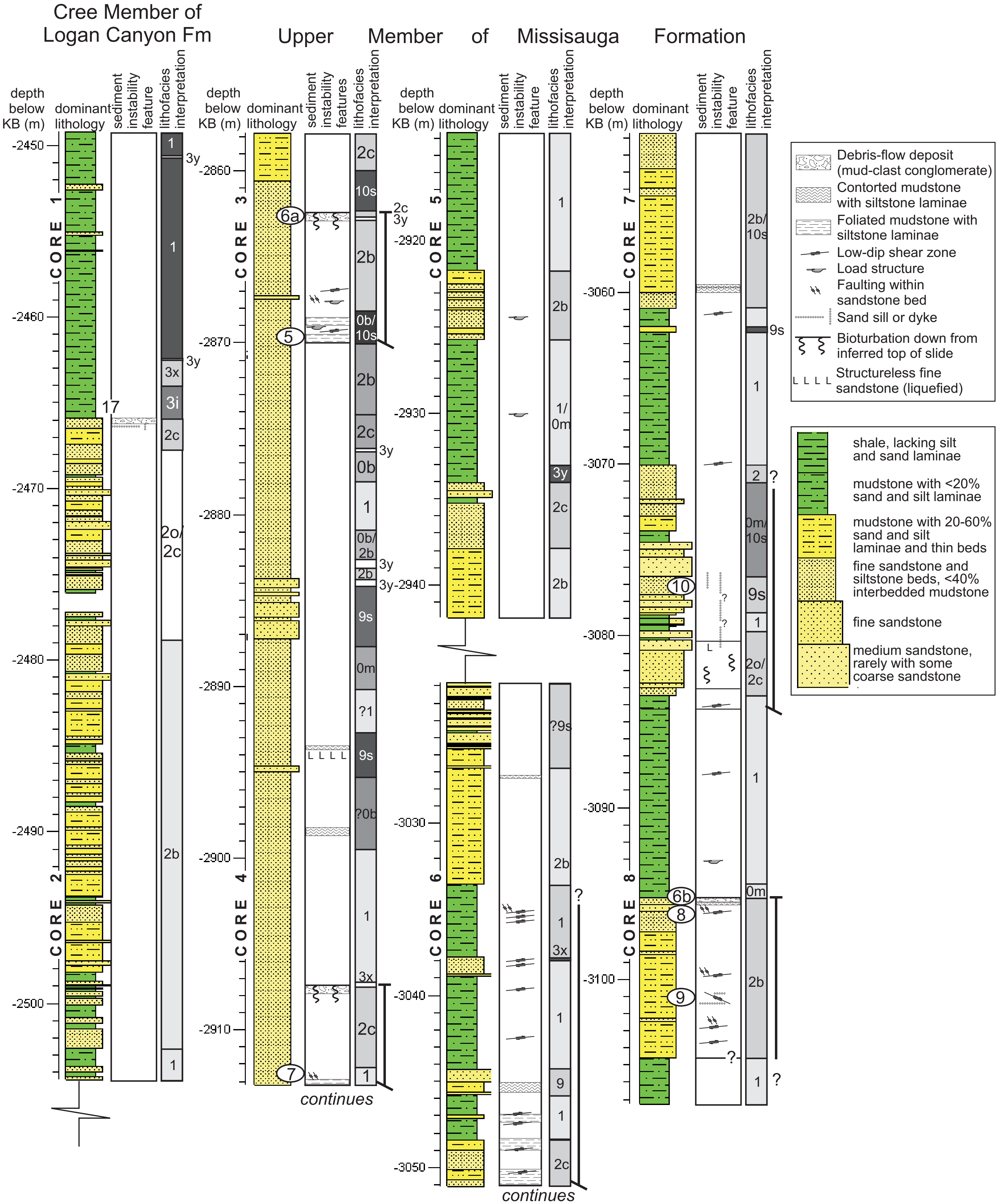


Figure 4: Summary log of conventional cores 1-8 from the Alma K-85 well. Lithofacies have been reinterpreted from Piper et al., 2004.

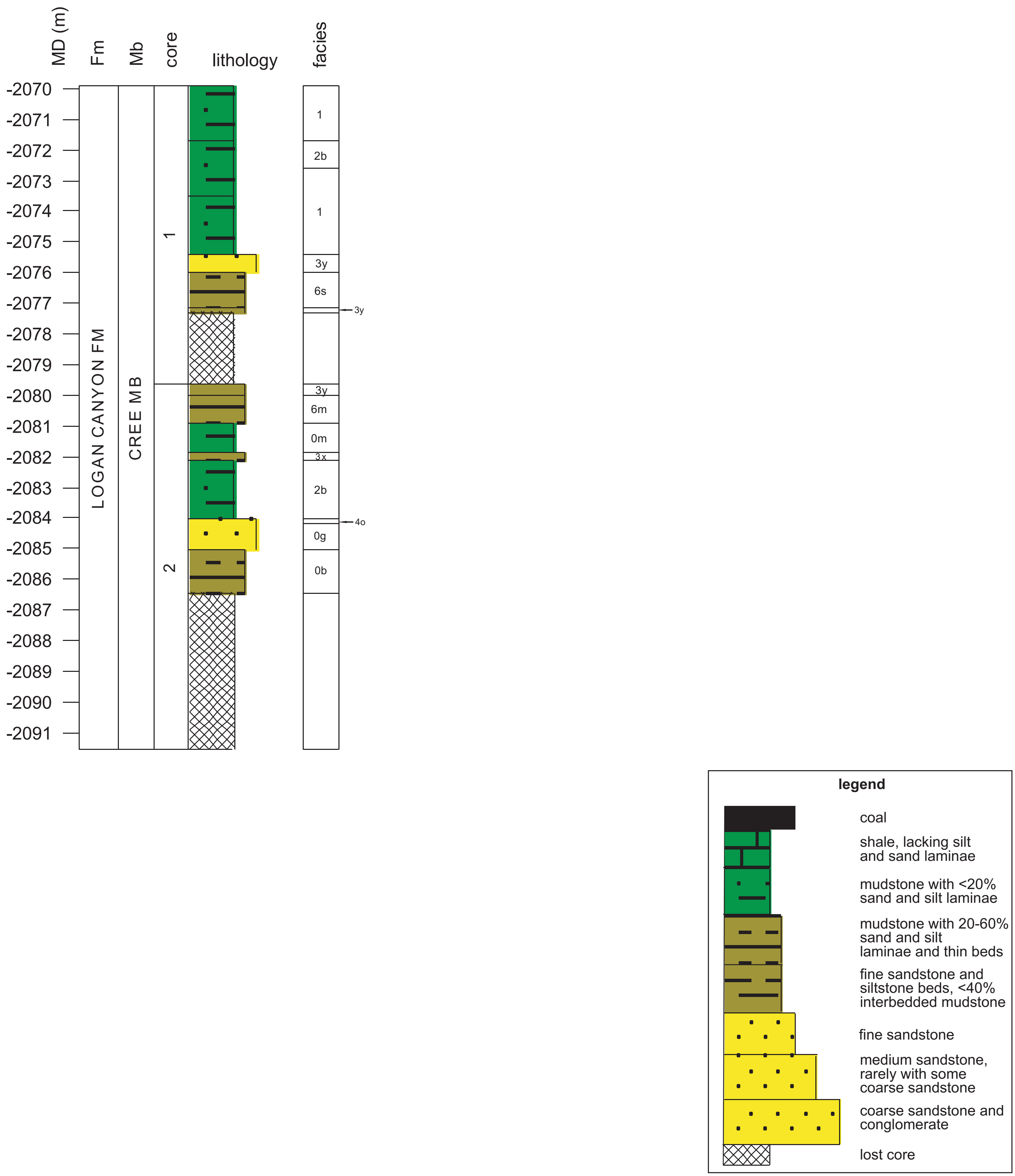


Figure 5: Summary log of core 1 and 2 in the Cohasset A-52 well.

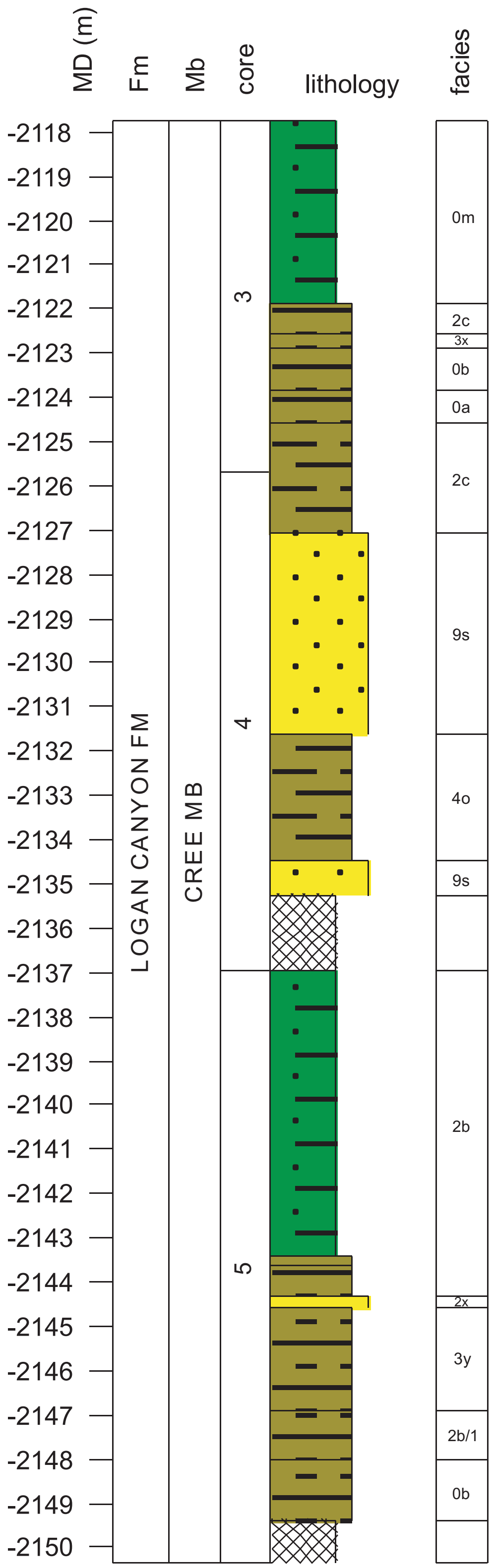


Figure 5 (con't): Summary log of cores 3-5 in the Cohasset A-52 well.

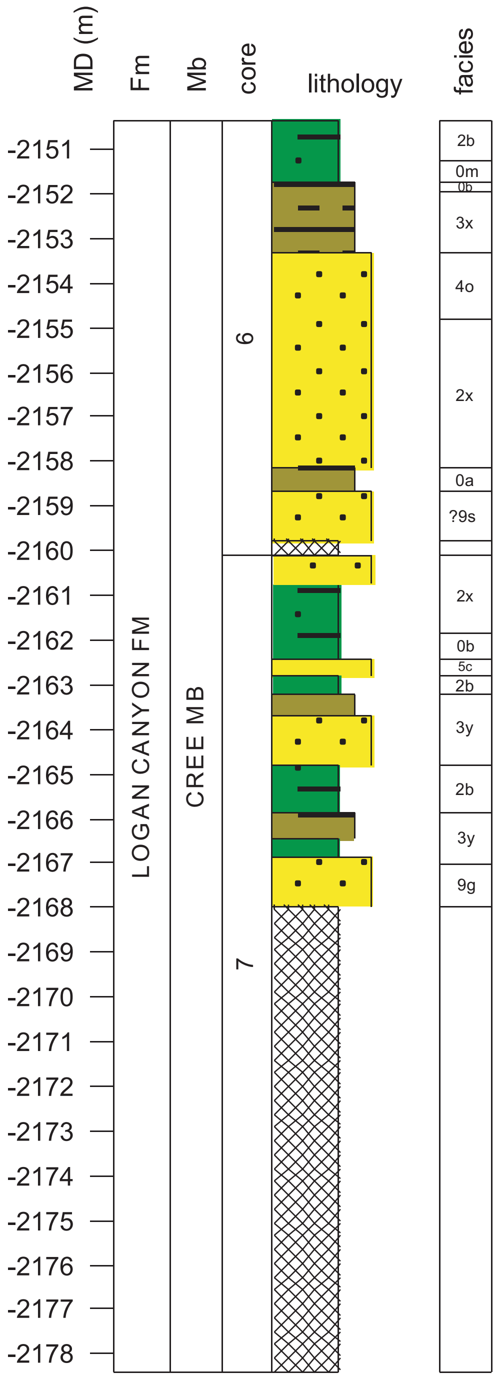


Figure 5 (con't): Summary log of cores 6 and 7 in the Cohasset A-52 well.

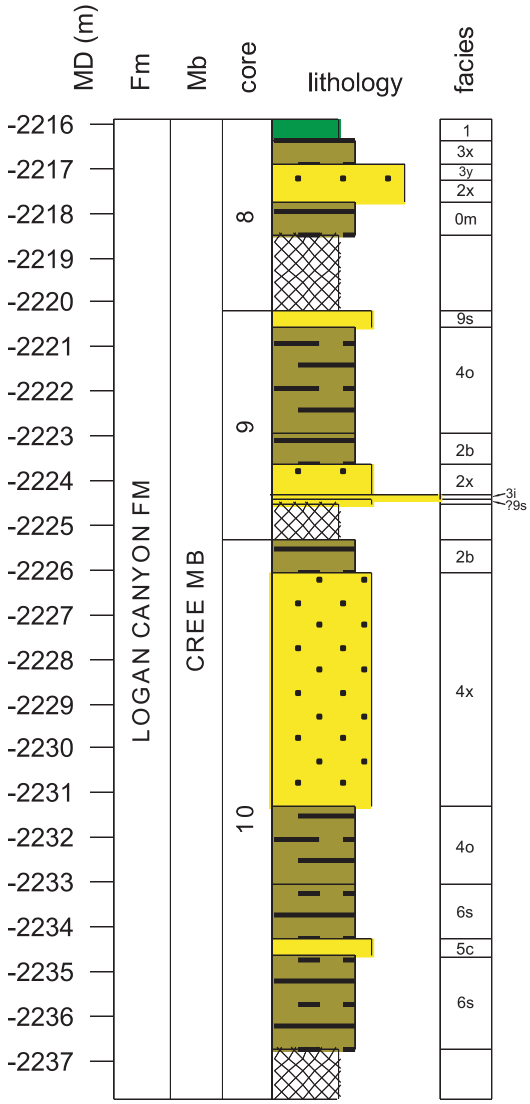


Figure 5 (con't): Summary log of cores 8-10 in the Cohasset A-52 well.

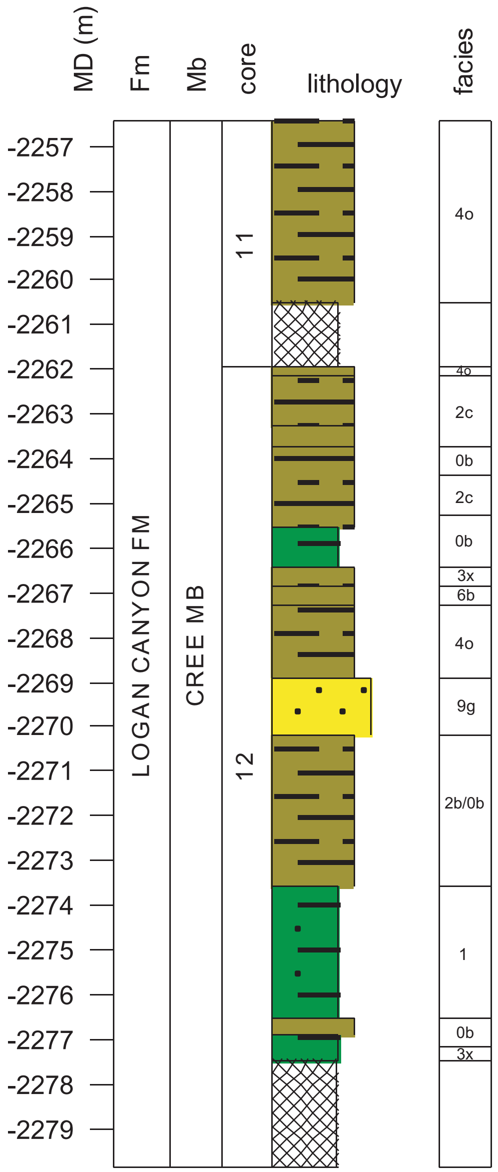


Figure 5 (con't): Summary log of cores 11 and 12 in the Cohasset A-52 well.

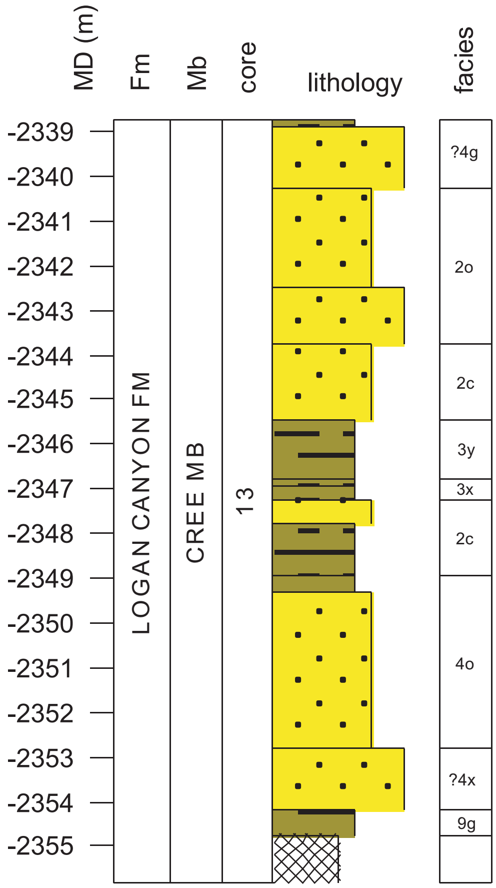


Figure 5 (con't): Summary log of core 13 in the Cohasset A-52 well.

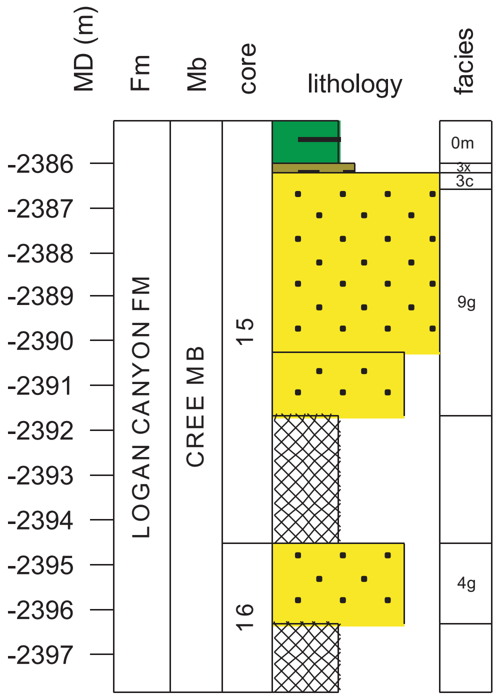


Figure 5 (con't): Summary log of cores 15 and 16 in the Cohasset A-52 well.

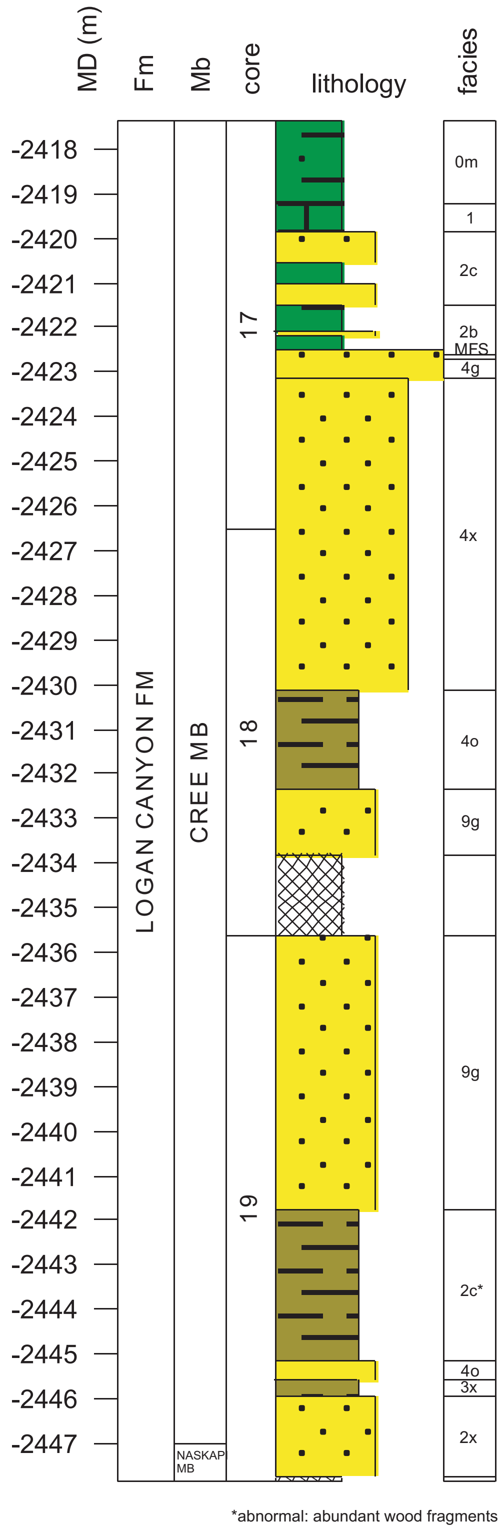


Figure 5 (con't): Summary log of cores 17-19 in the Cohasset A-52 well.

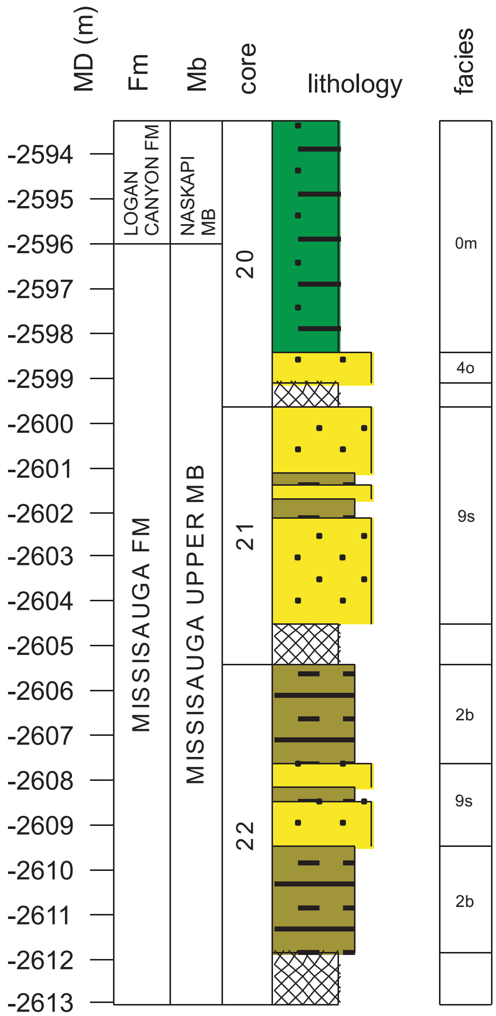
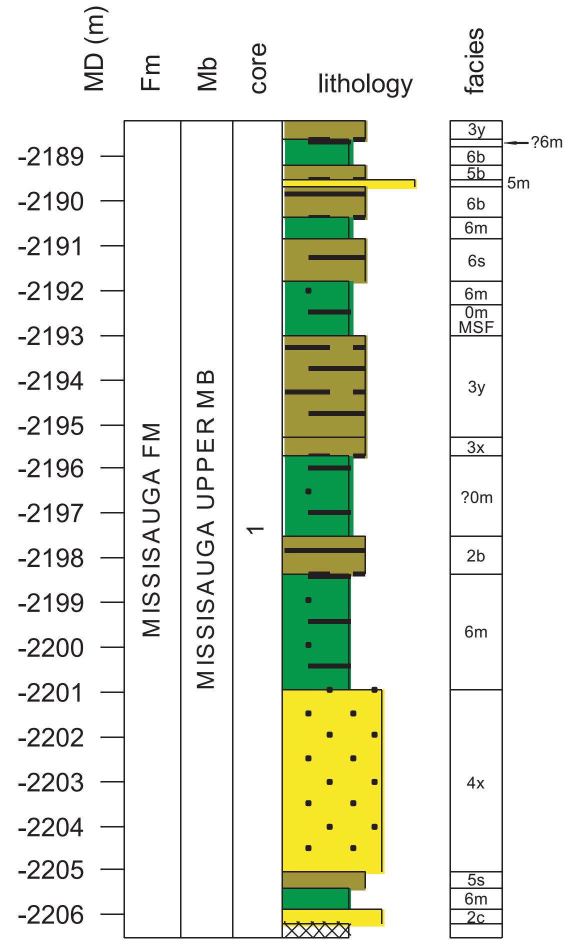


Figure 5 (con't): Summary log of cores 20-22 in the Cohasset A-52 well.



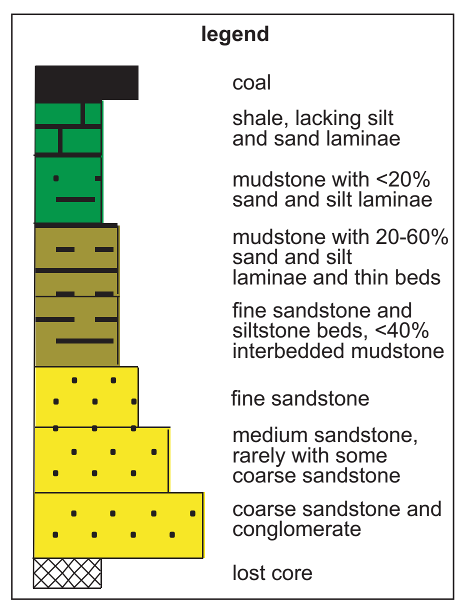


Figure 6: Summary log of conventional core 1 from the Como P-21 well.

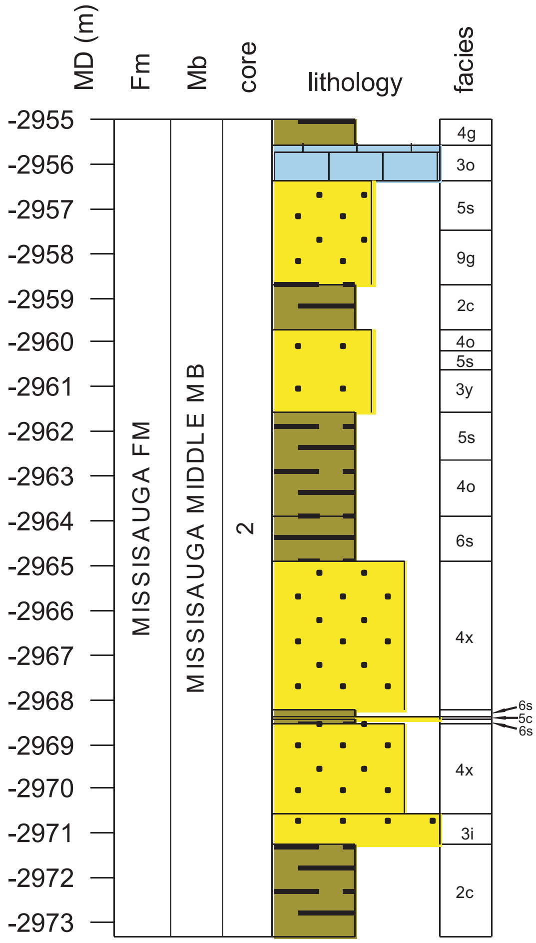


Figure 6: Summary log of core 2 from the Como P-21 well.

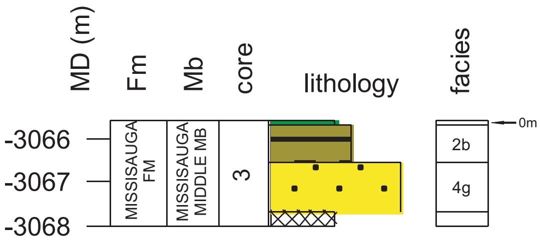
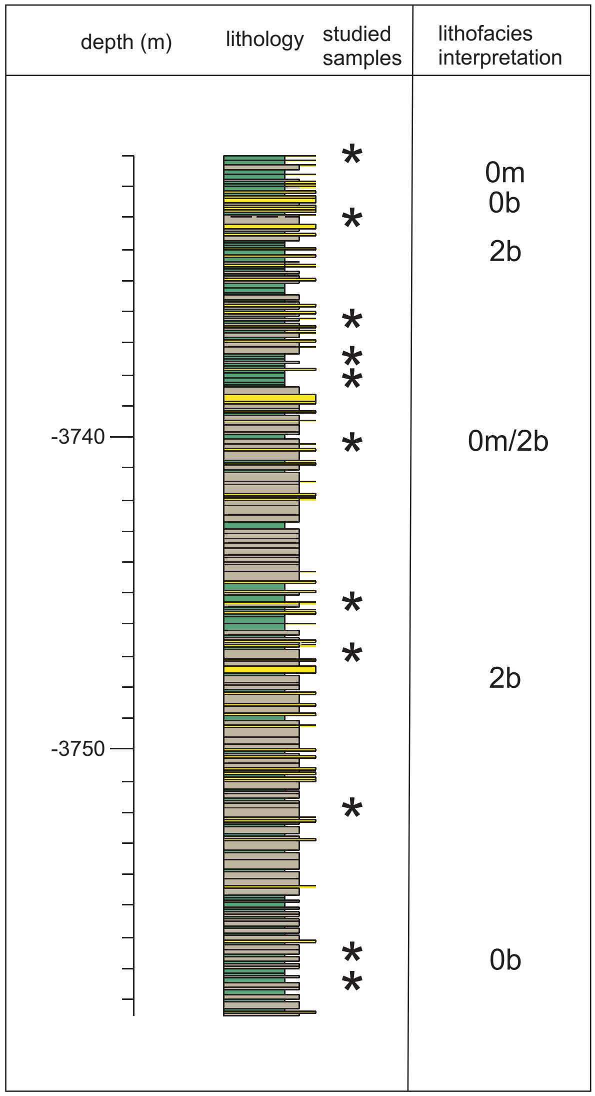


Figure 6: Summary log of core 3 from the Como P-21 well.



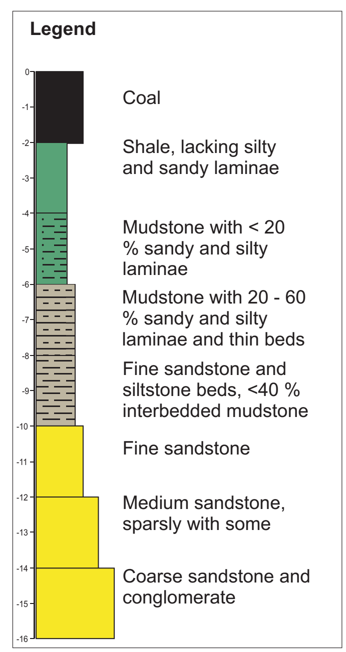


Figure 7: Summary log of conventional core 7 from Glenelg E-58A well. Lithofacies have been reinterpreted from Karim et al., 2008.

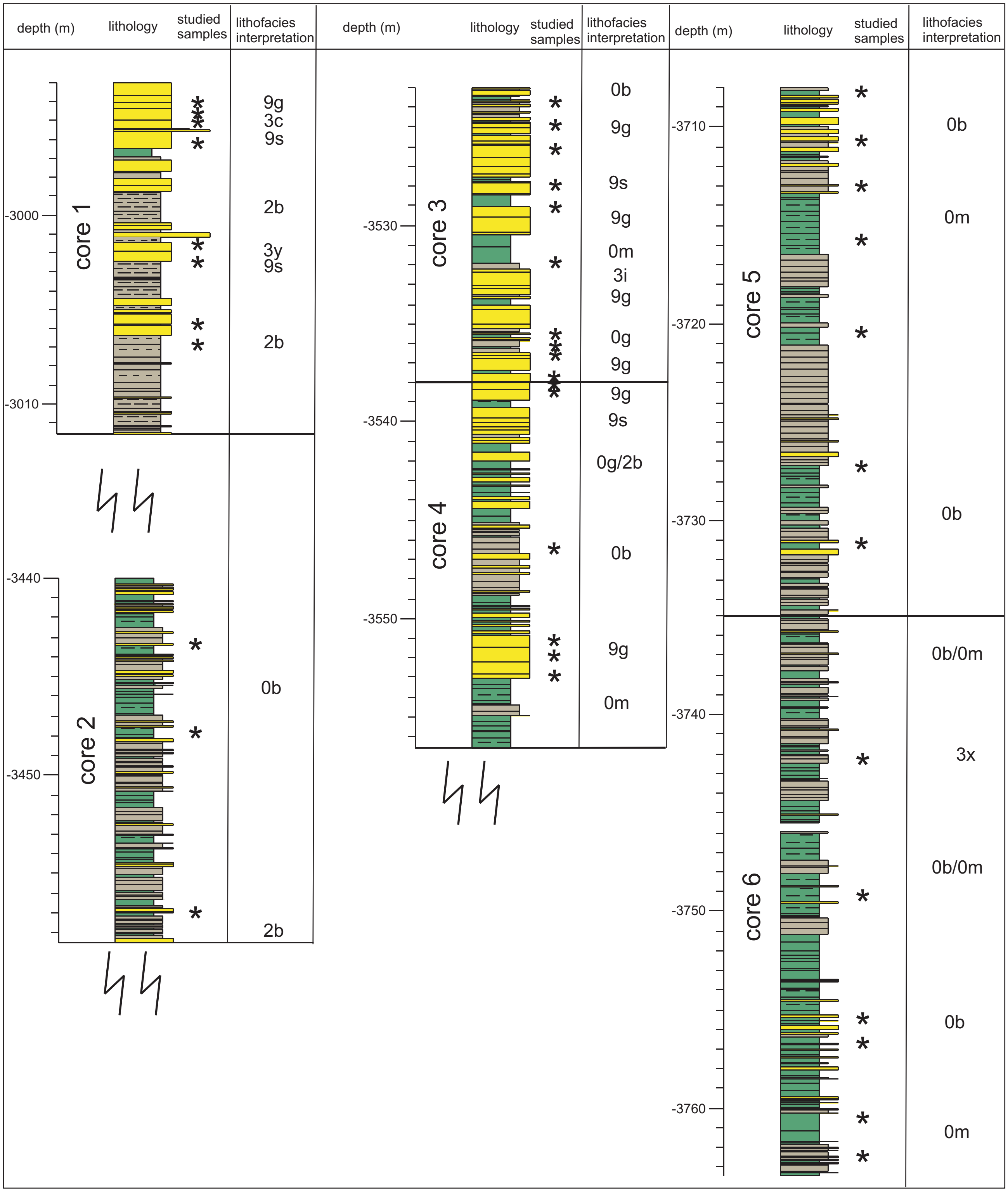
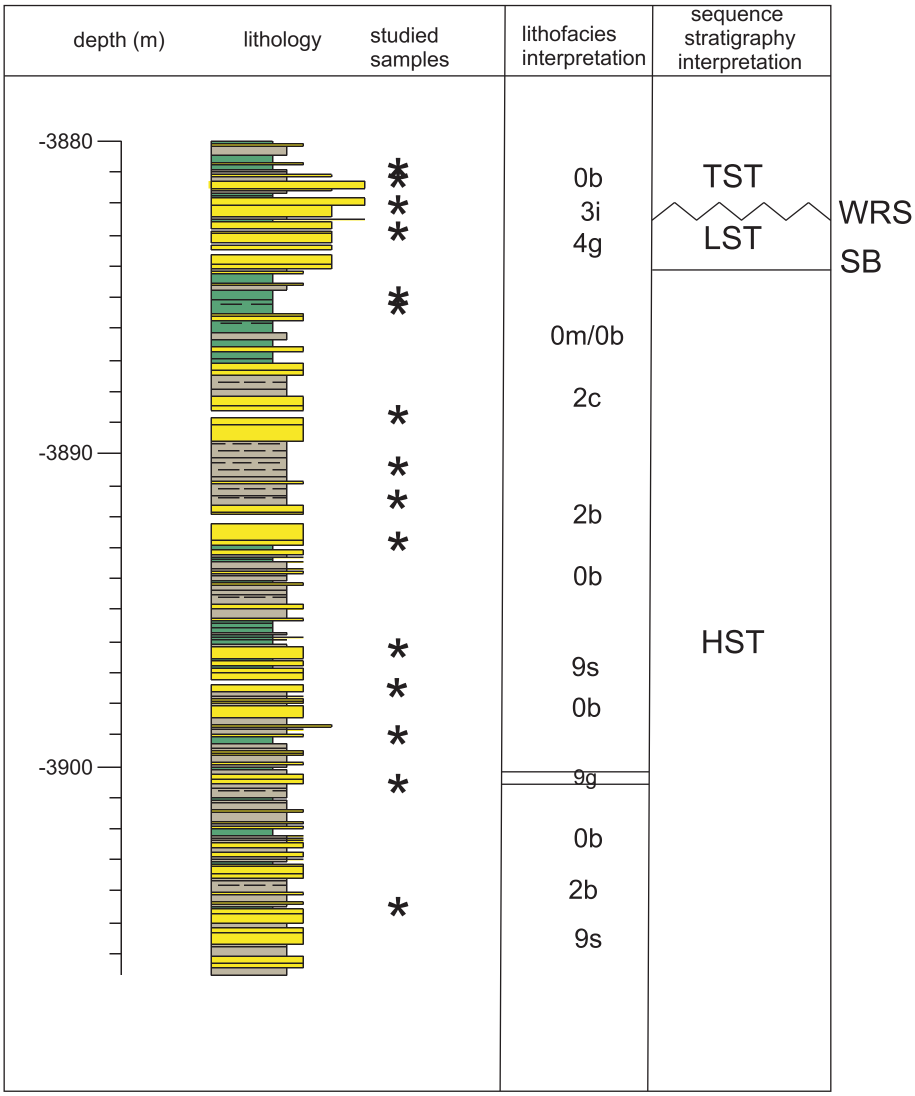


Figure 8: Summary log of conventional cores 1-6 from Glenelg E-58 well (refer to Fig.7 for legend). Lithofacies have been reinterpreted from Karim et al., 2008.



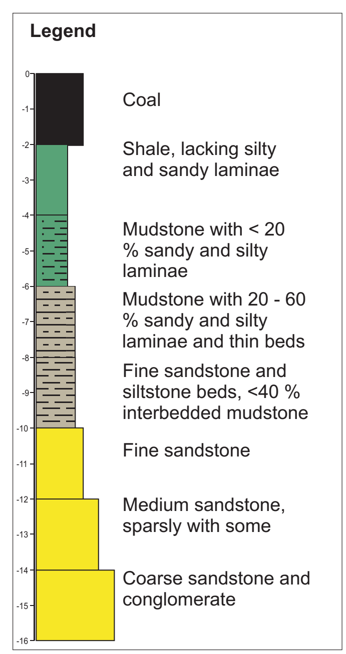
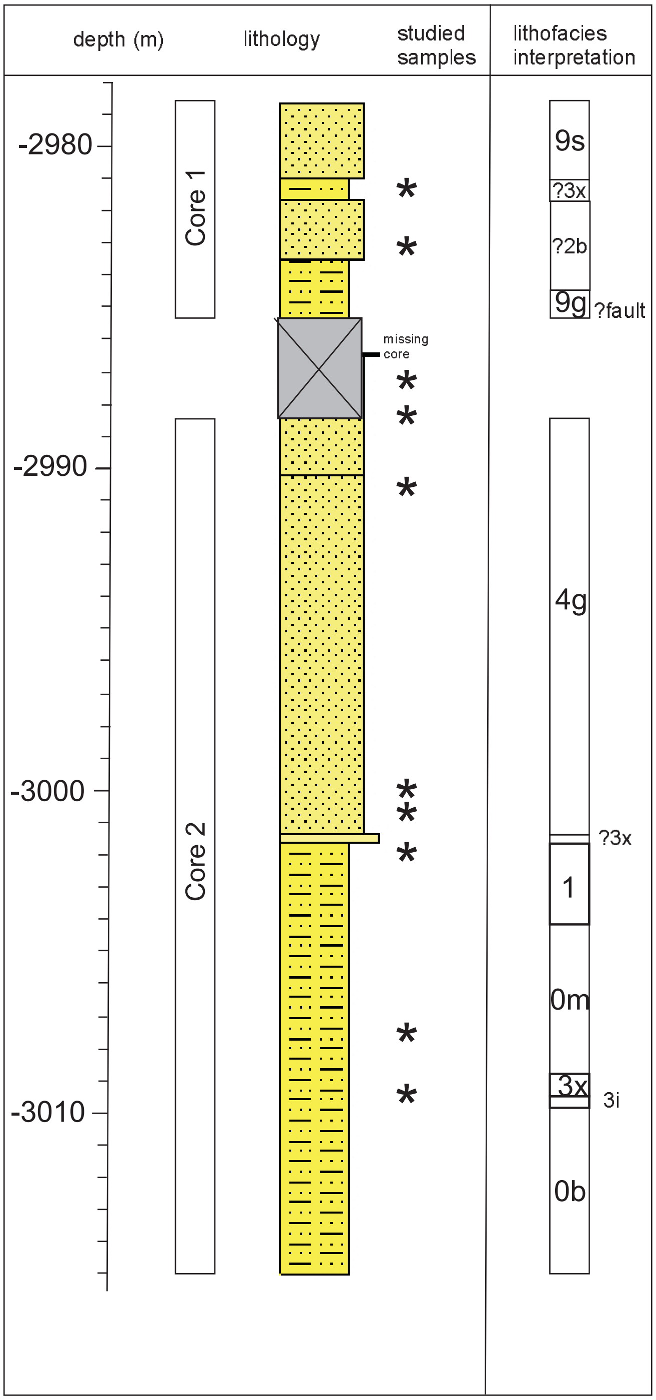


Figure 9: Summary log of conventional core1 from Glenelg H-59 well. Lithofacies have been reinterpreted from Karim et al., 2008.



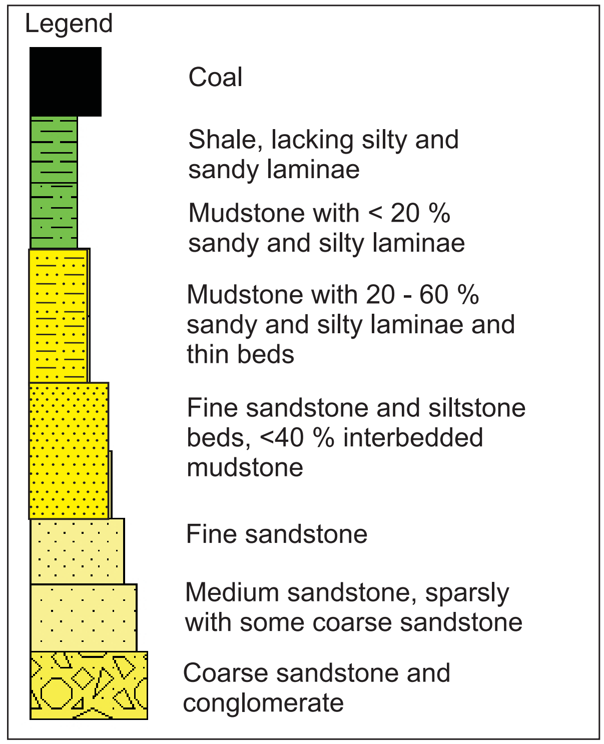


Figure 10: Summary log of conventional cores 1 and 2 from Glenelg N-49 well. Lithofacies have been reinterpreted from Karim et al., 2008.

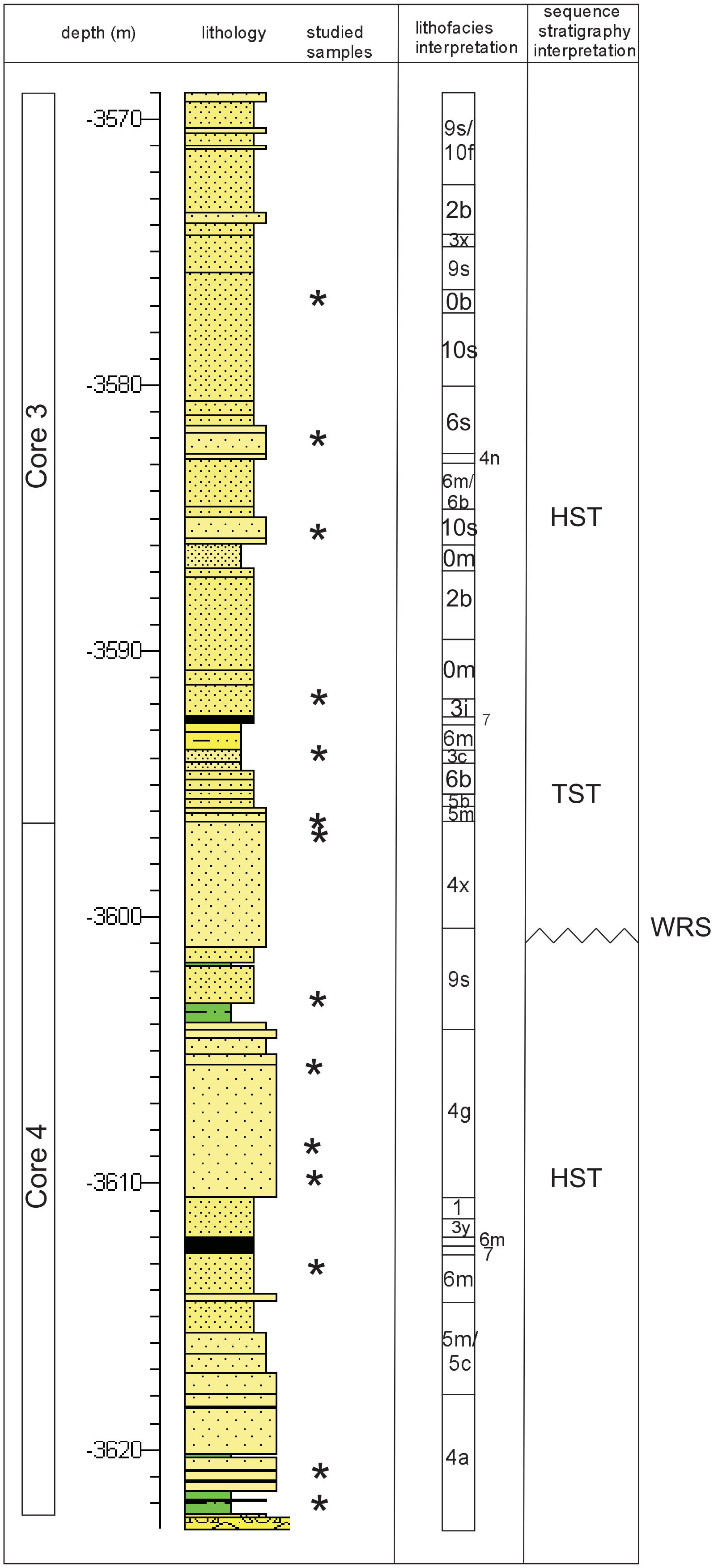


Figure 10: Summary log of cores 3 and 4 from Glenelg N-49 well. Lithofacies have been reinterpreted from Karim et al., 2008.

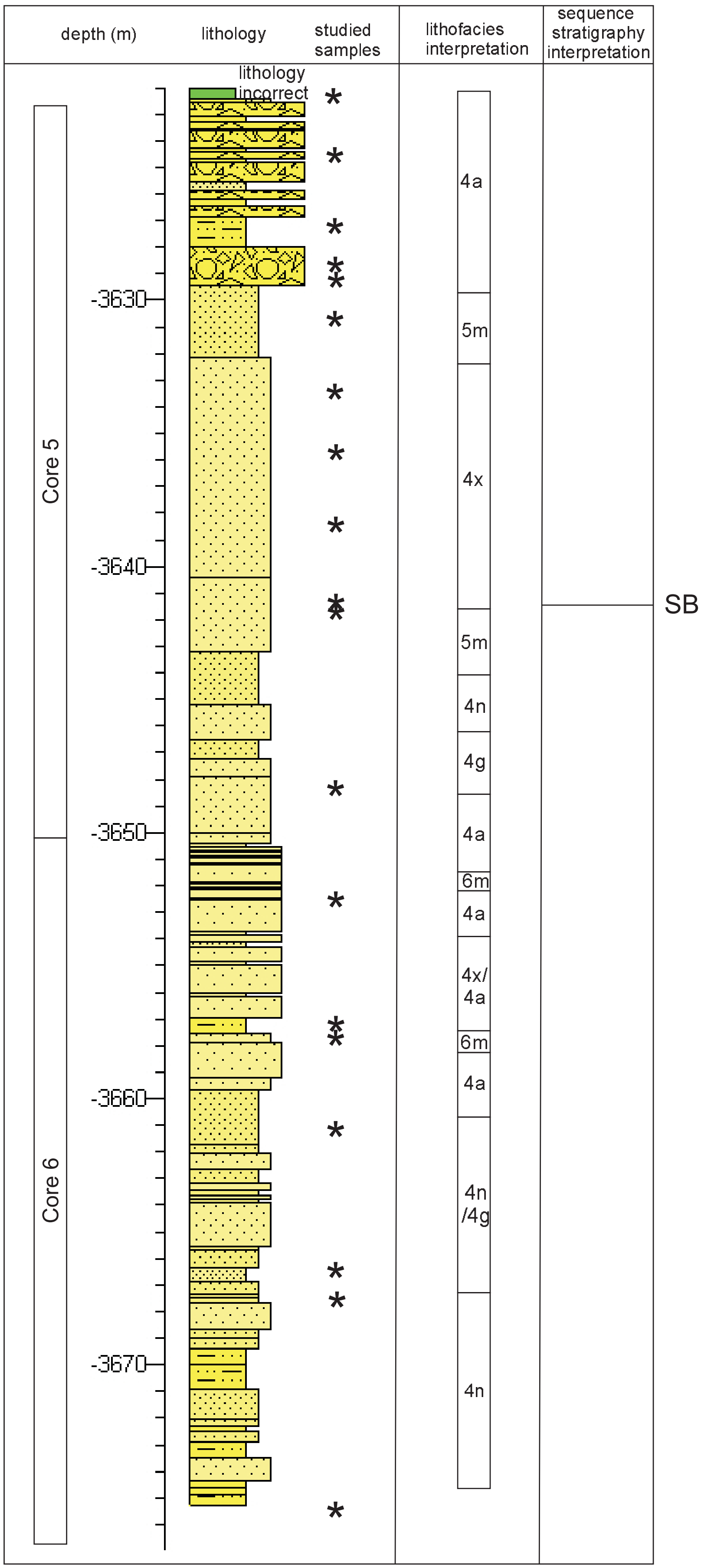


Figure 10: Summary log of cores 5 and 6 from Glenelg N-49 well. Lithofacies have been reinterpreted from Karim et al., 2008.

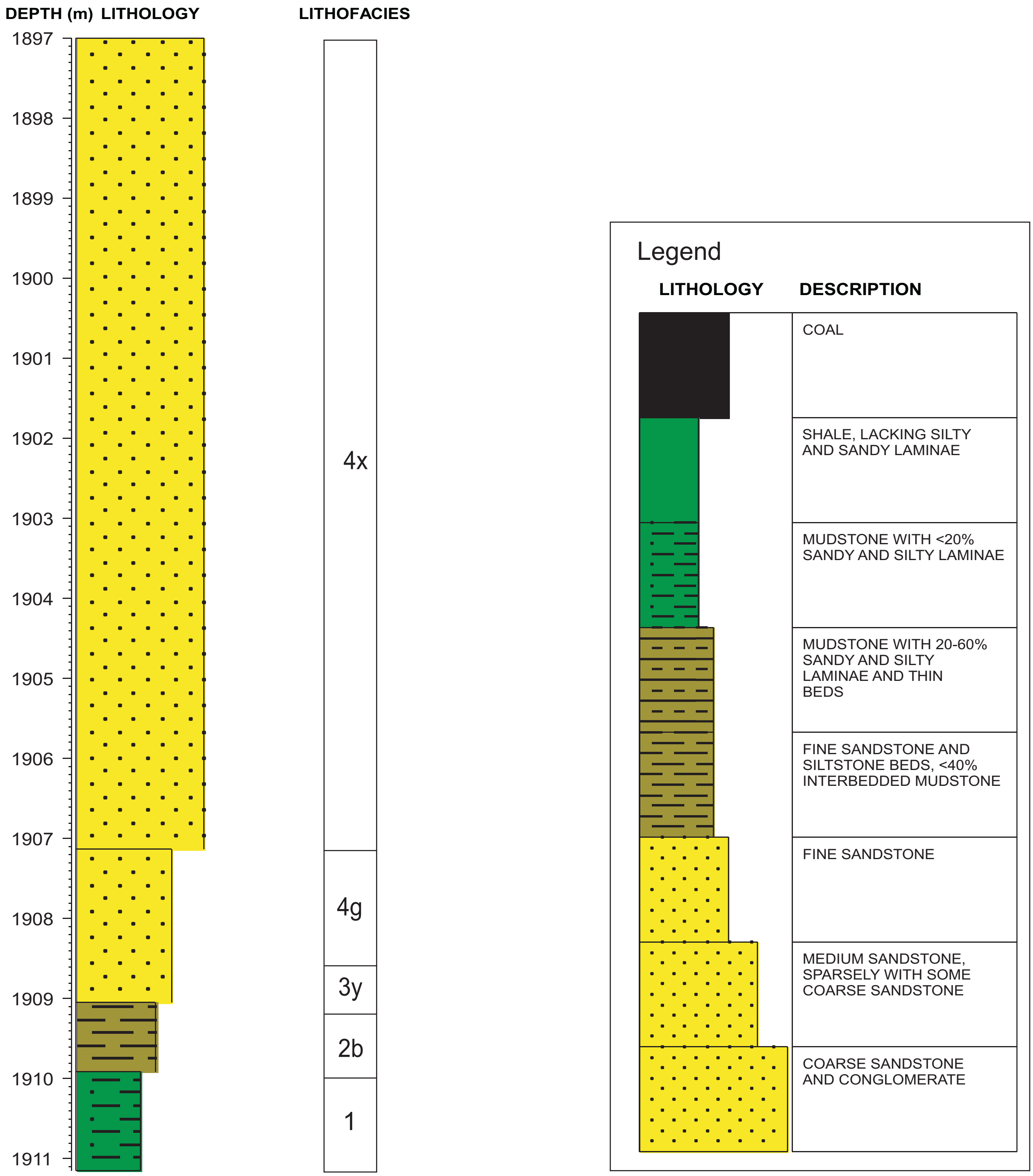


Figure 11: Summary log of conventional core 1 from the Kegeshook G-67 well. Lithofacies have been reinterpreted from Foley, 2008.

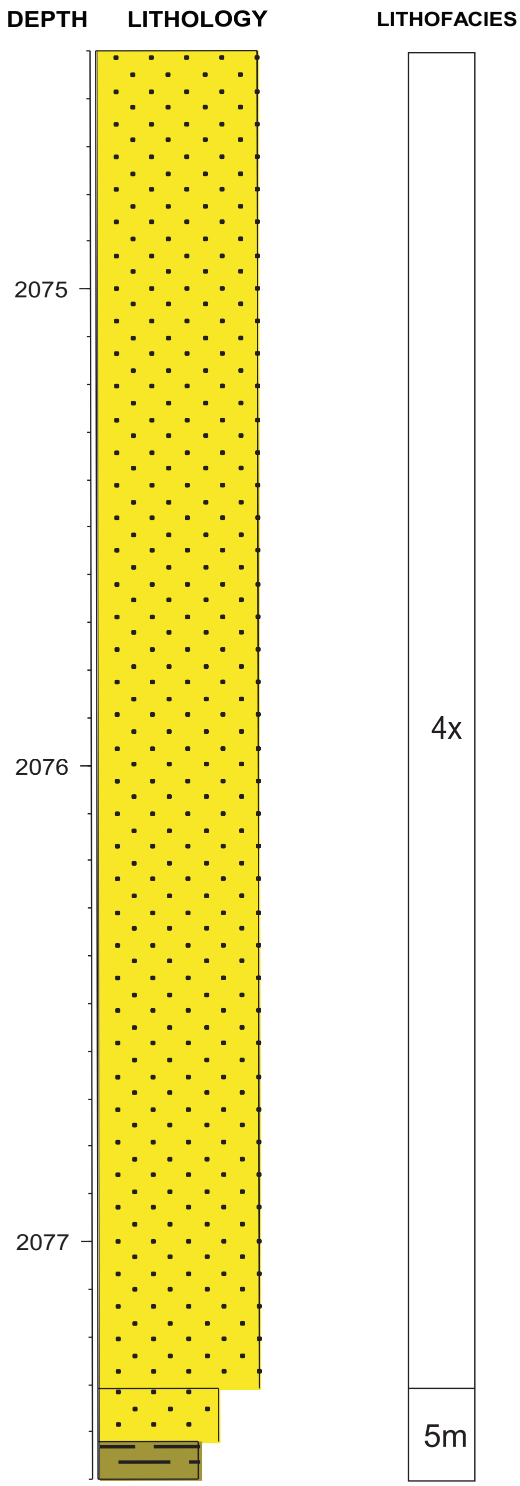


Figure 11 (con't): Summary log of conventional core 2 from the Kegeshook G-67 well. Lithofacies have been reinterpreted from Foley, 2008.

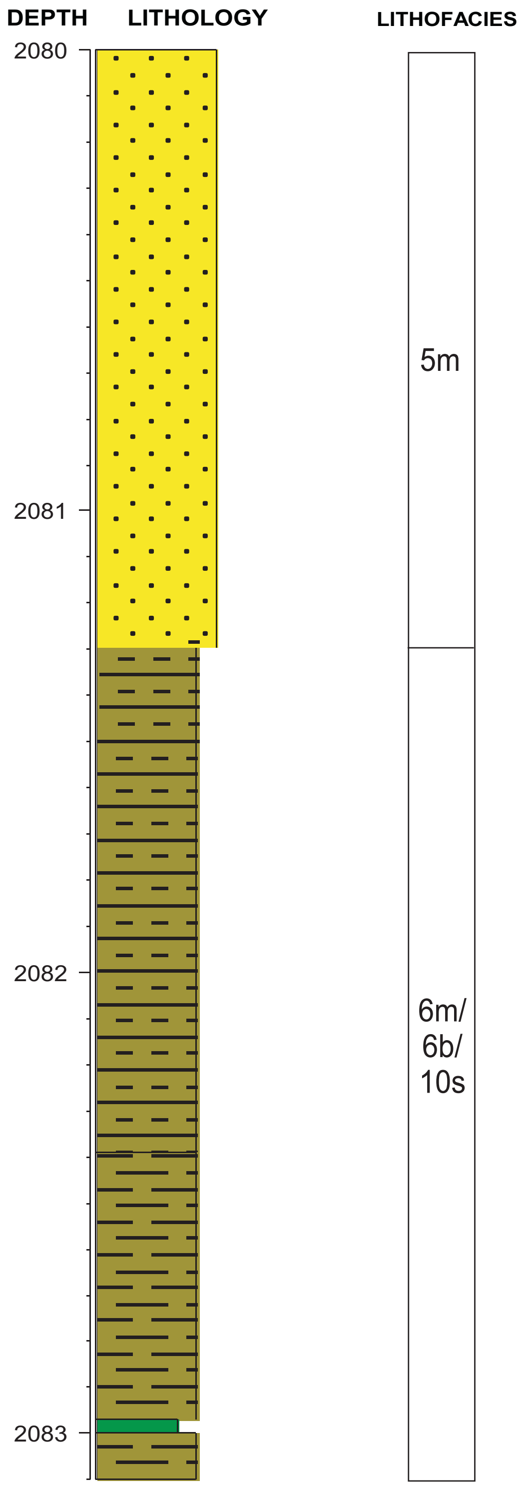


Figure 11 (con't): Summary log of conventional core 3 from the Kegeshook G-67 well. Lithofacies have been reinterpreted from Foley, 2008.

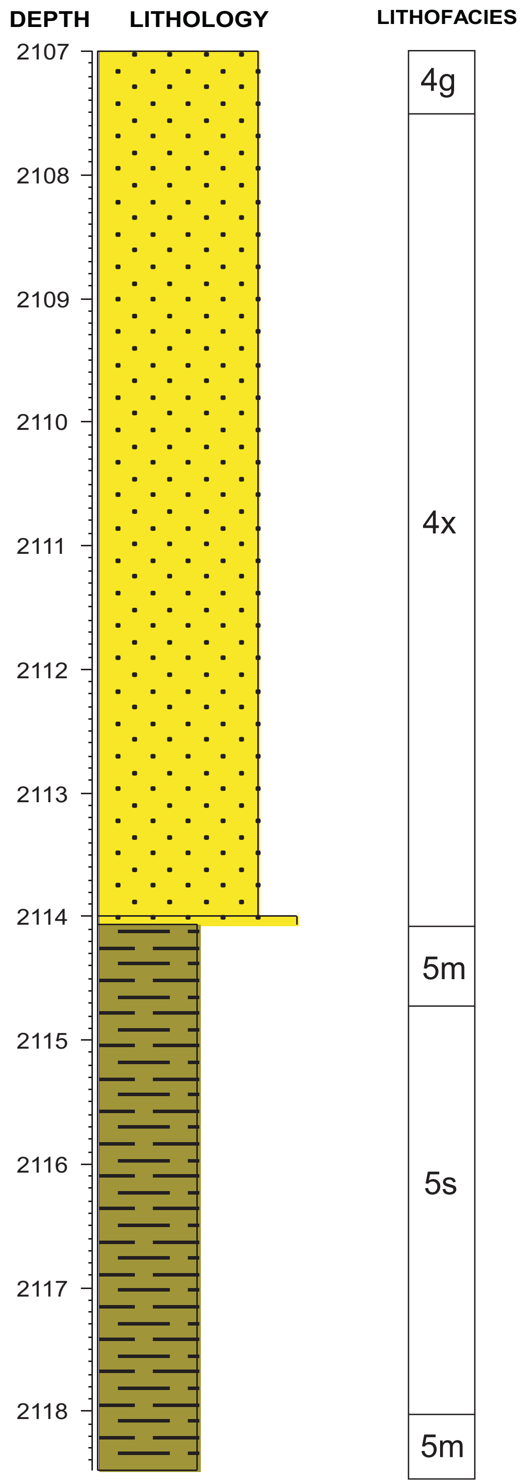


Figure 11 (con't): Summary log of conventional core 4 from the Kegeshook G-67 well. Lithofacies have been reinterpreted from Foley, 2008.

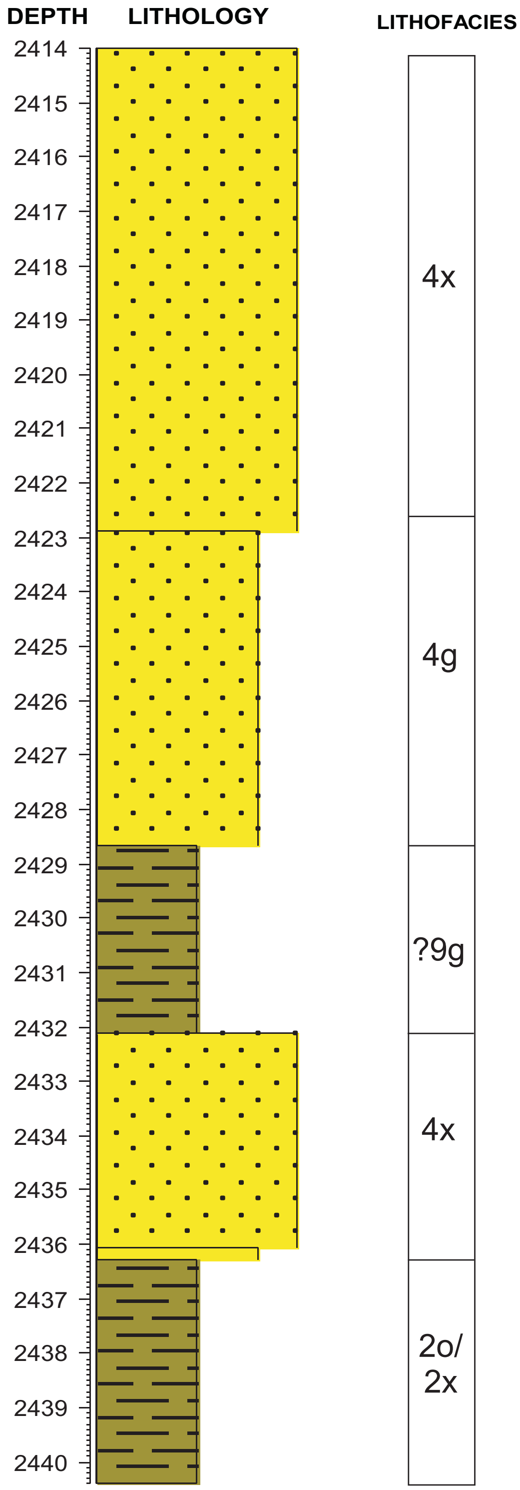


Figure 11 (con't): Summary log of conventional core 5 from Kegeshook G-67 well. Lithofacies have been reinterpreted from Foley, 2008.

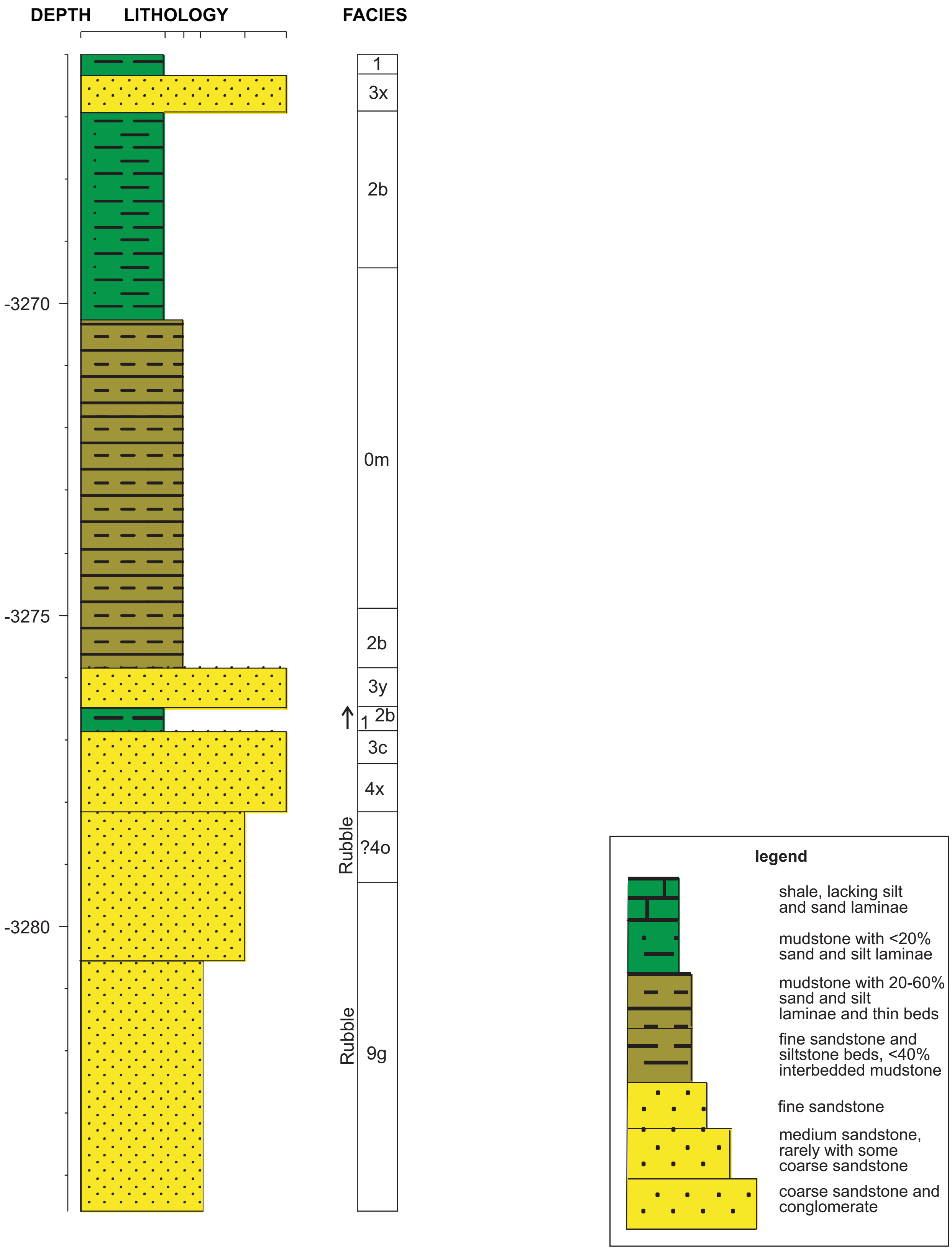


Figure 12: Summary log of conventional core 1 from North Triumph G-43 well. Lithofacies have been reinterpreted from McKee, 2008.

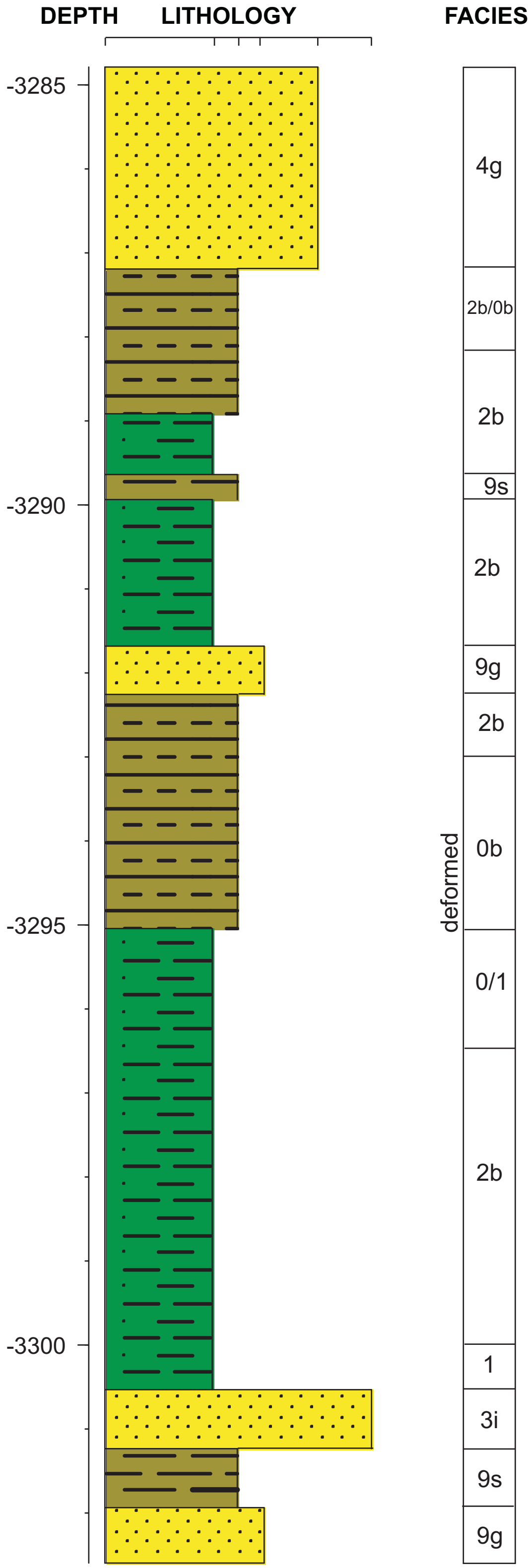


Figure 12 (con't): Summary log of core 2 from North Triumph G-43 well. Lithofacies have been reinterpreted from McKee, 2008.

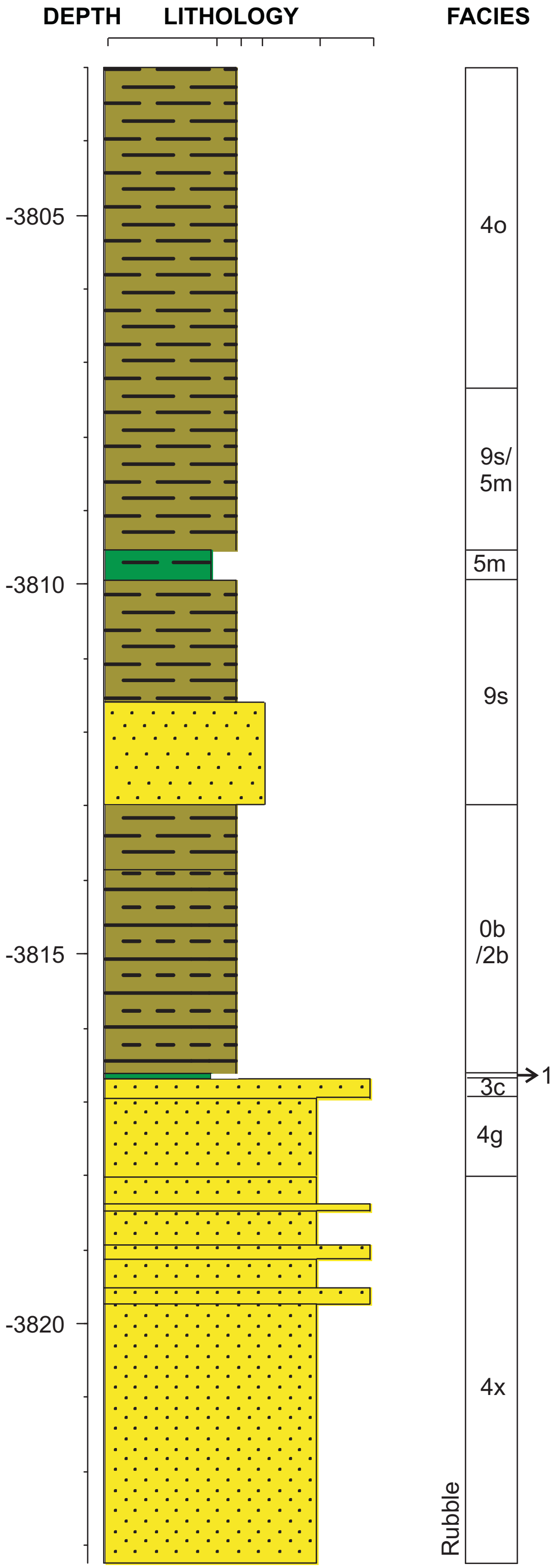


Figure 12 (con't): Summary log of core 3 from North Triumph G-43 well. Lithofacies have been reinterpreted from McKee, 2008.

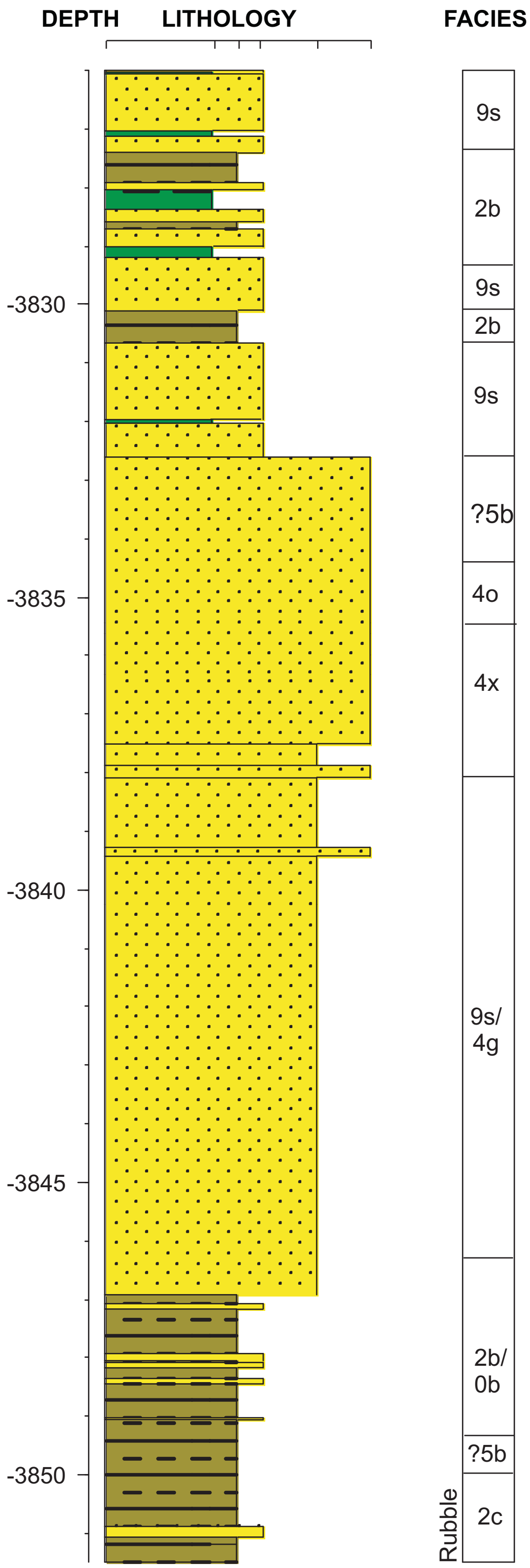


Figure 12 (con't): Summary log of core 4from North Triumph G-43 well. Lithofacies have been reinterpreted from McKee, 2008.

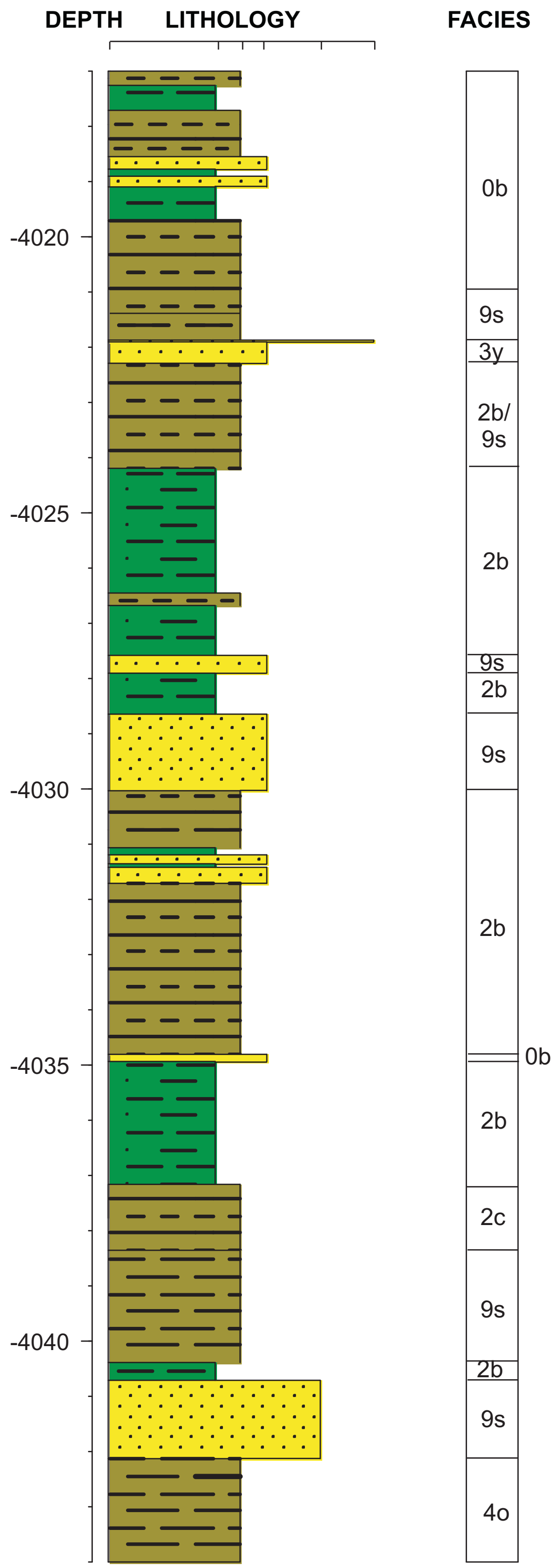


Figure 12 (con't): Summary log of core 5 from North Triumph G-43 well. Lithofacies have been reinterpreted from McKee, 2008.

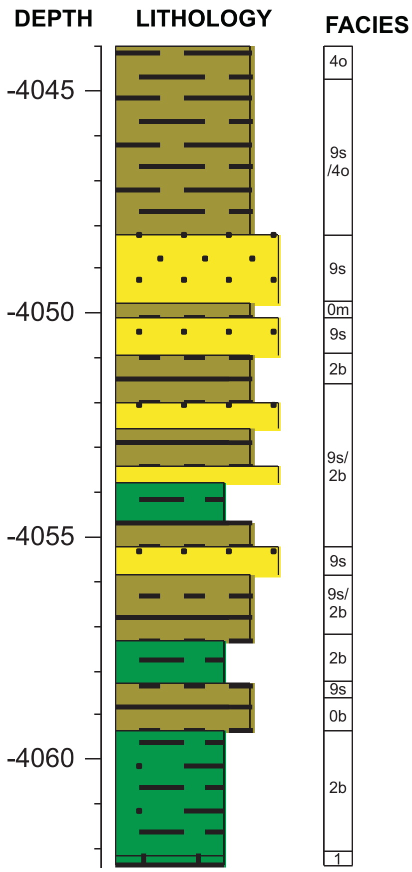


Figure 12 (con't): Summary log of core 6 from North Triumph G-43 well. Lithofacies have been reinterpreted from McKee, 2008.

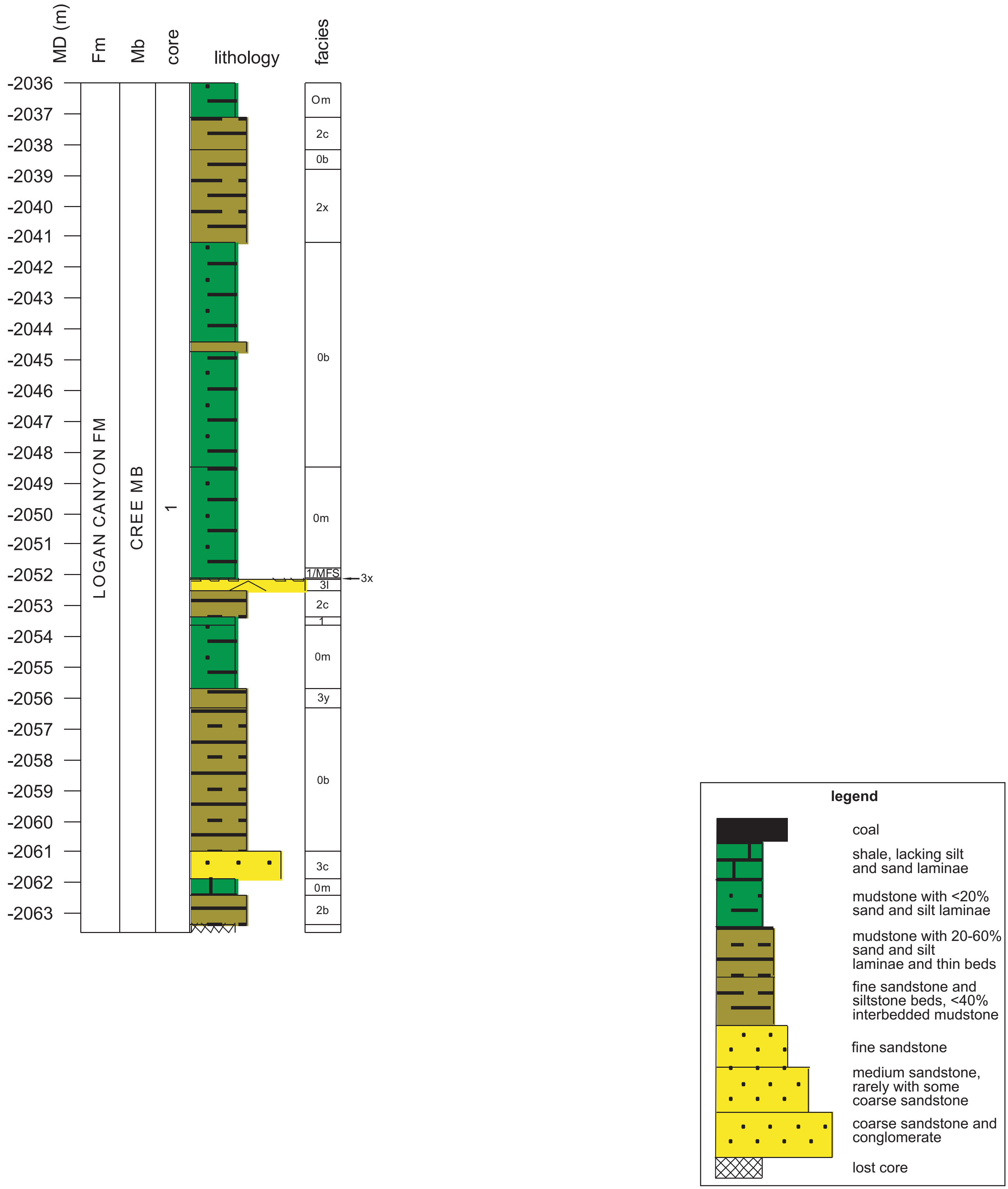


Figure 13: Summary log of conventional core 1 from the Panuke B-90 well.

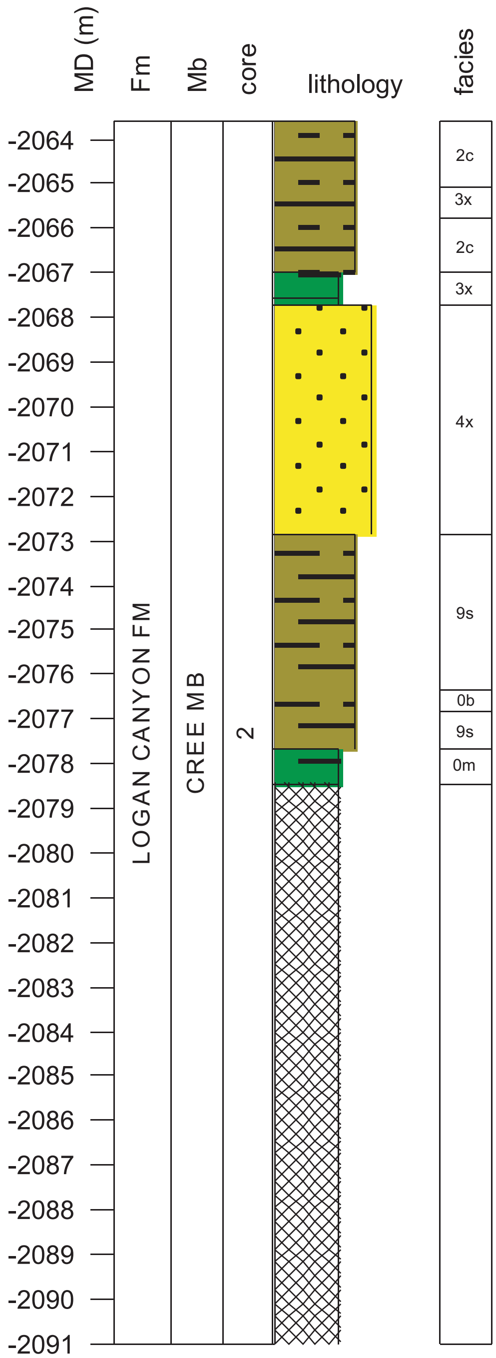


Figure 13 (con’t): Summary log of core 2 from the Panuke B-90 well.

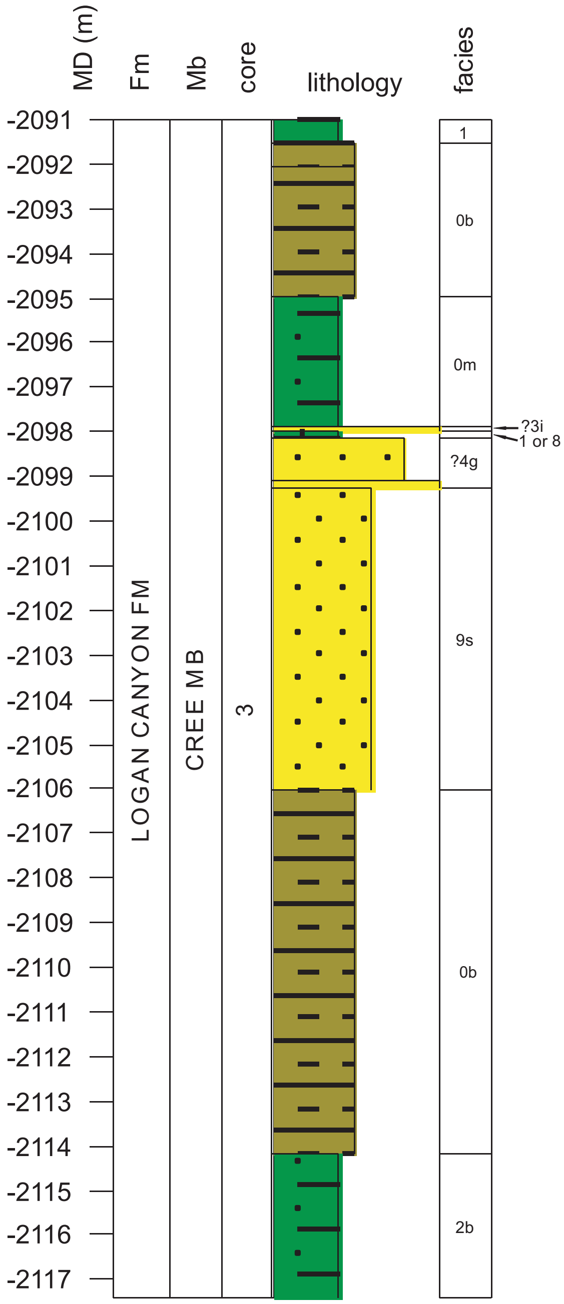


Figure 13 (con't): Summary log of core 3 from the Panuke B-90 well.

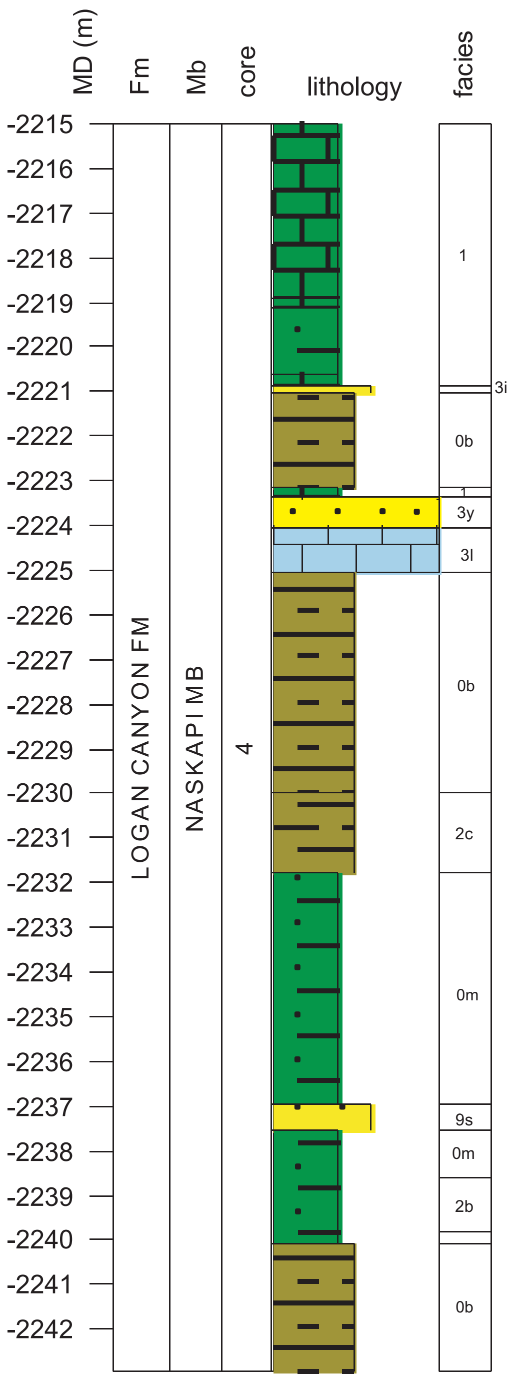


Figure 13 (con't): Summary log of core 4 from the Panuke B-90 well.

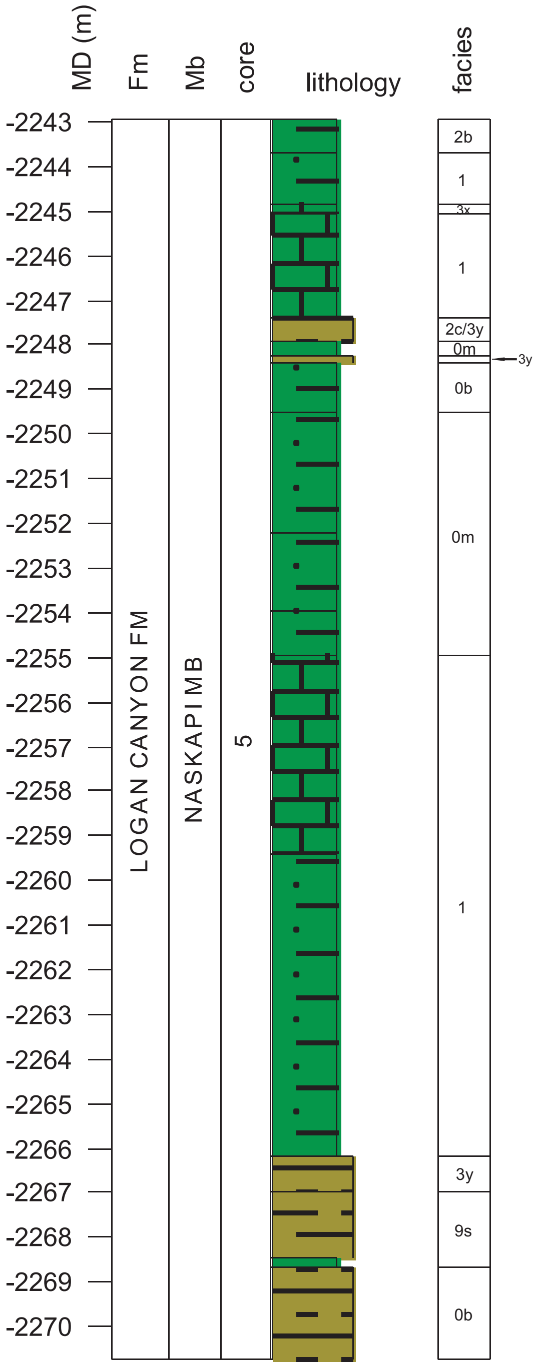


Figure 13 (con't): Summary log of core 5 from the Panuke B-90 well.

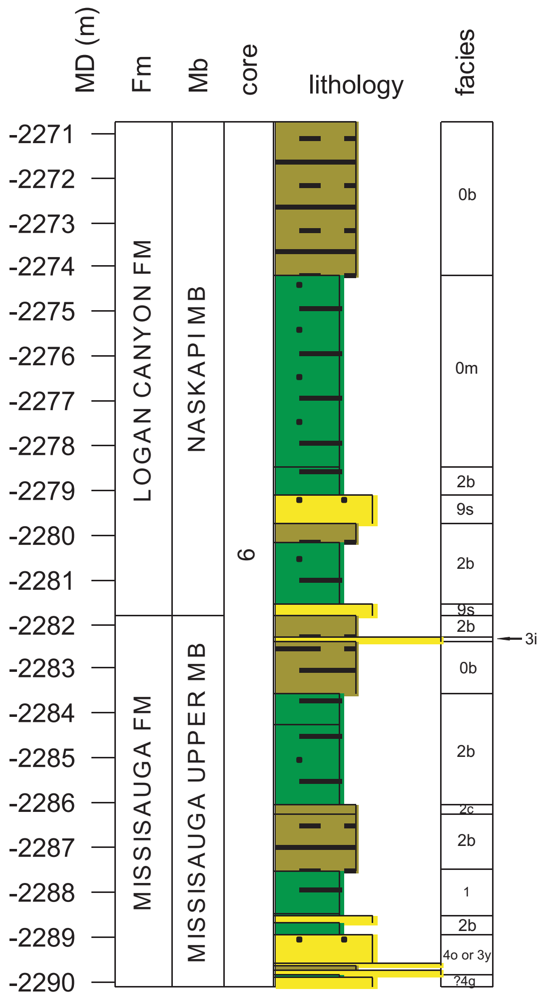


Figure 13 (con't): Summary log of core 6 from the Panuke B-90 well.

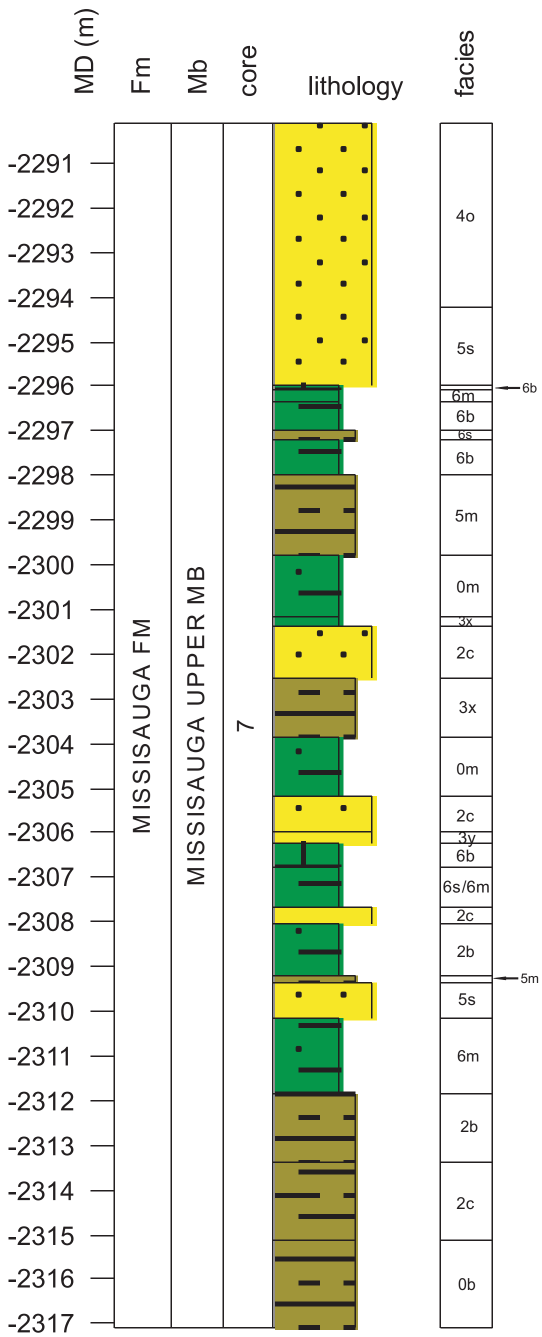


Figure 13 (con't): Summary log of core 7 from the Panuke B-90 well.

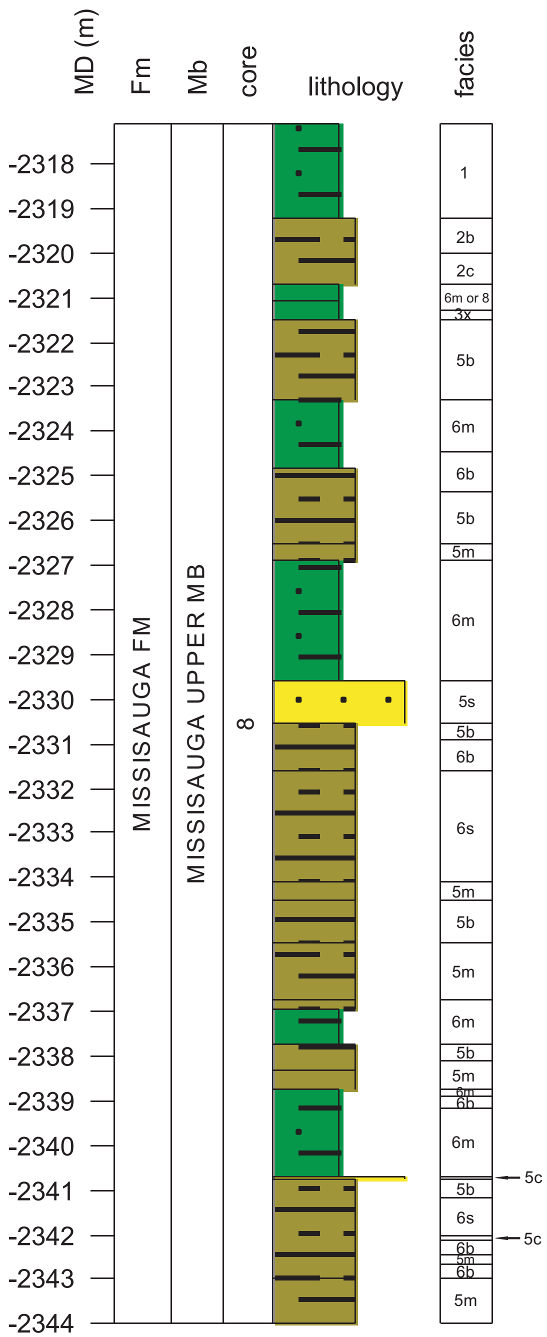


Figure 13 (con't): Summary log of core 8 from the Panuke B-90 well.

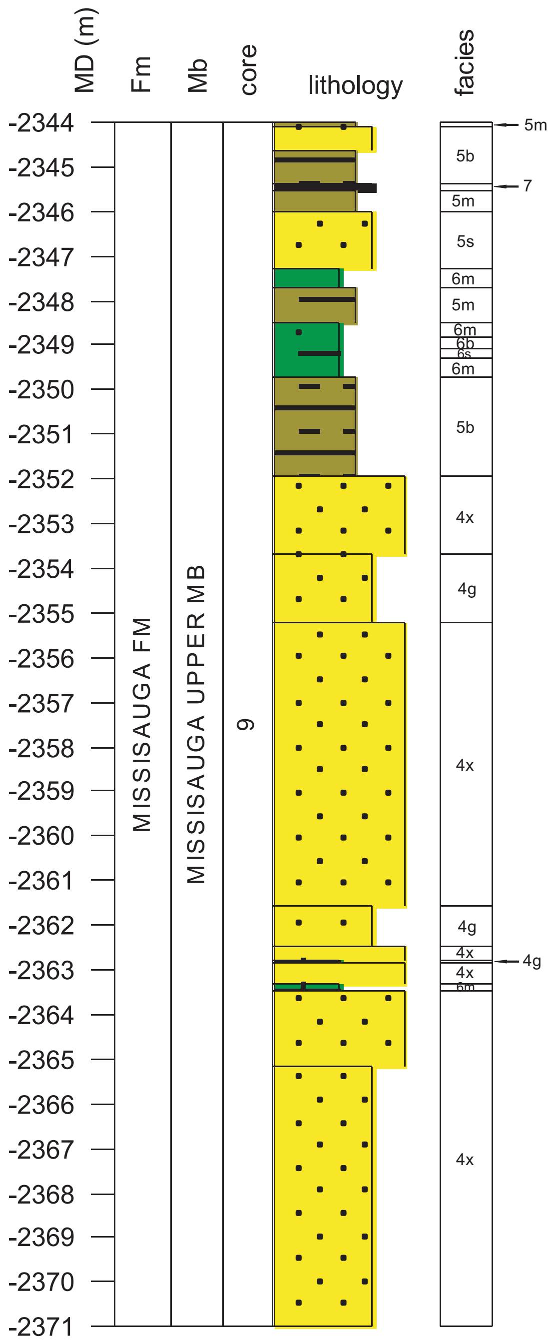


Figure 13 (con't): Summary log of core 9 from the Panuke B-90 well.

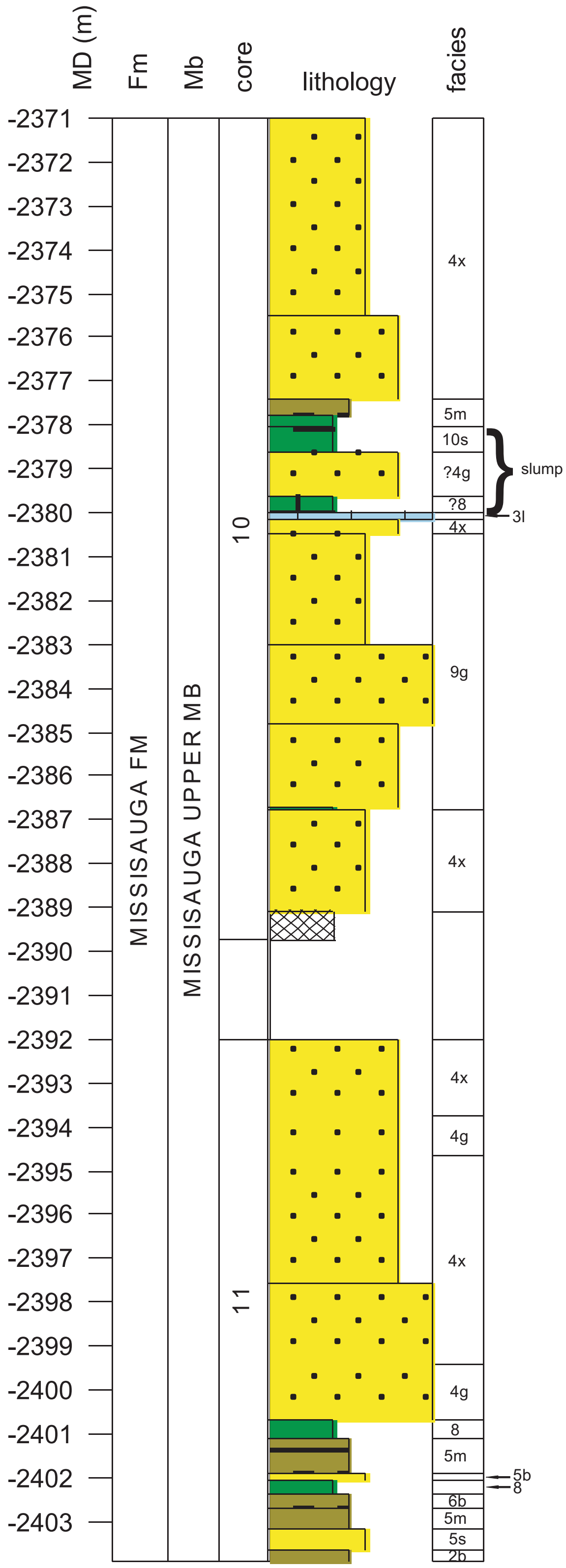


Figure 13 (con't): Summary log of cores 10 and 11 from the Panuke B-90 well.

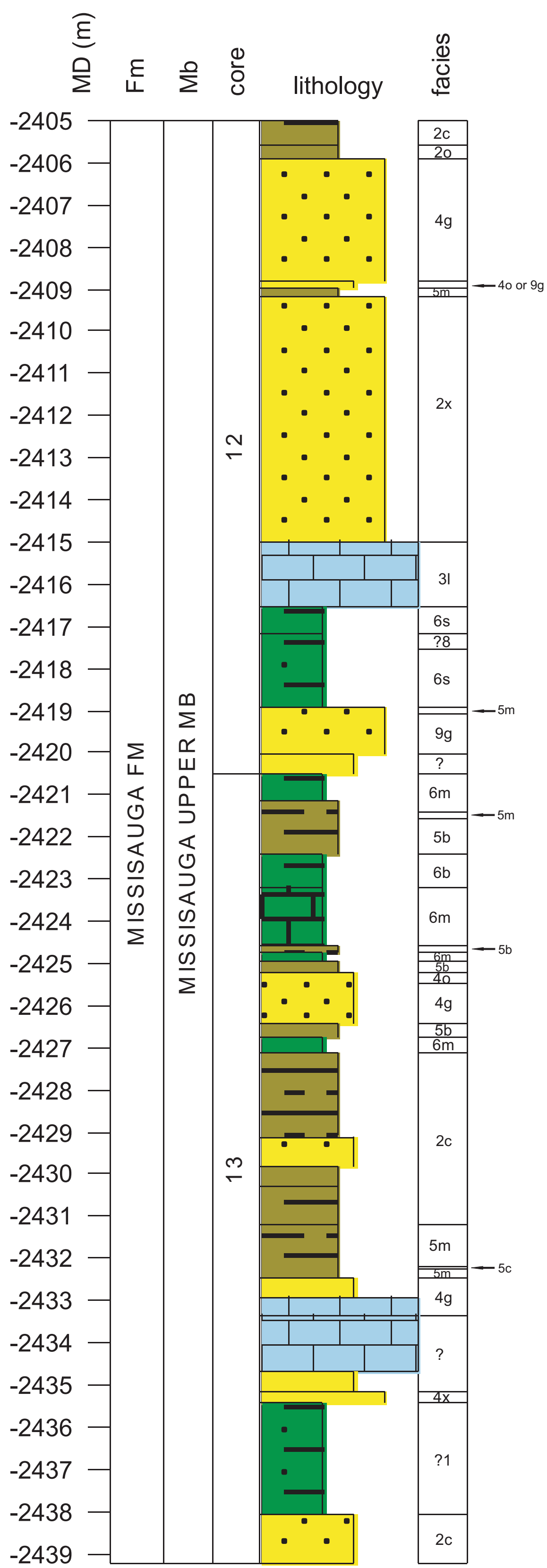


Figure 13 (con’t): Summary log of cores 12 and 13 from the Panuke B-90 well.

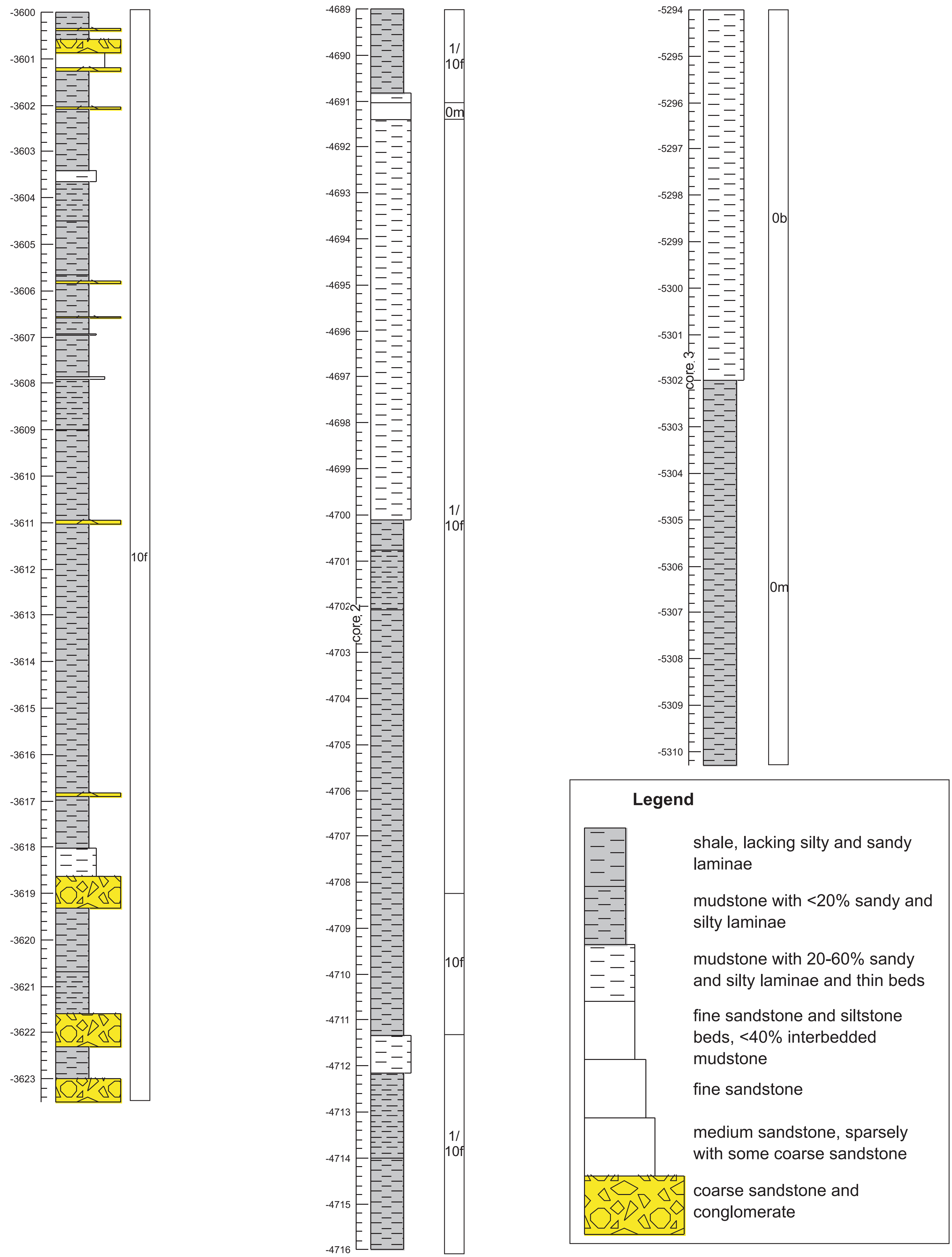


Figure 14: Summary log of conventional cores 1-3 from the Tantallon M-41 well. Lithofacies have been reinterpreted from Piper et al., 2010.

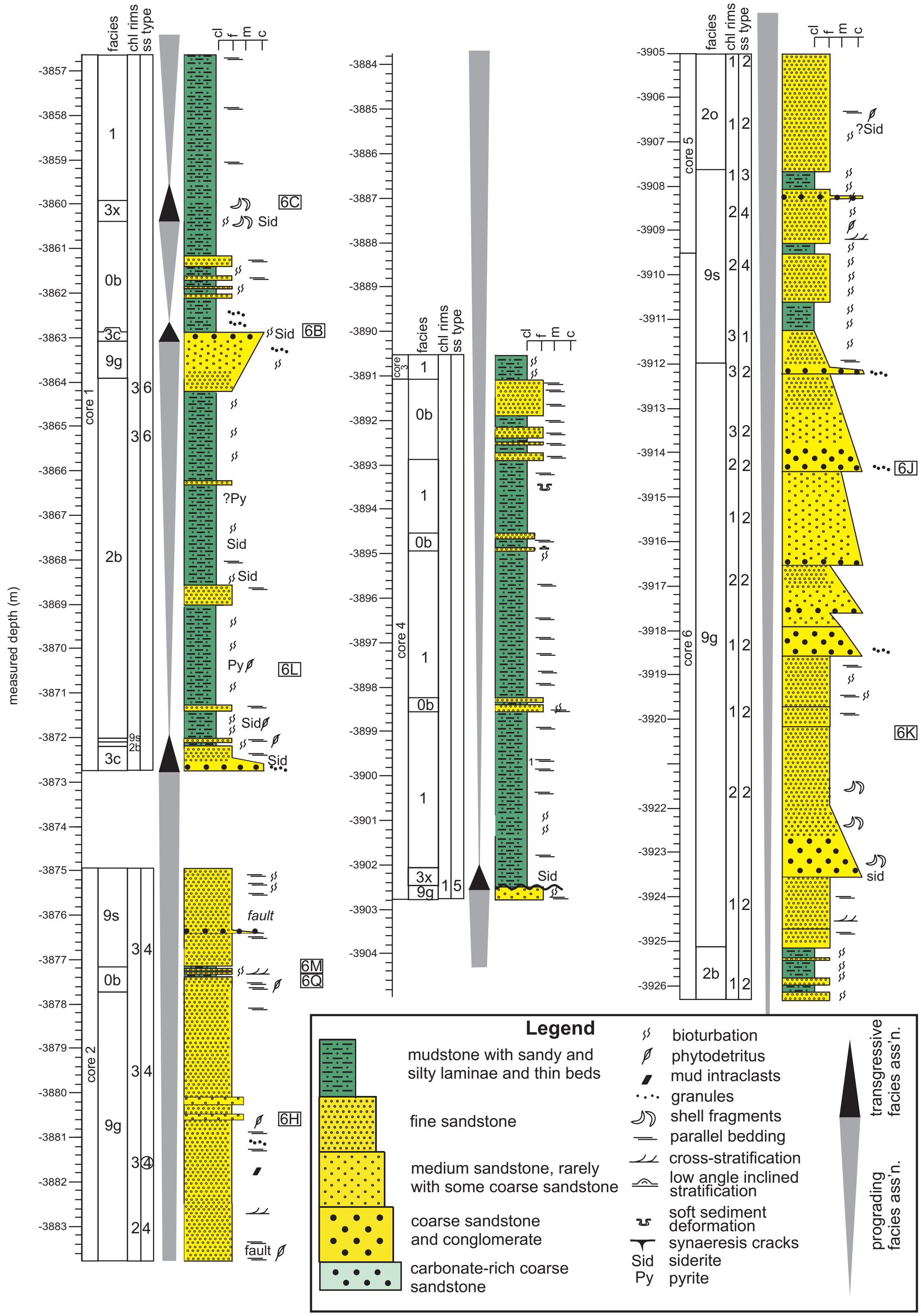


Figure 15: Summary log of conventional cores 1-6 from the Thebaud C-74 well. Lithofacies have been reinterpreted from Gould et al., 2010.

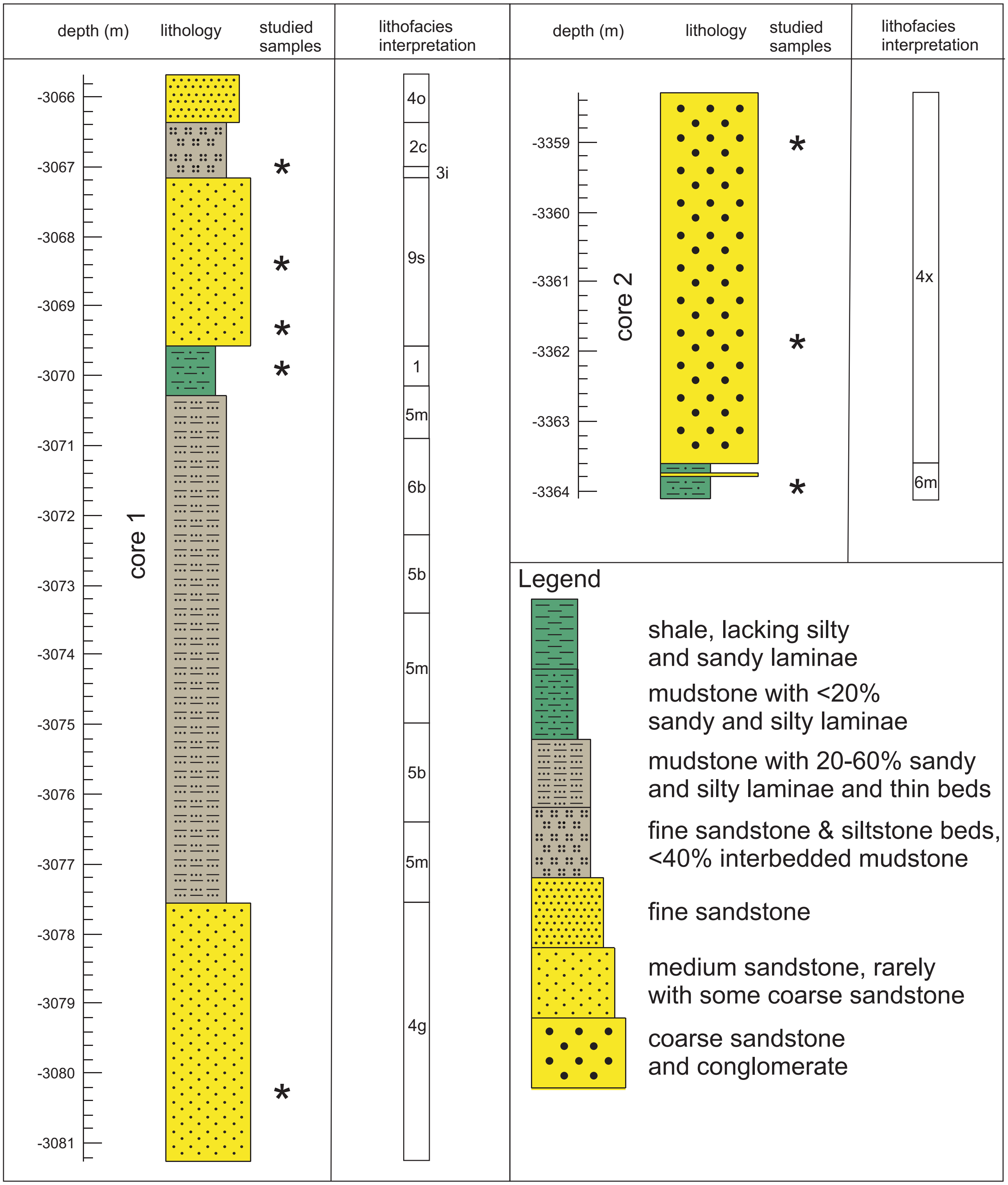


Figure 16: Summary log of conventional cores 1 and 2 from the Thebaud I-93 well. Lithofacies have been reinterpreted from Karim et al., 2008.

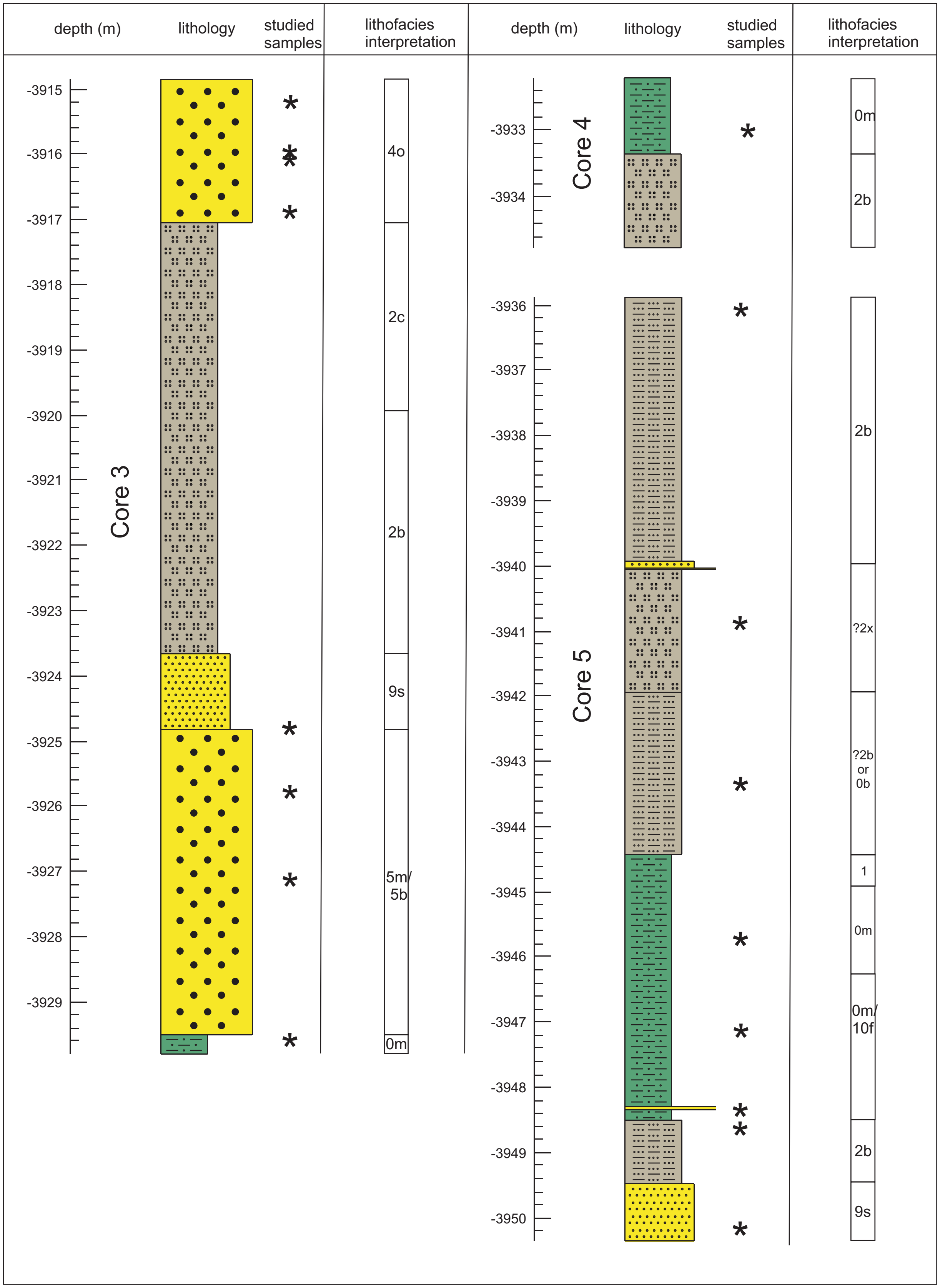


Figure 16 (con't): Summary log of cores 3-5 from the Thebaud I-93 well. Lithofacies have been reinterpreted from Karim et al., 2008.

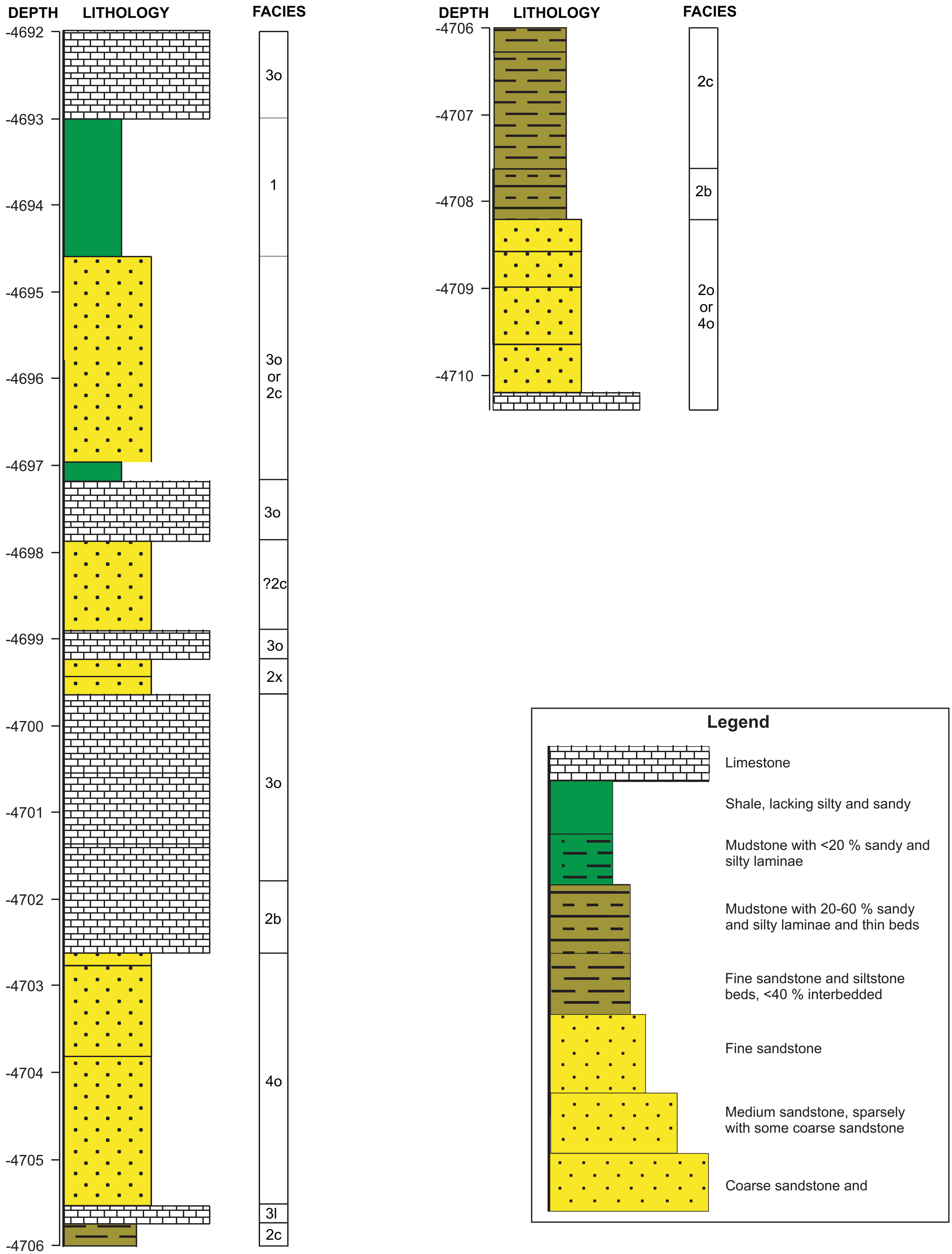


Figure 17: Summary log of conventional core 1 from the Venture B-13 well. Lithofacies have been reinterpreted from Karim et al., 2010.

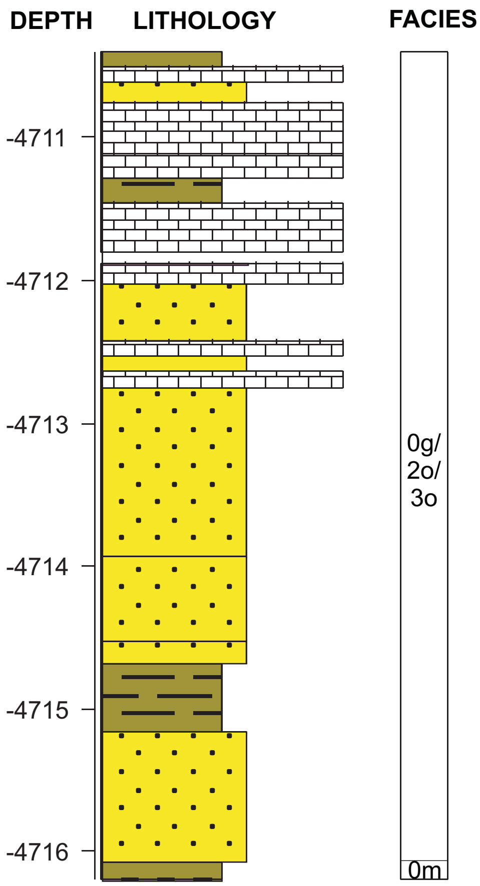


Figure 17 (con't): Summary log of core 2 from the Venture B-13 well. Lithofacies have been reinterpreted from Karim et al., 2010.

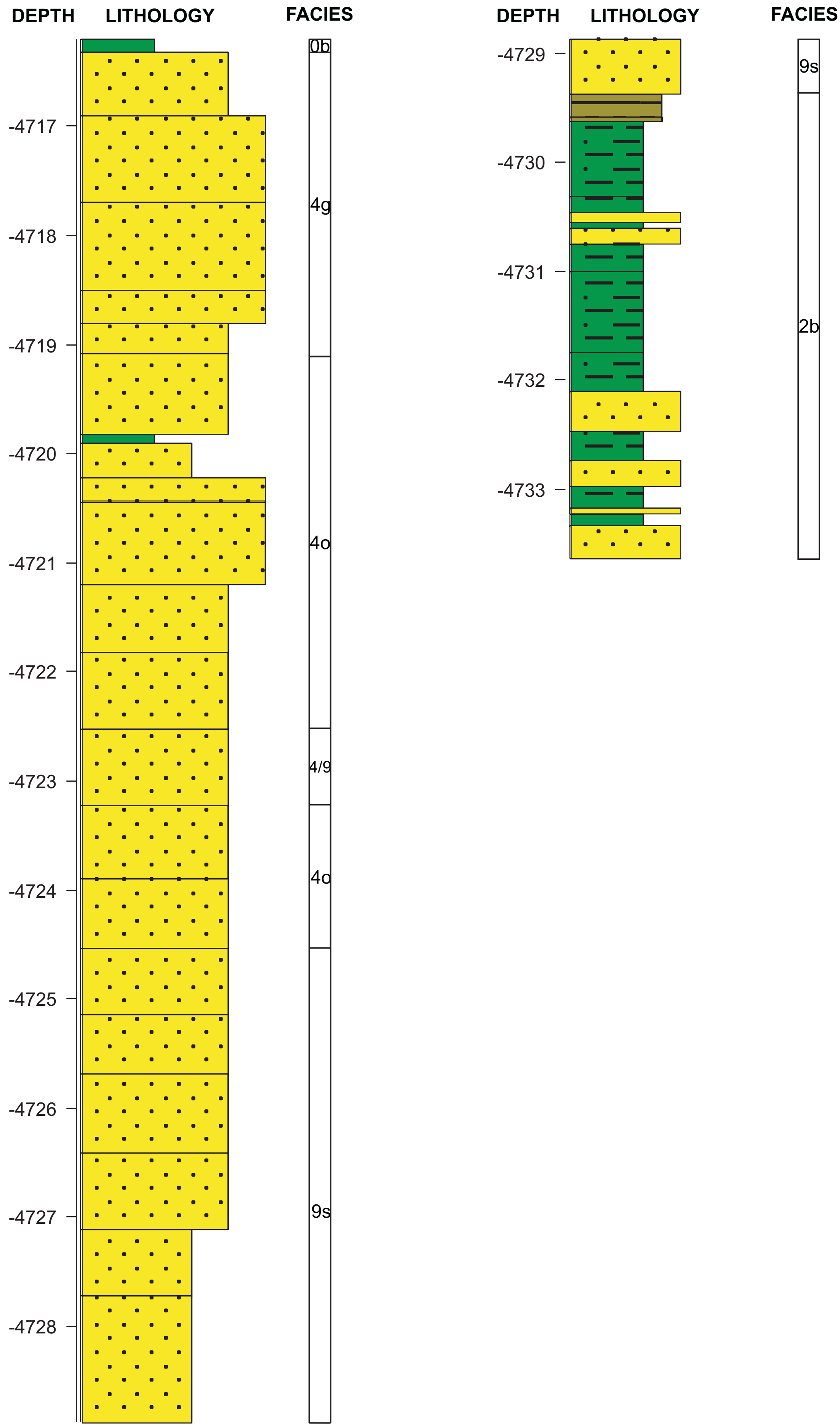


Figure 17 (con't): Summary log of core 3 from the Venture B-13 well. Lithofacies have been reinterpreted from Karim et al., 2010.

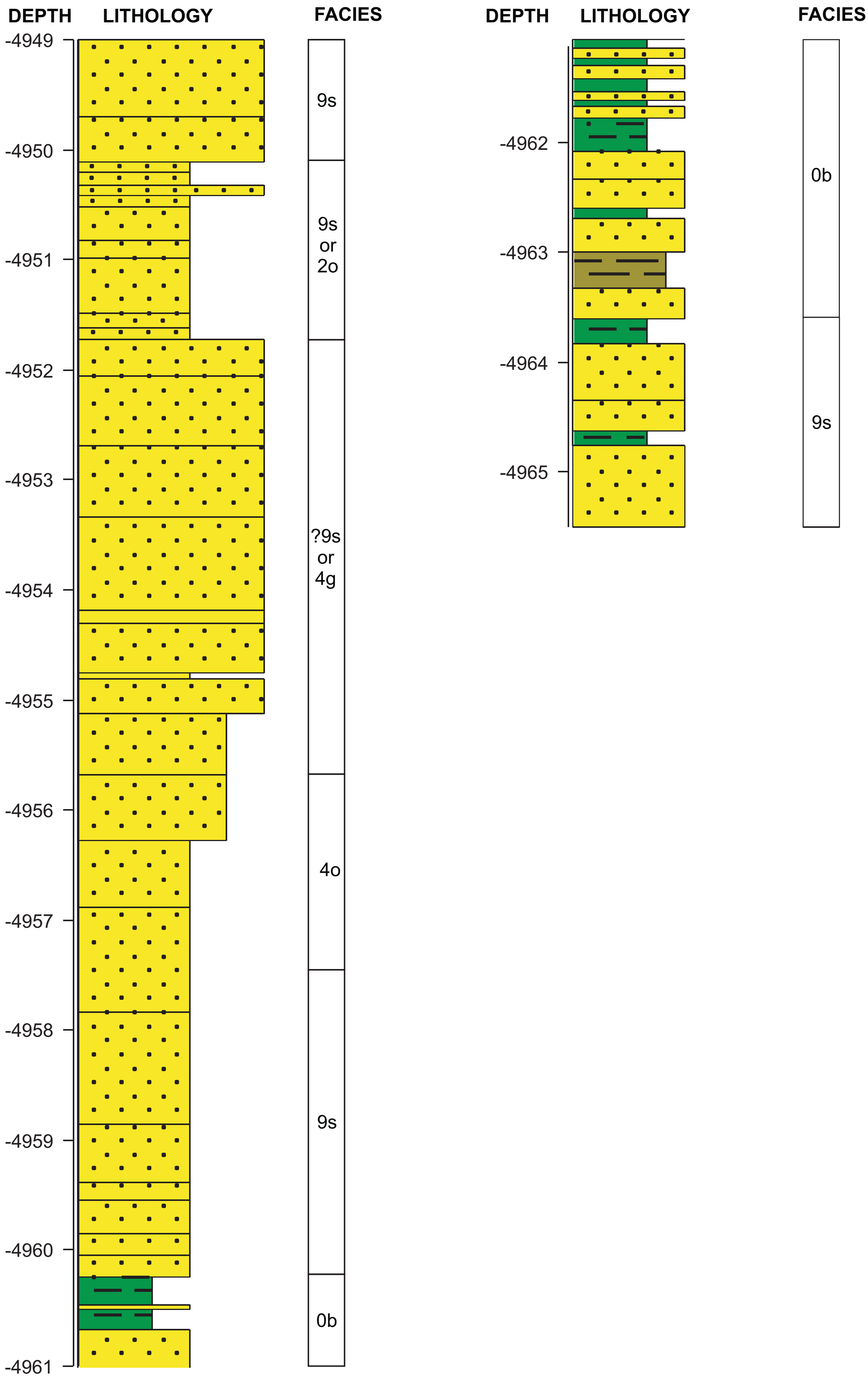


Figure 17 (con't): Summary log of core 4 from the Venture B-13 well. Lithofacies have been reinterpreted from Karim et al., 2010.

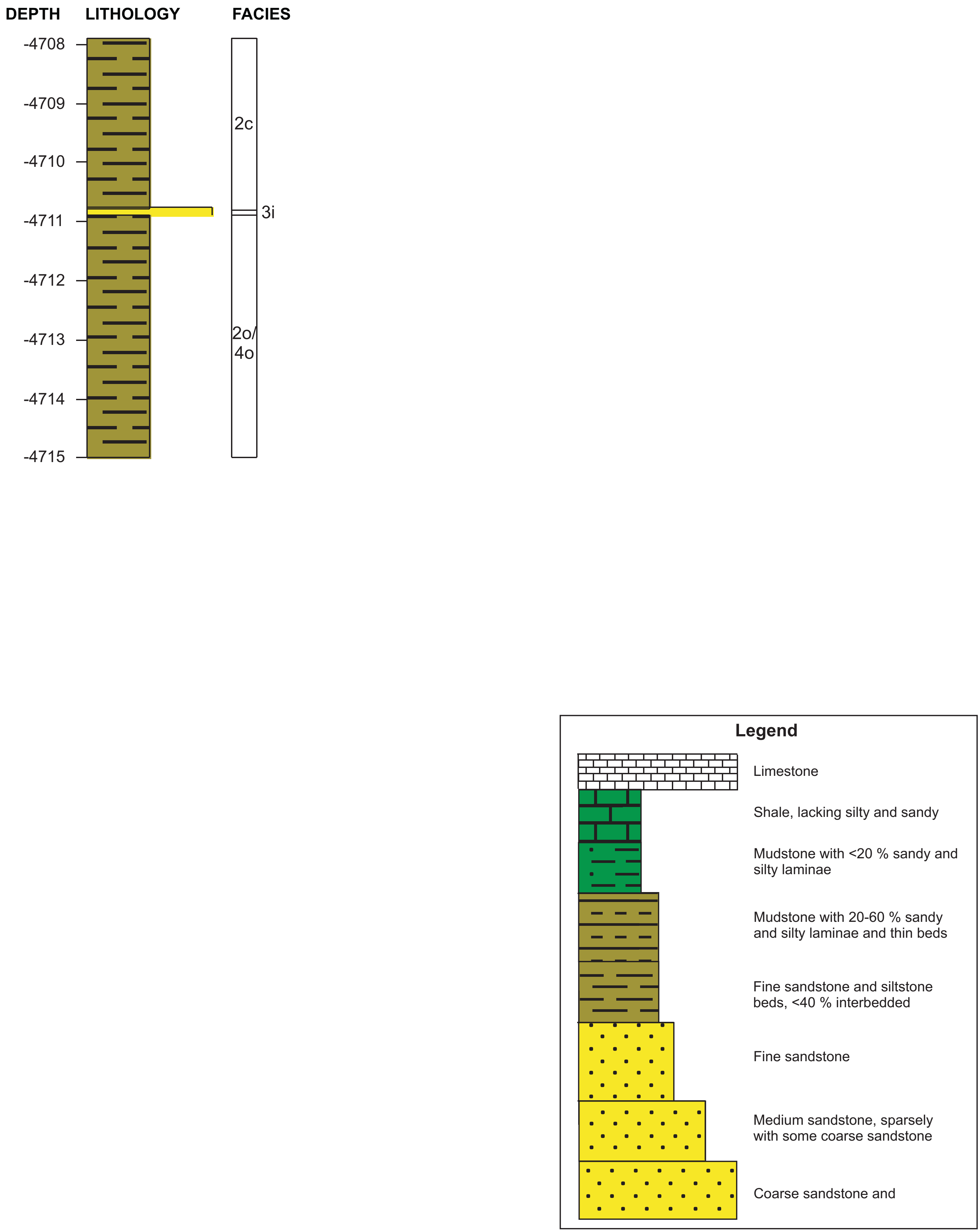


Figure 18: Summary log of conventional core 1 from the Venture B-52 well. Lithofacies have been reinterpreted from Karim et al., 2010.

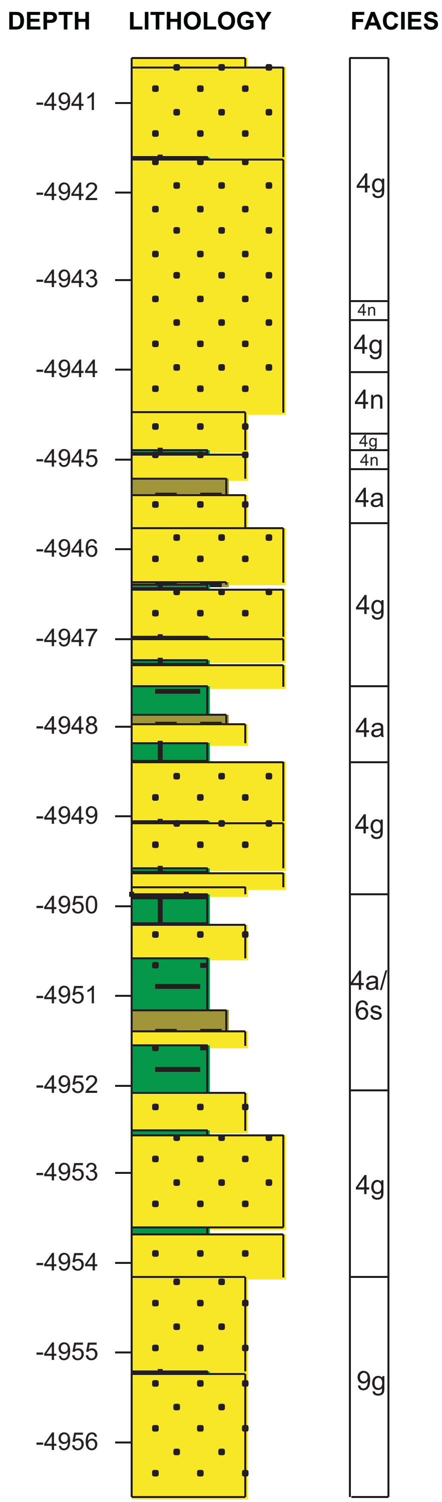


Figure 18 (con't): Summary log of core 2 from the Venture B-52 well. Lithofacies have been reinterpreted from Karim et al., 2010.

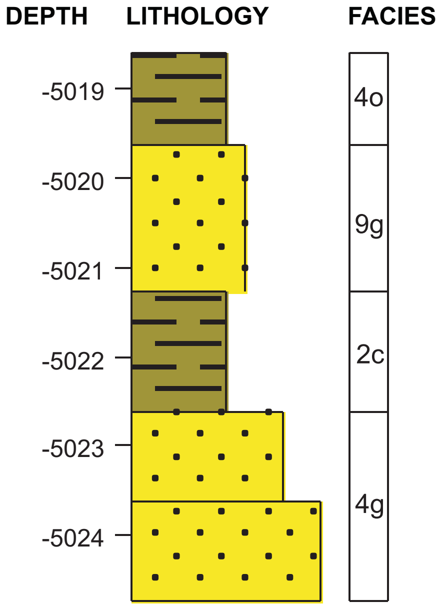


Figure 18 (con't): Summary log of core 3 from the Venture B-52 well. Lithofacies have been reinterpreted from Karim et al., 2010.

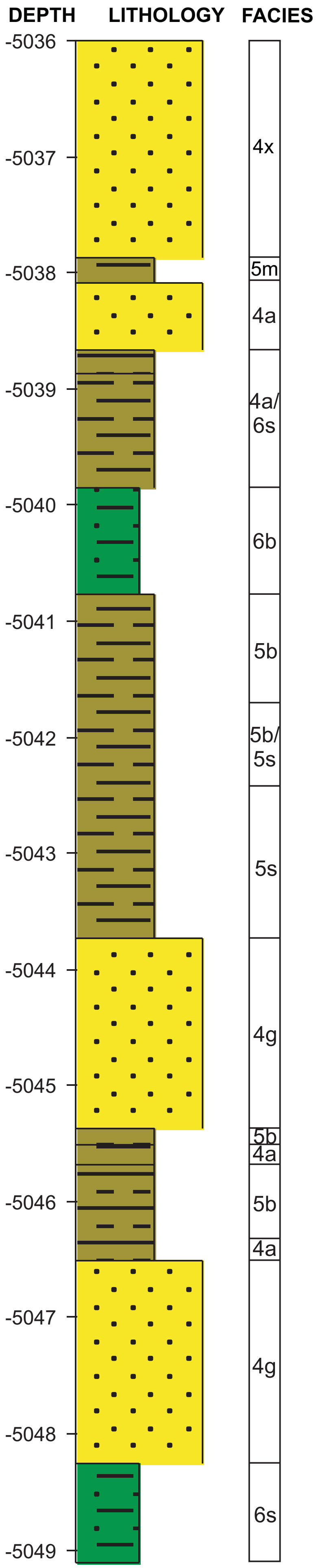


Figure 18 (con't): Summary log of core 4 from the Venture B-52 well. Lithofacies have been reinterpreted from Karim et al., 2010.

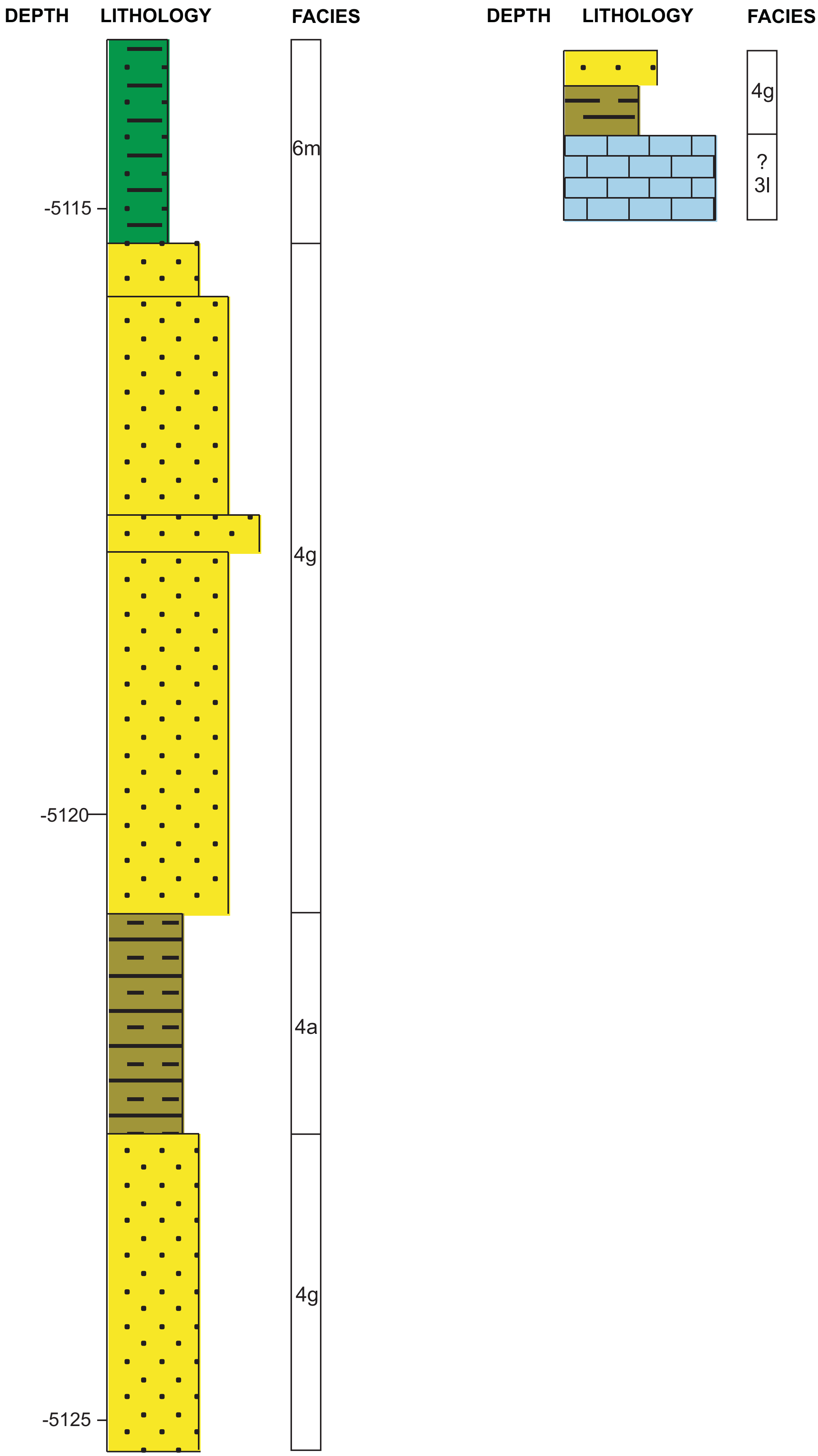


Figure 18 (con't): Summary log of core 5 from the Venture B-52 well. Lithofacies have been reinterpreted from Karim et al., 2010.

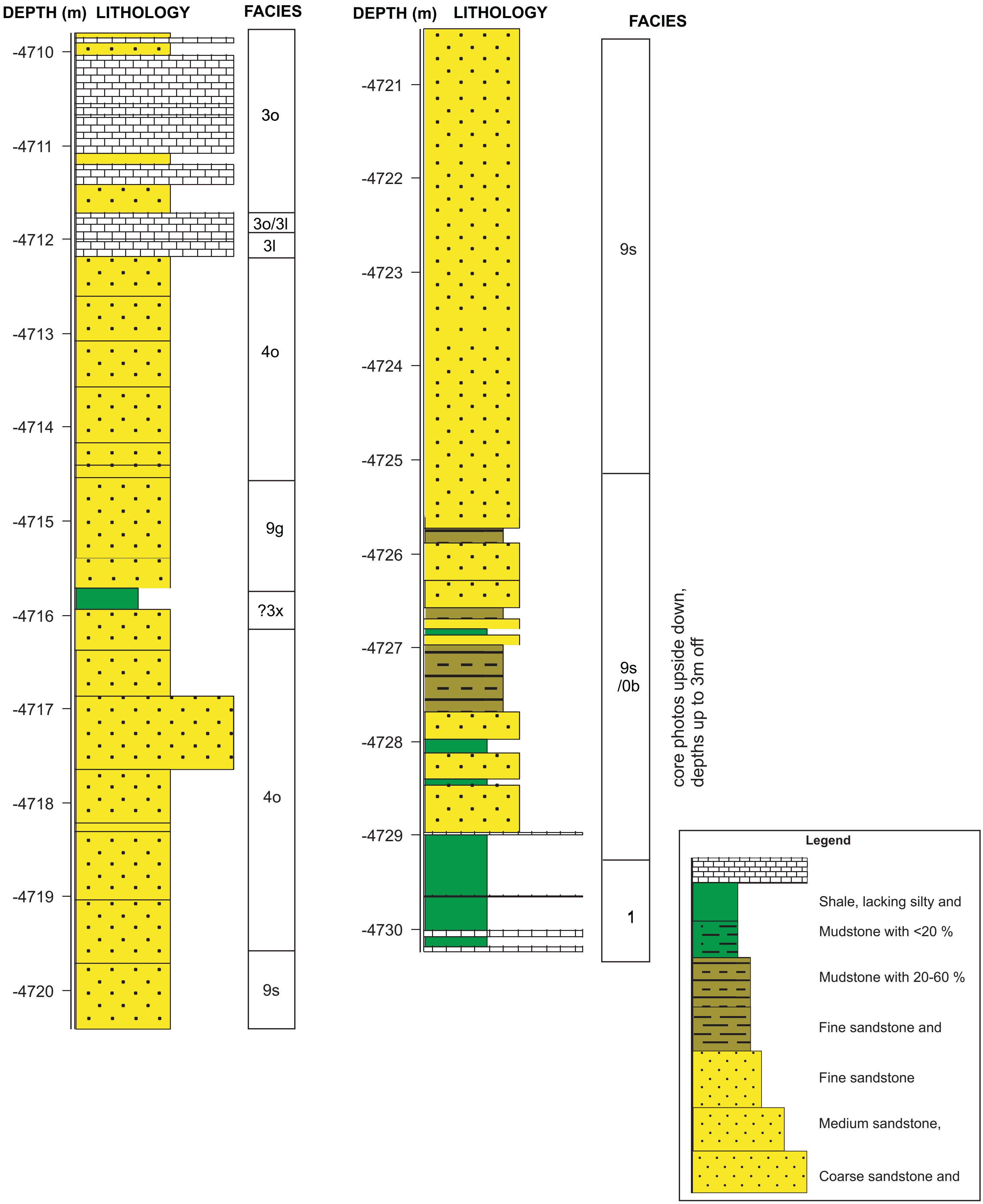


Figure 19: Summary log of conventional core 1 from Venture H-22 well. Lithofacies have been reinterpreted from Karim et al., 2010.

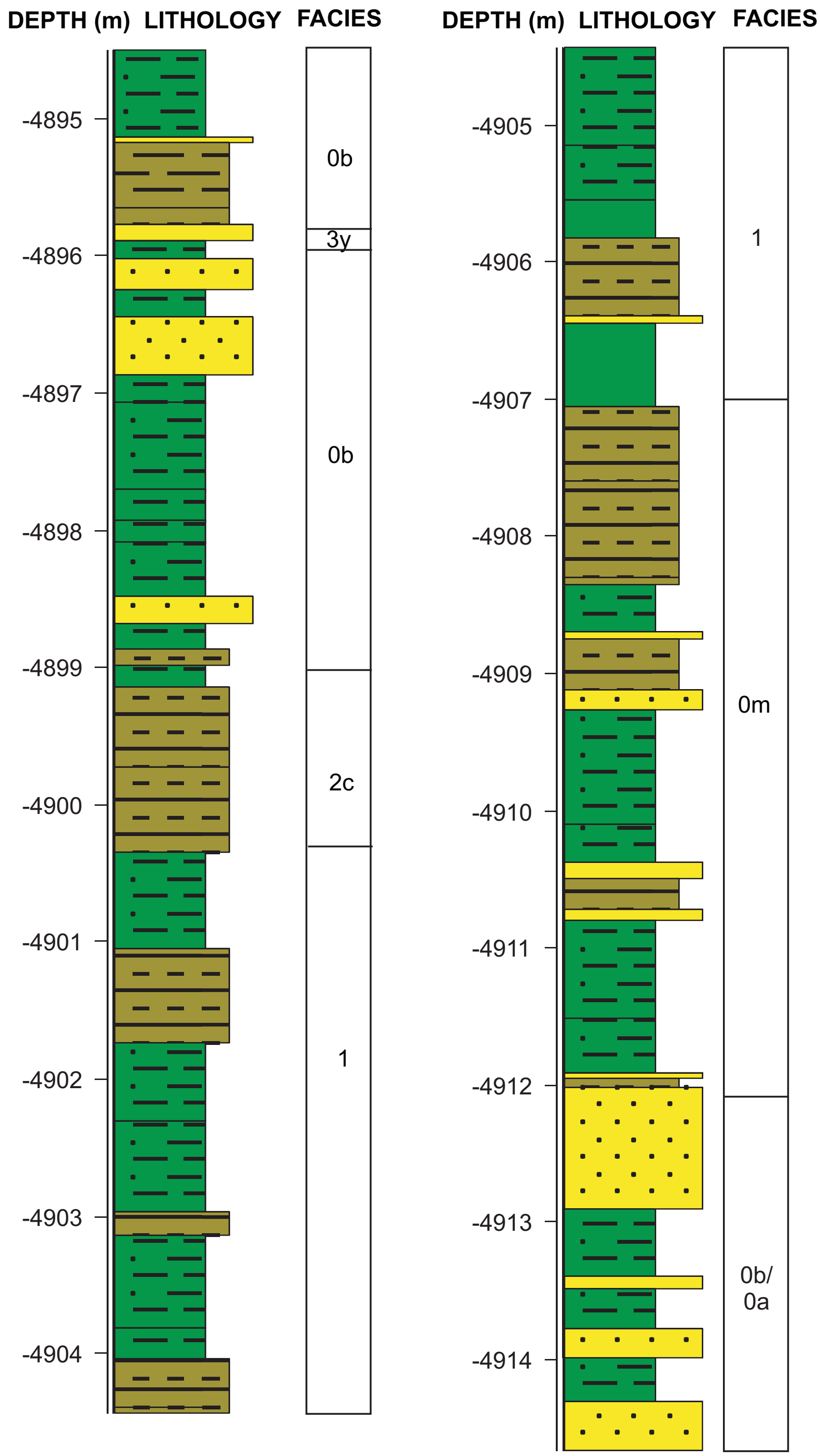


Figure 19 (con't): Summary log of core 2 from Venture H-22 well. Lithofacies have been reinterpreted from Karim et al., 2010.

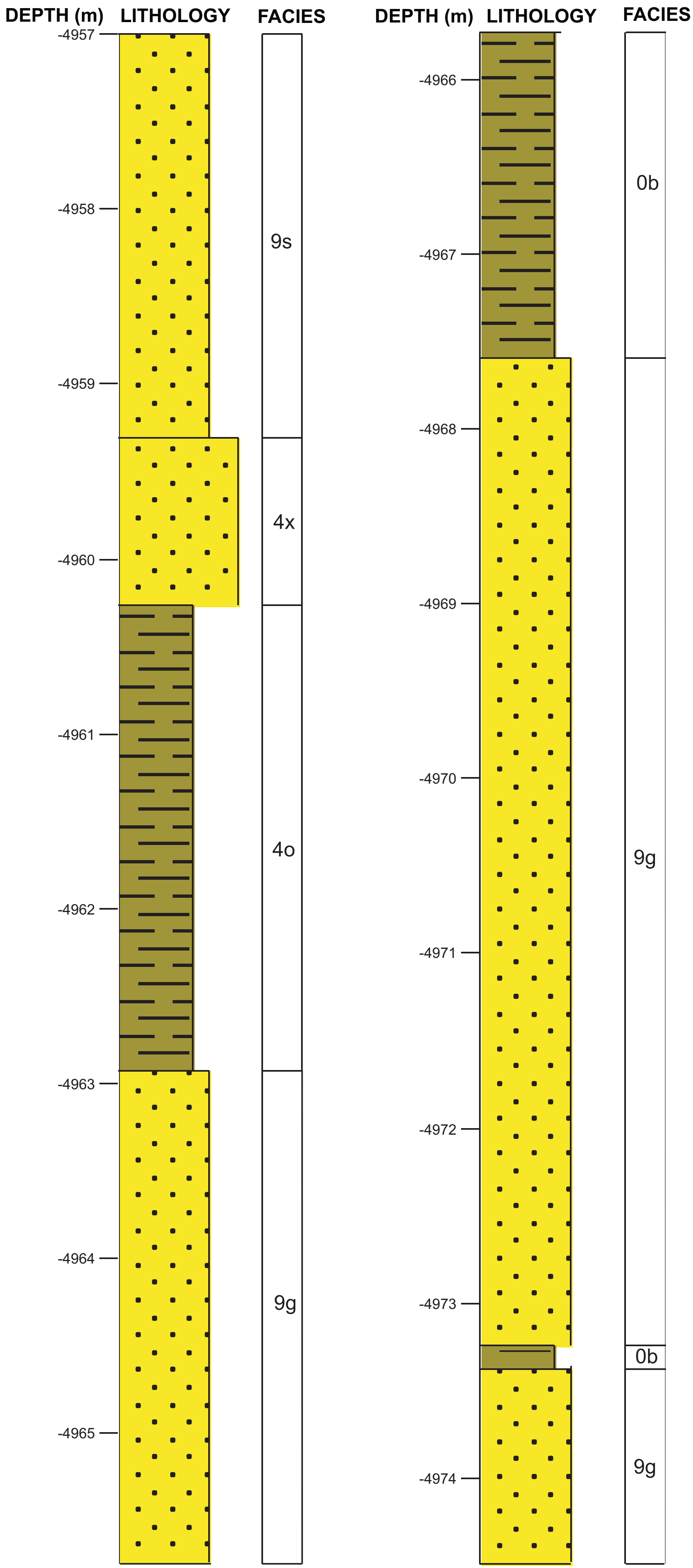


Figure 19 (con't): Summary log of core 3 from Venture H-22 well. Lithofacies have been reinterpreted from Karim et al., 2010.

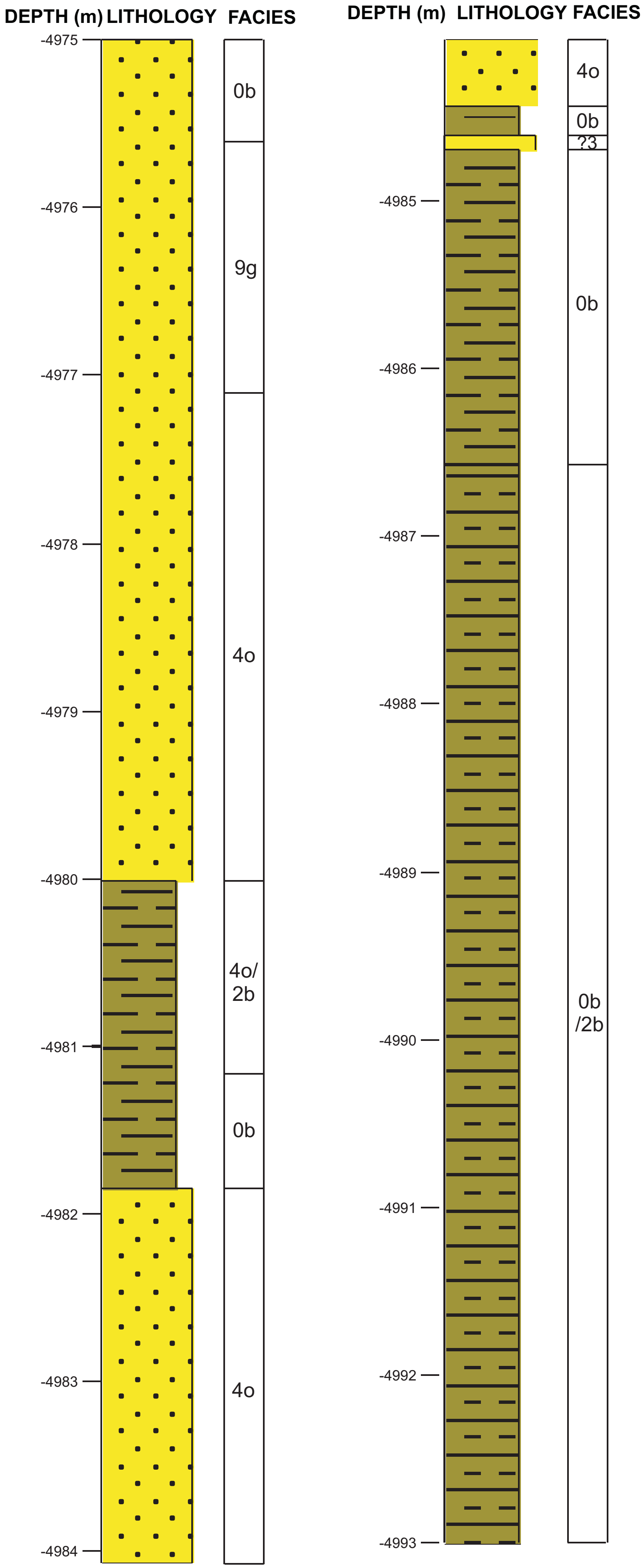


Figure 19 (con't): Summary log of core 4 from Venture H-22 well. Lithofacies have been reinterpreted from Karim et al., 2010.

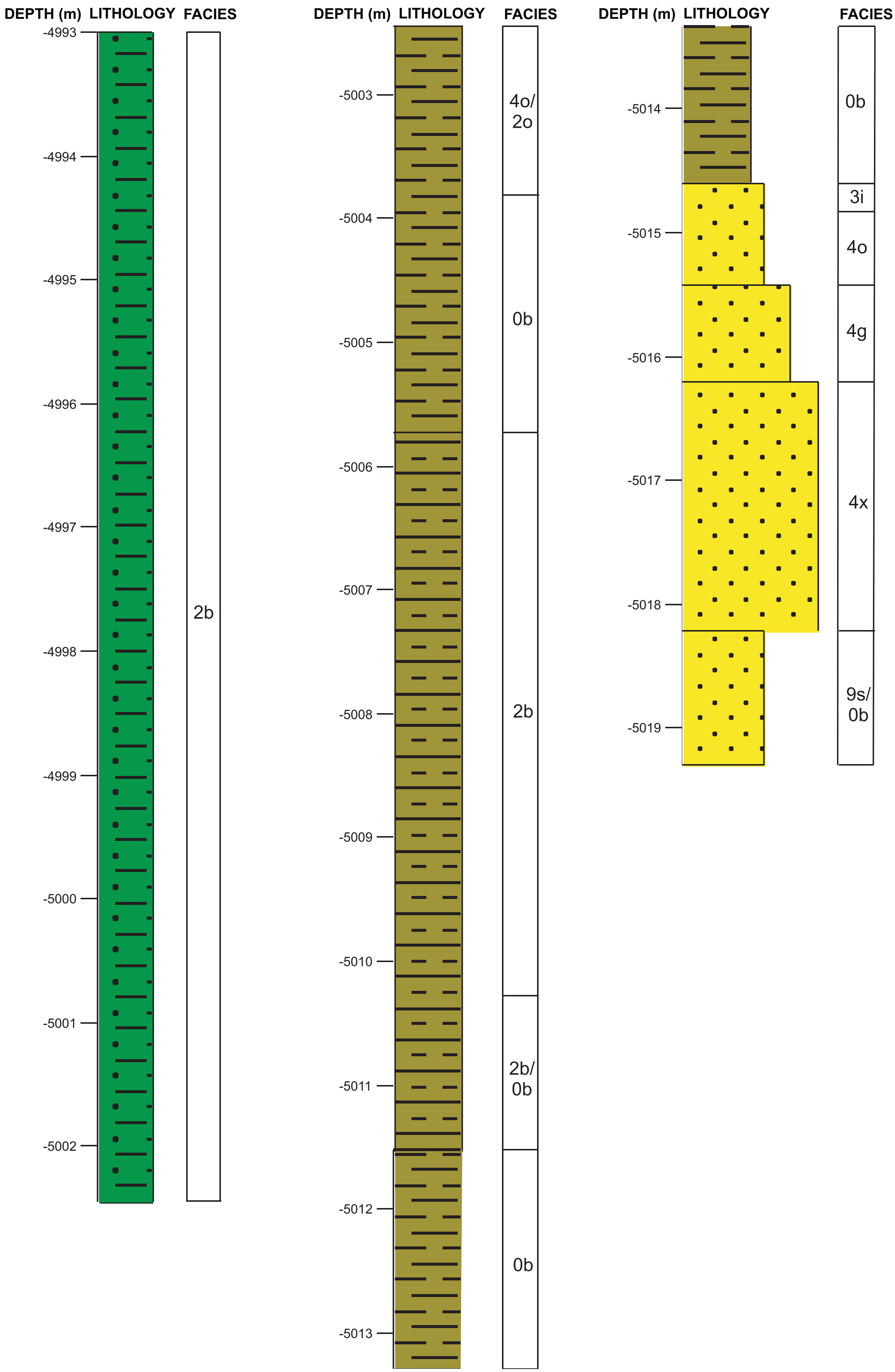


Figure 19 (con't): Summary log of core 5 from Venture H-22 well. Lithofacies have been reinterpreted from Karim et al., 2010.

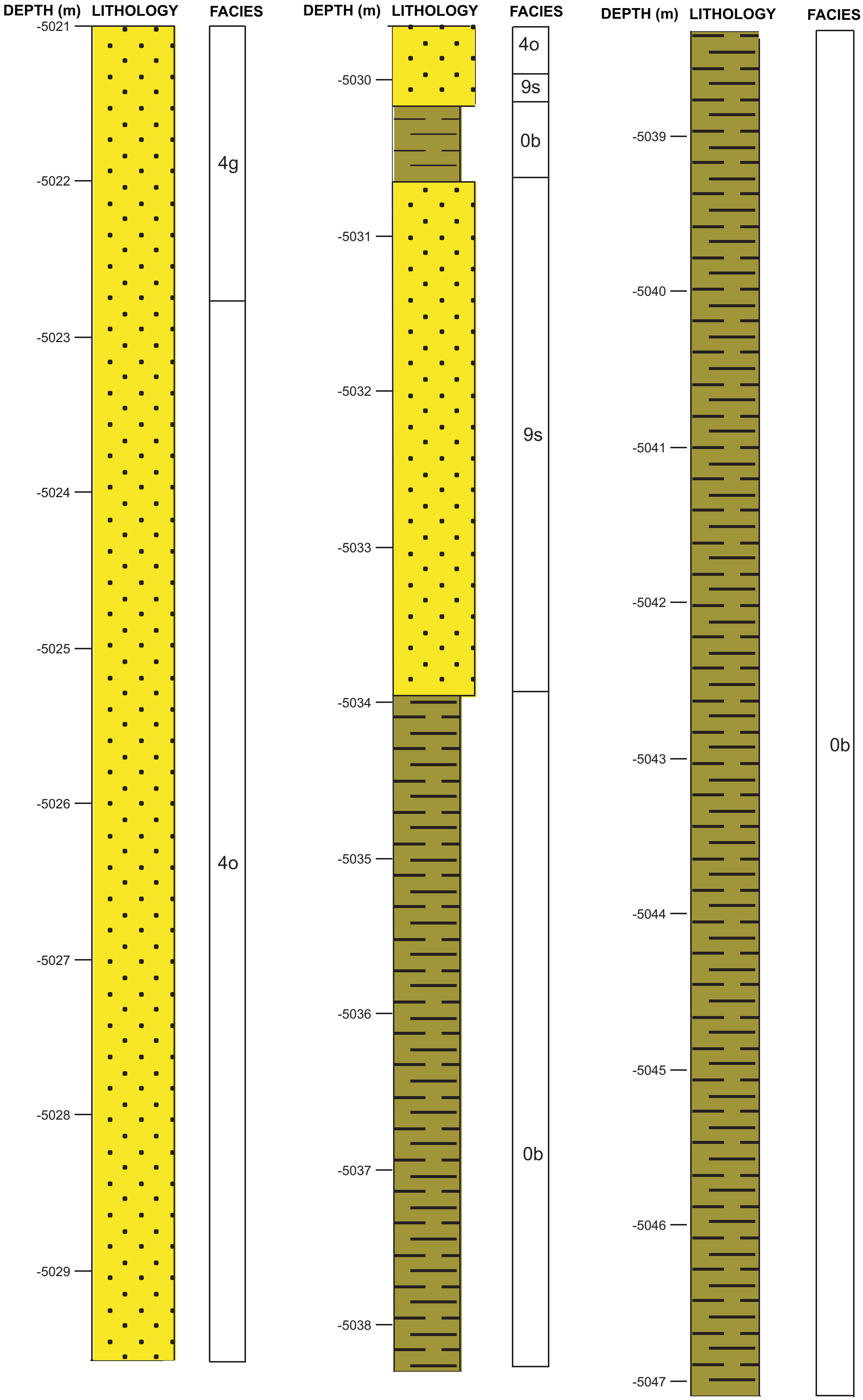


Figure 19 (con't): Summary log of core 6 from Venture H-22 well. Lithofacies have been reinterpreted from Karim et al., 2010.

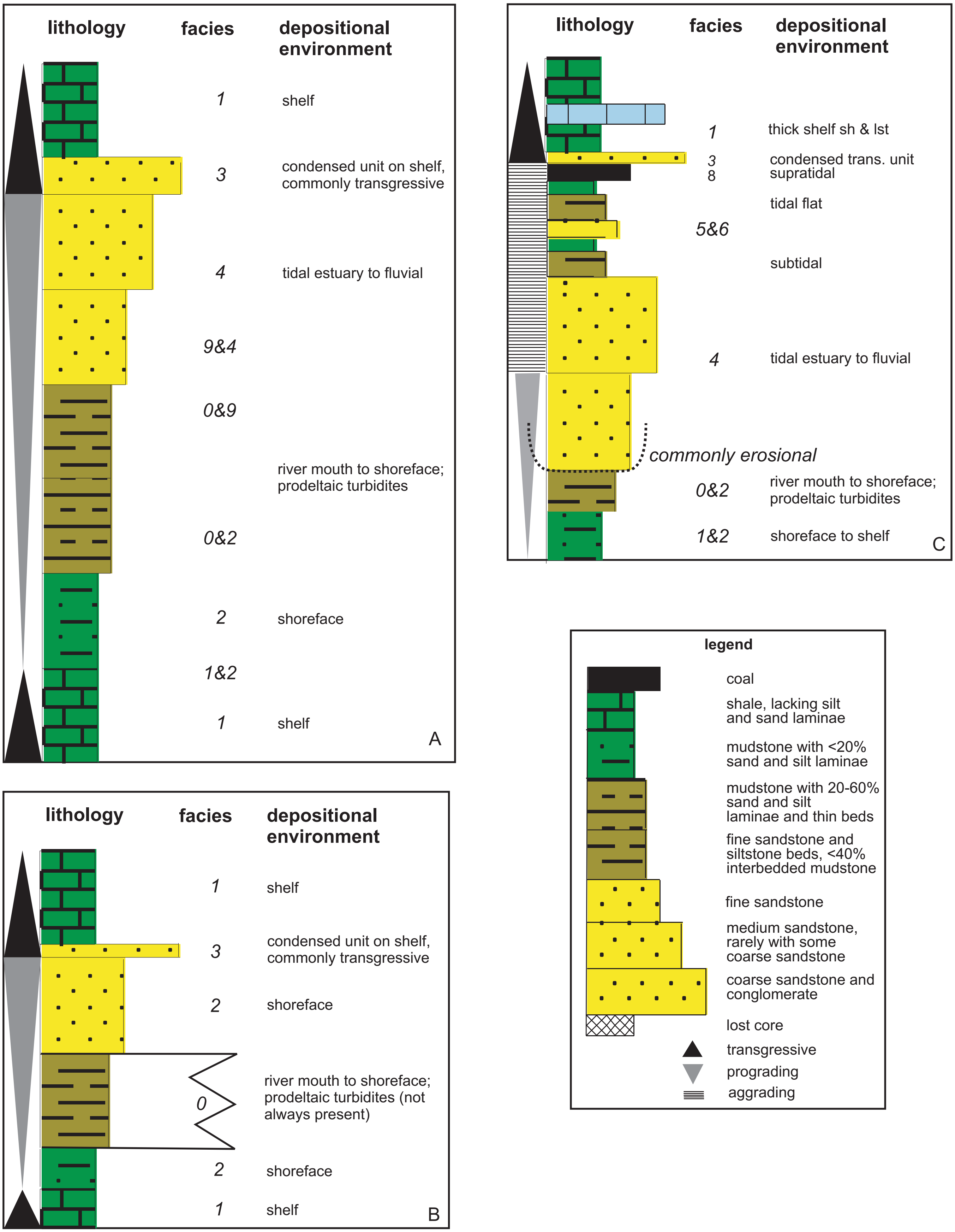


Figure 20: Vertical successions and facies associations seen in core. Some wells show a mix of both types. All facies may not be present in succession in core. A) Pro-deltaic parasequence; B) shoreface parasequence; C) tidal flat parasequence.