Geological Survey of Canada

CURRENT RESEARCH 2001-D14

New depositional environment for the Île d'Orléans Group, Quebec Appalachians

H. Longuépée and P.A. Cousineau

Natural Resources Canada | Ressources naturelles Canada

Canada

Catalogue No. M44-2001/D14E-IN
ISBN 0-662-29889-6

Available in Canada from the
Geological Survey of Canada Bookstore website at:
http://www.nrcan.gc.ca/gsc/bookstore (Toll-free: 1-888-252-4301)

A copy of this publication is also available for reference by depository libraries across Canada through access to the Depository Services Program's website at http://dsp-psd.pwgsc.gc.ca

Price subject to change without notice

New depositional environment for the Île d'Orléans Group, Quebec Appalachians[1]

H. Longuépée[2] **and** *P.A. Cousineau*[2]
GSC Quebec, Québec

Longuépée, H. and Cousineau, P.A., 2001: New depositional environment for the Île d'Orléans Group, Quebec Appalachians; Geological Survey of Canada, Current Research 2001-D14, 11 p.

[1] Contribution to the Appalachian Foreland and St. Lawrence Platform NATMAP Project

[2] Applied Sciences Department, Université du Québec à Chicoutimi, Chicoutimi, Québec, G7H 2B1

Abstract

Detailed logging of the sedimentary structure of the Cambro-Ordovician Île d'Orléans Group near Québec have permitted us to proposed a new interpretation of depositional setting of these sedimentary rocks. It is proposed that the Anse Maranda Formation, with its highly bioturbated mudstone and sandstone was probably deposited at the outer part of a continental shelf. The Lauzon Formation exhibits sedimentary facies like those of a fine-grained turbidite fan. The Pointe-de-la-Martinière Formation shows facies that most likely represent the upper continental slope with contourite and/or tempestite beds.

Résumé

Une description détaillée de la structure sédimentaire du groupe cambro-ordovicien d'Ile d'Orléans nous a permis de proposer une nouvelle interprétation du milieu de dépôt de ces roches sédimentaires. Le mudstone et le grès très bioturbés de la Formation de l'Anse Maranda se seraient déposés sur la partie externe d'une plate-forme continentale. La Formation de Lauzon présente des faciès sédimentaires semblables à ceux d'un cône turbiditique à grain fin. La Formation de Pointe-de-la-Martinière montre des faciès avec des lits de contourite et/ou de tempestite qui représenteraient la partie supérieure du talus continental.

INTRODUCTION

The Île d'Orléans Group ((?) lower Cambrian to middle Ordovician) is part of the Bacchus nappe which is located at the edge of the external domain of the Humber Zone near Québec (Fig. 1). The group contains three formations that are from base to top: the Anse Maranda, the Lauzon, and the Pointe-de-la-Martinière. The lithostratigraphy of the Île d'Orléans Group has been defined by St-Julien (1995) and by Lebel and Hubert (1995). All rocks have been interpreted as a deep-water turbidite sequences, although no detailed sedimentology study of this group has been done. This paper presents an overview of recent field data that result from detailed mapping of sedimentary structures in each of the three formations. We propose that a second-order promontory, the Montmorency promontory (Belt et al., 1979), has played a significant role in sediment distribution and that rocks of the Île d'Orléans Group represent shallower depositional environments than previously suggested.

ANSE MARANDA FORMATION

The base of the Anse Maranda Formation is not exposed, but the formation is presumed to have rested on the Grenvillian bedrock prior to Appalachian thrusting (Lebel and Hubert, 1995). The top of the formation has been interpreted as a nondeposition surface overlain by the Ville Guay conglomerate which marks the base of the Lauzon Formation (Rasetti, 1946); however, fieldwork indicates that the Ville Guay conglomerate is in contact with the Anse Maranda Formation at only one of the three reported localities. Elsewhere the conglomerate is located higher up within the Lauzon Formation. The contact between the Anse Maranda and the Lauzon formations is usually unexposed.

The age of the Anse Maranda Formation is poorly constrained. It is based on a single fragment of Early Cambrian trilobite found 3 m beneath the top of the formation (Rasetti, 1946). The overlying Lauzon Formation is Tremadocian (Early Ordovician) (Rasetti, 1946; Lebel and Hubert, 1995). Thus, a major 20 Ma hiatus is present between the Anse Maranda and Lauzon formations.

Over the 2000 field season, three sections of the Anse Maranda Formation were measured and studied in detail. Six lithofacies have been documented (**Table 1**). They were equated with previously recognized lithofacies (St-Julien, 1995; Lebel and Hubert, 1995). Numerous currently unidentified trace fossils were observed.

The AM1 lithofacies is an alternating green and greyish-green mudstone-rich lithofacies. Locally, near the top of the formation, there are some red mudstone units, but this colour is due to postdepositional diagenesis. There are few siltstone laminae interbedded with the mudstone. The main characteristic of that lithofacies is the high bioturbation, which has not been documented before. There are three types of trace fossils (Fig. 2), the first type is a short, black line disrupting the bedding plane in the green mudstone and the second type is more circular. The third type is a light patch that gives a pseudo-nodular aspect to the rocks, and is filled with glauconite ooids and coarser grained debris than the surrounding sediments.

The AM2 and AM4 lithofacies contain glauconitic sandstone beds that appear to be massive and that have been previously interpreted as turbidite beds; however, fresh cuts clearly show that these sandstone beds are highly bioturbated and contain disrupted mud laminae (**Fig. 3**). Parallel laminations are the sole, occasional sedimentary structures observed. Less bioturbated mudstone beds are strongly schistosed and show no sedimentary structure. Three types of trace fossils are present. The first one is similar to the nodule-like trace fossil described in the AM1 lithofacies. The quartz and glauconite sediments that fill these burrows are calcite cemented. These traces can be more than 1 m in length on the bedding plane (**Fig. 4A**). The second type of trace is a short black or rusty line (**Fig. 4B**) and, the third type is a concentric alternation of black and green circles (Fig. 4B). The last two traces are visible on the bedding plane.

The AM3 lithofacies is a chaotic facies located near the top of every section of the Anse Maranda Formation. It has a sandstone-rich matrix and usually contains less than 25% of fragments.

The AM5 lithofacies has been recognized only at the Anse Maranda locality and is composed of green and occasional red glauconitic sandstone. The sedimentary features are similar to those of the AM1 lithofacies.

The AM6 lithofacies contains beds of crossbedded limestone and siliciclastic conglomerate within a muddy sequence. The lithofacies has been identified at the Anse aux Canards locality (northeastern point of Île d'Orléans) and on the islands eastward (D. Lebel, pers. comm., 2000).

The Anse Maranda Formation appears to be more intensively bioturbated than previously reported. Thus, the massive and muddy aspects of the sandstone beds are best explained by an intense bioturbation rather than by high sedimentation rates. Such intense bioturbation is more common in shallow environments than in turbidite sequences where organisms usually do not have time to extensively rework sediments. The Anse Maranda Formation has been correlated with rocks of the Cambrian shale-feldspathic sandstone assemblage (St-Julien and Hubert 1975); however, the Anse Maranda is not a feldspathic sandstone and its greenish colour comes from its glauconite content, and not from a chlorite content like in other rocks of this assemblage. The high glauconite content in every lithofacies could be indicative of low sedimentation rates and possibly of an outer shelf environment (Amorosi, 1995); however, the exact nature of the mineral interpreted as glauconite is not known and needs to be investigated. Similarly, a better understanding of the trace fossils should help in redefining the depositional setting.

The chaotic unit might indicates a major slope variation (perhaps active tectonic) or simply indicated a slope failure due to sediment overload. More detailed petrography and geochemistry will be done.

LAUZON FORMATION

The Lauzon Formation is Early Ordovician (Tremadocian) (Rasetti, 1946; Lebel and Hubert, 1995). It is generally composed of fine-grained sediments with colours ranging from green to dark grey and of medium- to coarse-grained limestone. There are a few conglomerate beds within the formation. The seven lithofacies of St-Julien (1995) and the seven lithofacies of Lebel and Hubert (1995) (Table 2) have been easily recognized for the various sections of the Lauzon Formation. A detailed section of each of Lebel and Hubert (1995) lithofacies has been done.

The conglomerate lithofacies (LZ1) represent the Ville Guay conglomerate. Some of the LZ1 lithofacies of Lebel and Hubert (1995) can be included in the subarkose (LZ2) lithofacies since both subarkose and conglomerate are part of a same thick (up to 1.5 m), normally graded bed. The massive base is overlain by planar laminations and then crosslaminations. Crosslaminations are of different scales, from dunes to ripples; possible antidune structures were noted in certain beds. Water escape structures and convolute lamination are common.

The fine-grained lithofacies LZ3, LZ4, LZ6, and LZ7 are composed of the same lithologies (*see* **Table 2**) but in different proportions and grain sizes. Planar laminations to crosslaminations are ubiquitous in coarser beds. Only few shallow channels have been observed. Fine-grained sediments show cycles defined by changes in colour and grain size. Bioturbation can be observed as short black lines in the green mudstone beds and as *Skolithos* ichnofacies in the LZ6 and LZ7 lithofacies.

The LZ5 lithofacies of Lebel and Hubert (1995) contains sedimentary structures typical of turbidite beds. There is no clear difference between LZ5 and LZ6 lithofacies except the thickness of the coarse-grained beds and the presence of a blue limestone bed in some of the LZ5 lithofacies sections. The sedimentary structures are the same as the other fine-grained lithofacies.

The Lauzon Formation can be interpreted as a fine-grained turbidite system, according to a model proposed by Normark et al. (1997). The LZ1 and LZ2 lithofacies can be interpreted as distributary channels. The LZ3 to LZ6 lithofacies probably represent the levee system, the LZ5 lithofacies being more proximal relative to LZ6. The LZ7 facies probably represent alternating pelagic muds and distal turbidite sequences. The *Skolithos* ichnofacies indicates that this fan was present on the upper part of the slope instead of the abyssal plain (Pemberton et al., 1992).

An olistostrome at Saint-Vallier, mapped as AM3 lithofacies by Lebel and Hubert (1995), does not display the same characteristic as the one at the Anse Maranda locality. This olistostrome (our LZ8 lithofacies) contains limestone and mudstone fragments. It is underlain by the LZ2 lithofacies and clearly grades into LZ5 lithofacies. This olistostrome can be interpreted as a levee failure deposit and is thus unrelated to the Anse Maranda olistostrome. Petrology, geochemistry, and paleocurrent studies remain to be done to better understand the different types of cyclic sedimentation and to help locate the source area.

POINTE-DE-LA-MARTINIÈRE FORMATION

The uppermost formation is the Pointe-de-la-Martinière Formation. This formation is Arenigian, but the top of the formation is not exposed. It is a varicolored mudstone formation with some calcareous sandstone and siltstone beds and few beds of limestone conglomerate. The eight lithofacies of St-Julien (1995) and the seven lithofacies of Lebel and Hubert (1995) have been recognized, correlated, and the most widespread were studied in detail (**Table 3**) with the exception of the limestone conglomerate lithofacies. A typical intense bioturbation (*Skolithos* ichnofacies) is present in the red mudstone beds (PM2 and PM3).

The PM2 and PM3 lithofacies are composed of the same mudstone beds but with different proportions of the various-coloured mudstone beds. Coarser grained beds generally show a bioturbated base. They also contain planar laminations overlain by crosslaminations, though numerous beds only show planar laminations. The sandier beds have a flat base and a wavy top that represent the surface of dunes or ripples (**Fig. 5**).

The PM4 lithofacies shows no clear cyclicity as in the LZ5 lithofacies, but a typical upward succession from planar laminated to crosslaminations is present. Massive beds, some with evidences of slumps, bioturbation, and water escape, are common.

The PM5 lithofacies contains the higher proportion of coarse-grained sediments. The sandstone beds show a thin base with planar lamination overlain by a thicker succession of crosslaminations. The top of each sandstone bed is bioturbated.

The PM6 lithofacies shows cycles similar to the Logan cycles defined by Landing et al. (1992); however, the quartz- and heavy mineral-rich laminae interpreted as a lag at the base of these cycles by Landing et al. (1992) are not located at any precise position within beds in the western part of the Pointe-de-la-Martinière Formation and are absent in the easternmost sections. At Pointe-de-la-Martinière those quartz-rich beds are conglomeratic and channellized.

The absence of typical channel lithofacies, as in the Lauzon Formation, suggests that the Pointe-de-la-Martinière represent a different environment. The Pointe-de-la-Martinière Formation could record a distal setting of a deep-sea fan, but the presence of extensive and thick sand sheet is not likely to occur in such environment (Normark et al., 1997). Alternatively, the Pointe-de-la-Martinière represents the upper part of a continental slope under influence of storm waves and combined flow. The presence of coarse-grained ripples could be related to storm remobilization (Leckie, 1988); the occurrence of some ripples with varying paleocurrent directions might indicates wave influence. The *Skolithos* ichnofacies also support a relatively shallow-water environment (deeper end of the shelf) (Pemberton et al., 1992). Slumps, indicative of slope failure, are common in such an environment. The apparent lower carbonate content relative to rocks of the underlying Lauzon Formation could indicate a source change or a shut-down of the carbonate factory.

The characterization of some cycles and more elaborated facies analysis will be done to determine the deposition environment.

CONCLUSIONS

Collected data on the first year of this project on the sedimentology of the Île d'Orleans Group has allowed to question prior interpretations and proposed alternative hypothesis. The Anse Maranda Formation with its high quartz and glauconite content and the bioturbation might represent the outer shelf instead of a deep-water fan. The Lauzon Formation is more typical of a fine-grained turbidite system and the *Skolithos* ichnofacies suggests an outer shelf environment. The Pointe-de-la-Martinière might represent a storm-dominated shelf, but a distal fine-grained deep-sea fan cannot be rejected at this point.

Future work will include detail petrology and mineralogy of the sandstone, carbonate, and mudstone. Whole-rock geochemistry will also be done, as possibly some isotope studies on the glauconite and carbonate concretions. A more detailed study of the glauconite of the Anse Maranda Formation will provide better constrains on the depositional environment, its diagenesis, and possibly its age (Ar^{40}-Ar^{39}). Some of the unique characteristics of the Île d'Orléans Group could be related to the presence of a second-order promontory near Québec.

ACKNOWLEDGMENTS

This study is supported by NSERC (OPG0037226 to PAC) and the Université du Québec à Chicoutimi. We thank the numerous persons that have granted us access to the outcrops through private roads, D. Lebel for unpublished information, and D. Lavoie for review of the manuscript.

REFERENCES

Amorosi, A.
1995: Glaucony and sequence stratigraphy: a conceptual framework of distribution in siliciclastic sequences; Journal of Sedimentary Research, v. B65, p. 419–425.

Belt, E.S., Riva, J., and Bussière, L.
1979: Revision and correlation of late Middle Ordovician stratigraphy northeast of Quebec City; Canadian Journal of Earth Sciences, v. 16, p. 1467–1483.

Landing, E., Benus, A.P., and Whitney, P.R.
1992: Early and early Middle Ordovician continental slope deposition: shale cycles and sandstones in the New York Promontory and Quebec Reentrant region; New York State Museum Bulletin, v. 474, p. 1–40.

Lebel, D. et Hubert, C.
1995: Géologie de la région de Saint-Raphaël (Chaudière - Appalaches); ministère de l'Énergie et des Ressources du Québec, ET 93-02, 81 p.

Leckie, D.
1988: Wave-formed, coarse-grained ripples and their relationship to hummocky cross-stratification; Journal of Sedimentary Petrology, v. 58, p. 607–622.

Normark, W.R., Damuth, J.E., and the Leg 155 Sedimentology Group
1997: Sedimentary facies and associated depositional elements of the amazon fan; *in* Proceedings of the Ocean Drilling Program, (ed.) R.D. Flood, D.J.W. Piper, and L.C. Peterson; Ocean Drilling Program Scientific Results 155, p. 611–651.

Pemberton, S.G., MacEachern, J.A., and Frey, R.W.
1992: Traces fossils facies models : environmental and allostratigraphic significance; *in* Facies Models: Response to Sea Level Change, (ed.) R.G. Walker and N.P. James; Geological Association of Canada, p. 47–72.

Rasetti, F.
1946: Cambrian and early Ordovician stratigraphy in the Lower St-Lawrence valley; Bulletin of the Geological Society of America, v. 57, p. 687–706.

St-Julien, P.
1995: Géologie de la région de Québec; ministère des Ressources naturelles du Québec, MB 94-04, 62 p.

St-Julien, P. and Hubert, C.
1975: Evolution of the Taconian orogen in the Quebec Appalachians; American Journal of Science, v. 275-A, p. 337–362.

Geological Survey of Canada Project 990001 QC

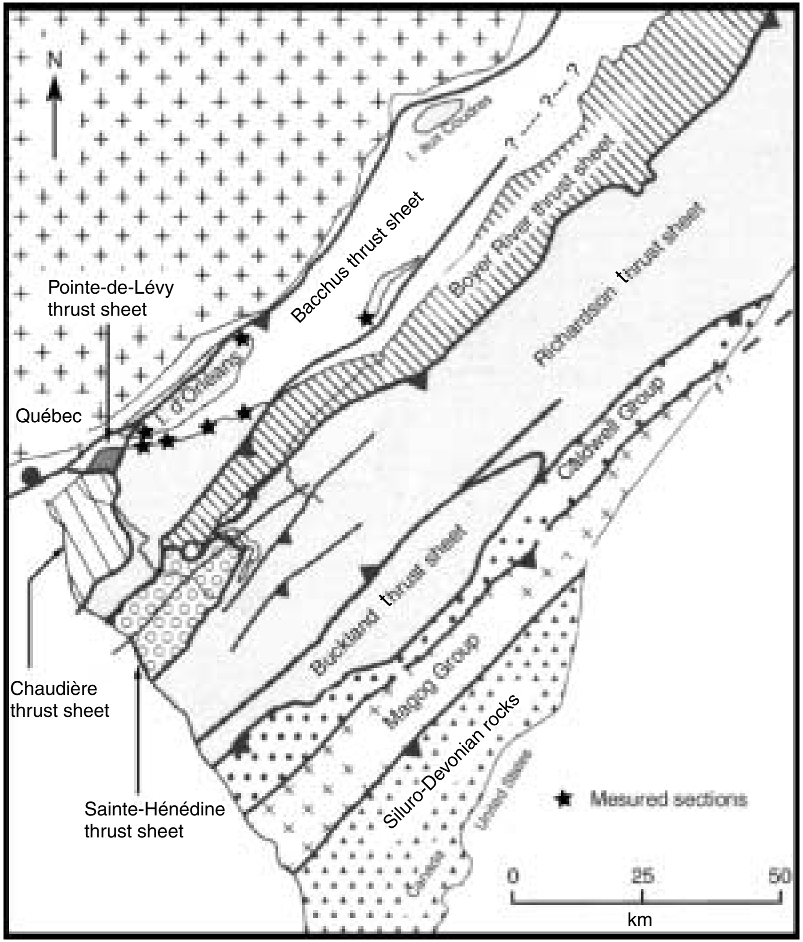

Figure 1. Humber Zone of the central Quebec Appalachians and location of the measured sections (*modified from* Lebel and Hubert, 1995).

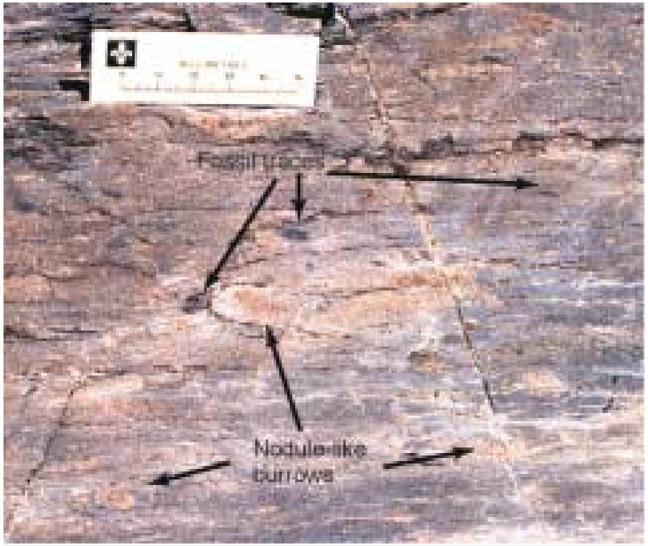

Figure 2. Fossil traces in AM1 mudstone (scale bar is 50 mm).

Figure 3. Internal aspect of a massive sandstone bed from the AM4 lithofacies.

Figure 4. Fossil traces in AM4 lithofacies sandstone. **A**) Long sinuous traces (dashed lines underscore major traces).

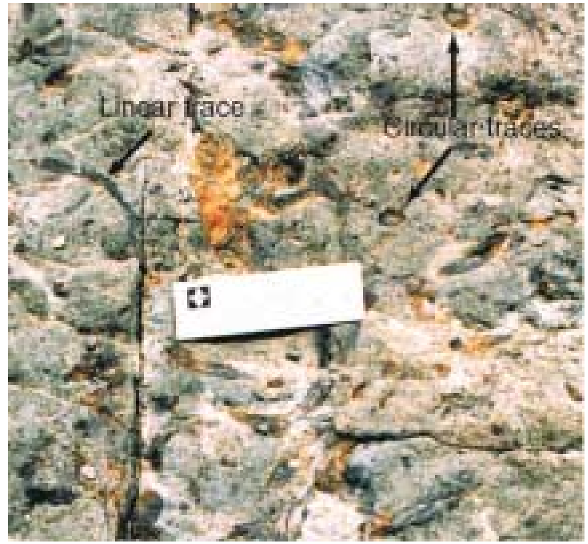

Figure 4. B) Short black lines and concentric circles (scale bar is 50 mm).

Figure 5. Coarse-grained ripple in the PM2 lithofacies.

Table 1. Proposed lithofacies for the Anse Maranda Formation and correlations with lithofacies from previous studies.

Longuépée and Cousineau (this paper)		Lebel and Hubert (1995)		St-Julien (1995)	
AM1	Green and red mudstone and shale	AM1 AM5	Red mudstone Red and green mudstone		
AM2	Green mudstone with less than 50% glauconitic sandstone	AM2	Green mudstone and green glauconitic sandstone	AM2	Glauconitic shale
AM3	Olistostrome	AM3	Olistostrome		
AM4	Green glauconitic sandstone with less than 50% mudstone	AM4	Green glauconitic sandstone with few green mudstone beds	AM3	Shale and schisteous glauconitic sandstone
AM5	Green and red sandstone			AM4 AM5	Green, locally red, glauconitic sandstone Red glauconitic sandstone
AM6	Sandstone, mudstone, conglomerate, and calcarenite				

Table 2. Proposed lithofacies for the Lauzon Formation and correlations with lithofacies from previous studies.

Longuépée and Cousineau (this paper)		Lebel and Hubert (1995)		St-Julien (1995)	
LZ1	Limestone conglomerate	LZ1	Limestone conglomerate	T2	Limestone conglomerate
LZ2	Subarkose and conglomerate	LZ2	Subarkose and/or calcareous sandstone	T5	Calcareous sandstone, calcarenite and limestone conglomerate with grey shale
LZ3	Grey and green mudstone with calcarenite or calcareous sandtone and few siltstone beds	LZ3	Green or grey mudstone interbedded with calcarenite, calcilutite, clacareous sandstone, and siltstone	T3	Grey shale interbedded with calcarenite, limestone conglomerate, and calcareous sandstone
LZ4	Grey and green mudstone with siltstone or calcilutite with few sandstone	LZ4	Grey and green mudstone interstratified with similar proportion of sandstone and siltstone	T4	Grey shale interbedded with calcarenite and calcisiltite
LZ5	Calcareous turbidite	LZ5	Calcareous turbidite		
LZ6	Grey and green mudstone with few siltstone beds	LZ6	Green and grey mudstone with few calcisiltite or siltstone beds	T6	Grey shale with few siltstone laminae
LZ7	Grey and green mudstone	LZ7	Grey and green mudstone	T7	(? Red shale)
LZ8	Olistostrome (St-Vallier type)				

Table 3. Proposed lithofacies for the Pointe-de-la-Martinière Formation and correlations with lithofacies from previous studies.

Longuépée and Cousineau (this paper)		Lebel and Hubert (1995)		St-Julien (1995)	
PM1	Limestone conglomerate	PM7	Limestone conglomerate	P1	Limestone conglomerate
PM2	Red, green, and purple mudstone with siltstone beds	PM1	Red, green, grey, and purple mudstone with beds of siltstone or calcisiltite	P4	Green shale with few red and green mudstone beds
				P7	Alternation of green and red shale
PM3	Red, green, and black mudstone with few siltstone beds	PM2	Red mudstone with few siltstone	P8	Red mudstone with few green shale or mudstone beds
		PM3	Red mudstone with siltstone, few green or black mudstone beds		
PM4	Calcareous sandstone with green or grey mudstone	PM4	Calcareous turbidite with green and grey mudstone		
PM5	Green and grey mudstone with some calcarenite beds	PM5	Greenish grey and purplish grey mudstone with siltstone and limestone	P2	Grey shale with limestone beds
				P3	Siltstone and green mudstone or shale
PM6	Dolomitic mudstone with grey, black, and green mudstone and some sandstone or conglomerate	PM6	Dolomitic mudstone alterning with grey, green, and black mudslate, few calcarenite or siltstone beds	P5	Alternation of green dolomitic mudstone and grey micaceous shale
				P6	Alternation of green dolomitic mudstone and green shale