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LITHOLOGICAL OBSERVATION ON GRANDE GREVE, YORK RIVER AND BATTERY POINT FORMATION, AND HYDROCARBON POSSIBILITIES IN EASTERN GASPÉ

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LITHOLOGICAL OBSERVATION ON
GRANDE GREVE, YORK RIVER
AND BATTERY POINT FORMATION, AND
HYDROCARBON POSSIBILITIES
IN EASTERN GASPE, QUEBEC.

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INTRODUCTION

This report includes lithostratigraphic, sedimentological and structural observations made during the 1975 field season. The main purpose of the study was to build a series of detailed stratigraphic columns of the Grande Grève, the York River and the Battery Point formations and establish some form of stratigraphic correlation within the area. Extensive sampling of the studied sections was also undertaken for future laboratory analyses for hydrocarbon potential studies. The samples can be examined at the Energy Branch Corehouse.

Structural observations were consistently utilized in the reconstruction of the stratigraphic columns. A summary of these observations is also included in the report.

Existing geological maps, especially those of McGerrigle (1950), were utilized as geological base for the present work. Aerial photographs and topographic maps were used for topographical control in the field. Lateral distances for stratigraphic computations have taken into account the scale distortions by comparing the photographs with the topographic maps. This distortion ranges from 1.1 to 1.5.

Four field assistants spent a total of 56 man/week in the field. A Bronco and a Ford Econoline were used as means of transportation.

HISTORY OF PETROLEUM EXPLORATION IN GASPE

The first account of the occurrence of petroleum in eastern Gaspé was published in the Proceedings of Literary and Historical Society of Quebec in 1836. Sir W. E. Logan, 1844, referred to bituminous matter and petroleum seepages on the Gaspé coast near Douglstown. An account of the seeps is also summarized in the Geology of Canada (Logan, 1863, p. 402-521). The first attempt to drill for oil was made in 1860 by the Gaspé Mining Company which subsequently drilled and abandoned two shallow wells located near oil seeps.

Between 1890 and 1903 over 50 wells were drilled in eastern Gaspé. These wells were drilled with cable tool equipment. The deepest one reached 3,700 feet. Oil was produced from some in small quantities, but all were abandoned. The initial results of the drilling program however, encouraged the construction of a refinery in Gaspé in 1901 by Canada Petroleum Company.

Notable recent wells include Gulf Sunnybank, drilled and cored to a total depth of 11,600 feet, and Imperial Lowlands Associated York, abandoned at a total depth of 3,712 feet. Most wells in the area, including the Sunnybank test, encountered shows of oil and/or gas. Some wells are still flowing.

Most of the wells were located on synclinal areas covered by the Gaspé sandstone, west of the Gaspé town, and along the northern slopes of the York River valley. Many other wells were drilled in the vicinity of oil and gas seeps areas along the St-Jean River Syncline. Some wells were drilled along the coastal areas of the Gaspé Bay on the Tar Point and Haldimand anticlines.

HYDROCARBON SEEPS, SHOWS AND SATURATION

Oil seeps and saturations are described by McGerrigle (1950), who undertook his own investigation in addition to summarizing a vast amount of existing well information. Some of the described seeps were visited during the 1975 season.

The oil seeps are generally aligned NW-SE, parallel to two trends, one along the Third Lake Fault System, and the other along the Dartmouth Lake Fault Trend. The seepages are grouped in Figure 1.

- A. It consists of several seeps along the Third Lake Fault. The seepage area is underlain by the York River Formation. One of the seeps originates at the fault contact between the Grande Grève and the York River.

- B. Ambre coloured oil flows out along the crest of tightly folded Grande Grève limestone. There are in all three seeps in this cluster, all in proximity to faults or tight anticlines.

- C. The seepage consist of ambre green oil flowing through gravel overlying the tightly folded Grande Grève.

- D. The seepage is located two and one half miles west of Gaspé town at the contact between the York River and the Grande Grève. The York River sandstone is also impregnated with brownish oil.

- E. The seep is situated at the Grande Grève and York River contact.

- F. The seepage is situated along the Eden Brook on a fault, and is underlain by the Grande Grève.

Other presently inactive seeps described by Logan (1963, p. 789), were situated between the Gaspé village and Tar Point along the Haldimand area, which is underlain by the Battery Point Formation.

Some wells in the area are still flowing:

POT 20 (well number 24 on McGerrigle's map, 1950) was drilled to total depth of 2,173 feet in 1896. Although the description assigns it as a salt water well with occasional oil flow, the well at present (1975) flows half gallon of red paraffin-rich oil per day, accompanied with gas (photo 1). Oil shows are described in the York River Formation in the well report (McGerrigle, 1950).

POT 16 (well number 20 McGerrigle's map, 1950) was drilled in 1895 to a total depth of 2,925 feet. It encountered oil shows at the Grande Grève and the York River contact. The well presently flows water with yellow waxy scum, and globules of red oil. There are numerous other wells which are reported to be still flowing small quantities of oil and gas or are characterized by oil soaked ground (McGerrigle, 1950, pages 129-150).

So far, 81 wells have been drilled in eastern Gaspé. Fifty eight were drilled prior to 1903. None of the wells showed sustained commercial production. The wells were mostly located in the Gaspé sandstone covered synclinal areas. In many cases they were drilled to the underlying Grande Grève.

Among the wells drilled after 1948; Bald Mountain Number 2, and Imperial Gaspé Number 1 tested the Lower Devonian Saint-Léon. The latter test recovered oil and gas shows. Quebec oil tests numbers 1 and 2, located on the Grande Grève core of the Joncas anticline yielded no shows. Imperial Mississippi Number 1, located south of the Mississippi anticline on the Grande Grève Formation, encountered the Cap Bon Ami, and Saint-Alban Formations, and recovered water at a rate of 890 gallons per minute.

CPL Number 1 located at the crest of the Mississippi anticline drilled through 2,750 feet of Grande Grève. It flowed fresh and brackish water at 420 and 96 gallons per hour respectively. Continental Gaspé Number 1, located 647 feet NNE of CPL No. 1, on the same structure after acidizing produced 1.55 Bbls of water/day over 12 days. Further acidizing increased the flow rate to 4 barrels per day. A small amount of oil (approximately 20 gallons) was recovered on bailing.

The best recovery however, was obtained from C-56, (POT 22) located NW of Gulf Sunny Bank test from the Grande Grève and the York River Formations (17 barrels/day). Other notable recoveries were from C-54 (POT 20) and C-51 (POT 17) which flowed at 8 and 6 barrels/day respectively. The former is still flowing at a rate of 1/2 gallon/day. For detailed recoveries see Globensky (1973).

Oil saturation is common in the Grande Grève, the York River and the Battery Point Formations. Some notable observations are described in the following.

Oil staining and globules were observed in bugs and fractures, and in dark laminations in the Grande Grève silty limestone along the Saint-Jean River (one half mile downstream from Saint-Jean Fishing Club camp, lat. $48^{\circ}47'$, long. $64^{\circ}42'15''$). The clay rich laminations lack the saturation. This occurrence is also reported by McGerrigle (1950).

The Grande Grève Formation at the Gulf Sunny Bank test contains oil saturated fractures. These highly permeable fractures are also suggested by the neutron log.

The York River sandstone is saturated less than two and one-half miles west of the Gaspé village near Hay Creek. Along the Tar Point coast solid black bitumen is present in grey medium to coarse grained well laminated, and highly crossbedded York River sandstone (photo 2). The saturation is laminated in the sense that the sands rich in calcite and illite matrix lack oil saturation. This occurrence is described in the Tar Point North Flank section. At the coastal Tar Point section, viscous bitumen also occurs in vugs and fractures in the York River Formation in the calcite veins along minor offsets (photo 3). A diabase dyke also contains viscous bitumen in the calcite lined silica veins which occur in local shear zones.

The Battery Point Formation along Cap-aux-Os (approximate location, lat. $48^{\circ} 50' 20''$, long. $64^{\circ} 21' 00''$) contains round and elliptical concretions of up to 2 foot diameter (photo 4). The outer layer of these concretions consists of black solid bitumen. Occasionally, the bituminous material crosses the concretion along bedding.

ORIGIN OF OIL AND GAS

Oil in the Grande Grève and the York River Formations was suspected to have originated in the underlying Devonian carbonates (McGerrigle, 1950; Park, 1930).

A large number of wells in eastern Gaspé has recovered oil from the York River or the Grande-Grève Formations. The oils vary from 27^o API to 47^o API gravity, and in colour, from brown or green black to wine red. The physical characters of the oil are not related to their occurrence in a certain rock type. The York River oils are not necessarily light and red in colour. Although Ellis (1902) did suggest that the dark and heavier oils were associated with the calcareous units. This correlation is possibly rendered difficult owing to vertical secondary migration along faults and fractures.

A recent chemical study suggests that the Cap Bon Ami and Grande-Grève source rock extracts are similar in composition at the Gulf Sunny Bank test (Sikander, 1975, p. 287). The York River Oil on the other hand is relatively rich in saturates, and poorer in heavier molecule aromatics and alphaltenes. On the basis of the presence of sulphur rich thiophenic compounds which serve as geochemical tracer compounds, in the Cap Bon Ami and Grande Grève source rocks extracts and the York River oil, a Cap Bon Ami Grande Grève source is suggested for the overlying York River oil.

Oils in lower stratigraphic levels, given a similar source matter composition, being more mature should be lighter in composition. The fact that the oil in the stratigraphically higher York River Formation is generally lighter than the deeper oils suggests that it originated in the lower calcareous series, and migrated upward through fractures. The lighter nature of the York River oil is explained by a natural fractionation during migration.

MATURATION OF THE SILURIAN AND DEVONIAN SEDIMENTS

A scheme of sediment maturation and hydrocarbon generation is presented in Table 1.

The Silurian rocks in the Gaspé Peninsula generally show an increase in the organic metamorphism with the total sediment thickness. In the Gaspé Peninsula the maturation studies (Sikander and Pittion, in press) suggest that the Silurian rocks in general are situated at mature to overmature stages of organic metamorphism, demonstrating mainly a gas potential. In eastern Gaspé, however, the Silurian rocks are situated at initially mature to overmature stages suggesting an oil and gas potential. This is especially true for the Saint-Jean River, Silurian arch in eastern Gaspé.

The Devonian carbonates and clastics in eastern Gaspé, which are characterized by frequent shows and seeps, are situated at immature to post-mature stages of organic metamorphism. It is evident from the vitrinite reflectance observations that the Gaspé Limestone series are situated at initially mature to post-mature stages of organic metamorphism, whereas the York River Formation is situated at immature to marginally "initially mature" stages (Sikander and Pittion, in press, and Hacquebard and Donaldson, 1970). The Battery Point has not yet been included in the maturation studies, but it is presumed to be immature. Maturation study on the Tar Point anticline well suggests that the York River at this location is situated at the immature to initially mature boundary.

TABLE 1: SOME SCALES OF ORGANIC METAMORPHISM
(AFTER HOOD AND CASTANO, 1974, AND HOOD et al, 1975)

LOM	COAL			SPORE-CARBONIZATION	THERMAL ALTERATION	VITRINITE REFLECT.	STAGES OF HC GENERATN.	
	RANK	BTU	%VM				(5)	(6)
2	(1)							
4	LIGN.				SLIGHT BROWN-YELLOW		EARLY METHANE	
6	SUB C BIT. B	8		YELLOW				IMMATURE
8	C HV B BIT. A	9	45		2.5	.5	PRINCIPAL OIL FORMATION PHASE	INITIAL MATURITY
10		10	40					
12	MV BIT	11	35	YELLOW DARK BRN	3 MOD. BROWN	1.0	WET GAS & CONDENSATE	MATURE
14	SEMI ANTH.	12	30		3.5	1.5		
16	ANTH.	13	20	BLACK	3.7	2.0	HIGH TEMP. METHANE	POST MATURE
18		14	15		4.0	2.5		

- (1) SUGGATE, 1959. (2) GUTJAHR, 1966. (3) CORREIA, 1967.
 (4) INTERNATIONAL HANDBOOK ON COAL PETROGRAPHY, 1971.
 (5) VASSOYEVICH et al, 1970. (6) HOOD et al, 1975.

In conclusion, recent studies have demonstrated that:

1. Fairly rich organic source beds occur in the Lower Devonian Cap Bon Ami and Grande Grève Formations. Although the York River, generally lacks thick and widespread organic rich shale beds, disseminated organic matter and sapropelic organic debris, possibly deposited in shallow water lagoonal conditions, are frequent.

2. The maturation studies suggest that the lower Devonian carbonates have an oil and gas potential whereas the overlying York River primarily has an oil (with some gas) potential. The hydrocarbon shows and seeps in eastern Gaspé, have probably formed within the organic rich lower Devonian carbonates and migrated upward through faults and fractures into the overlying poorly permeable York River clastics. This secondary migration has also resulted in residual oil saturation in vugs and fractures in the upper most Grande Grève. In this context it is important to note that the hydrocarbon shows in the York River are in the basal part of the York River in the vicinity of important fault systems or tight anticlines.

3. A future oil and gas exploration program on the Devonian rocks in eastern Gaspé should include the premise of mapping potential structural traps involving the Grande Grève where

probability of fracture porosity is high, and mapping the primary as well as the secondary reservoirs (sand pinchouts), and fracture porosity in the York River Formation.

PREVIOUS WORK

The Devonian rocks of eastern Gaspé have been investigated by a large number of workers ever since Logan measured the coastal sections of the Gaspé Sandstone in 1843. Logan summarized the works of Murray, Richardson and Bell in the Geology of Canada (1963). The exposed Devonian rocks were divided into Gaspé Limestone and Gaspé Sandstone series and these were assigned Silurian and Devonian ages respectively.

Ells (1902) summarized the Geology of eastern Gaspé and noted the petroleum possibilities.

Clark (1908, 1913) investigated the coastal sections of the Forillon and Percé areas. His work was later adopted to a large extent by later workers.

Park (1929) summarized the oil occurrences in eastern Gaspé. He compiled the geology and the well data on the oil and gas drilling in the region.

Alcock (1926) and Jones (1930-38) mapped much of the Gaspé area. McGerrigle (1950) in the Geology of eastern Gaspé included these detailed maps. The maps have served as base maps for the present study.

Skidmore (1970) briefly outlined the regional paleogeographic and geologic setting for the Gaspé region for a better comprehension of the oil and gas possibilities.

Mason (1971) in a doctoral dissertation studied the stratigraphic and the paleoenvironmental aspect of the Gaspé Sandstone in eastern Gaspé. The study is a comprehensive petrographic study of the Grande Grève, the York River, the Battery Point Formations, and the Fortin Group. The reader is referred to this study for further petrographic information.

Recent age determinations based on macro-fossils are discussed by Cooper (1942), McGerrigle (1950) and Cumming (1959), Boucot et al (1967) presented paleontological evidence suggesting an Early Devonian (Siegenian-Emsian) age for the upper Gaspé Limestone and the Gaspé Sandstone series.

McGregor using palynological control contended that the Battery Point Formation in the Tar Point section, ranges in age from Emsian to Eifelian (Lower-Middle Devonian). It is evident from the present field work that the lower part of the section studied by McGregor is faulted and that the base of the alleged Battery Point (placed at a coaly marker, is actually situated within the York River Formation.

Recent work by Bourque (manuscript) suggest that the upper Saint-Léon section previously included in the Silurian, is actually of a Lower Devonian age. The age assignment and nomenclature of the pre-Cap

Bon Ami rock units is currently under revision at the Québec Department of Natural Resources. The age of the Gaspé Limestone is also currently under revision by Dr. Lespérance of the University of Montréal.

GEOLOGY

Eastern Gaspé constitutes the eastern tip of the Appalachian Mountain Chain on the North American continental mainland. The rocks range in age from Precambrian to Carboniferous. The central part of the study area contains rocks that vary in age from Ordovician to Carboniferous. The area has been subjected to the late Ordovician-Early Silurian. Taconian Orogeny and the late Devonian Acadian Orogeny.

The eastern Gaspé area is deformed into three broad synclines: From the South, the Fortin Syncline, the York-Champou Syncline and the Gaspé Syncline separated by the Saint-Jean and the Dartmouth anticlines.

Late Ordovician Matapedia Group rocks are exposed along the Saint-Jean River Anticline, and the lower Devonian along the Dartmouth Structure hinge areas.

The Mississippi Anticline constitutes a major structural feature north of the Saint-Jean River Anticline. The anticline parallels a thrust fault which curves in the eastern part into a NW-SE direction to merge with the Third Lake Fault System.

The Third Lake and the Dartmouth strike faults are two parallel strike slip lineaments striking at N130° E, that divide the area into three blocks of distinct regional style and intensity. The northeast situated block is the least deformed, and the southwest situated block is the most intensely folded.

TABLE - 2 - TABLE OF FORMATIONS, EASTERN GASPE, QUEBEC

CARBONIFEROUS				
		BONAVENTURE 800'	Red conglomerate, sandstone, shale, angular-rounded boulders, occasional limestone.	
		CANNES DE ROCHE 200-500'	Persistently reddish, interbedded sandstone and conglomerate red and green shale.	
DEVONIAN	MIDDLE	MALBATE 2,000'	Red interbedded conglomerate, sandstone and shale. Knobby, finely crystalline limestone. Conglomerate. Matrix grey to reddish brown, feldspathic, medium-coarse grained calcareous sandstone.	
		"GASPE SANDSTONE"	BATTERY POINT 5,000-7,000'	Greenish grey medium to coarse highly cross bedded, pink feldspar (orthoclase) rich, occasionally conglomeratic sandstone. Red colouration with dessication features and channels in upper part.
			YORK RIVER 530-4,000'	Greenish fine-to medium immature grey feldspathic sandstone. Illite and chlorite matrix, minor calcareous. Shale greenish, bioturbated; frequent in lower part.
			YORK LAKE 0-4,000'	Interbedding of typical York River and Grande Grève lithologies with shaly limestone, conglomerate and quartzose sandstone.
			GRANDE GREVE 1,500-4,500'	Grey to dark grey often irregularly bedded hard siliceous cherty shaly, silty limestone, and calcareous shale.
	LOWER	"GASPE LIMESTONE"	CAP BON AMI 1,050-6,000'	Grey to dark grey, well bedded, shaly to fine sandy limestone, dolomitic, calcareous shale softer than Grande Grève.
	SILURIAN	GROUP	<u>NORTHERN OUTCROP BELT</u>	
			INDIAN POINT (St. Leon): Greenish mudstone, slightly calcareous, locally sandstone or shale. Variable 825-1,980'	ST. JEAN RIVER ANTICLINE ST. LEON: Dark greenish grey shale slightly calcareous occasionally sandy, silty. 660-2180'
			RONCELLES: Grey, greenish, brownish, medium bedded calcareous mudstone. Upto 700'	CENTRAL OUTCROP BELT INDIAN POINT (St. Leon): Greenish grey mudstone, slightly calcareous, locally sandy or shaly. 1,320-3,500'
			WEST POINT (Sayabec): Grey, fine-coarse crystalline, well bedded, massive calcarenite, calcirudite, limestone, coral, stromporoid, bryozoan-rich. Upto 400'	OWL CAPE: Pebble and cobble, conglomerate grading south-west, into CEDAR BARN volcanics. Total max. thickness interbedded basic lava and volc. conglomerate approximately 1,650'
GASCONS Greenish grey mudstone, calcareous, locally sandy. Upto 400'			CENTRAL OUTCROP BELT WEST POINT (Lefrançois): Coarsely crystalline thick bedded, stromporoid and coral rich "reefal" limestone. Upto 800'	
CHALEURS		GRIFPON COVE RIVER: Red green calcareous siltstone pebble and cobble conglomerate, thin limestone beds. 0-375'	GASCONS (St. Leon): Greenish grey mudstone, slightly calcareous, locally sandy. Upto 1,650'	
		LAFORCE: Interbedded sandy limestone and fine grained calcareous sandstone, calcarenite, calcirudite, limestone breccia. 1000-1800' (Burke, 1964): 150-650' (Bourque, 1975).		
		BURNT JAM BROOK: Dark grey, dark green, generally soft and splintery, some blocky mudstone ± 1,300 max. thickness in St. Jean anticline area cover 3,000 feet in Mt. Alexander area.		
		WHITE HEAD: Very fine grained dark grey argillaceous limestone, intraformational conglomerate, dark grey shale. Petroliferous odour on freshly broken surface. 1,500-8,000'		
		CAP DES ROSIERS: Grey-dark grey, red, green shale, and limestone. Some conglomerate and sandstone.		
ORDOVICIAN	UPPER	MALBATE GROUP		

FORTIN GROUP: Grey-dark grey slate, limestone, fine to medium grained calcareous sandstone, conglomerate.

REFERENCES: Boucot, A.J., L.M. Cumming. and H. Jaeger, 1967
 Bourque, P.-A., 1975
 Burke, C.F., 1964
 Lespérance, P.J., and P.-A. Bourque, 1970
 McGerrigle, H.W., 1950
 McGregor, 1973

The fact that the strike slip faults separate the structural style, and the fact that the folds merge into the lineaments suggests that the two are contemporaneous Acadian deformations, which broadly resulted in accentuation of previous structures, and a north westerly slippage of the south-westerly part of eastern Gaspé relative to the northeast.

The Devonian rocks are briefly outlined in the table of formations (Table 2).

GRANDE GREVE FORMATION

The type locality for the formation is situated along the north shore of the Gaspé Bay along the Forillon Peninsula (Clarke, 1908). Here it consists of a 287 foot shale, soft limestone, bentonite and sandstone unit (Shiphead Member of Russel, 1946, p. 3), overlain by a 600 foot dark siliceous silty limestone and calcareous siltstone with thin shale breaks and chert segregations (Indian Cove of Russel, 1946). The overlying member is widespread throughout Gaspé.

To the southeast, the Murailles Formation was assigned to include the Cap Bon Ami and the Grande Grève.

DESCRIPTION

The formation was studied in the following traverses:

Dartmouth River Section: This section offers good exposure and consequently has been sampled every 30 meters for future geochemical control (Figure 1).

The Grande Grève consists of a lower 210 meter thick (690 feet) grey, light grey-beige weathering, thin to very thin bedded slightly argillaceous and calcareous siltstone. Calcite occurs as pinpoint and needle-shapes, and varies between 5-30% of the total composition. The siltstone contains varying amounts of chert.

The middle unit consists of a 180 meter (588 feet) thick slightly argillaceous calcareous chert. It is thin to thick bedded and frequently contains irregular and disrupted bedding. Thin shale laminations are common. Calcite occurs as pinpoints and needles. Intraformational conglomerates are common. The rock has a typical porcellaneous lustre. The upper unit consists of a thick bedded cherty and silty limestone and calcareous siltstone. Silt-size dolomite crystals were observed 375 meters above the base in the calcareous chert.

St-Jean River Section: The section is situated three miles southwest of the Baillargeon Lake (approximate location: lat. $48^{\circ} 46' 0''$, long. $65^{\circ} 45' 50''$) along the north flank of the Saint-Jean River Anticline (Figure 1). The section is poorly exposed in the lower part and is disrupted by the Third Lake Fault in the upper part. The thickness computations are

imprecise owing to variable dips.

The Grande grève is calculated to be at least 1,390 meters (4,545 feet) thick. The lower part is composed of 685 meters (2,240 feet) of grey to dark to light grey-tan weathering calcareous siltstone. The siltstone is thin to thick bedded, and contains argillaceous laminations. Calcite occurs as needles (100 m long) and pinpoints. Penecontemporaneous warping, and slumping cause occasional discordance within the siltstone beds. Limestone in some beds constitutes up to 30% of the total composition. Calcite filled joints are frequently spaced at 2-5 cm. Chert is generally lacking in this section.

The middle unit, which consists of calcareous chert, cherty limestone and calcareous limestone and calcareous siltstone containing silica and calcite veins, is possibly 210 meters thick, but only the uppermost 40 meters are exposed.

The upper 493 meters consist of grey to dark grey laminated to thinly laminated calcareous siltstone, silty shale with minor argillaceous limestone. In the uppermost 100 meters dendritic algal clusters (or algal mats) or Zoophycos (Plicka, 1968, Photographs 5, 6) occur. The laminated siltstone show convolute bedding.

The Upper Grande Grève usually contains a petroliferous odour on freshly broken surface. The uppermost 75 meters included in the Saint-Jean River Section, frequently contain bitumen saturated hairline fractures with diffused edges. The argilaceous limestone also contains heavy oil bleeding vugs and fractures.

YORK RIVER FORMATION

The formation was defined by William (1910) as a basal, calcareous marine and fossiliferous zone of the Gaspé Sandstone. It was redefined by McGerrigle (1950) as including all rocks having the lithology of the general series of the "York River beds".

The York River Formation consists of greenish grey, pale grey weathering, fine to medium grained sandstone and minor shale. It develops to different thicknesses in various parts of the area. The Sydenham Brook section is 187 m (611 feet) thick. The York River section, which is the type section for the York River Formation, includes the Diner Island and the York River sections and is at least 1,618 m (5,290 feet) thick. The Bazire Brook section, in the Central part of the area, is at least 812 m (2,655 feet) thick. An approximate thickness distribution is shown in Figure 2.

In the southern part of the study area, especially along the Malbaie River, the formation is often cut across by major faults, however, at least 770 meters of the York River and York Lake are present above the cherty calcareous siltstone of the Grande Grève.

The lithology of the York River Formation generally consists of fine to medium grained subrounded to subangular, fairly well sorted feldspathic quartzite and greywacke. The feldspars, typically grey in colour, are predominantly orthoclase (Mason, 1971, p. 91) with minor

amounts of plagioclase and microcline. The matrix typically consists of an illite-chlorite mixture with minor amounts of calcite cement.

The sandstone beds usually show gradational lower contacts with silty shale units, and are overlain by thin silty shale units. The sandstone contain planar cross-lamination indicating slight erosion. Complete uneroded cross bed forms are frequently preserved (photograph 7).

Through cross bedding is generally absent from the typical York River development. It is however associated with granules and pebbles in proximity to the Battery Point contact (Tar Point, York River and Gravelly Brook sections).

The York River sandstone contain noticeable concentration of organic matter. Three types of occurrences were distinguished in the field.

1. Dispersed organic matter: it usually consists of fine organic debris intermixed with silt or shale and fine sandstone. When deposited parallel to bedding, the debris is often concentrated along ripple troughs. In a section, it resembles small discs (Photograph 8).
2. Organic matter concentrated in curved lower foreset portions of the cross bedded units: the organic laminations converge into the lower ones downdip, and reach a total thickness of several centimeters. The "seams" are laterally discontinuous and die out within 5-10 meters (Photograph 9).

The solid organic matter concentration, discretely intermixed with sand, and occasionally associated with glauconite, consists largely of megaspores and some algal matter (Alpern, Correia, personal communications). The sapropelic organic matter is usually resinous, reddish brown to yellowish-brown in transmitted ordinary light and shows a yellow fluorescence in ultra-violet light. The intensity of the colour and fluorescence are however, dependent on the degree on the sediment maturation. This type of organic matter laminations is considered to have accumulated in shallow marine to brackish coastal environment during high energy regimes caused by tidal or stormy conditions.

3. Well laminated parallel bedded coaly seams: These beds are fairly continuous and can laterally extend over hundreds of meters. They are often associated with shale and siltstone. The maximum thickness can be over a meter thick. This organic matter is truly coaly in nature, and does not appear to contain abundant megaspores and algal matter as in the previously described occurrence. (Pittion, 1975, verbal communication). The organic matter particles are fine and laminated. This type of organic matter is considered to be deposited in calm waters in marshes and lagoons in a coastal environment. Most sections such as Bazire, York River, and Tar Point show a frequent occurrence of the last mentioned type. Rarely the coal seams attain a cumulative thickness of one meter. In the field the types 2 and 3 have not always been distinguished.

The shale interbeds are more frequent in interior sections. The shale is highly silty and often contains thin micro-cross-bedded, very fine grained sand beds. The silty shale contains dispersed organic matter. Bioturbation and animal burrowing are frequent.

Some pure shale units especially in the middle part reach a total thickness of up to 30 meters and are often slumped and injected into the overlying sandstone units (as observed in the Bazire, and the York River sections).

DESCRIPTION

Although many sections have served to formulate various ideas on the stratigraphic and sedimentological aspects of the York River Formation, the following are the important ones.

Sydenham Brook: The York River is conformable with the cherty and silty limestone of the Grande Grève. (Enclosure 3). It is 187 meter thick. The lower 128 meters consist mainly of a greenish grey, fine to medium grained, subrounded to subangular feldspathic quartz sandstone. The sandstone units are thin to thick bedded and planar cross bedded. Ripple marks are common. The cross-bedding show a predominant southwesterly maximum. The sandstone is estimated to contain up to 5% vuggy intergranular porosity in binocular examination.

The upper part consists a 59 meter thick silty and sandy shale with non-porous sandstone (up to 7.5 meter thick) beds.

Dartmouth Upstream: Approximately 40 of the 164 meter thick York River is exposed (Enclosure 4). It consists of grey to greenish grey, fine grained subrounded to subangular, poorly sorted planar-cross-bedded sandstone. The sandstone contains abundant illite-chlorite matrix. Shale conglomerates are common. The organic matter laminations are relatively rare. The upper part contains frequent 1-3 meter thick shale and silt.

Gravelly Brook: The York River overlies the calcareous limestone and minor silty shale (Enclosure 6). It consists of 833 meter thick sandstone and shale sequence that grades into the Battery Point. The section is divided into three parts. The lower part consists of 260 meter thick predominantly sandy unit; the middle, of a 240 meter thick shaly; and the upper of a 343 meter thick sandy subdivision.

The sandstone in all the subdivisions are of a grey to greenish grey colour, fine to medium granulometry and are commonly cross-bedded. Ripple marks are relatively rare. The shales are frequently bioturbated and in the middle unit, slumped and injected into the overlying sands.

Bazire Brook: The section includes the exposure along the Bazire Brook and from the Bazire Brook confluence upstream along the Saint-Jean River. The York River is more than 812 meters thick (Enclosure 7).

The basal silty shale of the York River is conformable with a highly argillaceous limestone and calcareous mudstone of the Grande Grève. Approximately 50 meters of York Lake facies develops as calcareous shale and sandstone interbedding.

The York River is arbitrarily subdivided into 3 units. A 229 meter thick lower unit consisting of an interbedding of the typical greenish grey fine to medium grained, occasionally ripple marked sandstone accompanied with bioturbated siltstone and silty shale. Lateral and vertical contacts are gradational. Organic laminations are common, and their maximum thickness reaches 15 cm.

The middle unit consists of a 128 meter thick shaly sequence which is composed of approximately 50% siltstone and shale. The sandstones are thin to very thin bedded and planar cross-bedded. The shale is often slumped and injected into the overlying sandstone. Brachiopods are common in this division.

The upper unit is 455 meter thick and consists of a typically poorly sorted, fine to medium grained greenish grey sandstone

and minor silty shale and siltstone. The sandstones are thin to very thick bedded and occasionally massive. Some units are trough cross-bedded. In general, the bedding contacts suggests a higher energy deposition than in the underlying units.

Organic matter frequently occurs at the base of the cross-bedded units. Laterally continuous 50 centimeter thick "seams" of coaly organic matter are frequent. Silty shales often contain lenses of brachiopod fossil debris.

Dinner Island - York River: McGerrigle (1950) chose this section as the type section for the York River Formation. The 1618 meter section forms the southern limb of the York River Syncline.

The lower contact with the Grande Grève is conformable and the upper contact with the Battery Point is eroded (Enclosure 8). The lower section (up to 836 meters above the base) is composed of greenish, grey siltstone and grey silty shale. The finely laminated siltstone contains finely dispersed organic matter. It is frequently ripple marked and bioturbated. Greenish grey, fine to very fine grained sand units, up to 15 meter thick, are common. The middle part consists mainly of of greenish grey, fine to medium-grained sandstone and minor siltstone and silty shale. The sandstones consist of sub-rounded, poorly sorted subgreywacke to greywacke. It is very thin to thick but rarely "very thick" bedded. It is frequently planar cross bedded except in the uppermost 150 meters

where trough cross bedding is common.

The laminated organic matter in the upper sandy interval usually consists of organic debris. The organic laminations are up to 5 cm thick, minor silty shale and the interbedded fine grained sandstone are frequently bioturbated.

The uppermost York River shows high energy sedimentation characteristics such as abrupt sand shale contacts, trough-cross bedding. Granules, floating pebbles, poor lateral bed continuity, and thick to very thick stratification are common.

Tar Point: The section includes the York River exposed along the hinge area of the Tar Point Anticline between Anse-à Brillant and Anse aux Loups-Marins. The sequence along the hinge area is highly deformed (photograph 11, 12).

South Flank: The York River Formation exposed along this flank is cut across by a series of normal faults, and at the base of the section by a 30 meter thick diabase dyke (Enclosure 56).

The oldest rocks exposed on the south flank consist of medium to coarse grained light-grey-brown weathering sandstone. The stratification varies from thick to very thick. Planar and trough-type cross bedding are common. The organic matter concentration along bedding planes is common.

This lower sandstone member is 36 meter thick and consists of two massive sandstone units separated by a 9 meter thick silt and silty shale. The remaining York River sequence consists of an interbedding of fine grained sandstone silt and silty shale. The sandstone are typically pink-weathering grey and greenish grey in colour. Planar cross-bedding and ripple marks are very common in the sandstone. The organic particles are frequently concentrated on the foreset beds and in ripple troughs. (photograph 13).

A 10 cm thick laterally continuous coal seam consisting of organic matter interbedded with bioturbated silty shale occurs in this interbedded sequence. It is locally sheared into 40-50 cm thick pods. The upper and lower contacts do not show any unusual oxidation or root structures.

The upper contact of the York River with the Battery Point is faulted.

The York River siltstones and sandstones frequently contain a strong petroliferous odour and show a trace of oil saturation especially in the vicinity of small offsets and prominent fractures. This saturation is often characterized by a bright yellowish brown weathering colouration.

Bleeding bitumen is present in the diabase dyke, especially

in the cavities within the calcite and silica veins in the shear zones. The amygdules are also bitumen filled. The calcite veins along small normal offsets in the sandstone frequently contain bitumen saturated vugs. The rocks in the vicinity of the fractures contain strong petroliferous odour.

The exposed stratigraphic thickness is difficult to estimate due to a number of faults. The stratigraphic distance of coal marker from the Battery Point contact is not clear.

North Flank: The lower part of the exposed sequence is faulted (Enclosure 50). It consists of a bioturbated grey silty shale and a grey thinly bedded fine grained sandstone. Some oil saturation is observed in fractures. The lower sequence is overlain by 158 m of grey, medium to coarse grained friable sandstone. It is frequently gravelly and conglomeratic at the base. Cross-bedding on a large scale with quasi-planar erosion surfaces shows northward current direction. The sandstones lack the pink feldspar and the typical of the Battery Point bottle-greenish grey colour.

The lower 30 m of the sandstone is saturated with bitumen. The basal sandstone is grey to dark grey (owing to the oil saturation) and weathers yellowish rusty brown.

Malbaie River: The Malbaie River intersects the York River outcrop belt at several locations. The upper contact with the Battery Point Formation is generally faulted.

Upstream section: The York River sandstone overlies the thinly and irregular bedded calcareous siltstone included in the Fortin by McGerrigle (1950).

The basal part of the sequence consists of a 6 meter thick well rounded granule conglomerate with a quartz-sand matrix. That grades upward into a 206 meter thick York Lake and a 570 meter thick York River sequences (Enclosure 9).

The York Lake is composed of the following units:

1. Grey, medium grained subrounded thin to thick bedded pink weathering sandstone; 76 meters.
2. Interbedding between calcareous siltstone and calcareous sandstone. The calcareous interbeds decrease in frequency upward. The sand units have smooth lower but irregular upper contacts; 41 meters.
3. Mainly grey, medium to coarse sandstone; 54 meters.
4. Calcareous, argillaceous siltstone and shale; 35 meters.

The York River is arbitrarily divided into a lower 231 meter mainly greenish grey fine to medium grained sandstone, interbedded with minor but 50 meter thick calcareous siltstone and calcareous shale.

The middle part of the York River consists of 153 meter mainly grey to dark grey shale containing siltstone and very fine grained sandstone. A conglomerate bed with a clay matrix also occurs in the shaly member. Slumping and injection of the shale into sandstone beds is common.

The upper part consists of a 186 meter grey to greenish grey, fine to medium grained thin to thick bedded sandstone. The sandstone is planar cross-bedded and contains frequent 10 cm thick organic laminations.

The contact with the Battery Point is faulted.

Downstream Section: The downstream section is well exposed but the contact with the Battery Point is faulted. Here too the York Lake facies are well developed. (Enclosure 10).

The York River consists of grey, medium to coarse grained pinkish grey weathering sandstone. Frequent lenses of well rounded conglomerate and pebble-rich coarse sandstone are common in the middle part. The cross bedding is characteristically of the trough type. The pebbles consist of quartz,

quartzite, igneous rocks and shale. The feldspar grains are typically grey in colour. The matrix consists of greenish grey to white clay. The shale beds are generally lacking.

The downstream section although measured, was studied mainly to observe the lithology of the York River in the southern section.

CURRENT DIRECTIONS

The current directions in the York River Formation were mainly derived from cross-bedding. These were corrected to the horizontal bedding using a stereonet. A total of 324 observations have been used for the York River. An average of 31 observations are used for each section. The weighted means were used as average directions.

The York River Formation which contains largely a littoral and coastal clastic sequence shows complex current directions.

The northern sections in the area indicate westerly to south-westerly averages. The east-central sections (Tar Point), and the central (Saint-Jean River, Bazire and Gravelly Brook) sections and the southern (Malbaie River) sections show a dominant northwestern, northern to north-eastern trends.

The west-central sections (York River type section) demonstrate several maxima. The basal part of the section shows a NW-NE maximum. The upper part, on the other hand, shows diverse southwest to southeasterly maxima.

The current directions averages in the York River sands converge toward the interior Gaspé area and suggest that the York River was deposited in a westward opening restricted embayment. The presence of greater

shale content in the westerly situated Dinner Island - York River sections also suggests that the embayment probably opened westward.

The current directions also indicate the presence of a positive (presumably land) area to the south of the study area.

BATTERY POINT

The Battery Point is exposed along the coastal margin of the Gaspé Bay. The southern coastal exposure along the Gaspé Bay was used as the type section for the Battery Point. This section, measured between Anse-à-Brillant to Pointe-Jaune is at least 1,670 m (5460') thick. Several minor normal faults were observed in the section, so that the true Battery Point thickness is probably greater than measured. Owing to poor control the thickness distribution is not clearly discernible.

DESCRIPTION

The other Battery Point exposures described in this report are:

- 1 - The northern coast of the Gaspé Bay (northern flank of the Gaspé Bay syncline.
- 2 - The southern coastal section along the Gaspé Bay (Dartmouth River to Tar Point).
- 3 - Downstream Malbaie River Section.

Gaspé Bay; Good inland Battery Point sections are exposed along several streams such as the Bazire and Ascah north of the Gaspé Bay between Cap Petit Gaspé and Sainte-Majorique.

The coastal section consists of several repeats. West of Penouille, the section is poorly exposed.

The Battery Point consists of medium to coarse grained grey to greenish grey often conglomeratic sandstone (photo 14). Sorting is poor to fair. The grains are subangular to subrounded. Feldspar is characteristically pink.

The sandstone is usually trough cross-bedded (photograph 15, 16). The stratification is thick to very thick. Minor silty shales, usually 1-3 meter and up to 15 meter thick contain thin lenses of fine to medium grained sandstone.

The matrix in the sandstone consists of a greenish grey chlorite-illite mixture.

Some large 1 to 2 meter across concretions are present in the lower part of the Battery Point. These appear to have calcite-siderite cement. (photographs 17, 18). In the Cap aux Os section the concretions contain rims of bituminous matter. (Photograph 19). Ripple marks and mudcracks are common (photograph 20).

The base of the sand units is characteristically eroded and conglomeratic. The sequence grades upward, through a lower massive sand unit, to a finer grained usually silty and usually red coloured sandy shale with sand lenses. The top of each sequence is marked by an erosion surface which is overlain by the basal conglomerate of the overlying sequence. (Photograph 21).

The thickness of these depositional cycles is variable. In the section east of Cap-aux-Os beach it is of the order of 20-30 meters. Minor erosion surfaces within each unit are also common. Higher up in the Cap-aux-Os section thin shale interbeds are less frequent and the erosion at the base of the massive sand units are relatively widely spaced.

Plant fragments are abundant and fish fossils have been reported by other workers along the Cap-aux-Os section.

Approximately 435 meters (1,422 feet) of Battery Point has been measured along the north shore of the Gaspé Bay. The remaining section estimated to be in excess of a thousand meters is extremely poorly exposed thus not included in the measured section.

Anse-à-Brillant - Pointe Jaune: The base of the section is exposed north of the Brillant Cove. The base of the Battery

Point is faulted but appears to be gradational. Stunted brachiopods are found in the prism-weathering grey-dark grey shale south of the pier. Several faults are present in the lower part of the section.

The lower 1975 meters (3188 feet) consists of a medium to coarse, thick to very thick bedded, trough cross bedded and conglomeratic sandstone. Thin laminae of plant debris is common on the foresets. The conglomerates grading upward, consist of quartzite quartz, igneous rocks, pink feldspar and shale fragments. The base of the sandstone is usually marked by erosion, but the cyclic sedimentation is not as well developed as in the Cap-aux-Os section. Limonite concretion in the thin shale passages are common. Above the lower unit red shales become conspicuous. Green colouration is frequently observed adjacent to joint fractures and faults. (Photograph 22).

Near Fort Prevel, the shale interbeds are laterally discontinuous, and often slumped. Mud-cracks (photograph 23), ripple marks, load structures, rain prints, rill marks and small channels are very frequent.

The interval containing the red shales and the red stained sandstones ("Fort Prevel" member) is estimated to be 700 meters (2290 feet) thick. This upper member lacks fossils

and organic matter laminations that are common in the lower part.

Malbaie River: Malbaie River section is poorly exposed. It consists mainly of a greenish grey, medium to coarse grained pink feldspar rich sandstone with minor shale. The sandstones are thin to thick bedded and conglomeratic at the base. The lower bedding surface is marked by erosion. Owing to poor exposure the fluvial sedimentary cycles are not clearly observed.

Conglomerate lenses containing pebble fragments are common in the upper part of the formation. The clasts are composed of shale, quartz, quartzite and igneous rocks embedded in a fine sand matrix (photograph 24).

The upper part of the Battery Point is faulted against the Malbaie Formation. The red facies (the "Fort Prevel" facies of the coastal section) are not present in this section. Poor exposure and faulting does not permit a precise thickness estimate.

DEPOSITIONAL ENVIRONMENT

Lower Member: the sedimentary characters such as erosion surfaces, the massive conglomerate-sandy units at the base, the presence

of finer sediments at the top of each sedimentary cycle, the laterally discontinuous nature of the sand units and large scale trough type cross-bedding suggest periodic flooding and exposure of the sediments as they were being deposited in a large meandering and/or a braided fluvial system. There is little or no evidence of marine biota. On the other hand, the rare fish and frequent wood fragments suggest a fresh water to lacustrine conditions.

Upper Member: The upper member is usually associated with red, chocolate-red to green colouration of the sandstone and red-green shales. This facies of the Battery Point contains frequent channel development, laterally discontinuous sandstone beds, frequent conglomerates, ripped-up clasts, and abundant evidence of subaerial exposure. It is suggested that they were deposited in an alluvial fan-type of environment. Here, numerous small channels and the accompanying low areas are envisaged as being the sites of deposition during the frequent flood periods in a generally arid area.

Thus, the Battery Point deposition represents that transitional middle and upper phases of a fluvial regime. A similar braided stream-alluvial fan-type of environment model is suggested by Sikander (1975) for the Battery Point in the Berry Mountain Syncline area in central Gaspé.

CURRENT DIRECTIONS

The current directions during the deposition of the Battery

Point are interpreted from the cross-bedding directions. The data suggest unimodal or bimodal peaks in the northern sections, whereas southern sections show a polymodal distribution.

The Upstream Dartmouth section shows a northwesterly current direction. The Sydenham section shows a more northerly trend. The average current direction in the Cap-aux-Os section shows a northeasterly direction.

The two sections, investigated along the south shore of the Gaspé Bay (The Anse-à-Brillant to Pointe-Jaune section), and the Malbaie River, show a west-northwest and north-northwesterly directions in the lower part of the Battery Point. The upper part of the formation trends to show a weak easterly to southeasterly direction.

It is thus evident that the main trend for the currents in the Battery Point show a northwesterly to northeasterly direction, which suggest a general southerly to southeasterly provenance for the Battery Point clastics in eastern Gaspé.

CONCLUSIONS

In the post-Cap Bon Ami Lower Devonian time, the eastern Gaspé area was the site of a continuously regressive sedimentation. Silty limestone and calcareous siltstone were deposited in the Grande Grève time on a south sloping platform, the basin equivalent of which are the Fortin shales, siltstones, limestones and volcanics.

In the York River time, the area was the site of a west-opening embayment, along the margins of which shallow marine brackish, even tidal marine conditions prevailed. Here, low to moderate energy fine to medium grained sands and silty shales were deposited. In the deeper part of this embayment, situated in the western interior, shales, silts, and very fine sands were deposited in a low energy shallow marine environment.

The area rapidly shallowed at the end of the York River time, and was overrun by a generally north to northwest prograding fluvio-deltaic system of the Battery Point. The high energy fluvio-marine conditions at the end of the York River time gave way to a broad braided channel that deposited gravelly and medium to coarse monotonous, and at times cyclical (point bar) fluvial sands that are characterized by eroded gravelly base. The sands are rich in pink feldspar, and grade upward into silty shales in each cycle.

The fluvial Battery Point conditions were followed by the alluvial-fan conditions of the red beds in the upper Battery Point ("Fort Prevel" member).

Hydrocarbon shows and saturations were observed in the Grande Grève, the York River and the Battery Point. Dispersed as well as laminated organic matter is common in the Grande Grève and the York River formations. However, previous as well as present observations suggest that the Grande Grève and as the York River have fair to poor source rock possibilities (INRS, 1972; BEICIP, 1975). Further geochemical work is

required to identify the source rock potential of the Lower Devonian sequence of eastern Gaspé.

Maturation studies in the area (BEICIP, 1974; Sikander and Pittion, in press) suggest that the York River and the Grande Grève are at initially mature to marginally immature stages of maturation which are suitable for both oil and gas generation. The overlying Battery Point is suspected to be relatively immature.

The field work has revealed that a 87 meter (285') medium porous sand interval is present at the base of the York River in the sections exposed north of the Gaspé Bay. This high energy and highly cross bedded sand is not porous in the southern sections. The York River sands generally contain a clay matrix that inhibits effective porosity and permeability.

The south shore of the Gaspé Bay (Tar Point section) contains a 46 meter (150') heavy oil saturation in the medium to coarse grained upper York River (?). An effective seal that might permit any significant accumulation is difficult to visualize as this interval underlies the massive Battery Point sandstone which lacks significant shale interbeds.

The upper part of the York River Formation, especially along the York River Syncline in the western interior of eastern Gaspé, contains high energy possibly fluvial sands. But this interval is of minor interest for oil and gas since it is presently exposed, and probably is the youngest Lower Devonian preserved along the Syncline.

Future field investigations for oil and gas possibilities in eastern Gaspé should be undertaken to examine the relationship between the York River and the Battery Point formations, and also the York River sand development in the southern part of the area, especially south of the Malbaie River.

Structural traps where the Grande Grève is folded or thrust in a favourable configuration may have hydrocarbon possibilities in view of possible favourable secondary (fracture) porosity development. These, traps need to be defined at depth by geophysical methods possibly along thrust zones. Extensive fracture systems are not frequently observed in the Grande Grève. A fracture axial plane cleavage, however, develops in the basin equivalent Fortin Group shales.

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PHOTOGRAPHS

Photograph 1: POT 20, on road to Murdochville, 20 miles from Gaspé, flows 1/2 gallon of red waxy oil per day.



Photograph 2, 2a: Bitumen saturation in coarse grained upper York River sandstone. White patches are non-saturated calcite cemented sandstone.



a

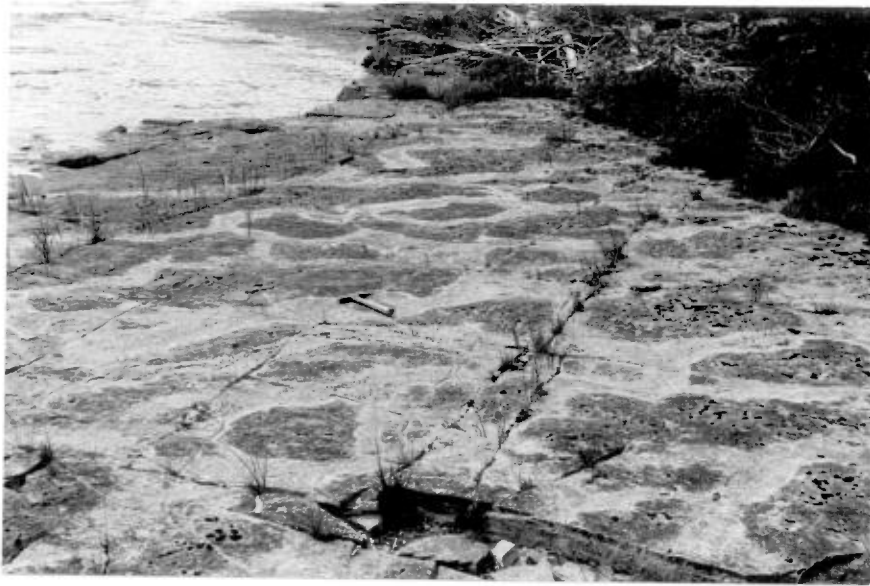




Photograph 3: Bitumen-bleeding calcite veins filling a minor fault fracture, Anse-à-Brillant-Tar Point.



Photograph 4: Solid Bitumen (black) rim around calcite concretions; Battery Point Sandstone, Cap-aux-Os.



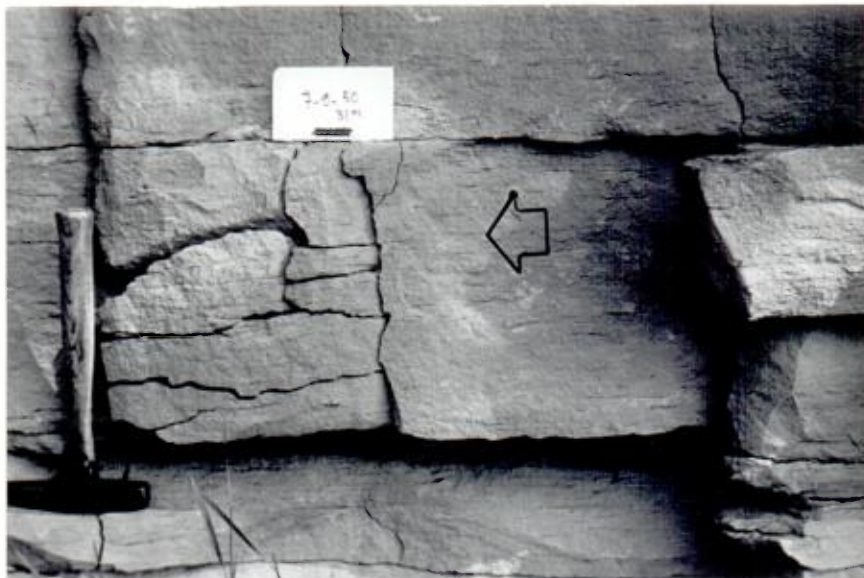
Photograph 5: Algal mats or worm colonies along bleeding planes near St-Jean Fishing Clubhouse, upper Grande Grève: Saint-Jean River, lot $48^{\circ}47'$; long. $64^{\circ}42'15''$.



Photograph 6: Close-up of photograph 5: Grande Grève Formation.



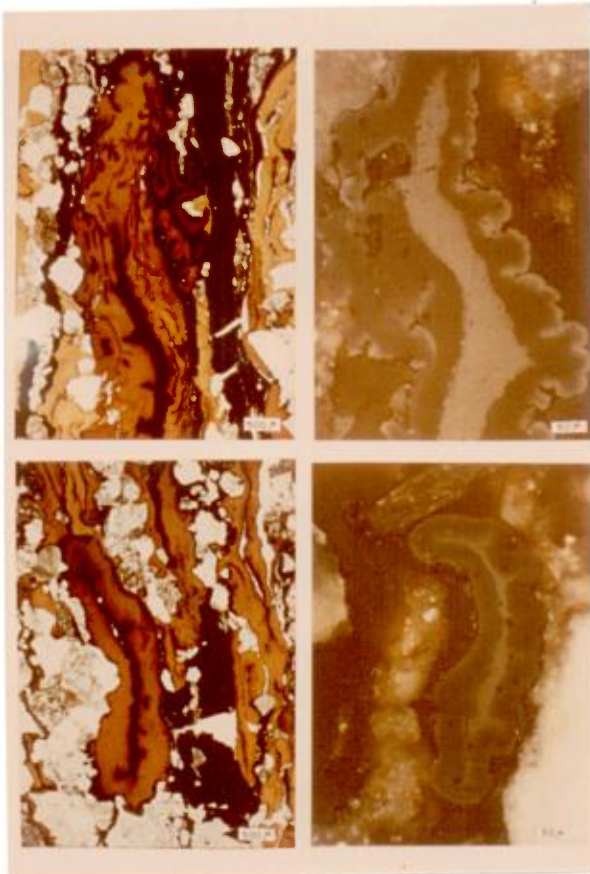
Photograph 7: Inclined bedding prograding over an eroded shale bed. No or little truncation in the topset of the cross bed. York River Formation, Bazire Brook.



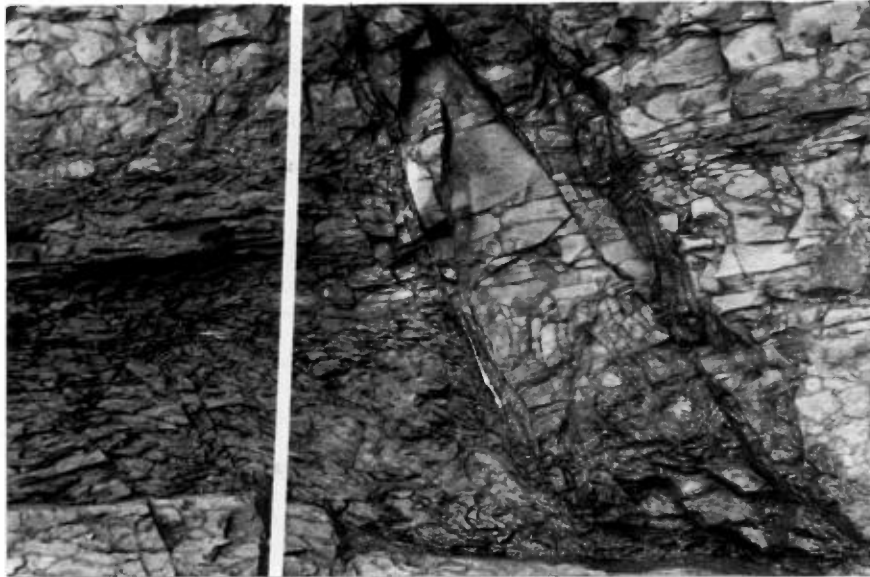
Photograph 8: Discontinuous disc shaped laminae of organic matter in fine grained York River sandstone, St-Jean River near the confluence of the Bazire Brook.



Photograph 9: Concentration of organic matter in the lower foreset of trough-shaped or planar cross beds, York River sandstone, Saint-Jean River near the confluence of Bazire Brook.



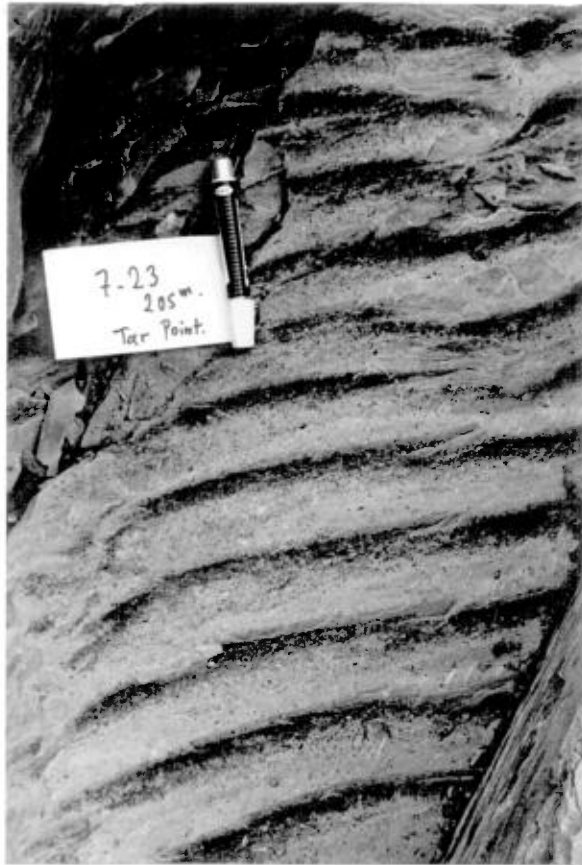
Photograph 10: Micro photographs of the organic laminae, largely made up of organic debris and megaspores. Right two photographs are taken in reflected light, and the left two in transmitted light. White particles are quartz grains. Laminae sampled is shown in Photograph 9. Saint-Jean River section.



Photograph 11: Faulted and sheared York River in the Tar Point area. Calcite vein filling commonly contain bitumen.



Photograph 12: Small normal fault offsets oblique to the main fracture. Bituminous odour from freshly broken surface in the Vicinity of the main fracture. Tar Point locality.



Photograph 13: Organic matter debris concentrated along asymmetric ripple troughs: Tar Point locality.



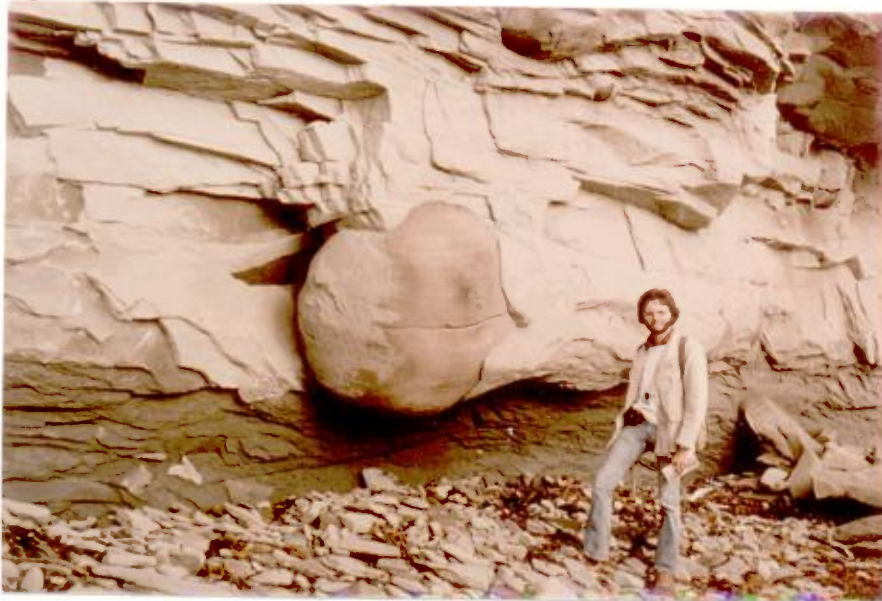
Photograph 14: Medium to coarse grained gravelly Battery Point sandstone. Note the coarse sandstone grading upward that represent high current regime: Cap-aux-Os, North Shore Gaspé Bay.



Photograph 15: Highly truncated large scale trough cross-bedding in Battery Point sandstone, Cap-aux-Os, North Shore, Gaspé Bay.



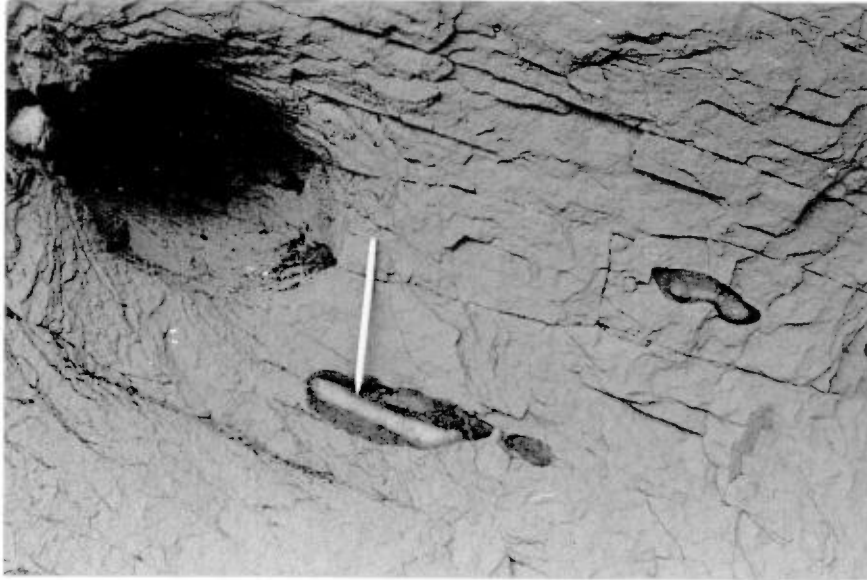
Photograph 16: Large scale bottom-set in a north advancing mega cross-bed unit. Cap-aux-Os, North Shore, Gaspé Bay.



Photograph 17: Large, upto one meter across siderite-calcite concretions in Battery Point sandstone, Cap-aux-Os section, North Shore, Gaspé Bay.



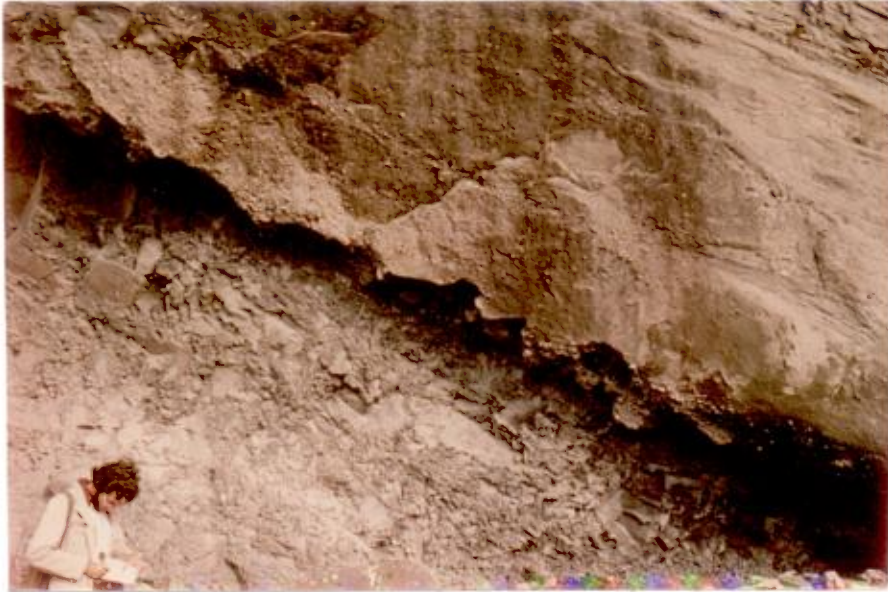
Photograph 18: Concentric nature of the concretions in the Battery Point sandstone: Cap-aux-Os section.



Photograph 19: Bitumen filled concretions in the Battery Point sandstone: Cap-aux-Os section, North Shore, Capé Bay.



Photograph 20: Ripple marks with superimposed mud-cracks in the Battery Point sandstone indicating periodic exposure of a shallow submerged area. Cap-aux-Os section.



Photograph 21: A typical erosion surface at the base of channel type sandstone in a typical point bar cycle. The sand unit grades upward into a silty shale sequence: Cap-aux-Os section, North Shore, Gaspé Bay.



Photograph 22: Red "Fort Prevel" member of the Battery Point Formation. Secondary green colouration is present along the joint fracture: Cap-Rouge section below Fort Prevel Hotel. Grande Anse-Point-Brûlé Traverse.



Photograph 23: Extensive mud-cracks in the "Fort Prevel" member of the Battery Point: Grande Anse-Point-Brûlé Traverse.



Photograph 24: Extensive gravelly sandstone development in the typical Battery Point sequence along the Malbaie River traverse: Malbaie River.