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LA THÈSE A ÉTÉ
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Sedimentology of the Pirate Cove, Fleurant and Bonaventure
Formations of the Western Baie des Chaleurs area, Maritime Canada;
A Depositional and Tectonic Model

By

Brian A. Zaitlin

A thesis
presented to the School of Graduate Studies
in partial fulfillment of the
requirements for the degree of
Master of Science
in
the Department of Geology

FRONTISPIECE :

View of Units 4 and 5 of the Pirate Cove Formation at low tide, looking east across Englishman's Brook.



COLOURED PICTURE.

ABSTRACT

Lower Devonian to Carboniferous sediments in the western Baie des Chaleurs region, Québec and New Brunswick, comprise a 2.5 km terrestrial succession deposited in successor basins of the Acadian and Appalachian Disturbances. The three formations studied - Pirate Cove (L/M Devonian); Fleurant (U Devonian); and Bonaventure (L Carboniferous) - were deposited in a range of alluvial environments that included alluvial fans to braidplains to meandering fluvial plains. The L. Devonian La Garde and Upper Devonian Escuminac Formations comprise the remainder of the molassoid deposits within the study area.

The Pirate Cove Formation (535 m) is divisible into 5 informal members (or units) comprising a) gravel-dominated, mid to distal alluvial fan (units 2 and 3) b) gravel-dominated, proximal to distal braidplain (unit 5), and c) sand-dominated alluvial braidplain (units 1 and 4) deposits. The Pirate Cove accumulated in a NE-SW trending basin, with a NW source area. Debris flow and sheetflood deposits, redbeds and minor caliche indicate ephemeral flashflood deposition in a semi-arid environment.

The Fleurant Formation (18 m) mainly comprises 1-5 m thick, horizontally bedded, imbricate, cobble to boulder conglomerates derived from a NW source. The grey-green colouration and absence of debris flow deposits and caliche indicate deposition under a more temperate climate. Sedimentation occurred mainly on large coalescing longitudinal bars under flood conditions on a proximal, gravel-dominated braidplain.

The Bonaventure Formation (170 m in the study area) represents deposition on a) proximal alluvial fan / talus slope b) gravel - and sand-dominated proximal to distal braidplain and c) transitional braided to meandering alluvial plain environments. The Bonaventure formed in a W-E

trending basin , bordered to the N , W , and S by marginal alluvial fan and proximal braidplain deposits, with W to E axial drainage.

Two depositional sequences, controlled by changing tectonic style, are postulated for the Devonian to Carboniferous succession. The L/M to U Devonian coarse clastic sequence, comprising the La Garde, Pirate Cove, Fleurant and Escuminac Formations, is characterized by an asymmetric lithofacies distribution within fault controlled basins. A shallow dipping subduction zone in the Fundy area, SW of the study area, occurring during the Acadian collision between Baltica and Laurentia, has been proposed by others as the causative mechanism.

The L Carboniferous (Bonaventure) sequence is attributed to deposition in strike-slip basins. Supporting evidence includes a symmetric distribution of lithofacies similar to that of some known strike-slip basins; in addition to en echelon folds. The postulated control was transcurrent motion to the SW of the study area created by the collision of Laurasia and Gondwana.

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Chapter I
INTRODUCTION

1.1 LOCATION AND ACCESS

The Baie des Chaleurs region is located along the southern Gaspé and northern New Brunswick coasts, between the Gulf of St. Lawrence and the mouth of the Restigouche River (Figure 1). The principal study area is situated near the western limit of the Baie, approximately 25 km east of Campbellton, New Brunswick. Population centers within the study area include Miguasha and St. Omer, Quebec; and Dalhousie, New Brunswick.

Outcrop and cliff sections of Devonian and Carboniferous age were examined in Quebec between Escuminac Point and St. Omer; and from 4 km west of Dalhousie, eastward to Belledune Point, New Brunswick (Figure 2). In addition, drill hole logs for Heron Island were obtained from the New Brunswick Electrical Power Commission (N.B.E.P.C.). Unfortunately, access to the island was not obtained throughout the duration of the study.

The best exposure is present as relatively low lying (0-20m), continuous sea cliffs that border the western margin of the Baie. These sea cliffs are fully accessible at low tide, when an intertidal gravel to mud beach is exposed.

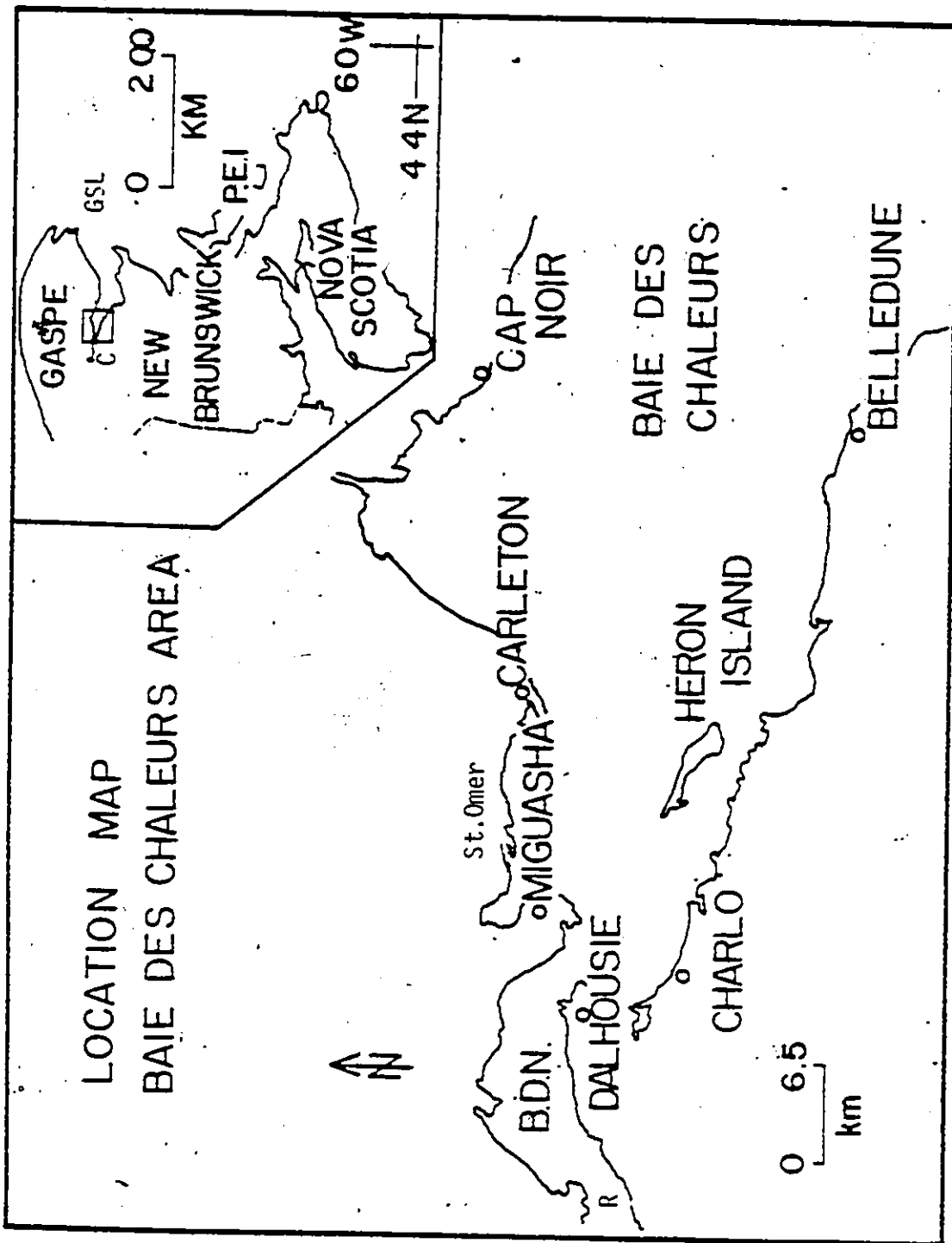


FIGURE 1: Location Map, Western Baie des Chaleurs Area
 (BDN : Baie de Nouvelle ; R: Restigouche River, C: Campbellton
 GSL : Gulf of St. Lawrence)

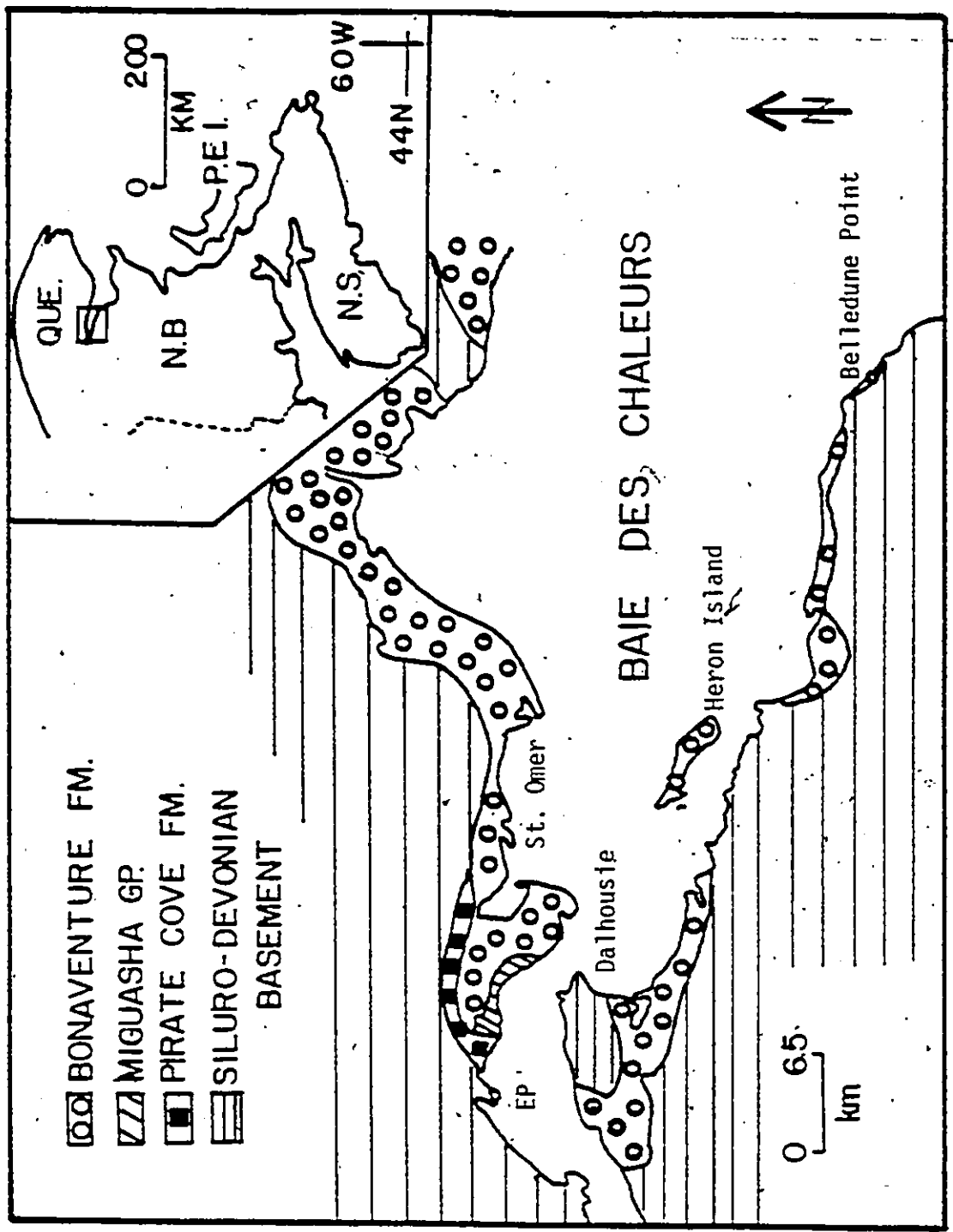


FIGURE 2: Simplified Geologic Map of the Western Baie des Chaleurs Area
 (after Dineley and Williams , 1968 a,b)
 (EP: Escuminac Point)

Isolated roadcuts, stream banks, scarps and gravel pits provide limited inland exposure. Away from the coast, the region is mostly covered by dense overgrowth and glacial material, hampering systematic inland traversing.

The region is dominated by the east-west trending Baie des Chaleurs "trough", controlling the topography and drainage pattern for the area. The southern Gaspé is composed of a narrow lowland area, with scattered marginal farms, rising rapidly into the Notre Dame Highlands. The New Brunswick region contains a more widely-extensive lowland, rising to the south and southwest to the New Brunswick Highlands. Figure 3 shows the physiographic subdivisions within the Baie des Chaleurs area.

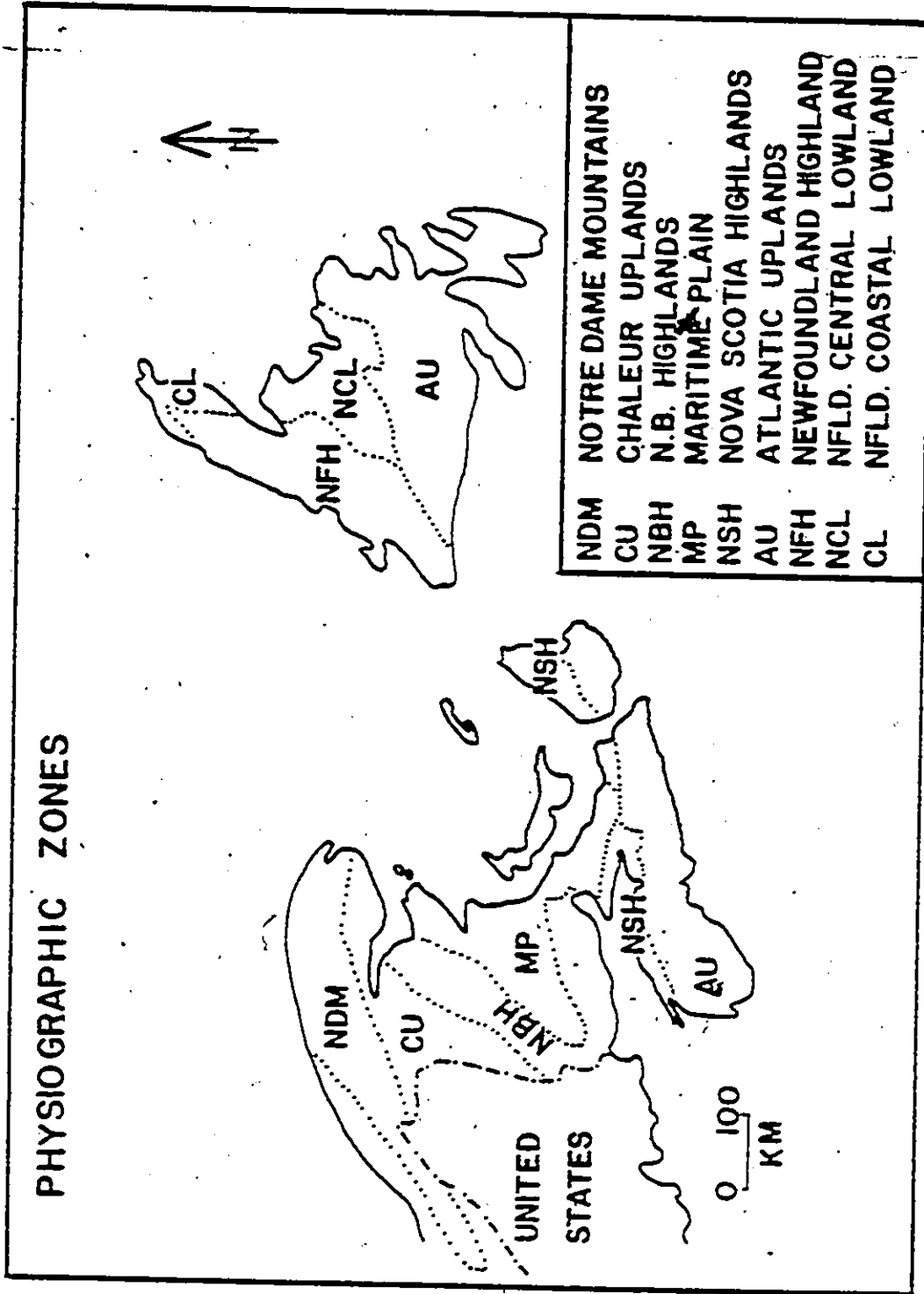


FIGURE 3: Physiographic Zones within Eastern Maritime Canada
 (after Williams et. al., 1972)

1.2 PREVIOUS WORK

The Baie des Chaleurs area has been a region of periodic geologic interest since the early to mid 1800's (Logan, 1846). Geologic investigations during the late 1800's were predominantly concerned with Devonian fish fauna within the "Atholville" beds and the Escuminac Formation near the western limit of the Baie (Whiteaves, 1881, 1889). The Geological Survey of Canada mounted major regional mapping studies in the area during the late 1920's and early 1930's (Alcock, 1935). The purpose of these studies was to determine the structure, stratigraphy and geographic distribution of the rock units within the area; and to determine the presence or absence of commercial mineral deposits.

The late 1940's and early 1950's saw renewed interest in the Devonian fish-bearing units (Orvig, 1957; Stensiø, 1958); and in detailed township mapping by the Quebec and New Brunswick Department of Mines. The latter investigations were intent on redefining stratigraphic and structural relationships in the field, and proposing depositional environments for the respective formations.

Kindle (1930) was the first to subdivide the Devonian succession within the Baie area. He proposed a five fold subdivision (A through E), listed below in descending order:

- 1. E- Grey argillaceous shales and sandy shales interbedded shaly and thin bedded sandstones terminating in a 16-foot member (E1) of reddish beds. Fossil fish and fine plant fossils (Escuminac Beds, Miguasha Bay)....370 feet
- 2. D- Coarse rounded-pebble and boulder conglomerate in grey matrix. Barren of fossils (Fleurant conglomerate); type locality Fleurant Point; also seen at Mushroom Rock (now eroded away)¹ and 1/3 mile southeast of Englishman's Creek (recently changed to Brook)¹45 feet
- 3. C- Coffee coloured shale (dull red, wet) with occasional green bands. Upper part with a conglomerate, 0 to 40 feet (C1). Lower part of formation partly concealed. Barren of fossils: (both sides of mouth of Englishman's Creek)....450 feet
- 4. B- Coarse, angular-pebble conglomerate with salmon coloured matrix....210 feet
- 5. A- Angular-pebble conglomerates interbedded with chocolate, green and grey argillaceous and sandy shalesapprox.400 feet

Kindle (1930) proposed that units A, B, and C were equivalent to the Gaspé Sandstone Series of Early Devonian age. He believed units D and E to be of Middle to Late Devonian age.

¹ added by the author from listing by Dineley and Williams, 1968 a.

Alcock (1935) modified Kindle's Devonian stratigraphy for the succession in the western Baie area. Alcock placed unit A with the Gaspé Sandstone Series and proposed that units B and C should have formational status (ie Pirate Cove Formation). Alcock (op. cit.) believed that the Pirate Cove was conformably overlain by the Fleurant and Escuminac Formations, not recognizing the well-developed unconformity to the east of Englishman's Brook.

Williams and Dineley (1966) were the first to note the unconformity between the Pirate Cove and Fleurant Formations. They proposed the stratigraphic framework that is used in this study (Table 1).

Williams and Dineley (1966) grouped the La Garde Formation (which rests unconformably upon lowermost Devonian (Siegenian) "basement"), and Pirate Cove Formation (which conformably (?) overlies the La Garde) into a Lower to Middle Devonian sequence. The Fleurant and conformably overlying Escuminac Formation were grouped together into the Upper Devonian 'Miguasha Group'. The Carboniferous Bonaventure Formation caps the terrestrial succession in the Baie area. It rests unconformably upon the Miguasha Group along the southern Gaspé shore, and rests unconformably upon pre-Devonian "basement" in New Brunswick.

Alcock (1935) noted the continental fluvial nature of the formations under study. Dineley and Williams (1968 a,b), in a more detailed account of the Devonian strata within the western Baie des Chaleurs area, proposed that the Pirate

	ALCOCK (1935)	WILLIAMS and DINELEY (1966)
CARBONIFEROUS	BONAVENTURE FM. — u/c —	BONAVENTURE FM. — u/c —
	ESCUMINAC FM.	ESCUMINAC FM.
UPPER DEVONIAN	FLEURANT FM.	FLEURANT FM. — u/c —
	PIRATE COVE FM. — ? — u/c — ? —	MIGUASHA GROUP
MIDDLE DEVONIAN	GASPE SANDSTONE GROUP — u/c —	PIRATE COVE FM.
	VOLCANIC and SEDIMENTARY ROCKS	LA GARDE FM. — u/c —
LOWER DEVONIAN		VOLCANIC and SEDIMENTARY ROCKS

TABLE 1: Stratigraphy of the Western Baie des Chaleurs Area
(after Alcock, 1935 ; Williams and Dineley, 1966)

Cove, Fleurant and Escuminac Formations were deposited "in a series of alluvial fans, flood plains, river channels and lakes" (Dineley and Williams, 1968a, p241). No mention was made of the fluvial style active during sedimentation, nor was a description of tectonic and depositional models given for either the Pirate Cove or Fleurant Formations. The Escuminac Formation was attributed to a lacustrine-turbidite origin. H. Shaw (per. comm. 1981) and M. Arsenault (per. comm. 1979, 1980) have determined that the Escuminac was deposited in brackish lacustrine waters.

Dineley and Williams (1968 a,b) subdivided the Pirate Cove Formation into five informal members ("units") based on their lithological characteristics. They proposed that the Pirate Cove was deposited as an "alluvial-fan floodplain complex.....from the northeast quadrant" (1968b, p950); however paleocurrent data given later show that the main source area was toward the northwest. Dineley and Williams (1968 a,b) interpreted the Fleurant Formation as a fluvial deposit and postulated a northeastward source terrain. This also will be re-evaluated in light of paleocurrent and clast studies given in this report.

The Carboniferous Bonaventure Formation has only been mentioned in passing by investigators in the Baie des Chaleurs area. The Bonaventure to date has been regarded as a thin capping succession to the more intensively studied Silurian-Devonian "basement" in the region. The Bonaventure

Formation has been mapped to the east as far as Percé by Alcock (1935), and was briefly mentioned by McGerri-
gle(1950), Badgley(1956), Aryton(1961,1967) and Sanschagrin
(1963).

The models proposed for the Bonaventure range from an "outwash fan delta" model by Sanschagrin (1963) to a "fan-glomerate" classification proposed by Belt (1968a). Some workers have proposed that the Bonaventure Formation is the proximal equivalent of the Bathurst and Clifton Formations in North and Central New Brunswick (Alcock, 1935; Howie and Barss,1963; Legun,1980) but others raise serious doubts to this hypothesis based on stratigraphic and palynological evidence (Van der Poll,per. comm. 1981).

Hacquebard (1972) correlated the Bonaventure Formation with the Riversdale and Canso Groups of Namurian to Westphalian A age. The Clifton and Bathurst Formations have been correlated with rocks of the Pictou Group. Table 2 shows this correlation, along with the correlations of the other units in this study.

Little detailed sedimentological work on the Devonian to Carboniferous succession has been undertaken since the early 1960's, aside from that of Béland (1958), Dineley and Williams (1968 a,b) and Zaitlin (1981). Present work within the study area includes that by H. Shaw of McGill University, Montreal, who is investigating the thermal maturation of shales within the Escuminac Formation ; M. Arsenault of the

	MIGUASHA	FORRILLON	QUEBEC	NORTH CENTRAL NEW BRUNSWICK	SOUTH BRUNSWICK	CAPE BRETONIS.	GRAND BANKS
PERM							
CARBONIFEROUS							
UPPER				CLIFTON FM. BATHURST FM.	PICTOU GROUP BOSS PT. FM.	PICTOU GROUP CUMBERLAND GR.	
LOWER		C.D.R. BONAVENTURE FM.			HOPEWELL GROUP	RIVERSDALE CANSO GROUP WINDSOR GR.	HORTON GROUP
DEVONIAN							
UPPER	ESCUMINAC FM. FLEURANT FM.			ALBERT FM. PERRY FM.			
MIDDLE	PIRATE COVE FM. LA GARDE FM.	MALBAIE FM. BATTERY PT. FM. YORK RIV. FM.				MCADAM LAKE FM. KNOYDART FM.	
LOWER	CARBONATE	INDIAN COVE FM.		CARBONATE			

TABLE 2: Stratigraphic Correlation of selected Devonian and Carboniferous Successions in Eastern Maritime Canada (after Hacquebard, 1972: St.-Julien et. al., 1972: Howie and Barss, 1975a) CDR, Cannes de Roches

Quebec Department of Tourism who is actively engaged in the study of the Escuminac macrofossils; and township mapping by the New Brunswick Department of Mines. No other geologic work is being undertaken in the area that is known to the author.

1.3 REGIONAL GEOLOGY AND TECTONICS

The Baie des Chaleurs region is part of the Appalachian Structural Province of eastern Maritime Canada (Williams et al. 1972). The Baie region is within the northern New Brunswick subzone of the Axial tectonic zone of Kennedy (1979); and is located in the Dunnage zone of Williams (1979). (The tectonic zonation proposed by both Kennedy and Williams is based upon the deformation history of the pre-Devonian "basement" rocks, and has little to do with the overlying Devono-Carboniferous sediments.)

The Baie des Chaleurs is within the Chaleur Bay Syncline of the Matapedia Anticlinorium (St. Julien et al., 1972). The study area is to the south of the Notre Dame Highlands and to the north and west of the New Brunswick Highlands (Figure 3). The area forms a small outlier of the New Brunswick Platform, which during the Carboniferous may have covered a much wider area than at the present. (Figure 4).

The pre-Siegenian "Basement" within the Baie area consists of shallow water carbonates, sandstones and volcanics of the Restigouche and Matapedia Groups of (Cambro-?) Ordovician to Silurian age (St. Julien et al., 1972). These de-

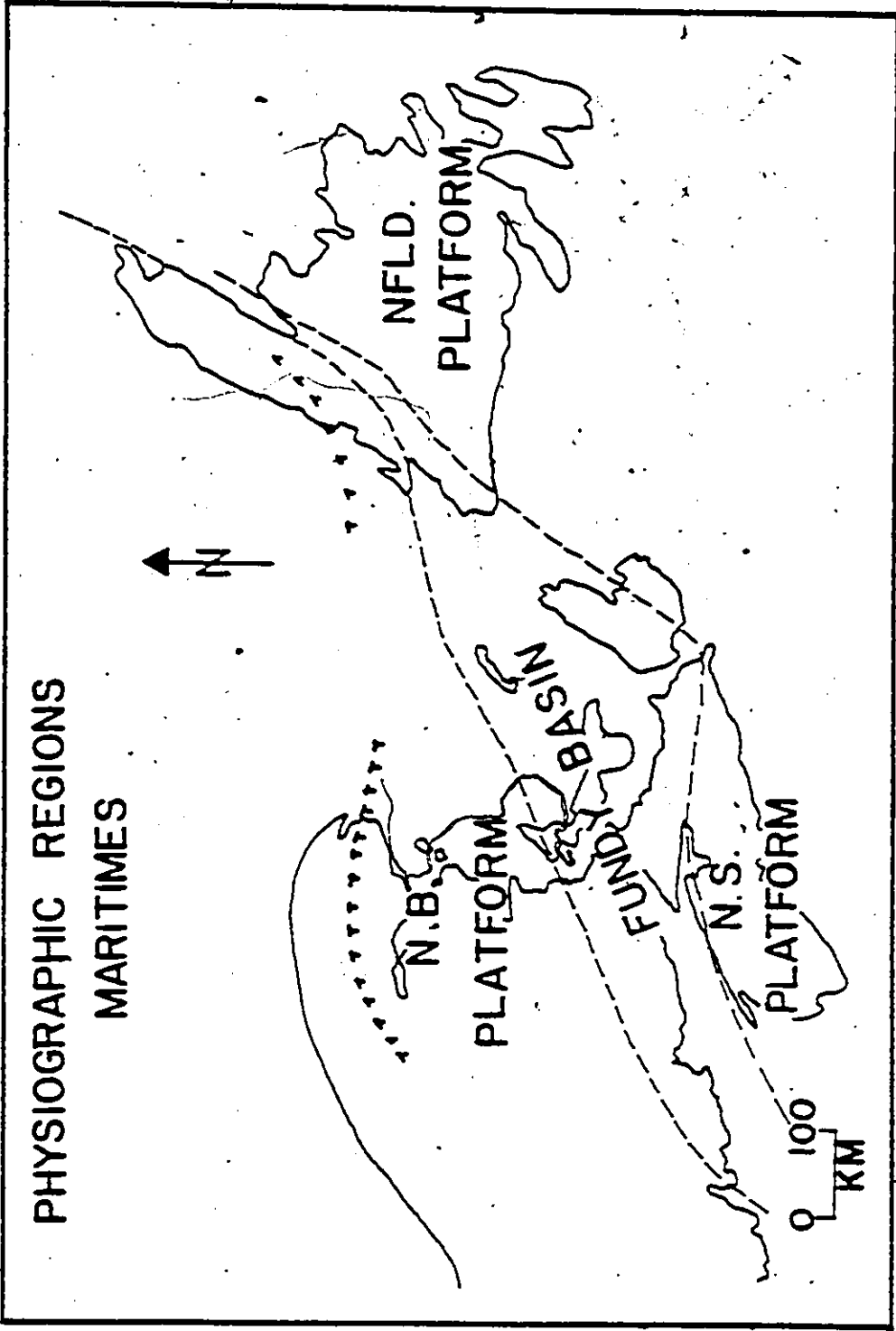


FIGURE 4 : Carboniferous Paleophysiographic Subdivisions within the Maritime Provinces (after Macquebard, 1972)
 T T T Limit of Deformation

posits were deposited within shallow epicontinental seas and coastal plains associated with the Iapetus Ocean (Poole, 1976). The "basement" may have undergone up to three orogenic events- Late Precambrian (Avalonian); Ordovician (Taconic); and (Late Silurian?) Devonian (to Permian) (Acadian-Appalachian). The main event that affected the Devonian-Carboniferous succession is the Acadian (and Appalachian?) Disturbance (Poole, 1967; 1976; Schenk, 1978; Williams, 1979).

The closure of the Iapetus Ocean by the continental collision of Laurentia, Baltica, Avalonia and England, (mid-Devonian?) (sensu Scotese et al, 1979), possibly resulted in the formation of small, isolated depositional basins within the Baie des Chaleurs area. These basins formed as strike-slip/half graben or intermontane/successor basins (Poole, 1967, 1976) as the result of postulated oblique collision between the plates (Scotese et al, op.cit.). NW-dipping subduction, with Baltica overriding Laurentia, occurred to the SE of the Baie des Chaleurs. Rust (in press (b)) postulates that the collision resulted in broad shallow upwarping, and the deposition of molasse-like deposits of Devonian age near the eastern tip of the Gaspé (York River, Battery Point and Malbaie Formations). These deposits are marked by their uniformity across their respective depositional basins, and the lack of fan deposits which would indicate abrupt source relief. The Pirate Cove will be shown to

possess fan deposits and will be discussed in relation to the above theory. This tectonic event is the Acadian Disturbance, which may have started as early as the Middle Silurian in some parts of the Maritimes. Continental molasse sediments were deposited in these basins as a result of this disturbance.

The Acadian Disturbance appears to "grade" into the Appalachian or Maritime Disturbance (U. Devonian to Permian?); and may have resulted in the reactivation of Acadian zones of weakness due to renewed continental collision to the southeast (Poole, 1967, 1976). Williams (1979) noted the lack of volcanics and ophiolites present in postulating that the latter Disturbance was not due to a collision that included subduction. Scotese et al. (1979) and Ziegler et al. (1979) theorized a collision between Laurasia and Gondwana to the SW during the formation of Pangea, causing sinistral movement along the previously-existing Acadian zones of weakness. The sense of movement along the resulting wrench fault or oblique strike-slip fault planes is problematic.

One example of this is the dextral movement attributed to the same collision by Arthaud and Matte (1977). The discrepancy in sense of movement may be attributed to the fact that these fault zones may have had different directions of movement during different times of their history.

The Acadian Disturbance has been correlated with the Caledonian Event of Europe which resulted in the deposition of the Old Red Sandstone (Allen et al, 1967; Howie and Barss, 1963, 1975a, b; Poole, 1967; and many others). Similar evidence equates the Appalachian Disturbance with the Alleghenian of the eastern United States and the Hercynian of Europe (Scotese et al, 1979; Zeigler et al, 1979).

1.3.1 Geology of the Western Baie des Chaleurs Area

The stratigraphy of the western Baie des Chaleurs area is presented in Table 1. The formations investigated in this study include the Lower to Middle Devonian Pirate Cove Formation (approx. 545 m); the Upper Devonian Fleurant Formation (approx. 18 m); and the Lower Carboniferous Bonaventure Formation (approx. 200 m within the study area) ranging up to 300 m at the eastern tip of the Gaspé Peninsula. The other units that complete the approximately 2.5 km thick molasse sequence in the study area include the La Garde and Escuminac Formations. Table 2 attempts to summarize the succession and their correlatives throughout the Maritimes.

The Pirate Cove Formation has been correlated with the Battery Point and Malbaie Formations (McGerrigle, 1950; Dineley and Williams, 1968 a, b; McGregor, 1963, 1973). The Miguasha Group has been correlated with the Horton Group (Howie and Barss, 1975a, b). The Bonaventure Formation correlates with the Cannes de Roches and possibly with Canso-Rivers-

dale rocks of the southern Maritimes (Alcock, 1935; Howie and Barss, 1963, 1975a, b; Belt, 1968a; Hacquebard, 1972).

1.4 FLUVIAL SYSTEMS- A DISCUSSION

1.4.1 Introduction

Channel patterns of fluvial systems have been subdivided into four main varieties:

1. straight
2. anastomosing
3. meandering
4. braided

by a variety of authors (Schumm,1968,1977; Rust,1977,1978a). Straight fluvial systems are rare at the present day, and have yet to be recognized in the ancient succession. Anastomosing systems are widespread today within tectonically active (aggrading?) dry to humid areas, and have only in the past few years undergone intensive study (Smith and Smith, 1980;Smith and Putnam,1980; Legun and Rust,1981,in prep.; Rust, in press (c)). Meandering systems are relatively well known in both the present and ancient successions, encompassing a wide range of depositional and climatic environments (Allen, 1970,1965,1964 etc.). An interesting review of the study of fluvial deposits is presented by Miall (1978a).

1.4.2 Braided Fluvial Systems

The braided fluvial system has only been under intensive study within the last 15 years. The last three years has seen the development of a series of depositional models to

help explain the braided fluvial process (Miall, 1977, 1978b; Rust, 1978b). These models are based on both modern and ancient braided fluvial successions ranging from glacial fluvial (ex. Boothroyd and Ashley, 1975; Williams and Rust, 1969; Rust, 1972b, 1975) to ancient deposits (ex. Cant and Walker, 1976).

Lithofacies as outlined according to the scheme proposed by Miall (1977, 1978b) and Rust (1978b) are subdivided on the basis of their:

1. lithology - gravel (G) vs sand (S) vs silt and mud (F)
2. structure - type and scale of structure

Lithofacies are determined by the dominant lithology and structure within the bedding unit, and may be gradational, abrupt, erosional etc., with the units above or below. The sequence of states, the presence or absence of cyclicity, and the vertical and horizontal variations of the lithofacies aid in the reconstruction of the original depositional environment.

Table 3 lists the models proposed for braided fluvial successions by Miall (1977, 1978b) and Rust (1978b). The models are subdivided on the basis of:

1. dominant lithofacies association
2. proximity to source terrain
3. energy level during deposition- including duration

4. sedimentary structures and the presence or absence of cyclicity.

Miall (1977,1978b) subdivided gravel-dominated braided environments into the Trollheim, Scott and the Donjek models. These models are equivalent to those proposed by Rust (1978b) as G1, G2 and G3 respectively. The G1 /Trollheim model is characterized by poorly sorted, angular, clast- to matrix-supported conglomerates. These conglomerates are massive to thickly bedded, with abundant erosional surfaces, and may show no cyclicity on a local scale. Large scale repetitive alluvial fan sequences have been reported from Norway (Steel et al, 1977; Steel and Aasheim, 1978). Muddy matrix-supported conglomerates (Gms) indicate deposits of debris flow origin in a proximal fan position. This type of deposit is reasonably diagnostic of a proximal alluvial fan, above the intersection point (Hooke, 1967; Hooke and Rohrer, 1979), in which channel processes are not the dominant transporting medium. Sheetfloods and mass movements of either an ephemeral or seasonal nature are the main transporting process.

The Scott model (or G2) has been proposed for mid- to distal alluvial fan proximal gravel-dominated braided fluvial deposits. These conglomerates are horizontally bedded to massive, and can be well imbricate (Gm). Gravels of this type were most likely deposited as the result of channel or sheetflood processes.

ASSEMBLAGE	NAME	LITHO FACIES		ENVIRONMENT	COMMENTS
Rust, 1978b	Miall, 1977, 1978b	Rust, 1978b	Miall, 1977, 1978b MAIN MINOR		
O1	Trollheim	Gms, Gm, St Sp, Pl/Pm	Gms, Gm St, Sp, Pl, Pm	Proximal rivers alluvial fans subject to debris flow.	Great lithological variation. Crude cycles may be present.
O11	Scott	Gm, Op, Sp Sh	Gm Op, Gt, Sp, St Sr, Pl, Pm	Proximal rivers (incl. Alluvial fans) with stream flows.	Gm may contain well developed imbrica- tion. Gp dominate in Pre-U Paleosol deposits.
O111	Donjek (cyclic)	Gt, St, Gm, Sh, Pl	Gm, Gt, St Op, Sh, Sr, Si	Distal gravelly rivers.	Fining upward cycles.
S11	South Saskatchewan (cyclic)	Se, St, (Se) Sp, Sr, Pl/Pm	St Sp, Se, Sr, St, Se, Si, Gm, Pl, Pm	Distal sandy rivers on Alluvial braid plain.	Fining upward cycles. Transitional with meandering rivers.
S1 (Bijou)	Platte (non-cyclic)	Sh, Sp, Sr	St, Sp Sh, Sr, Se, Gp Pl, Pm	Distal sandy rivers on Alluvial braid plain.	Sh dominant
f1 (Kaibale)	Bijou	Se, St, St, (Sa)	Sp, Sr	Ephemeral deposits Ephemeral deposits	Scour surfaces and facies variability.
S11t		Pl/Pm		Distal braid plain with colluvial reworking.	

TABLE 3: Braided Fluvial Models (after Miall, 1977, 1978b; Rust, 1978 b)

The Donjek model of Miall (1977), analogous to the G2 model of Rust (1978b) deals with braided deposits in the mid- to distal braided river and/or braidplain characterized by cyclic deposits of coalescing longitudinal bars. These deposits contain a paucity of fines, which are only found capping fining-upward cycles as Fm deposited out of suspension. The predominant process is the reworking of clasts during cyclic flood conditions. Well-developed imbrication and channels are to be expected.

Sand-dominated braided fluvial deposits are divided into the cyclic South Saskatchewan type; the non-cyclic Platte River model; and the ephemeral (Malbaie and/or) Bijou Creek deposit (Miall, 1977, 1978b). These are analogous to Rust's (1978b) S2 and S1 types for the first and last two pairs respectively.

The sand-dominated deposits may be transitional between themselves and/or with meandering or anastomosing deposits. Large tracts of the alluvial braidplain in which these deposits accumulate are inactive during long durations of time, allowing for the formation of calcretes, silcretes, ferri-cretes, coal etc., dependent on the climatic conditions.

Detailed discussion of the models presented in Table 3, and the lithofacies contained within, will be given during the analysis of the formations under study.

1.5 AIMS OF STUDY

Little detailed work concerning the depositional environments and the tectonic models controlling basin development has been undertaken in the Baie des Chaleurs area for the Devonian to Carboniferous molasse succession. The aims of the study are to determine:

1. depositional environments and history of the Pirate Cove, Fleurant and Bonaventure Formations.
2. if models proposed for alluvial fan and braided fluvial deposits by Miall (1977, 1978b) and Rust (1978b) can be applied successfully to these ancient terrestrial successions.
3. a paleogeographic reconstruction for each of the formations studied on the basis of their lithofacies, outcrop distribution, paleocurrents and clast composition.
4. changes (if any) in sedimentation style during the period of deposition of these units, and to determine if these changes were a result of tectonic, climatic or other changes within the environment.

1.6 METHOD OF STUDY

Field investigations in the Baie des Chaleurs area commenced during the fall of 1979, and continued during the spring and fall of 1980. A total of 15 detailed stratigraphic sections of the sea cliffs and pit exposures were measured, comprising:

1. Pirate Cove 4
2. Fleurant 1
3. Bonaventure 10

Measurements of bedding thickness, lithology, nature of contacts, clast size, lateral and vertical facies changes and paleocurrents were recorded. Photos and representative samples were taken back to the lab for analysis. In addition, 4 drill hole logs through a portion of the Bonaventure from Heron Island were obtained. The original core was unfortunately discarded by officials of the N.B.E.P.C. prior to 1979.

Field investigation was supplemented by computer analysis of the cyclicity within measured sections (Markov Analysis); and X-Ray Diffraction and Atomic Absorption analysis was undertaken on the calcrete of the Bonaventure. Representative thin sections were examined for each formation.

1.7 ACKNOWLEDGEMENTS

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Chapter II

PIRATE COVE FORMATION

2.1 INTRODUCTION

The Lower to Middle Devonian Pirate Cove Formation (approx. 545 m thick) is located near the northwestern end of the Baie des Chaleurs (Figure 5). The Pirate Cove outcrops within a gently folded NE-SW trending syncline, parallel to the axis of Englishman's Brook. Outcrop is present from Escuminac Point eastwards past Englishman's Brook for approximately 1 km. The Pirate Cove is believed to be conformable on the underlying La Garde Formation; and is unconformably overlain by the Upper Devonian Fleurant Formation (Williams and Dineley, 1966).

Relatively little detailed work has yet been completed on the Pirate Cove Formation. McGregor (1963, 1973), and McGregor (in Dineley and Williams, 1968 b, p. 949) dated the Pirate Cove to be of Emsian and/or Eifelian age. On this basis the Pirate Cove has been correlated with portions of the Battery Point and Malbaie Formations of Eastern Gaspé.

Dineley and Williams (1968 a, b) subdivided the Pirate Cove into five depositional units (Figure 6) representing deposition within an "alluvial fan - floodplain complex of sediments the derivation of the clastic components being dominantly from the northwest quadrant." (1968 b, p. 950).

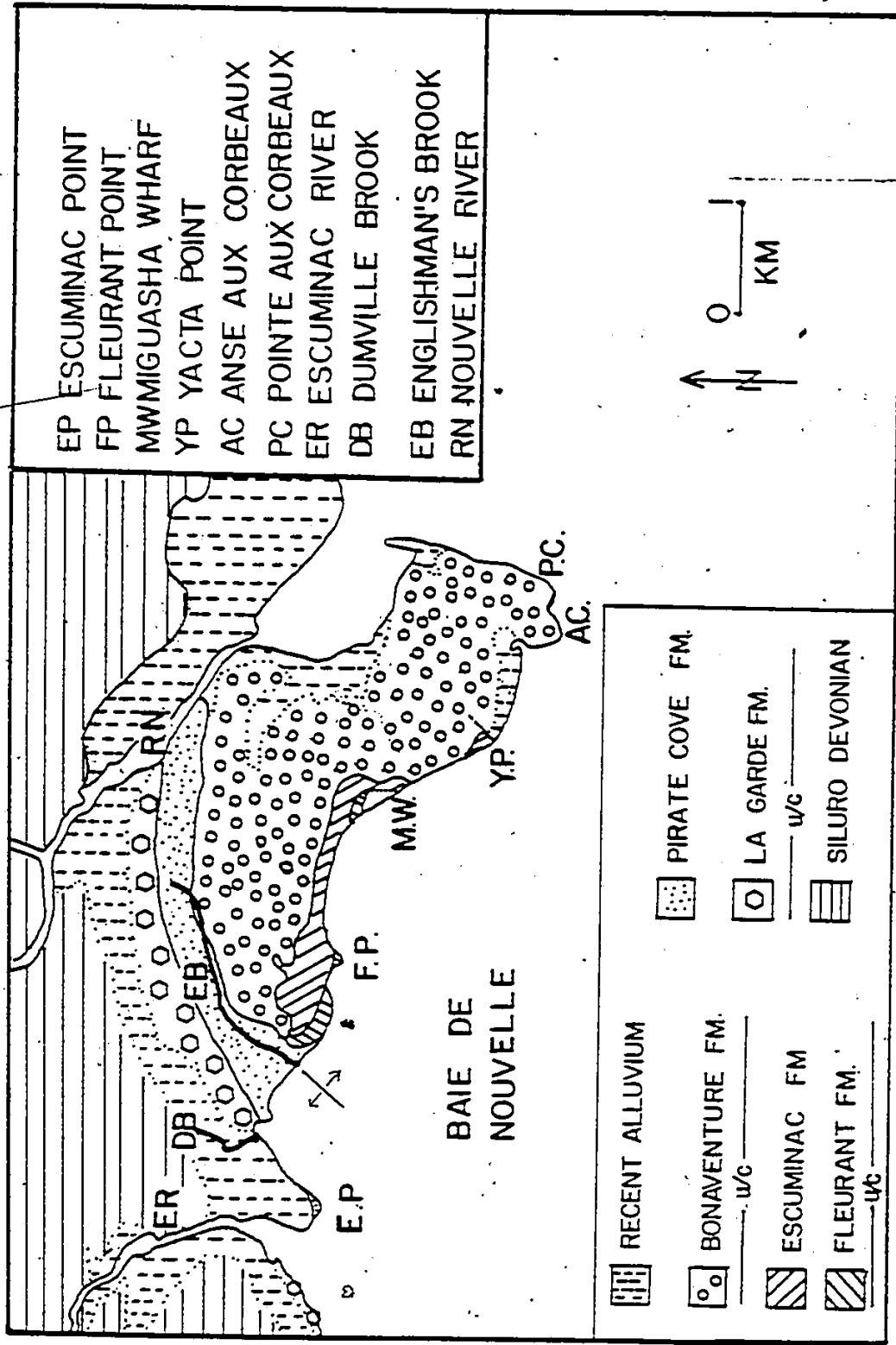
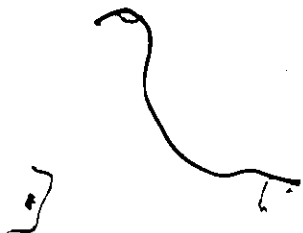


FIGURE 5: Baie de Nouvelle Geology (after Dineley and Williams, 1968a,b)

↕ Syncline

Figure 6 gives the spatial arrangement of the subdivisions about the Baie de Nouvelle coast.



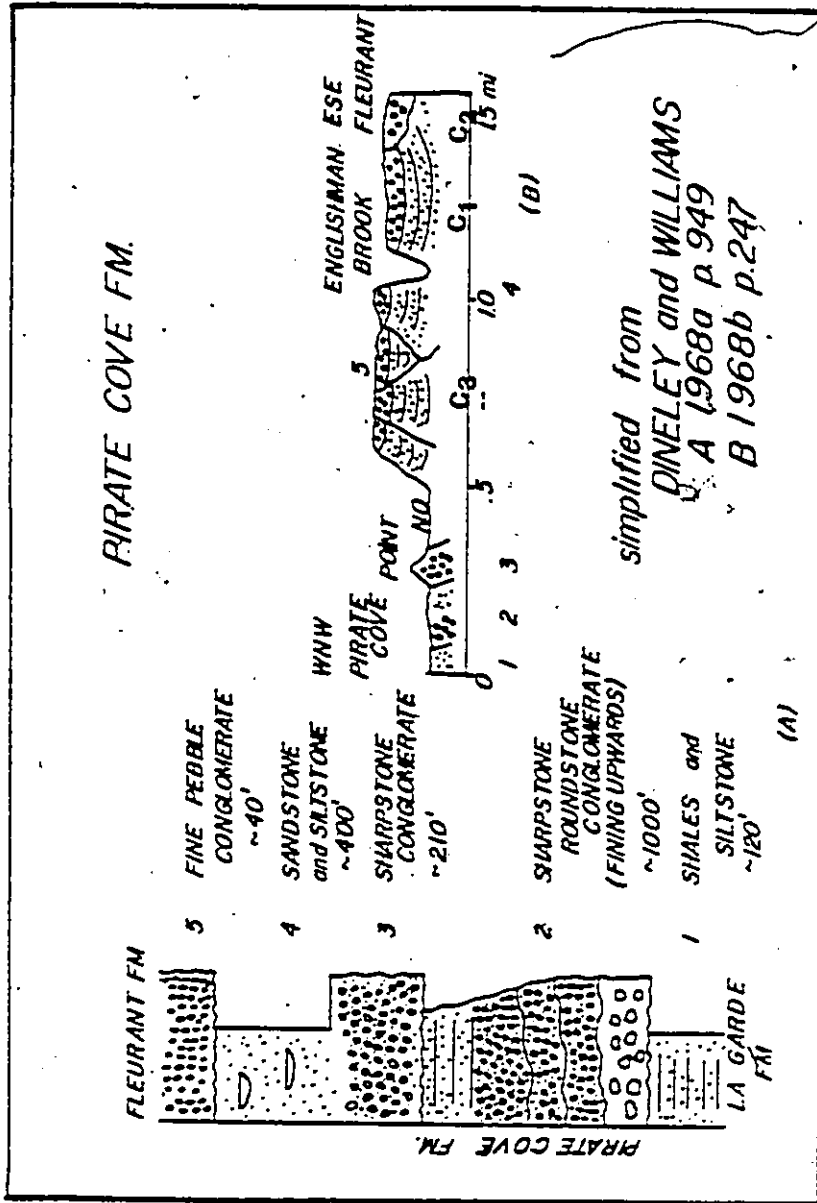


Figure 6: a) Composite section exhibiting the 5 depositional units of the Pirate Cove Formation
 b) Spatial distribution of Pirate Cove depositional units about the Baie des Nouvelles - with approximate locations of measured sections from this study (C1-3).

2.2 LITHOFACIES

The Pirate Cove Formation is composed of 11 distinct lithofacies states, as outlined by Miall (1977,1978b) and Rust (1978b). Table 4 summarizes the structures associated with the listed lithofacies.

2.2.1 Lithofacies States in the Pirate Cove Formation

2.2.1.1 Mudstone, Siltstone and Fine Sandstone

1. Fm- Red to dark grey finely laminated to massive siltstone and mudstone . Fm ranges in thickness from mm.'s representing mud drapes ,to m's in thickness representing overbank deposits from suspension. Internal structures include ripples, desiccation cracks, plant chaff, rootlets, rhizoconcretions, incipient caliche and caliche nodules, and isolated reduction spots. In some cases Fm contains thin grey to grey-green layers that may have marked a fluctuating water table. Fm is usually present in cyclic fining-upward deposits as a capping unit.
2. Fl- Red and mottled siltstone to fine sandstone exhibiting low angle (< 10 degrees) planar x-stratified sets. Other structures include ripple x-lamination and ripple drift, desiccation cracks , caliche nodules and occasional rip up clasts. Fl units range

LITHO-FACIES	GRAVEL SAND				STRATIFICATION				STRUCTURE				COLOUR		CALICHE						
	Gm	Gms	Sh	Sp	Sp	Sl	Sr	Sp/Sr	Fl/S-	Fl	Fm	1	2	3	4	1	2	3	4		
BOULDER	C	R																			
COBBLE	A	A																			
PEBBLE	A	A	A	A	A	A	A	A	A	A	A										
COARSE	C	A	C	C	C	C	C	C	C	C	C										
MEDIUM	C	C	A	A	A	A	A	A	A	A	A										
FINE	R	C	A	A	A	A	A	A	A	A	A										
SILT & MUD	C	C	R	R	R	R	R	R	R	R	R										
MASSIVE	A	A																			
HORIZONTAL	C	C	A	A	A	A	A	A	A	A	A										
PLANAR BEDDED	R	R	C	A	A	A	A	A	A	A	A										
TROUGH X-BEDDED	R	R	A	A	A	A	A	A	A	A	A										
PLANAR LAMIN.	C	C	A	A	A	A	A	A	A	A	A										
DUNE			R	R	R	R	R	R	R	R	R										
GRADED	R	R	R	R	R	R	R	R	R	R	R										
RIPPLES			R	R	R	R	R	R	R	R	R										
LINEATION																					
CURRENT CRESCENT	C	R																			
DESICCATION CRACKS			R	R	R	R	R	R	R	R	R										
IMBRICATION	A	A																			
ROOTLETS			A	A	A	A	A	A	A	A	A										
RED	A	A	A	A	A	A	A	A	A	A	A										
DRAB			R	R	R	R	R	R	R	R	R										
	R	R																			
			C	C	C	C	C	C	C	C	C										
			C	C	C	C	C	C	C	C	C										

TABLE 11 : Structures of Pirrate Cove Formation Lithofacies

R- Rare ; C- Common ; A - Abundant

1- rhizocconcretions; 2- isolated nodules; 3- nodular crusts; 4- well developed caliche

in thickness from .25 to 3 m, and can be transitional to Fm and Fl/S... . Fl most probably represents deposition in the upper portion of the low flow regime during crevasse-splay, sheetflood or channel fill events.

3. Fl/S... -consists of interbedded Fl and fine to medium ripple drift and small scale trough x-bedded and planar x-bedded sandstones. Occasional horizontal and current lineated sandstones. Fl/S... ranges in thickness from .1 to 3 m and occurs in cyclic repetitions within flood deposits. Fl/S... is transitional with Fl and a variety of S lithofacies, and usually shows gradational contacts.

2.2.1.2 Fine to Pebbly Sandstones

1. Sp/Sr- Fine to coarse interbedded sandstones exhibiting ripple drift and planar stratified sets (up to .2 m thick sets) in .1 to 2 m thick composite sets. Sp/Sr are present within both fining- and coarsening-upward cycles, and are transitional with Sp, Sr, and Fl/S... facies.
2. Sr- Fine to medium sandstones exhibiting small to medium scale current ripples and ripple drift. Occur in .1 to .4 m thick sets, with composite sets reaching 2 m. Present within fining- and coarsening-upward cycles in sheetflood, crevasse-splay/levee and

channel fill deposits. Sr is transitional with Sp/Sr, St and Sp lithofacies, and can have either abrupt or erosional contacts.

3. St- medium to pebbly sandstones exhibiting solitary or grouped sets of medium to high angle trough x-beds. Sets range in thickness from .1 to .3 m, with composite sets up to 1 m. St is transitional into Sp and Sr facies in sheetflood, bar, and crevasse splay/levee type deposits.
4. Sp- Fine to pebbly sandstone exhibiting moderate to high angle, solitary to multiple planar x-bedded sets from .1 to .5 m thick.
5. Sh- Medium to coarse horizontally laminated to finely bedded sandstones up to 1.2 m thick. Sh may show well-developed current lineations. Minor amounts of low angle planar x-stratification (Sh/1) is incorporated into Sh. Sh is thought to be deposited in the transitional phase between low and high flow regime in proximal sheetfloods.

2.2.1.3 Conglomeratic Associations

1. Gm- massive to horizontally bedded, pebble to boulder conglomerate showing open- and closed-framework, clast-supported texture with a medium to coarse-pebbly sand matrix. Clasts are poorly to moderately sorted, angular to moderately rounded and in places show very well-developed imbrication. Gm oc-

curs in both cyclic and non-cyclic deposits , and within both fining- and coarsening-upward cycles. Depositional environments include alluvial fans and a variety of bar forms within the gravel-dominated braidplain and channels. Minor amounts of planar x-bedded (Gp) and trough x-bedded gravels (Gt) are included in Gm.

2. Gms- Massive, poorly sorted open-framework paraconglomerate with pebble to boulder clasts set in a muddy siltstone to fine sandstone matrix. Deposits of this type lack any apparent internal fabric and represent debris flows on the proximal to mid portion of alluvial fan complexes (Bull, 1964, 1972, 1977; Lowe, 1976, 1979).

2.2.1.4 Other Facies

1. C- Carbonate filled rhizoconcretions, nodular crusts and 'pseudoanticlines' representing pedogenic calcrete (Allen 1974, Leeder, 1975). Caliche occurs in the distal braided fluvial region of unit 3 and the braidplain of unit 4.

2.3 STRATIGRAPHIC SECTIONS

2.3.1 Introduction

Four detailed stratigraphic logs of the Pirate Cove Formation (totalling approximately 180 m) were measured between Escuminac Point to the east of Englishman's Brook (Figure 5). Section A (Figure 7) represents the topmost portion of unit 1 and the basal portion of unit 2 located at Escuminac Point. C1 and C3 represent vertical sections through units 4 and 5 near Englishman's Brook; and are graphically displayed in Figure 8, 10. Section C2 (Figure 9) contains the contact between unit 4 of the Pirate Cove and the overlying Fleurant Formation.

Unit 3 was not measured due to poor, discontinuous (and faulted) exposure along the north shore of Baie de Nouvelle. Available outcrop was visited and found to be composed primarily of well imbricated Gm, with minor Sp, St, and Sr. The Gm was present as "sheets", .25 to 1.75 m thick, and showed well developed horizontal bedding.

Unit 3 appears to have been deposited as a result of intermittent sheetfloods depositing gravels as longitudinal (and/or traverse bars) in a shallow, low relief, proximal gravel-dominated braided-fluvial environment (Miall 1977, 1978b; Rust, 1972b, 1978b, Church and Gilbert, 1975). The paleocurrent data exhibits two well-developed directions almost at right angles, which may indicate that the unit was deposited at the junction of a braidplain and fan complex. The paleocurrent data was obtained from clast imbrication within facies Gm.

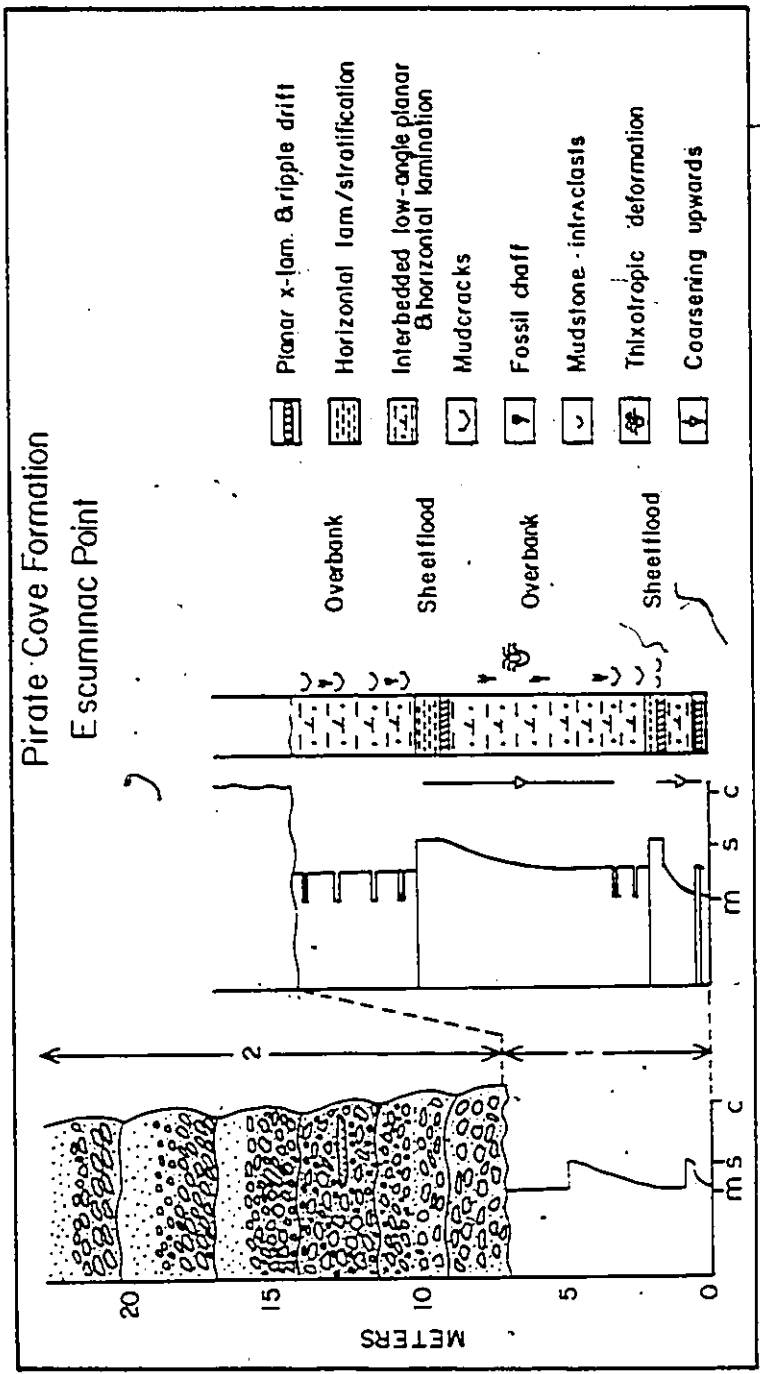


FIGURE 7 : Measured Section, Pirate Cove Formation, Escuminac Point

6

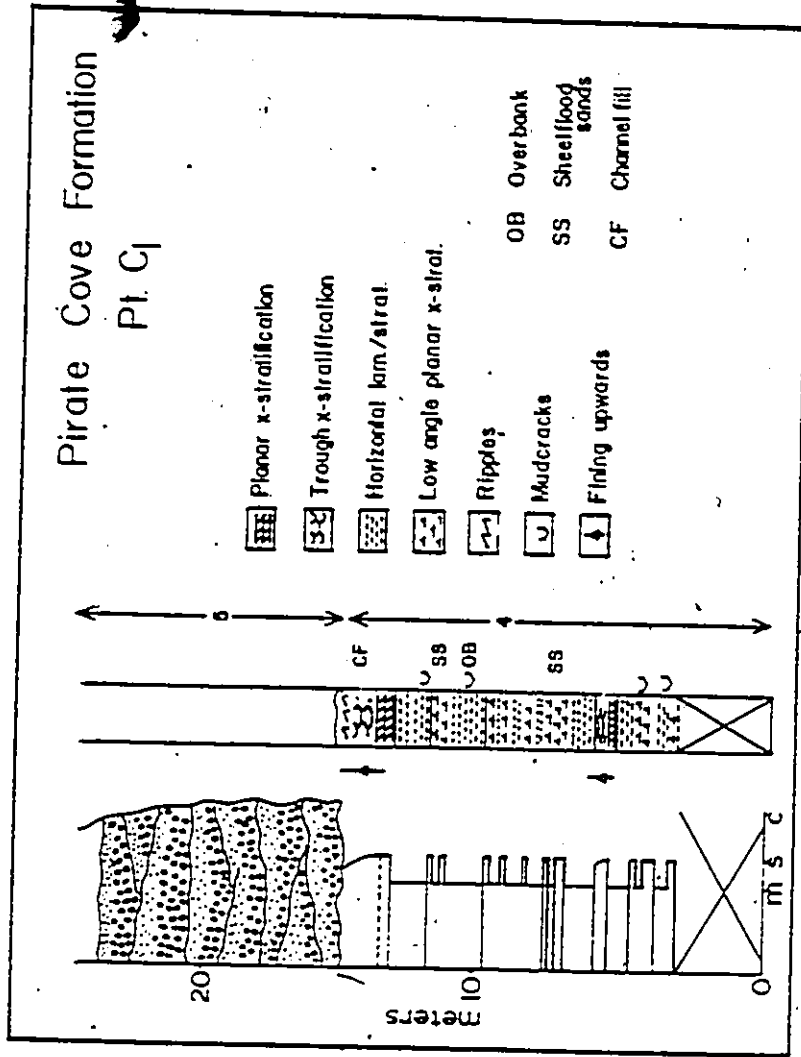


Figure 8: Measured Section, Pirate Cove Formation, Pt. C1, Units 4 and 5.

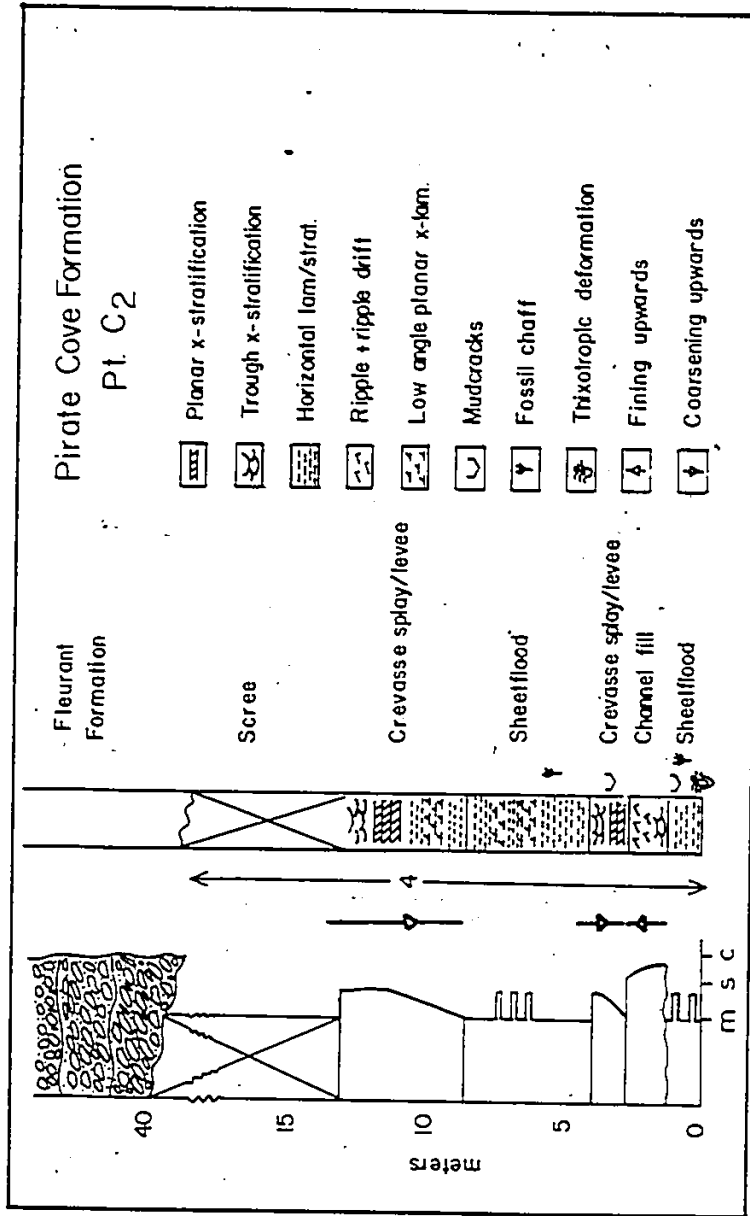


FIGURE 9: Measured Section, Pirate Cove Formation, Pt. C₂

Unit 4.

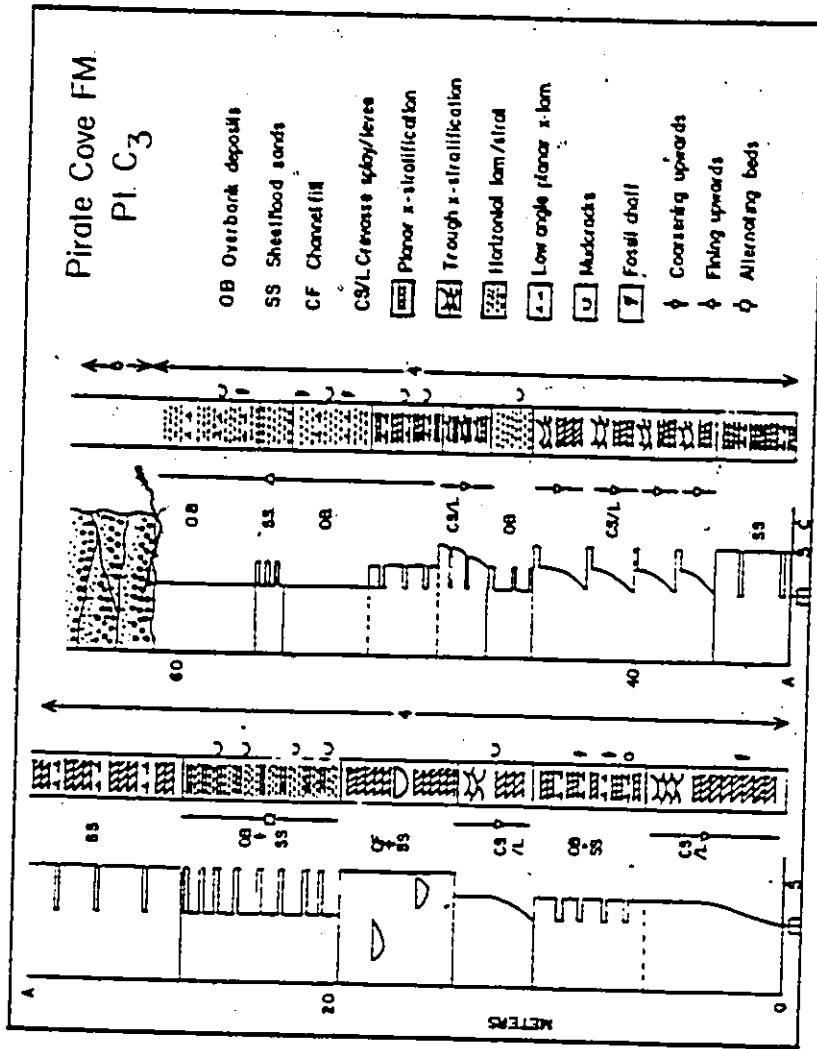


Figure 10: Measured Section, Pirate Cove Formation, Pt. C₃, Units 4 and 5.

A more detailed description of the environment of deposition for unit 3 will be given in the paleogeographic reconstruction (Section 2.7).

2.3.2 Sections

2.3.2.1 Log A Escuminac Point


The measured section at Escuminac Point encompasses the topmost 7.1 m of unit 1 and approximately the basal 20 m of unit 2 (Figure 7). Unit 1 is composed primarily of fine sandstone and siltstone of lithofacies Fl (40.2 %), Sh/l (10.5 %) and Sp (49.3 %). Unit 2 is characterized by pebble to small boulder conglomerates with minor amounts of sandstone. The lithofacies within unit 2 are Gm (60%), with Gms (5%) at the base and St (25%) and Sp (10%) scattered throughout.

The contact between units 1 and 2 is sharp and erosional, with little relief. The nature of the contact appears to show that unit 2 prograded quickly over unit 1 as a sheet. Two possibilities may explain the nature of the contact between units 1 and 2. First, the increase in grain size and the erosional contact may indicate uplift within the source area. A second possibility entails an increase in rainfall that would increase runoff, and cause coarse material to prograde over unit 1. The fact that unit 2 is a fining-upward sequence and that it forms the lower portion of a "mega" fining-upward sequence (units 2-3-4) tends to favor the hypothesis of uplift followed by degradation of the source. Also the unit is a well-developed redbed, and con-

tains minor amounts of caliche that tend to indicate little climatic change between the deposition of units 1 and 2.

Figure 7 depicts the section located at Escuminac Point. Unit 1 exhibits 2 distinct coarsening-upward cycles of red-mottled sandstones and siltstones capped by Sp and Sh/l. Interbedded within these cycles are thick zones of Fl with plant chaff and desiccation cracks throughout. The relatively thick, interbedded mudstones and siltstones (Fl) are interpreted as overbank deposits. The desiccation cracks, plant material and red beds indicate periods of subaerial exposure.

The coarsening-upward cycles, capped by Sp and Sh sandstones, may represent sheetflood deposits and/or crevasse-splay/levees. These may have developed due to channel avulsion during flood events. The presence of low angle planar x-stratification possibly indicates deposition under ephemeral discharge conditions (McKee et al., 1967; Turnbridge, 1980) Convolute laminations due to thixotropic deformation resulted when the coarser and denser flood sands were deposited upon the overbank material. The resulting density difference between flood sands and overbank fines may have caused the fines to behave as a highly mobile plastic material. The fines would then be "squeezed" upward and the coarser material would be displaced downward thereby creating the convolute laminations.



A channel fill deposit is present to the east of section A within unit 1. Coarsening-upward sheetflood sandstones appear to develop away from this feature. The large lateral and vertical variability within the unit, and the lithofacies association appear to be characteristic of silt- and sand-dominated braided fluvial deposits of an ephemeral nature. This evidence would place unit 1 into the S1 model of Rust (1978b), or the Bijou Creek model of Miall (1977, 1978b)

Another possible interpretation for unit 1 is deposition by ephemeral flood processes into an interlobe portion of a fan complex (bajada?). Limited exposure inhibits the choice of one model of deposition over the other. The author favours the first explanation.

Unit 2 is composed of angular, poorly sorted pebble to cobble Gm with minor amounts of Gms, Sp and St. The unit is thickly bedded to massive at the base, passing upward into cycles .5 to 2.5 m in thickness. The Gm in these cycles can show well-developed imbrication. The cycles fine upward from Gm - Sp-St (Plate 1). The matrix-supported Gms is found exclusively near the base of the unit, and is interpreted as distal debris flows (Hooke, 1967; Bull, 1972, 1977; Miall, 1977, 1978b; Rust, 1978b; Lowe, 1976, 1979).

Clast size appears to decrease upsection in conjunction with increased cyclicity. The fining-upward cycles of Gm or

Gm-Sp -St, and the minor sandstone channels are interpreted to represent the passing from a proximal alluvial fan to the portion of the fan that is dominated by coalescing of longitudinal (and possibly transverse) bars (Williams and Rust, 1969; Rust, 1972a, 1978b; Church and Gilbert, 1975; McGowan and Groat, 1971). Unit 2 therefore is placed, based on lithological and facies relationships, into the G1 model of Rust (1978b); or transitional between the Trollheim and Scott models of Miall (1977, 1978b).

2.3.2.2 Log C1 Englishman's Brook

Section C1 (Figure 8), located approximately 125 m east of the mouth of Englishman's Brook, contains the topmost 15 m of unit 4 and the basal 12 m of unit 5. Unit 4 is dominated by Fm and Fl lithofacies, with minor associated St, Sr and Sp sandstones. The sandstones represent deposits from sheetflood and channel fill events. Unit 5 is predominantly composed of a pebble to small cobble conglomerate (Gm) in repeated fining-upward cycles of Gm- Sp- St (-Fl).

The overbank materials within unit 4 (Fl, Fm) are well-developed red beds, with isolated nodular caliche and occasional pseudoanticlines (Blank and Tynes, 1965; Allen, 1974). Plant chaff is found throughout the unit along with small scale desiccation cracks and ripple drift.

Two distinct types of sandstone bodies are present within unit 4. The first type is composed of grey to grey-green sheeted sandstones, exhibiting fining-upward Sp- St- Sr cycles in thin, laterally extensive bodies. These grade upwards into thick Fl/S... and Fm overbank deposits. The sandstones have an abrupt to erosional base, which may indicate that they were deposited as a result of periodic overbank floods. The trough x-beds measured within these sandstones are probably a true indication of the paleoslope of the alluvial braidplain because this part of the braided tract is "instantaneously" covered by flood events (Williams and Rust, 1969; Rust, 1972a,b).

The second type of sandstone body comprises laterally extensive, shallow channel fill deposits with depth to width ratios of 1:125. A small depth to width ratio is diagnostic of braided fluvial deposits (Schumm, 1977). The sandstones that compose the channel fill are light buff-grey medium to coarse grained Sp, St and Sr lithofacies. Plate 1 shows the edge of one such channel sand cutting into adjacent overbank deposits.

The interpretation of unit 4 will be given after discussion of the unit within sections C2 and C3.

Unit 5 overlies 4 with a sharp erosional contact with minor topographic relief (< .5 m). The unit is composed of facies Gm, and is very well sorted pebble to small cobble conglomerate. Gm is present in .25 to 1.5 m thick fining-upward cycles that are usually erosionally based. The typical cycle goes from Gm- Sp- St or Gm- Sh/l- St- Sr. Minor Sp/St- Sr- Fm channel fills dissect the larger (coalesced?) cycles.

Plate 2 shows cyclic fining-upward repetitions within unit 5. Unit 5 is attributed to coalescence of longitudinal and/or traverse bars in the main braided channel tract below a fan complex (McGowan and Groat, 1971; Church and Gilbert, 1975). The G3/S2 models of Rust (1978b), or the Donjek/South Saskatchewan models of Miall (1977, 1978b) best approximate the depositional environment for unit 5.

3

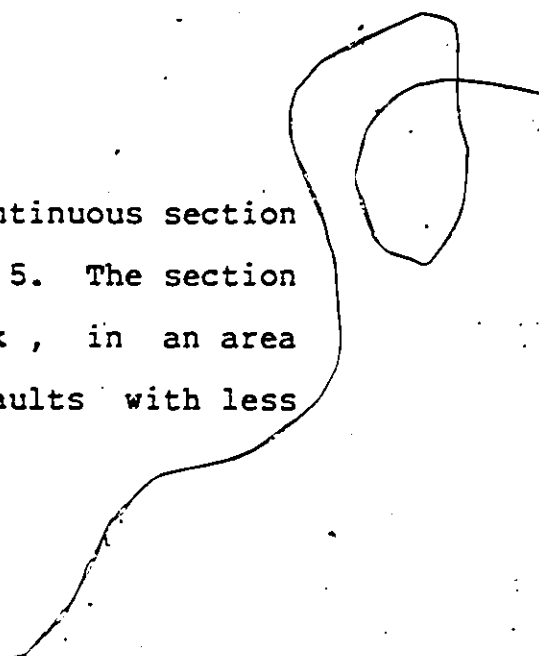
2.3.2.3 Log C2 Englishman's Brook

Section C2, located to the east of Englishman's Brook (Figure 9) represents the topmost 40 m of unit 4 and the unconformably overlying Fleurant Formation (Plate 3). Unit 5 of the Pirate Cove is completely cut out at this location. The unconformity between the Pirate Cove and Fleurant Fm. is sharp and erosional, with up to .75 m of relief. Minor amounts of Pirate Cove material are incorporated into the basal portion of the Fleurant.

Unit 4 is again dominated by Fm and Fl lithofacies of overbank origin with three distinct sandstone bodies. Types 1 and 2 are the channel fill and sheetflood sandstones described in the discussion of section C1. The third type, consisting of thick, coarsening-upward sandstone bodies, starts from an abrupt lower planar contact overlain by the cycle Sh - Sp - St. Mudchips and plant material are incorporated into the lower portions. This type of sandstone body is interpreted as either a crevasse splay or levee deposit.

2.3.2.4 Log C3 W. of Englishman's Brook

Section C3 (Figure 10) contains the most continuous section through unit 4 (62 m) capped by 10 m of unit 5. The section is located 150 m west of Englishman's Brook, in an area where unit 4 contains some minor normal faults with less



than 5 m displacement. The lack of major displacement allows the section to be reconstructed in the field.

The description of unit 5 is identical to that in section C1, and will not be further discussed.

Unit 4 can be subdivided into the 4 lithofacies associations which are interpreted as :

1. fine-grained overbank deposits
2. fining-upward sheet sandstones
3. laterally extensive channel fill sandstones
4. coarsening-upward crevasse splay/levee deposits

All 4 associations have been discussed in the previous sections and only the features not already described will be elaborated.

Large segments of unit 4 are dominated by interbedded to massive Fl, Fl/S... and Fm. Desiccation cracks at specific horizons within these .5 to 3 m thick zones, together with concentrations of rhizoconcretions and caliche nodules indicates periods of subaerial exposure. Pedogenic processes in an arid to semi-arid climate were active on the alluvial braidplain. The sequence of sediments indicate that it was deposited out of suspension in more than one event. The presence of low angle planar x-bedded material and horizontal laminations is diagnostic of ephemeral events (McKee et al, 1967; Turnbridge, 1980). This is consistent with a semi-arid climate.

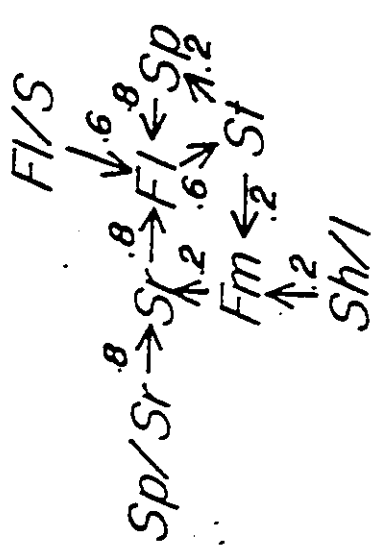
2.4 MARKOV ANALYSIS UNIT 4

Markov analysis on sand- and silt-dominated fluvial deposits has been successfully undertaken by a large number of authors for both modern and ancient fluvial successions (see Miall 1973, 1976, 1977). Markov analysis was attempted on unit 4 of the Pirate Cove Formation for the 8 lithofacies that compose the section. 31 transitions from approximately 110 m of section were recognized, and were analysed for Single Imbedded Markov Analysis according to Miall (1973), as programmed by B. Jones. The small number of transitions coupled with the number of lithofacies recognized place in doubt the absolute values obtained. The analysis can only be used to determine trends in the broadest sense, and is not to be used as an absolute indicator of cyclicity. Calculations are presented in Appendix B.

Figure 11 is the graphical representation of the analysis and of the cycles obtained. Only transitions with greater than a .2 probability of occurring have been included in the cycles.

Single Imbedded Markov Chain Analyses do not take into consideration the thickness of the units nor the fact that similar lithofacies may overlies each other with indistinct erosional surfaces. An example of this would be the thick sequences of overbank Fm deposits that are deposited as successive events.

PIRATE COVE
UNIT 4
MARKOV
ANALYSIS



- 1) Sp/Sr → Sr → FI
 - 2) FI → St → Sp → FI
 - 3) FI/S → FI
 - 4) Sh/I → Fm → Sr → FI
 - 5) Sp/r → Sr → FI → St → Sp → FI
- H ——— L
- proximal —→ distal
- crevasse
splay
sheetflood
- EROSIONAL SURFACE

FIGURE 11: Markov Analysis, Unit 4, Pirate Cove Formation (only probabilities >.2 listed)
H-----L : High Energy ----- Low Energy

Cycles 1 and 2 represent sheetflood deposits that were laid down proximal to a channel avulsion. These cycles are dominated by Sp/Sr, Sr and St deposits fining-upward to Fl. They erosionally overlie Fm and Fl overbank facies. Cycles 3 and 4 represent sheetflood sandstones capped by overbank deposits. In all 4 cases the large amount of Sh/l, Fl/S, and Fl is indicative of the ephemeral nature of the deposits.

Cycle 5 is an attempt to show the transitional nature of a proximal to distal cycle from a channel avulsion. Levee and/or crevasse splay deposits grade laterally into sheetflood sandstones that are finally overlain by overbank deposits during the waning stage of the flood event.

2.5 PALEOCURRENT ANALYSIS

Paleocurrent measurements from the imbricate Gm facies of units 2 and 3, and from the St facies within the sheet sandstones of unit 4 are shown in Figure 12, and summarized in Table 5. These data, in addition to the geometric distribution of the facies and clasts were used for paleogeographic reconstruction of the Pirate Cove Formation.

Gm facies in units 2 and 3 comprise clast-supported, normal to ungraded, massive to horizontally bedded conglomerate. Clasts have A-axes transverse to the flow direction with the AB plane dipping upstream, indicative of fluvial transport (Rust, 1972a, 1975). Dips of the AB plane

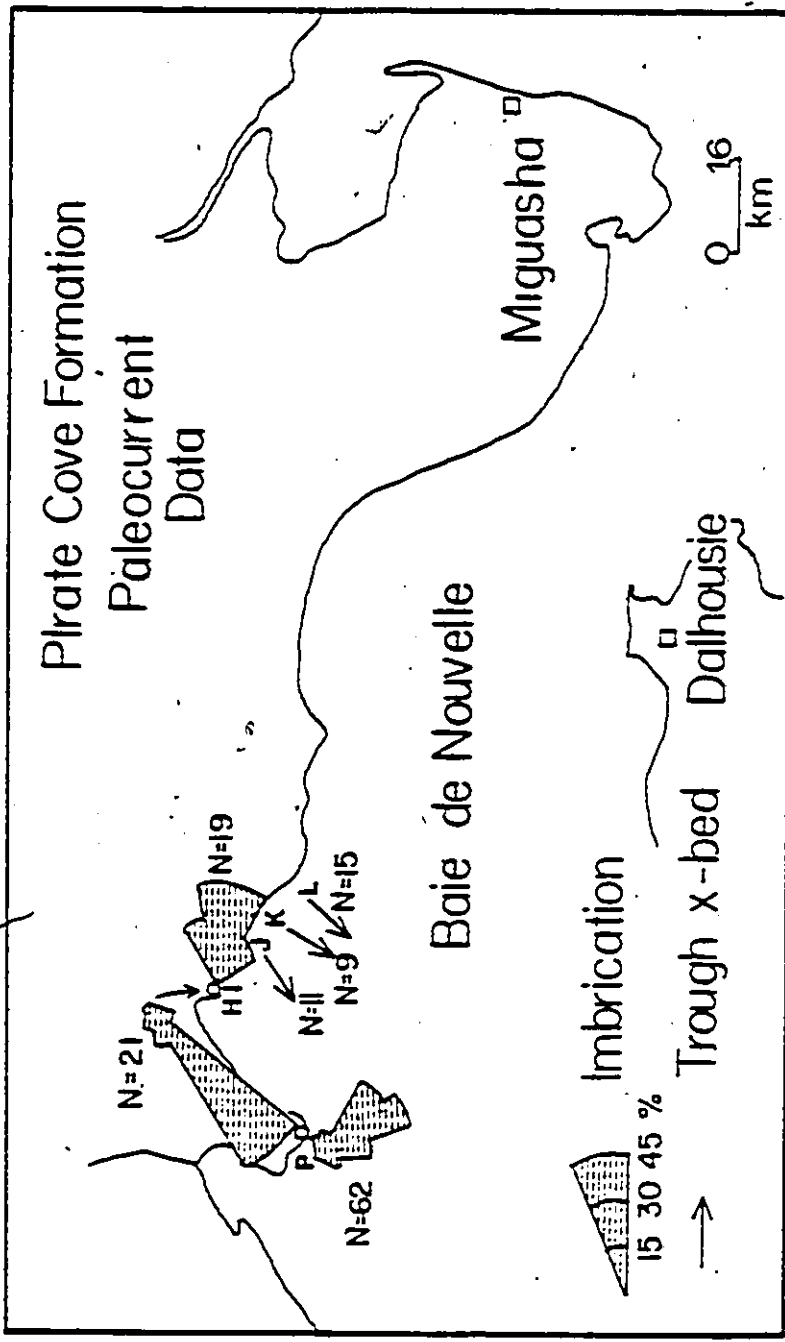


Figure 12: Paleocurrent Data, Pirate Cove Formation (N= no. of readings per station; letters refer to stations (see table 5))

Station	N	Vector Mean O	Arithmetic Mean X	Vector Magnitude %	Mean Dip Angle γ	Significance P	
UNIT 2	E	22	127.8	91.76	23.8	6.63×10^{-33}	
	F	20	163.6	94.45	20.5	1.03×10^{-31}	
	G	20	144.3	95.19	26.4	3.25×10^{-32}	
	Pooled P	62	145.7	90.71	24.2	2.34×10^{-89}	
UNIT 3	H ₁	14	103.5	93.52	18.14	5.36×10^{-22}	
	H ₂	6	243.7	96.65	12.80	1.03×10^{-10}	
	I ₁	15	235.2	94.22	21.27	1.12×10^{-29}	
	I ₂	5	86.5	99.03	15.60	3.03×10^{-9}	
	H ₁ - I ₂	19	98.9	103.7	94.14	17.47	5.60×10^{-30}
	H ₂ - I ₁	21	237.7	236.2	94.70	18.85	1.92×10^{-33}

Clast Imbrication Data--Pirate Cove Formation

J	11	235.6	235.6	93.40
K	9	21.3	215.3	96.28
L	15	226.4	223.7	92.73
Pooled	35	220.9	225.3	97.67

Trough 4-Red Data--Pirate Cove Formation--Unit 4

TABLE 5 : Paleocurrent Data, Pirate Cove Formation (units 2 and 3 refer to Imbrication; unit 4 refers to St sheetsandstones) N- no. of readings (see Fig. 12)

are within the range of fluvial conglomerates as summarized by Koster (1977, p.19, table 3).

Small to medium scale trough x-beds within the sheetflood sandstones represent periods of flood in which the entire braidplain was covered, and therefore should closely represent the paleoslope direction.

Unit 1 did not yield enough paleocurrent measurements to be significant (7 St crossbeds showing paleoflow from the NE to SW). Unit 2, from 3 locations near Escuminac Point, gives a mean paleocurrent direction of 144.9° (with $L=90.71\%$) from 62 measurements at three stations that are strongly indicative of NW source area. Unit 3 (corrected for the small fault tilting the unit) yielded 2 sets of paleocurrent directions at approximately right angles to each other. These values give a NW-SE and a NE-SW paleocurrent direction for the unit. The latter unit direction is analogous to the values obtained for the St sets within unit 4, while the primary direction is near the values for unit 2.

The trough x-beds within unit 4 give a mean paleoflow direction of 228.9° ($L=97.67$) and indicate a NE-SW paleoslope for the braidplain of unit 4, perpendicular to the coarse Gm "bajada?".

Units 2, 3 and 4 are interpreted as a vertical sequence through a fan/ braidplain complex. The source of the fan is to the NW, debouching into a NE-SW trending paleovalley. The presence of coarse detritus on only one side (ie asymme-

tric) possibly indicates a half-graben situation, but may be a function of the lack of exposure along the New Brunswick coast due to latter folding associated with the Chaleur Bay Syncline.

2.5.1 Clast Composition

Field clast counts on Gm lithofacies in units 2, 3 and 5 are presented in Figure 13. The Pirate Cove clasts are predominately carbonates (95%), subdivided by visual inspection into micrite (80%) and fossiliferous micrite/sparite (15%). The remaining 5% are of mixed sandstone and volcanic (andesitic) composition. The limestones were most probably derived from the Matepedia and/ or Restigouche Groups which outcrop to the north and northwest of the study area. The sandstones and volcanics most probably derive solely from the Restigouche Group.

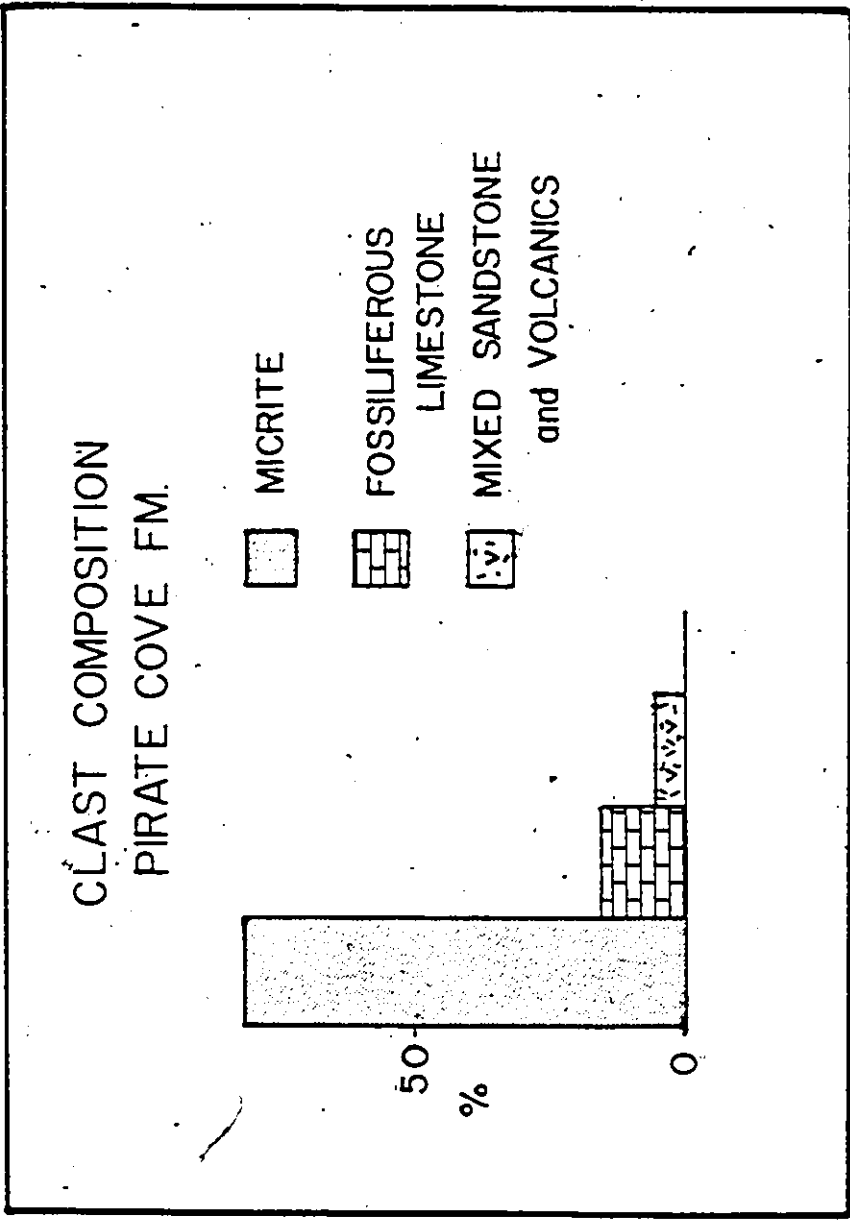


FIGURE 13 : Clast Composition , Pirate Cove Formation (approx. 200 clasts)

2.6 INTERPRETATION

The 5 units of the Pirate Cove Formation are plotted against the percentage of lithofacies in each unit (Figure 14). The interpreted depositional models of Rust or Miall are placed in an adjacent column. Figure 15 shows the proposed paleogeographic reconstruction of the Pirate Cove Formation as a whole.

Unit 1, thought to be conformable with the underlying La Garde Formation (Alcock, 1935, Béland, 1958; Dineley and Williams, 1968a, b) is the first red bed unit in the succession. As was seen in the interpretation of unit 1 this unit is dominated by fine clastics exhibiting ephemeral flashflood depositional features. The unit may have developed on either an alluvial braidplain or in interlobe areas of an alluvial fan complex. The presence of low angle planar x-beds and horizontally laminated and bedded sandstone is diagnostic of ephemeral deposition in a semi-arid climate (McKee et al, 1967, Turnbridge, 1980). Unit 1 is proposed as an analogue for the Bijou Creek model and/or the S1 model of Miall (1977, 1978b) and Rust (1978b) respectively.

Units 2, 3 and 4 represent a complete sequence of alluvial fan to braidplain deposits. Unit 2, dominated by massive to cyclic Gm deposits, contains a minor amount of Gms at the base, which is interpreted as a debris flow deposit thought to form principally on alluvial fans (Hooke, 1967; Bull, 1972, 1977). The low abundance of facies

PIRATE COVE FORMATION

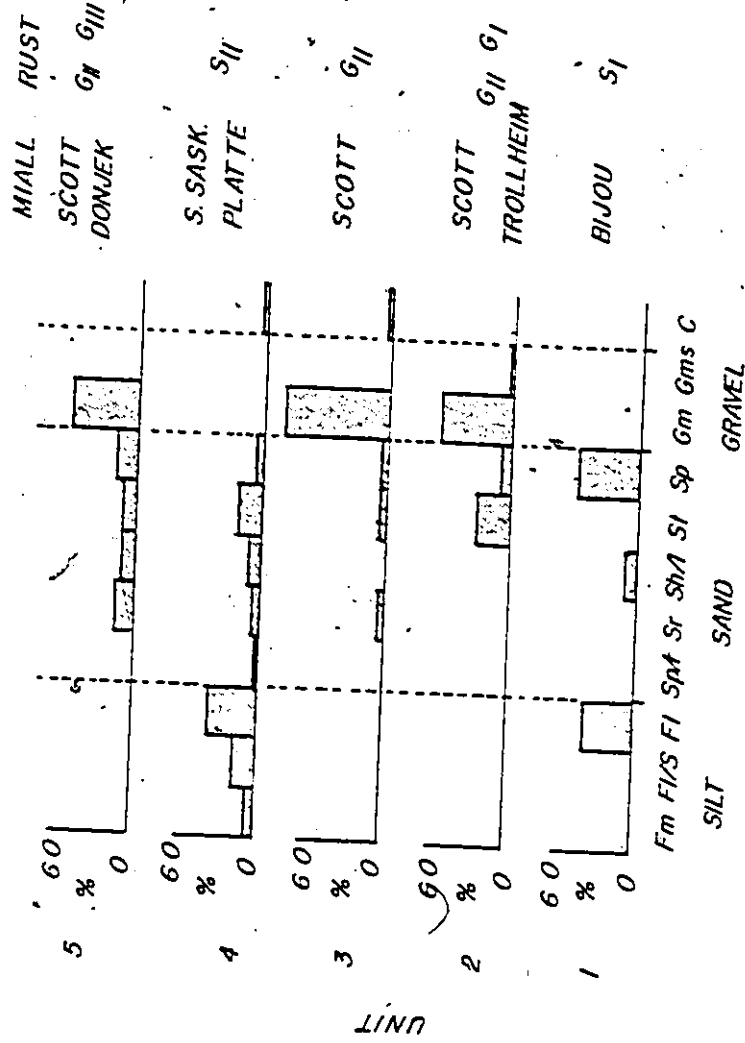


FIGURE 14: Percentage Lithofacies vs Depositional Unit
Pirate Cove Formation (with Pluvial Models
via Miall (1977, 1978a) and Rust (1978b))

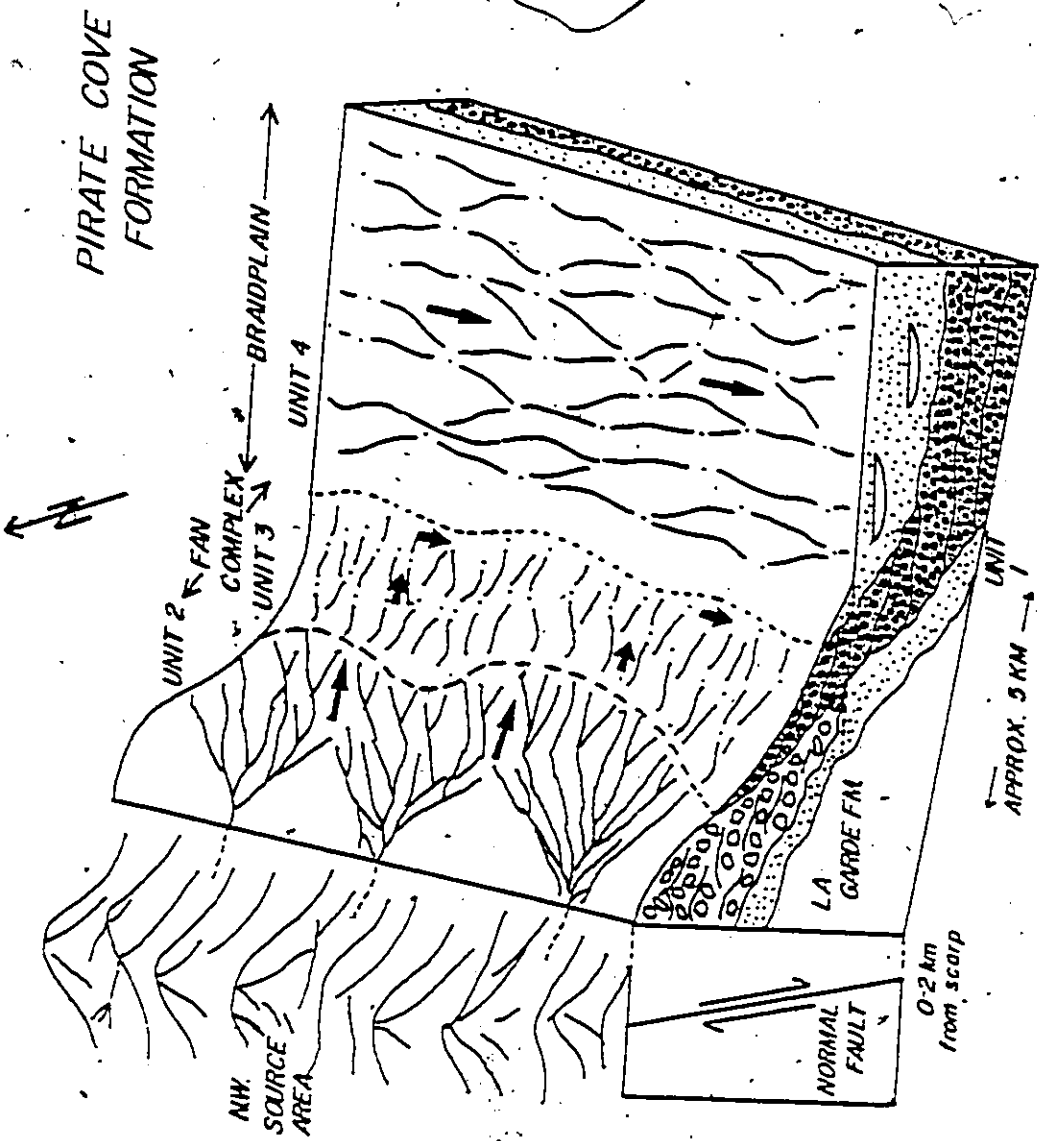


FIGURE 15 : Microneographic Reconstruction, PIRATE COVE FM. UNITS 1-4.. Unit 5 will "prograde" over 2-4 as a diffuse gravel sheet.

Gms and the well-imbricate nature of facies Gm indicate that the unit was deposited in the mid to distal fan area (McGowan and Groat, 1971). Minor Sp and St facies represent waning flow deposition or dissected channel bar deposits.

The lack of Gp and Gt deposits may indicate an absence of well defined channels. Facies Gms needs an appreciable slope to form, and is a strong indicator of (mid to distal) alluvial fan deposition. Unit 2 is therefore modelled as an alluvial fan deposit transitional between the Trollheim and Scott models of Miall (1977, 1978b) or the G1 model of Rust (1978b).

Unit 3 appears to have been deposited as a result of sheetflood events below intersection points (Hooke, 1967). The predominance of sheeted Gm, and the paucity of fines are indicative of coalescing sheet (longitudinal) bars that have undergone winnowing. These bars possess low relief in relation to the channels and surrounding braided tract. Open-framework clast-supported conglomerates may have had their interstices filled by finer material carried by later floods.

This type of deposit forms in the braided reaches below the alluvial fan complex. A second possibility may be that they are "sieve" deposits occurring on the mid to distal reaches of the fan. Lack of suitable exposure makes the choice between one model or the other tenuous, but the author prefers the first due to the fact that sieve deposits are not deposited extensively on fan complexes (Bull, 1972, 1977).

The two paleocurrent directions indicate that at times runoff from the fans was the major or controlling hydrologic factor, while the NE-SW trend shows that flood events on the braidplain sometimes reworked the clasts. Any minor Sp and St facies found within unit 3 were the result of waning flow deposition. Unit 3 is modelled as the Scott or G2 models of Miall (1977, 1978b) and Rust (1978b) respectively.

Caliche within unit 3 takes the form of isolated nodules or nodular crusts on limestone clasts. This indicates that portions of the tract were inactive for prolonged periods of time allowing for the formation of caliche. Leeder (1975) estimates that mature caliche profiles take on the order of 10^3 to 10^4 years to form. This possibly indicates that the caliche within unit 3 is immature, and took much less than 10^4 years to form. Portions of unit 3 must have been at the most distal end of the fan or proximal braidplain to allow for the formation of caliche. Therefore areas of the braided tract must have been active on a 10^3 - 10^4 year time scale.

Unit 4 was deposited on a NE-SW trending sand-dominated alluvial braidplain. This unit can be modelled either as the South Saskatchewan/ Platte River type or S2/Silt type of Miall and Rust respectively, dependant upon whether the cyclicity that is weakly displayed in the markov analysis truly exists.

Unit 4 is dominated by (ephemerally derived?) overbank deposits, accompanying sheetflood sandstones, crevasse splays and channel fill sandstones. The presence of caliche, desiccation cracks and well-developed red beds indicates subaerial exposure in a semi-arid environment.

Unit 5 exhibits well sorted pebble to cobble Gm in fining-upward cycles. These flood-influenced cycles are indicative of gravel-dominated distal braided fluvial processes that undergo repeated fluvial reworking. The G3 model of Rust (1978b) best approximates this deposit, or the transition between the Scott and Donjek models of Miall (1977, 1978b) adequately satisfies the features present.

2.7 PALEOGEOGRAPHIC RECONSTRUCTION

The Pirate Cove Formation appears to have formed in a laterally restricted asymmetric half-graben trending NE-SW. The main source was to the NW, and may have been undergoing active faulting during the deposition of the Pirate Cove. Based on the ephemeral nature of the overbank deposits and the presence of redbeds and caliche, the climate appears to have been of a semi-arid nature.

Figure 15 gives a schematic representation of the Pirate Cove during its deposition. The formation appears to have formed an alluvial fan complex to the NW, parallel to the postulated fault scarp, and debouched into a NE-SW trending alluvial braidplain. Units 2, 3 and 4 formed as la-

terally equivalent deposits representing mid alluvial fan--
-distal fan/proximal braidplain -- to alluvial braidplain de-
posits. The toe of the bajada is contained within unit 3,
and can be distinguished by the two paleocurrent directions
in the Gm facies. The bajada was most probably composed of a
series of alluvial fans deriving from the scarp. At times
either the bajada or the braidplain were the main sites for
reworking the gravels.

The internal erosional surface between units 1 and 2 pro-
bably represents syndepositional tectonic movement. Another
period of uplift most probably occurred between the deposi-
tion of units 4 and 5, causing unit 5 to "prograde" over
unit 4. The cycles in unit 5 developed due to periodic
flood events. This is a classic example of autocyclic con-
trols overprinting allocyclic controls (Miall, 1980). Final-
ly, renewed tectonic movement occurred with the deposition
of the overlying Fleurant Formation.

2.8 SUMMARY

The Pirate Cove Formation was deposited into a NE-SW trending half-graben with the fault scarp to the NW. The formation represents the complete transition from an alluvial fan to alluvial braidplain environment. The five units within the Pirate Cove represent:

1. Unit 1 - Ephemeral flash flood sands
2. Unit 2 - Mid to distal alluvial fan gravels
3. Unit 3 - Proximal gravel-dominated braidplain deposits at the toe of the fan
4. Unit 4 - distal gravel- to sand-dominated alluvial braidplain parallel to the scarp ridge
5. Unit 5 - Distal gravel-dominated braidplain deposits.

Chapter III

FLEURANT FORMATION

3.1 INTRODUCTION

The Fleurant Formation (Late Devonian age) is a 20 m thick conglomeratic unit outcropping along the northern shore of the Baie de Nouvelle (see Figure 5). Vertical sea cliffs, composed of shallow eastward dipping conglomerate, range from 2 to 15 m high. Beach exposure is relatively continuous from a point approximately 1 km east of Englishman's Brook to Pointe à Fleurant, and is accessible only at low tide. Spot outcrops of poor quality are present inland along the roadcuts between Escuminac Flats and the village of Fleurant; and along the banks of Smiley Brook.

The locality west of Miguasha Pier exhibits the contact of the Fleurant and overlying Escuminac Formation (Plate 4). The contact is marked by a thin, red, fine-grained sandstone to siltstone that follows the irregular surface of the Fleurant Formation. The contact also marks the abrupt change from olive-green fluvial conglomerates capped by a minor redbed, into grey-green lacustrine turbidites. A change in the source area from the NW (this study) to the E for the Escuminac (Dineley and Williams, 1968, a, b) also occurred. A transition of this type is not the normal beach to lacustrine facies change. It is based on this evidence

that the contact between the Fleurant and Escuminac formations should be termed a disconformity .

The presence of a disconformity within the Miguasha Group may or may not be laterally extensive. The Group as a whole was deposited under similar tectonic and climatic conditions, and therefore the retention of Group status given by Williams and Dineley (1966) should be maintained.

The unconformable contact between the Pirate Cove and the Fleurant is seen in Plate 3 . The Pirate Cove was folded into a gentle syncline prior to Fleurant deposition and the erosional surface between the Pirate Cove and Fleurant contains scours and hollows up to .75 m deep. The Fleurant eroded into the Pirate Cove at an apparent angle of 7-15 degrees. Clasts of Pirate Cove material are incorporated into the lower portions of the Fleurant.

The age of the Miguasha Group is based on the presence of Archaeopteris spp. in the Escuminac Formation (McGregor, 1963, 1973, per. comm. 1980), which indicate Frasnian to Famennian age. Macrofossils listed by Arnold (1936), McGregor and Terasmae (1959) and Dineley and Williams (1968 a,b) yield similar ages.

The Fleurant Formation has undergone little sedimentological study to date. Clarke (1924) proposed a glacial origin for the formation ,while Alcock(1935) was the first to propose a fluvial origin. Dineley and Williams (1968 a,b) also suggested a fluvial origin based on the facies associa-

tions and the presence of percussion marks (though these were not observed in this study). Dineley and Williams (op. cit.) proposed an east to west paleoflow direction for the formation which is in conflict with results obtained from this study. The ambiguity is dependant on the hierarchy of the structure used for the measurement of paleocurrents. Dineley and Williams (op. cit.) measured planar x-beds that may be in variance to imbrication from the Gm facies. This will be expanded on in a latter section. They also did not propose a comprehensive model for the deposition of the formation.

3.2 LITHOFACIES

3.2.1 Introduction

The Fleurant Formation is subdivided into 5 distinct lithofacies below. Table 6 summarizes the structures within the lithofacies.

1. Gm-. This facies consists predominantly of framework-supported polymictic orthoconglomerates of pebble to large cobble size (with the occasional boulder up to 1.2 m). The clasts are poorly to moderately sorted and exhibit poor to moderate sphericity and roundness. The clasts are set in an olive-green medium to coarse grit, lithic sandstone matrix. Minor amounts of coarse sparry calcite infill void spaces.

Cycles of massive to horizontally stratified Gm occur in .2 to 5 m thick units, that exhibit great lateral continuity. Cycles show a sharp to erosional basal boundary and in some cases fine upward into Sp and/or St facies. Certain zones are strongly imbricate with the A-axis transverse to flow and AB- plane dipping up paleoslope, indicative of fluvial deposition (Rust, 1972). Induration varies within the facies.

2. Gp- Facies Gp consists of framework orthoconglomerates, clasts being better sorted and rounded in relation to Gm. The clasts are somewhat smaller (pebble to cobble size), set in a matrix similar to Gm. Coarse crystalline sparry calcite cement can be a ma-

major component, filling in void space between clasts and is more abundant than in Gm.

Gp occurs in .1 to 1 m thick, large-scale planar cross-bedded sets, with low to moderate foreset dips. Gp can be present in upward-fining cycles grading into pebbly Sp and/or St facies with an erosional basal surface. Imbrication of the variety previously mentioned for facies Gm appears to be ubiquitous throughout Gp, though no statistical study was performed on the clasts. Imbrication, however, appears to be more variable than in Gm.

3. Sp- Facies Sp is composed of medium-grained to pebbly, olive-green to drab-grey lithic sandstones. Sp occurs as small scale planar x-stratified units, .5 to 50 cm thick, with foreset dips rarely greater than 25 degrees.

Facies Sp is found as either lenses or wedges ranging from cm's to 10's of m in lateral extent; between Gm and Gp cycles; or as part of fining-upward cycles.

4. St- Facies St is similar in grain size to Sp, although in some cases it is more fine grained. St occurs in small to medium scale trough x-stratified sets from .05 to 1 m in thickness. The small scale trough x-strata were grouped with the small scale ripple and ripple drift into the St facies in the field.

Facies St is found as part of sandstone lenses and wedges; and as part of Gm or Gp based fining-upward cycles.

5. Fl- Facies Fl is a very minor component in the Formation, occurring as massive and /or thinly laminated olive-green siltstone/ mudstone units.

Facies Fl increases upsection, and is found oxidized at the contact between the Fleurant and Escuminac Formations. The minor amount of Fl found within the section is most probably due to the poor preservation potential of fines within the fluvial tract.

LITHO FACIES	GRAVEL		SAND		STRATIFICATION							STRUCTURE			COLOUR	
	Gm	Gp	Sp	Sl	F1											
	A	A														
BOULDER	A	A														
COBBLE	A	A	R	R												
PEBBLE	A	A	R	R												
COARSE	C	C	C	C												
MEDIUM	C	C	C	C	R											
FINE	R	R	R	R	A											
SILT & MUD	R	R	R	R	A											
MASSIVE						C										
HORIZONTAL						C										
PLANAR X-BEDDED							R	A	R	A						
TROUGH X-BEDDED							R	A	R	A						
PLANAR LAMIN.								A	R	A	C					
TROUGH X-LAMIN.								R	A	R	C					
DUNE								R	R							
GRADED								R	R	R						
RIPPLES								R								
LINEATION											C					
CURRENT CRESCENT											R					
DESICCATION CRACKS											R	R	C			
IMBRICATION											A	A				
RED																
DRAB																C

TABLE 6 : Structures of Pleurant Formation Lithofacies
R - Rare : C - Common : A - Abundant

3.3 ANALYSIS OF COMPOSITE SECTION

A composite 18 m section for the Fleurant Formation was constructed from section C2 (Pirate Cove) and a number of stations along the coast (Figure 16). The vertical nature of the sea cliffs prevented the measurement of complete sections through the Fleurant.

The section is composed of massive to thickly bedded, well-imbricate Gm (65%), with subordinate amounts of Gp (15%), Sp (10%), St (8%) and Fl (< 2%) lithofacies. Facies Gm is found in .1 to 5 m thick horizontally bedded units. Minor erosional bases occur with the Gm facies "stacked" one atop the other. The Gm, from visual estimates, appears to be present in fining-upward-coarsening-fining-upward cycles. Bedding has a very low dip angle and is laterally continuous. Plate 5 shows the continuous nature of the conglomerate sheets that appear to fine in the down paleoslope direction.

Facies Gp also commonly has an erosional base, and fines upward into Sp and St sandstones. Gp fills in erosional hollows and scours up to 4.5 m deep, that are interpreted as broad shallow channels. The fining-upward cycles of Gp-Sp-St are interpreted as bar or channel fill deposits.

Minor sandstone lenses of Sp-St may contain minor amounts of Sh sandstones as part of the Sp facies (Plate 5). Cycles may occur where either Gm or Gp facies are the basal members overlain by Sp-St (-Fl).

SKETCH SECTION

FLEURANT FM.

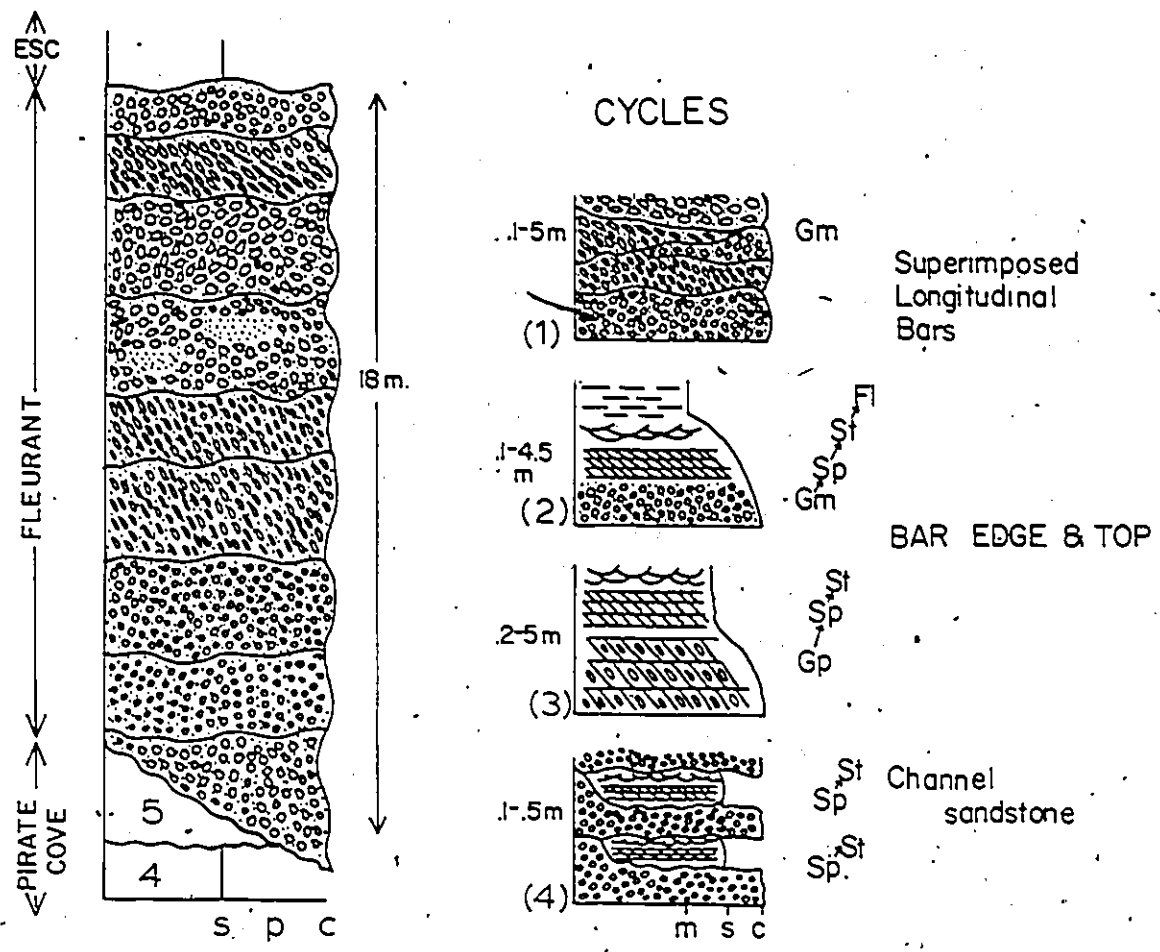


FIGURE 16 : Composite Section and Proposed Cycles, Fleurant Formation

3.3.1 Cycles

Four distinct cycle-types are present within the Fleurant Formation and are presented in Figure 16 . The first cycle is dominantly composed of composite sets of thickly-bedded to massive Gm facies ranging in thickness up to 5 m. These are laterally continuous, fining laterally in the down paleoslope direction ,and contain many minor basal erosional surfaces. These erosional surfaces are good evidence that this cycle was deposited in a sequence of events.

Cycle 1 is attributed to a number of flood events washing coarse detritus onto the braidplain. A variety of bar forms most probably developed, the most common being longitudinal bars in shallow channels. The thickness of the Gm deposits and the internal erosional surfaces indicate that these deposits developed from the coalescing of longitudinal bars. The "sheeted" nature of the Gm indicated rather broad, shallow channels. Absence of debris or debris like flows, angular poorly sorted conglomerates or large scale channels indicate that this cycle was deposited on a gently sloping braidplain rather than an alluvial fan complex.

Cycle types 2 and 3 are variants of similar deposits. Both begin with an erosional base overlain by either Gm or Gp facies. The conglomeratic facies then fine upward into Sp - St -(Fl) facies. These cycles appear to represent bar

edge or channel fill deposits. Again the shallow nature of the channels postulated would not possess the energy to cut into the channel banks due to the low gradient. The bars grew upward and downslope, and their edges were reworked during waning flood events, producing cycles 2 and 3. The fining-upward nature indicates decrease in flow velocity as the bar either "grows" upward or outward into adjacent channels or scours as the flood conditions wane.

Cycle 4 consists of minor sandstone channels of Sp-St (-F1) deposits with subsidiary Sh and Sr deposits. These most likely formed during waning or low flow conditions when floodwaters dissected the previously existing bars. These minor sandstones may also form as channel fill deposits.

3.4 PALEOCURRENT ANALYSIS

Clast imbrication within facies Gm was measured from 4 stations along the northern Baie de Nouvelle coast (Figure 17). Thirty clasts were measured at each station. Table 7 summarizes the paleocurrent data. The mean paleocurrent direction obtained for the Fleurant was 128.9 degrees (n=120) with L=88.10%. This value indicates a northwesterly source for the Fleurant, possibly indicating that the scarp that controlled Pirate Cove development was re-activated during Fleurant time.

These results differ from those presented by Dineley and Williams (1968 a,b) and quoted in Greiner (1978). It appears that Dineley and Williams (op.cit) used facies Gp and St to obtain their east to west paleocurrent direction. Therefore, their values were obtained from structures within lithofacies that have a greater degree of variance than imbrication within Gm (Miall, 1974). Williams and Rust (1969) and Rust (1972 a,b,1975) showed that Gp and Sp values can vary as much as 120 degrees from the paleoslope direction. Rust (1978b, in press(b)) showed that paleocurrent directions for facies Gp in the mid-Devonian Malbaie Formation were far more variable than directions derived for imbrication in facies Gm. The Gp and St values can be formed when flood conditions wane and dissection and reworking of previously deposited bedforms take place. Imbrication in Gm is thought to undergo less modification after being deposited under high flow conditions that affect the entire braidplain.

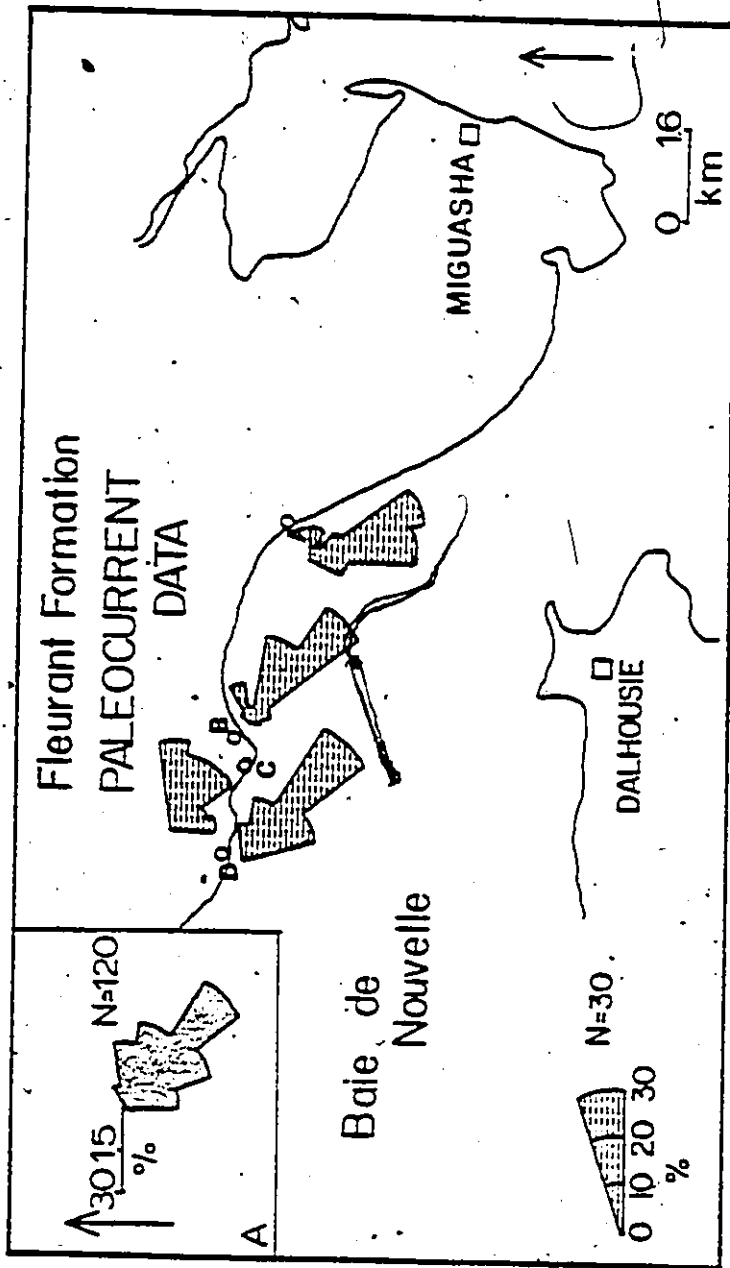


Figure 17: Paleocurrent Data, Fleurant Formation (Gm facies, clast imbrication; letters refer to stations- see table 7)
Inset- Pooled Data

Station	N	Vector Mean O	Arithmetic Mean \bar{x}	Vector Magnitude %	Mean Dip Angle y
A	30	152.0	151.1	89.50	36.30
B	30	120.0	121.2	88.43	30.13
C	30	115.7	114.5	92.47	25.60
D	30	127.3	127.5	95.20	24.87
Pooled	120	128.9	128.8	88.10	29.30

TABLE 7: Paleocurrent Data, Fleurant Formation (Clast Imbrication of Gm facies ; N- no. of readings per station (location of stations- see Fig 17))

The average AB-plane dips within the Fleurant range from 24-36 degrees with the average being 29.3 degrees. The principle A-axis is also perpendicular to the derived current flow. This agrees closely with the values quoted by Rust (1975) for AB-plane dips in gravelly braided rivers and is in the range for fluvial deposits quoted by Callieux (1945) and Koster (1977). These values are greater than the dips quoted by Callieux (op. cit.) of approximately 12 degrees for beach gravels.

3.4.1 Clast Composition

Figure 18 shows clast composition for facies Gm in the Fleurant Formation. Carbonate clasts are again the dominant lithology (60%) with volcanics (andesites) and sandstones comprising approximately 20 % each, with very minor plutonics. The carbonate clasts are subdivided into massive dull grey micrites (47 %) with the remainder being fossiliferous limestone clasts. Minor amounts of jasper pebbles also occur. Like the Pirate Cove Fm., the derivation of such an assemblage appears to be from the Restigouche and/or Matepedia Groups located north and northwest of the study area.

A Zingg (1935) plot of the B/A vs C/B axial ratios for 47 representative cobble-sized clasts is presented in Figure 19. The grouping is similar to that presented by Koster et al. (1980) for clasts derived from known braided fluvial deposits. Thus the information derived from this texture dia-

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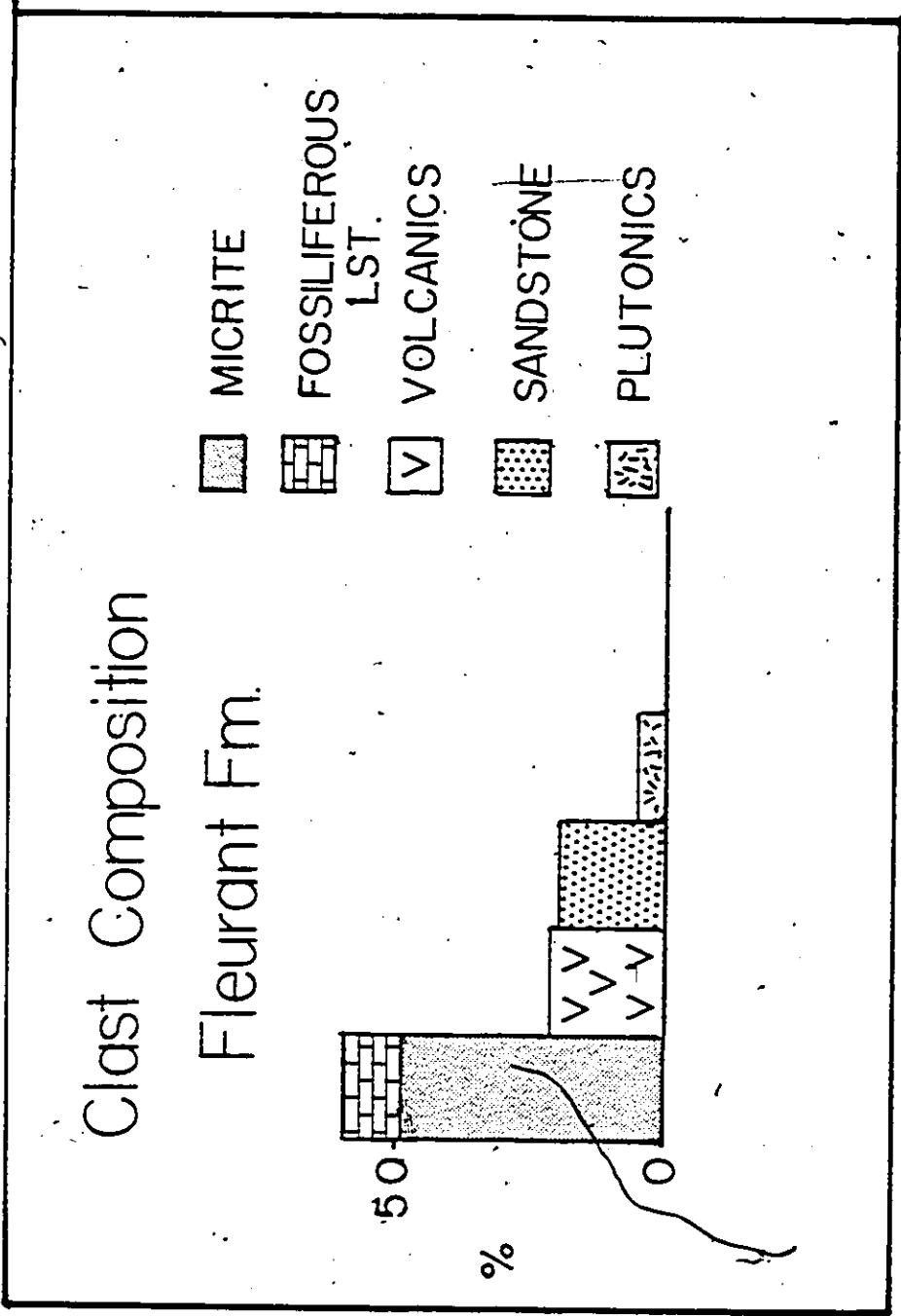


FIGURE 18 : Clast Composition, Fleurant Formation (approx. 200 clasts)

FLEURANT FM.

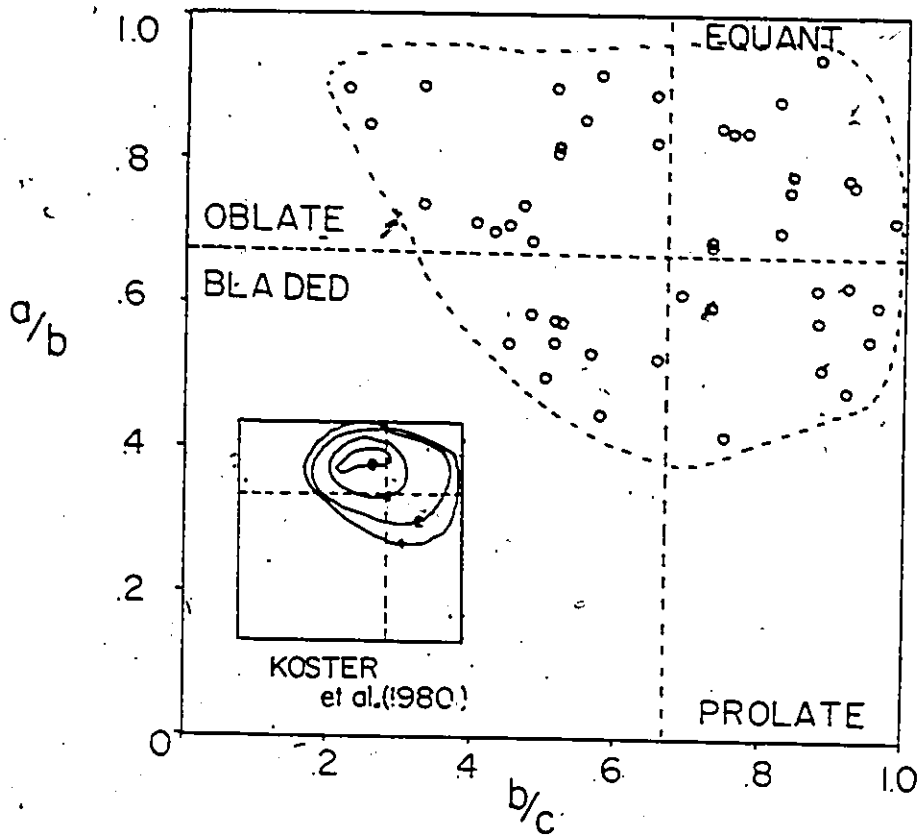


FIGURE 19 : Zingg Clast Texture Diagram, Fleurant Formation.
 N = 48 clasts (after Zingg, 1935)
 Inset after Koster et. al., 1980, showing distribution
 of clast texture from known braided fluvial deposits.

gram and the values for AB dip confirm the fluvial nature postulated for the Fleurant Formation.

3.5 INTERPRETATION

The Fleurant Formation consists of massive to horizontally bedded Gm conglomerates with minor amounts of secondary Gp, Sp, St and Fl facies. The conglomerates are present in large continuous "sheets" with abundant internal erosional surfaces that indicate deposition resulted from successive influxes of material. The conglomerates most probably developed from the coalescing of longitudinal bar forms.

The absence of caliche and redbed development are evidence that the climate was unlike that of the Pirate Cove Formation. The larger scale and laterally more continuous bedforms indicate intense and continuous flood conditions on a gently sloping braidplain. The grey-green to olive-green colouration of the matrix and sandstone may indicate an elevated water table. All of these lines of evidence indicate a more temperate climate during the deposition of the Fleurant.

The conglomerate sheets and the percentage and spatial arrangement of the lithofacies indicate that the Fleurant was deposited on proximal reaches of a gently sloping braidplain, below the alluvial fan complex (McGowan and Groat 1971). This type of deposit would be similar to the G2 model proposed by Rust (1978b) or the Scott model proposed by Miall (1977, 1978b)

3.6 PALEOGEOGRAPHIC RECONSTRUCTION

The well-developed unconformity between the Pirate Cove and Fleurant Formations indicates that the latter developed due to renewed faulting to the NW during the Upper Devonian. The re-activation of the same fault system that controlled half-graben development of the Pirate Cove is the most likely interpretation considering the NW-SE paleocurrent direction obtained for the Fleurant. In this case a transverse braidplain was formed (or preserved) perpendicular to the fault scarp.

Figure 20 is a schematic representation of the paleogeographic reconstruction for the Fleurant Formation. The Fleurant was deposited as sheet gravels most probably due to seasonal variation in pluvial activity. The 1 to 5 m repetitive fining-upward cycles are probably due to repeated flood events. A NE-SW trending fault system some distance to the NW (0-10 km?) of the present outcrop was uplifted, and acted as the sediment source. A diffuse G2 or Scott type gravel sheet prograded over the previously deposited Pirate Cove Formation. At some time the source area may have either subsided, or the fault block containing the Fleurant was tilted, dipping to the WNW, allowing for the lacustrine-turbidites of the Escuminac Formation (Dineley and Williams (1968 a,b) to accumulate in the resulting depression.

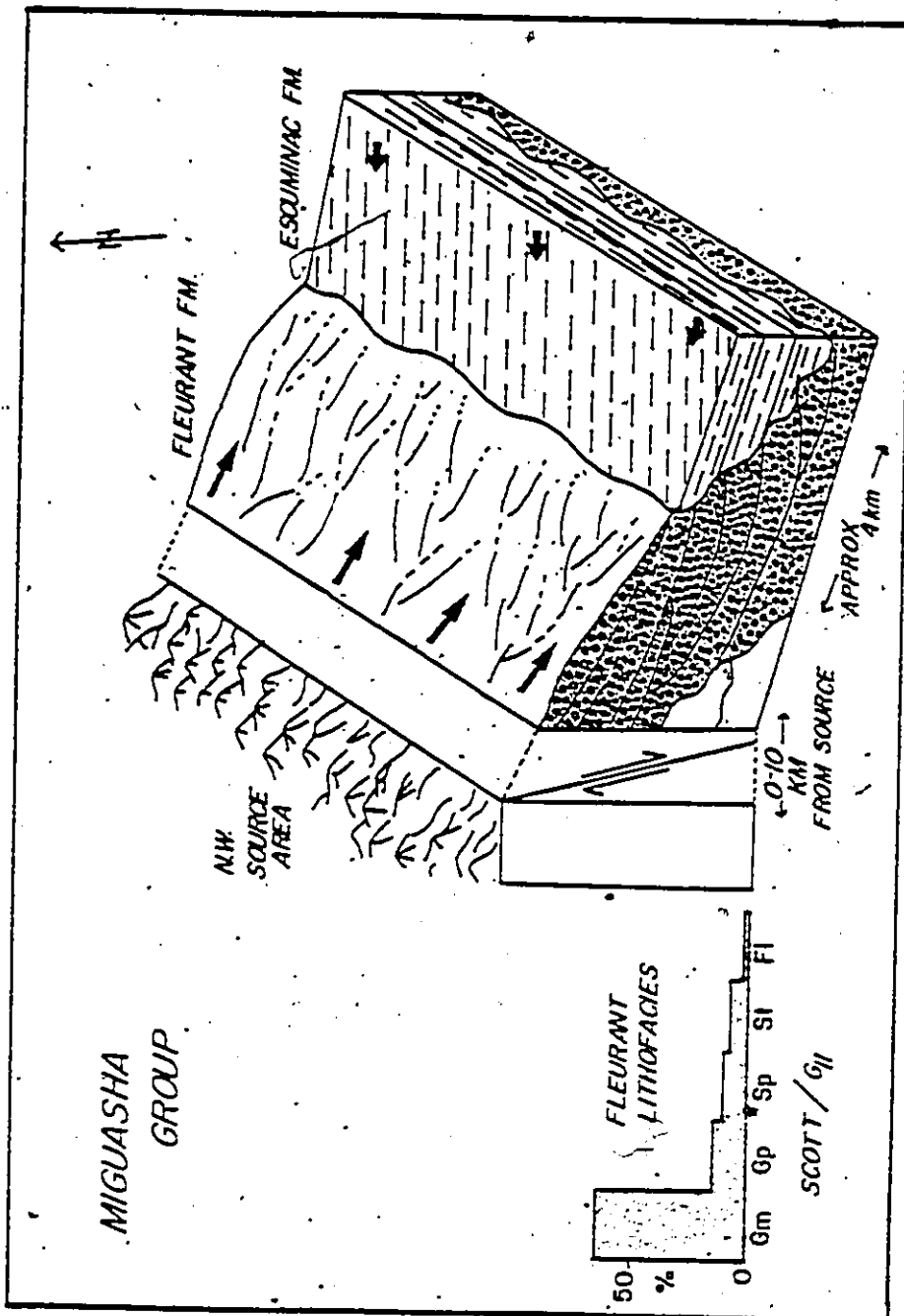


FIGURE 20 : Paleogeographic Reconstitution, Miguasha Group

Chapter IV

BONAVENTURE FORMATION

4.1 INTRODUCTION

The Carboniferous Bonaventure Formation forms a thin capping succession upon the Ordovician to Devonian sequences within the Baie des Chaleurs - Lower Restigouche River Region (Figure 2). The Bonaventure is flat lying, except in areas of minor faulting or gentle folding associated with post-Carboniferous events. The Bonaventure is either unconformable or in fault contact with the underlying "basement" Ordovician to Devonian rocks.

The redbed Bonaventure Formation is characterized by many rapid facies changes. Maximum thickness of the Bonaventure is approximately 250 m at Mount St. Anne, and reaches a thickness of 180 m on Bonaventure Island, near Percé, Quebec (Alcock, 1935; McGerrigle 1950). Thickness within the study area reaches approximately 170 m west of Miguasha.

The Bonaventure is a coarse clastic deposit believed to have been deposited into an extramontane basin (Zaitlin, 1981). The formation has been grouped with other terrestrial deposits of Canso-Riversdale age within the Maritimes (Howie and Barss, 1963, 1975a,b; Kelley, 1967; Hacquebard, 1972) and "fanglomerate" deposits (Belt, 1968a). Re-

gional studies have regarded the Bonaventure Formation as a capping unit to the pre-Carboniferous "basement" (Kindle, 1930; Alcock, 1935; Sanschagrin, 1963; Aryton, 1961, 1967; Dineley and Williams, 1968 a,b). These authors have not dealt with the sedimentology of the formation in any detail.

Paleomagnetic studies of the Bonaventure Formation east of the study area yielded a paleolatitude of 35 and 38 degrees north (Roy, 1966, 1969). Reconstructions by Scotese et al. (1979) and Ziegler et al. (1979) for Westphalian time would place the unit between 10 and 15 degrees north latitude. The differing results are a function of the precision, accuracy, and the size of the data base used by Roy. Scotese and Ziegler use a multidisciplinary approach that included faunal and lithological distribution in conjunction with paleomagnetic evidence for their reconstructions and are therefore believed to be more accurate. The difference between paleopoles is not critical, though, because both sets of values would allow for a climate that is thought to be conducive to redbed and caliche development (see Chandler, 1980 for a review of red bed development).

4.2 LITHOFACIES STATES

The Bonaventure Formation is divisible into 11 distinct lithofacies states. In certain cases lithofacies are combined when structural or lithological parameters cannot be separated (ex. Sp and St = Spt) as summarized in Table 8. The following are the lithofacies states found in the study area :

4.2.1 Conglomerates

1. Gm- similar in bedding, texture and grain size to facies Gm in the Pirate Cove Fm. Cycles are not as pronounced in stratigraphically lower portions of the formation.
2. Gms- similar to Gms within the Pirate Cove Fm. Can contain ripup clasts of caliche Fl, Fm and Sh sandstones in addition to extrabasinal pebbles and cobbles.
3. Gp- similar to Gp in the Fleurant Formation except that the matrix is red sandstone and may include coarse crystalline calcite cement in void spaces.
4. Gt- Facies Gt consists of framework-supported, pebble to cobble sized orthoconglomerates. Clasts are moderately to well sorted, and rounded, showing a moderate degree of sphericity.

Gt contains large scale trough cross-beds up to 1.5 m thick. Gt is found within Gm or Gp based fining-upward cycles associated with channel fills.

4.2.2 Sandstones

1. Sh/l- Facies Sh/l consists of horizontally to low angle planar x-bedded current-lineated sandstones in mm to 2 m thick sets. Found in both fining- and coarsening-upward cycles, they are transitional with Sp, St and Fl lithofacies.
2. Sp- similar in all respects to Sp in the Pirate Cove Formation.
3. St- similar in all respects to St in the Pirate Cove Formation.
4. Sr- similar in all respects to Sr in the Pirate Cove Formation.

4.2.3 Siltstones and Fine Sandstones

1. Fl- similar in all respects to Fl in the Pirate Cove Formation.
2. Fm- similar in all respects to Fm in the Pirate Cove Formation.

4.2.4 Other facies

1. C- Caliche is well-developed in the Fm, Fl, Sh/l and Sp/St lithofacies. Caliche can occur as isolated rhizoconcretions, isolated nodules, crusts, honeycomb and hardpans (Plate 6).

4.3 ANALYSIS OF STRATIGRAPHIC SECTIONS

4.3.1 Introduction

The locations of the ten stratigraphic sections through the Bonaventure Formation measured in this study are presented in Figure 21. Six sections were measured in the vicinity of Miguasha, P.Q.:

1. Yacta Point
2. Hugh Miller Cliffs
3. Anse aux Corbeaux East
4. Anse aux Corbeaux West
5. Pointe aux Corbeaux
6. Miguasha Road Section

and four sections in northern New Brunswick:

7. Pit Section at Dalhousie Junction
8. Charlo
9. Armstrong Brook
10. Belledune Point

In addition, logs from four cored drillholes completed for the N.B.E.P.C. on Heron Island by A.D.I. Consultants were made available by Mr. J. McGrath of the Commission. Unfortunately the core was discarded prior to 1979.

Yacta Point offers the most complete and continuous section in the study area through the Bonaventure (approx the basal 115 m), and represents a complete transition from alluvial fan to braid/alluvial plain deposits. The other sec-

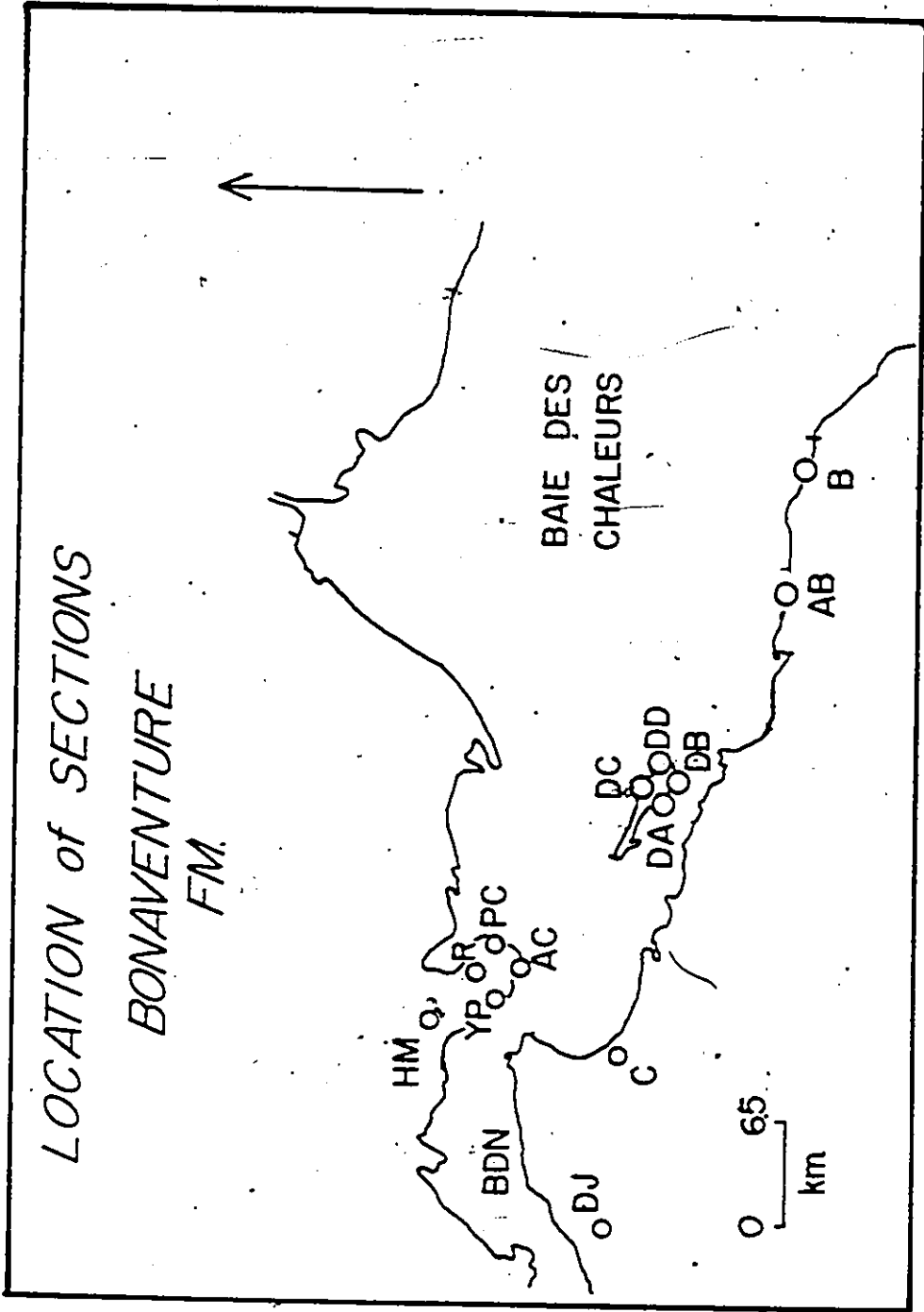


FIGURE 21 : Bonaventure Formation - Locations of measured sections and drill holes
 (HM: Hugh Miller Cliffs; YP: Yacta Point; R: Road Section; PC: Pointe aux Corbeaux; AC: Anse aux Corbeaux; DJ: Dalhousie Junction; C: Charlo; AB: Armstrong Brook; B: Pelledune; D-A, B, C, D; Drill Hole; BDN: Baie de Nouvelle)

tions are confined to 1 (or possibly 2) specific subenvironments within the braided fluvial environment.

4.3.1.1 Yacta Point

The Yacta Point section starts approximately 1/2 km east of Miguasha Wharf where the Bonaventure rests with pronounced angular unconformity upon the Upper - Devonian Escuminac Formation (Plate 7). The unconformity is sharp and erosional, displaying up to 10 m of stepped topographic relief. Large blocks of Escuminac material (up to 1.3 m) are incorporated into the lowest portions of the Bonaventure. The contact contains no evidence of regolith development, which possibly indicates rapid deposition after uplift.

The Bonaventure exhibits a 15-20 degree (depositional) dip at the contact that shallows quickly upsection to approximately 3 degrees. The dips are assumed to represent the original paleotopography during deposition. The Bonaventure has undergone little later tectonic movement except for minor open folds and flexures trending NE-SW. In addition minor normal faults and intrusives are reported to the east (Alcock, 1935; McGerrigle, 1950).

The section (Figure 22) is divisible into three distinct portions :

1. a lower portion dominated by Gm, with minor Gms near the base. This portion represents the proximal to mid alluvial fan environment (approx. 48 m).
2. a middle portion dominated by fining-upward cycles of Sh/Sr- Sh-Fl sandstones and siltstones that are representative of ephemeral braided fluvial deposits below the fan complex (approx. 35 m).
3. an upper portion dominated by Fl, Fm and minor Sandstone lithofacies that represent overbank deposits. The channel and sheetflood sandstones within the overbank deposits may indicate a transitional deposit between braided and meandering environments (approx. 40 m).

The lower portion of the section contains 2 conglomerate-dominated "cycles" separated by a minor amount of medium to coarse grained sandstones and siltstones. The lower conglomerate is dominated by Gm, with Gms lithofacies near the base. The Gm is a massive, non-imbricate clast-supported boulder to large cobble orthoconglomerate. No internal cycles were discerned.

Interspersed with Gm are zones of ill-sorted matrix-supported Gms, interpreted as debris flow deposits. At the contact between the Escuminac and the Bonaventure Fm., Gms contains sub-horizontal blocks of the Escuminac that have a maximum length of 1.3 m (Plate 7). This type of deposit is attributed to plastic flow conditions that resulted in grain and/or cohesive debris flow deposits (Lowe, 1979). Upward

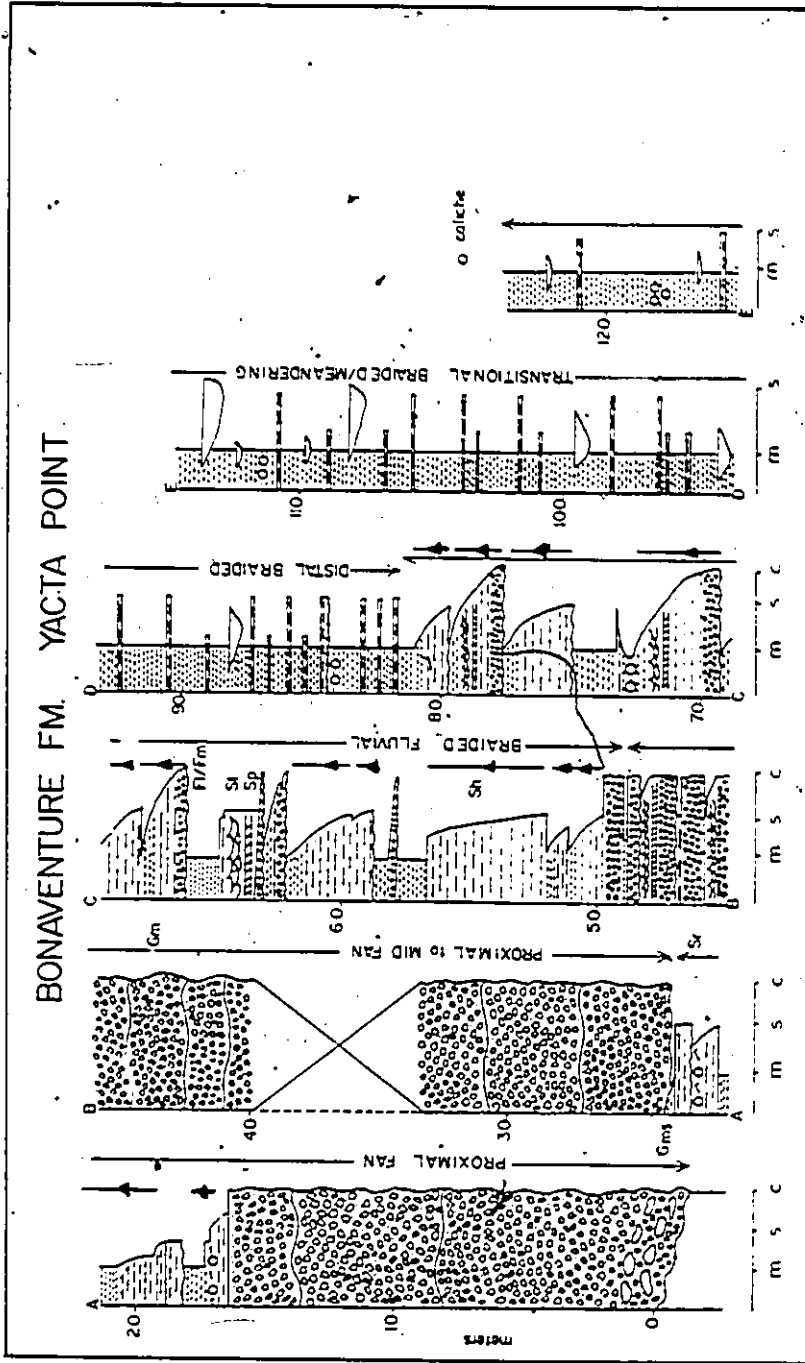


FIGURE 22: Yacta Point Section

dispersive pressure in this type of mass flow would cause the blocks to assume sub-horizontal orientation. Flows of this type occur in areas of steep slope, adjacent to scarps (for example). A second possibility for the orientation of the blocks is that they are still attached to the Escuminac Fm.. In this case the blocky nature would be the result the original paleotopographic surface that may have developed due to some "Karst" type of weathering. The presence of a high original depositional dip (15- 20 degrees) and the lack of regolith development at the contact tend to indicate "talus" environment, near the scarp. On this basis the second possibility is deemed unlikely. Debris flows that formed upsection appear to have characteristics that indicate deposition under more fluidized conditions. The depositional dip of up to 20 degrees may be indicative of talus slope deposits along the margin of a scarp.

The upper cycle is also dominated by Gm, but appears to contain (indistinct) fining-upward cycles of boulder- cobble conglomerate. Minor amounts of imbricate Gm and Gt are present upsection, with some Sh and Sh/Sr sandstones.

The interval between the two cycles is composed of gritty to medium sandstones in repetitive fining-upward cycles capped by Fm. The relatively thick Fm deposits contain some caliche. All features are typical of ephemeral deposition (McKee et al., 1967; Turnbridge, 1980).

The lower portion of the Yacta Point section is interpreted as a proximal alluvial fan deposit. The presence of well developed Gms and massive Gm deposits, the high angle of depositional slope and its position adjacent to the apex of the fan indicate deposition on a fan complex (bajada?). The upper cycle may also have been formed on a fan, but further away from the fan apex than the lower cycle.

The small amount of intervening sandstone (with Sh/l) is thought to have been deposited under high energy ephemeral conditions (Turnbridge, 1980). The sandstones indicate either an interlobe area that was not receiving coarse detritus, or that two syndepositional tectonic uplifts occurred.

The lower portion of the Yacta Point section conforms to the G1 or Trollheim model of Rust (1978b) and Miall (1978b) respectively. The second conglomerate cycle appears to have developed under more fluvial than mass flow conditions (note presence of Gt, imbricate Gm, etc.) and may represent a transition between the Trollheim and Scott models of Miall (op. cit.). The G1 model of Rust (op. cit.) holds for both cycles.

Red bed development, the presence of Gms, and the coarse clastic nature of the deposit indicate that the fault scarp that controlled sedimentation was near by. Paleocurrent data given later indicate the scarp was to the north and northwest. The climatic environment is thought to have been arid to semiarid due to the presence of caliche and redbeds.

The middle portion of the Yacta Point section is characterized by repeated fining-upward cycles of Sh- Sh/Sr- Sp- St- Fl (and Fm) sandstones and siltstones. Cycles are based on minor erosional surfaces and may contain incipient caliche within the finer grained lithofacies.

Laterally extensive sheet sandstone bodies are profuse in the lower part of the middle portion of the section. These consist of Sh-Sp-St-Fl sandstone bodies which may incorporate occasional rip up clasts. Channel fill sandstones and coarsening upward crevasse splay/levee (?) deposits are present within the middle of the section. Large scale desiccation cracks (up to 2.5 m deep) that may contain nodular caliche are present in the crevasse splay deposits (Plate 8).

The predominance of Sh and Sh/Sr sandstones near the base of the middle portion indicates the recurrence of ephemeral conditions. The presence of channel fill, sheetflood sandstones and crevasse/splay deposits indicates more continuous pluvial conditions (possibly seasonal). Models proposed for deposition of this type would be a transition from the Bijou Creek to S.Sask./Platte River (Miall, 1977, 1978b). or the S1/S2 transition terminology of Rust (1978b). The lack of well-developed Ss and Se facies would place the base of this portion in the Bijou Creek submodel of Rust (op.cit.).

The upper portion of the section is dominated by Fl, Fm and Sh/l overbank and sheetflood sandstones. Well-developed

channel fill with moderate to high depth:width ratios increase upsection (Plate 8). The channel fills contain at their base laterally continuous (up to 4 m), sinuous, bifurcating, 3-10 cm deep scours occurring in a radiating pattern parallel to the channel axis (Plate 9). They are filled with coarse grit to small cobble material lacking any apparent internal structure. Spacing appears regular (20-40 cm apart) depending on the size of the channel. These are interpreted as harrow or kolking structures that are indicative^{of} high energy turbulent scours and infills in ephemeral channels (Harvey, 1980; Karcz, 1967). Caliche development increases upsection.

These characteristics are indicative of an alluvial (braid?) plain environment. The fine grain size of the material and the (apparent) lack of cyclicity make it difficult to place in the scheme of Miall (1978b). The low depth to width ratios of the channels fall below those proposed for braided systems by Schumm (1977). In addition, indistinct lateral accretion surfaces occur in the channel fills. All of these features would tend to favour a meandering channel pattern.

The presence of the kolking features indicate extreme energy conditions that were channelized. Sheetflood sandstones may form in either braided or meandering environments. The most likely interpretation of the top portion of the Yacta Point section is that it was formed in a transi-

tional position within the alluvial plain, between true braided and meandering deposits. Transitions from braided to meandering sequences are well known as gradient decreases away from the scarp. An anastomosing model was not considered due to the absence of vertically persistent sandstone bodies and the low to subequal ratios of channel sandstones to overbank deposits.

In summary, the Yacta Point section represents the transition from alluvial fan through proximal-distal braidplain into a transitional braided/meandering depositional environment.

4.3.1.2 Hugh Miller Cliffs

The Hugh Miller Cliffs are located approximately 9 km west-north-west of Miguasha, and form the prominent red cliffs inland from Escuminac Bay. The section presented (Figure 23) is a composite 40 m thick because no one section was completely accessible. The section is divisible into two distinct units:

1. a lower Gm-dominated unit
2. an upper, repetitively fining-upward mixed Gm and S... unit

The lower unit (approx. 12 m thick) is dominantly a large cobble to pebble, well-imbricate, horizontally bedded Gm unit. Indistinct fining-upward cycles (from .5 to 1.5 m

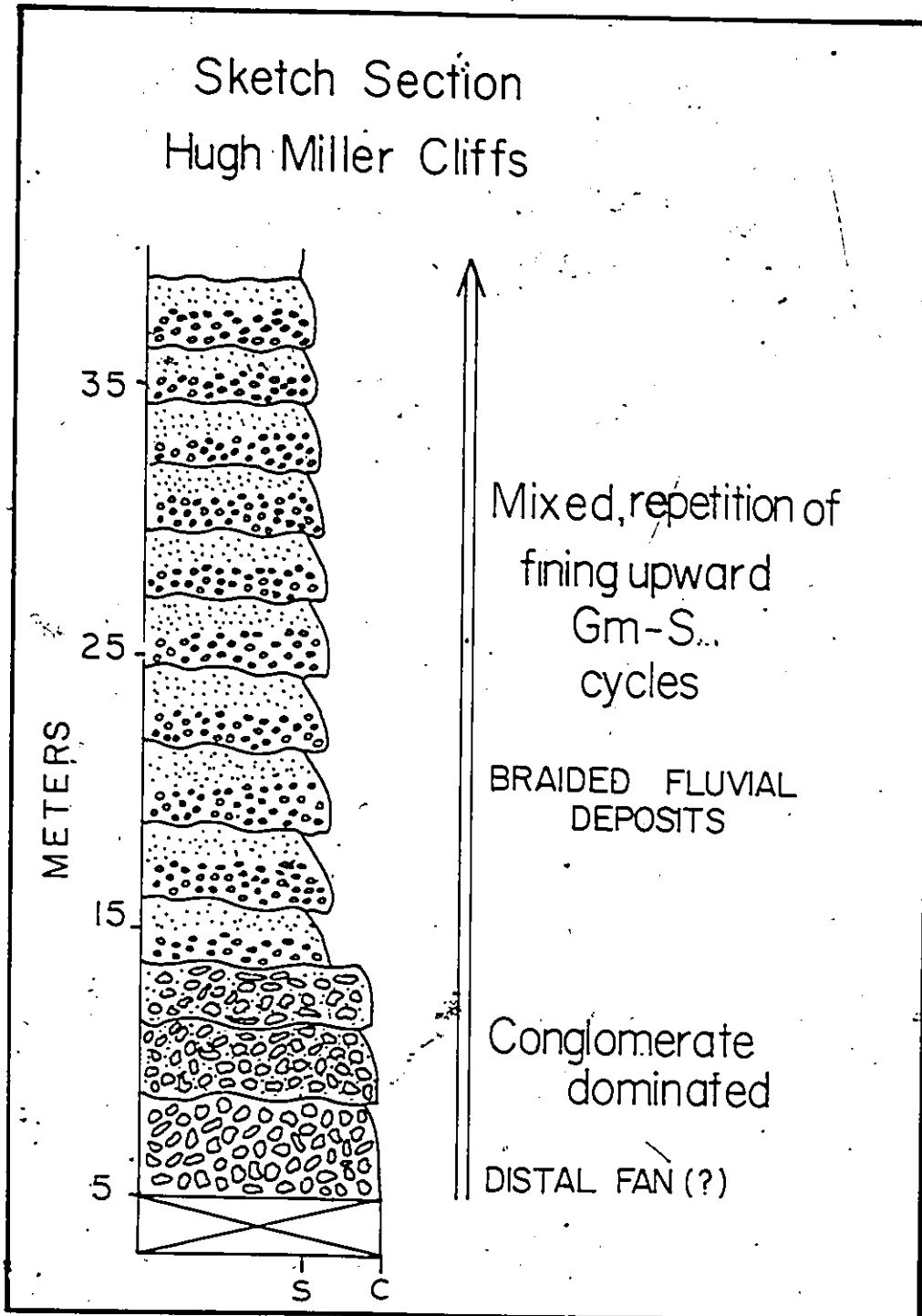


FIGURE 23: Hugh Miller Cliffs section

thick) contain abundant internal erosional surfaces and minor Sp-St channel fill sandstones. The proportion of sandstone appears to increase upsection. Occasional "Gm" zones are massive, and ill-sorted, displaying an open- to matrix-supported framework that approaches Gms. These latter deposits may be interpreted as the most distal of debris-flow like deposits.

The fining-upward cycles of Gm or Gm-Sp-St, in addition to the channel sandstones that dissect these deposits, may be indicative of mid to distal alluvial fan sedimentation (McGowan and Groat, 1971). Well-developed imbrication may indicate flood reworking of the clasts within unchanneled flow (Bull, 1977; Koster, 1977). Models proposed for the lower portion of the Hugh Miller cliffs are a Scott-like deposit (Miall, 1977, 1978b); or transitional between G1 and G2 of Rust (1978b).

The upper portion of the Cliff section (34 m approx.) is a mixed repetitive fining-upward conglomeratic-sandstone unit. Cycles range from .25 to 1.5 m thick and contain local erosional surfaces, laterally persistent conglomerate sheets and well-imbricate Gm. The unit probably represents coalescing longitudinal and/or traverse bar sheets (Church and Gilbert, 1975) below the intersection point of a fan complex (Hooke, 1967). The unit is very similar to unit 5 of the Pirate Cove Formation but contains much larger clasts, and cyclicity is not as well established.

The sheeted nature, abundant erosional surfaces and fining-upward cycles indicate deposition in the proximal braided fluvial tract at the distal end or past the fan complexes. The models that best represent this type of deposit are the Donjek (with cyclicity) or G2 model of Miall (1978b) and Rust (1978b) respectively.

Note: The Hugh Miller cliffs are stratigraphically above the Yacta Point Section. These two sections, when placed in stratigraphic context, give a minimum thickness for the Bonaventure within the study area in excess of 170 m. Together they can be interpreted to form two major fining-upward cycles on the scale of 10's to 100 m.

4.3.1.3 Miguasha Road Section

The Miguasha Road section Figure 24, located along the secondary road between Miguasha and Miguasha West, is a 17.5 m thick mixed pebble to small cobble conglomeratic-sandstone succession composed of .75 to 3.25 m repetitive fining-upward cycles. The cycles may be erosionally based and show a poor degree of induration.

The cycles present include fining-upward Gm ; Gm- Sh- Fl; Gm- Gp- Spt ; and St- Sp- and Fl deposits. Interspersed within the cycles are interbedded Gm / Sh-Fl deposits. Minor Sh-Fl and Fl deposits are also present.

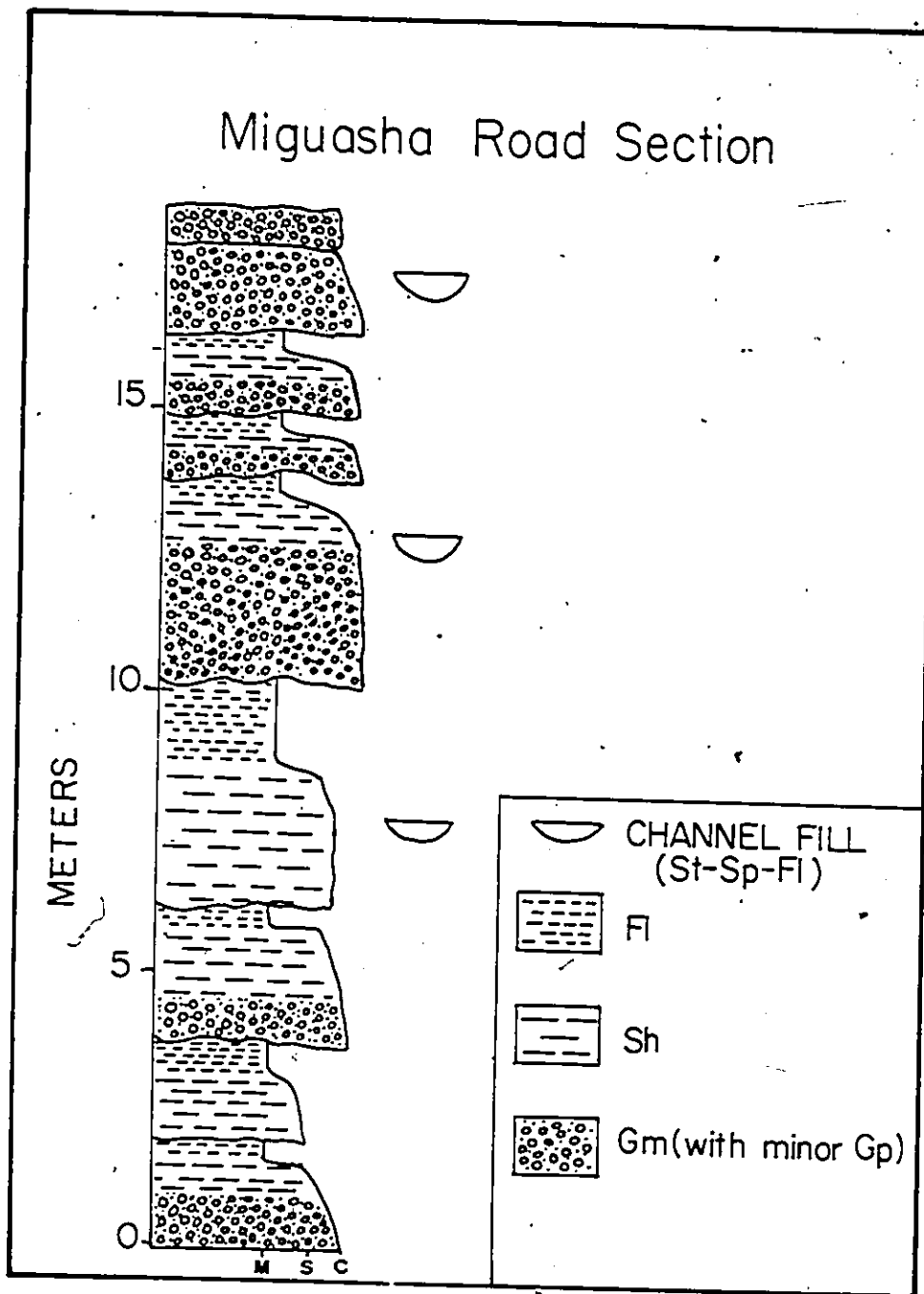


FIGURE 24 : Miguasha Road Section

The cyclic nature of the units and the fining-upward nature indicates successive depositional events. The type of sedimentation may indicate a distal gravel-dominated braided fluvial environment on a braidplain. The model that best characterizes the deposit is the Donjek type or a transitional deposit between the G2 and G3 of Miall (1977, 1978b) and Rust (1978b) respectively. The presence of Sh and Fl sandstones and siltstones within the unit, and the lack of well developed channel or channel fill deposits are evidence for ephemeral deposition (Turnbridge, 1980).

4.3.1.4 Anse aux Corbeaux- East and West

Anse aux Corbeaux is located at the southwest tip of Mi-guasha Peninsula, in a small isolated cove. Two sections (Figure 25) were measured on the east and west limbs of a gentle, open anticline. The sections are divisible into two distinct units :

1. a lower sandstone-dominated unit with minor sheet-flood and channel fill deposits.
2. an upper small boulder to cobble conglomeratic unit possessing massive to sheeted Gm deposits.

The lower unit ranges in thickness from 25 - 35 m and is predominantly composed of interbedded fining-upward cycles of Sh/S1- Sh/Sp- Fl deposits with subordinate sheetflood and channel fill sandstones. Plates 10 and 11 exhibit abundant

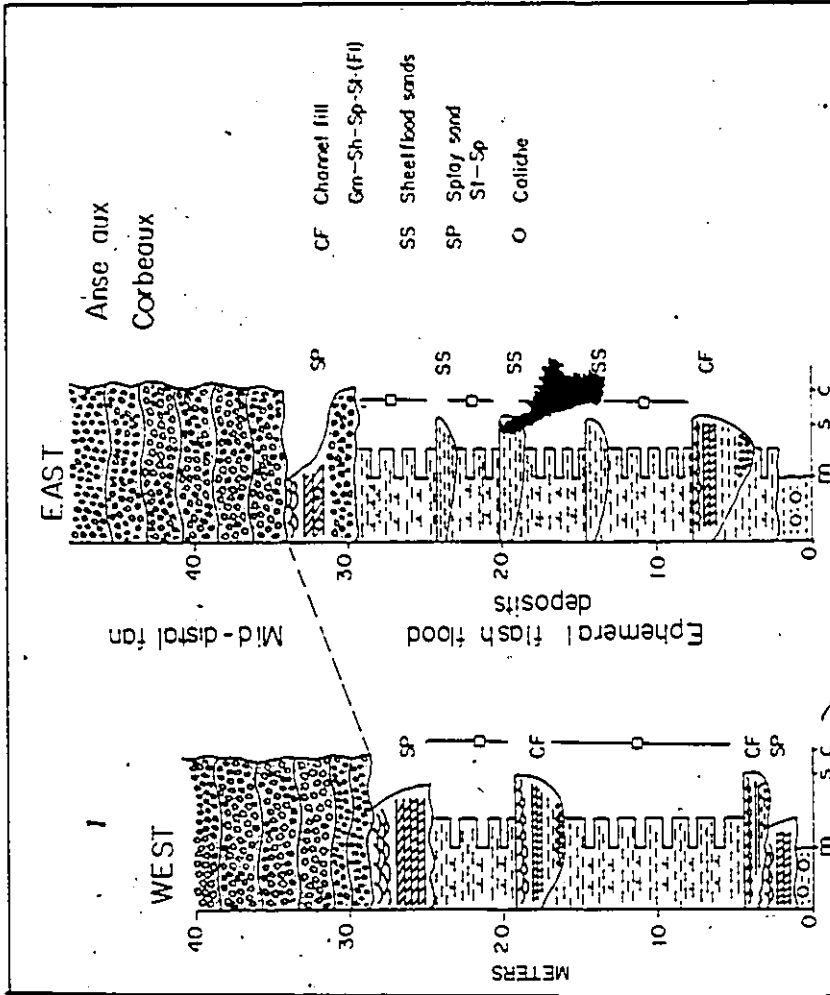


FIGURE 25: Anse aux Corbeaux- East and West Sections

erosional surfaces, low angle planar x-bedded and single pebble horizons. Grey-green reduction spots indicate the presence of disseminated plant material. (Plates 10 and 11 show the repetitive interbedding of Sh and Sl with minor amounts of Sp/St. -Single pebble horizons and a scour near the top filled by an assortment of pebble and caliche types are visible. Plate 11 shows the presence of an imbricate mud-chip conglomerate zone with Sh and single pebble horizons.

Laterally extensive sheetflood sandstones have abrupt lower contacts. Channel fill bodies, possessing width to depth ratios on the order of 100:1 are erosionally based and contain Gm- Sh- Sp- St- Fl or Gm- Gp -St fining-upward cycles. The top and bottom of the section contains minor Fl. and Fm deposits that contain caliche .

The features mentioned for the lower unit of Anse aux Corbéaux indicates an ephemeral sand-dominated braided fluvial deposit of the Bijou Creek-or Sl type (McKee et al., 1967; Turnbridge, 1980; Miall 1977, 1978b; Rust, 1978b).

The upper unit is a larger fining-upward sequence of massive to horizontally bedded Gm (>70%), with associated amounts of Gp, Gt, Sh, Sp, and St. The contact between the lower and upper unit is sharp above a moderately developed caliche horizon. This may indicate a small lapse in time between the deposition of the lower unit and the progradation of the overlying unit.

The massive to horizontally bedded Gm deposits contain indistinct fining-upward cycles and channel fill. In many regards this portion of Anse aux Corbeaux is similar to the upper conglomeratic cycle within the Yacta Point section. As one continues upsection the conglomerates become more sheeted and fines become rarer (Plate 12). The depositional environment for the lower conglomerate portion resembles that of the distal braided portion of a fan complex, above the intersection point (Hooke, 1967); the sheeted Gm would have developed in unconfined flow conditions at the toe of the fan or the proximal portion of the braidplain below the intersection point (similar to unit 3 of the Pirate Cove Fm.). Depositional models for the upper portion include the Scott or G2 model of Miall (1977, 1978b) and Rust (1978b) respectively.

4.3.1.5 Pointe aux Corbeaux

The Pointe aux Corbeaux section (Figure 26) is located along the eastern coast of Miguasha Peninsula, north of the Pointe. A 35 m plus continuous section of mixed sandstone/conglomerate was measured that exhibits two (and part of a third) major fining-upward cycles averaging between 15 and 20 m in thickness. The cycles are based by massive, well-imbricate, fining-upward Gm (and Gm-Gp) deposits that contain kolking structures (Harvey, 1980; Karcz, 1967). The Gm or Gp facies are overlain by Sh or interbedded Sh/F1 units.

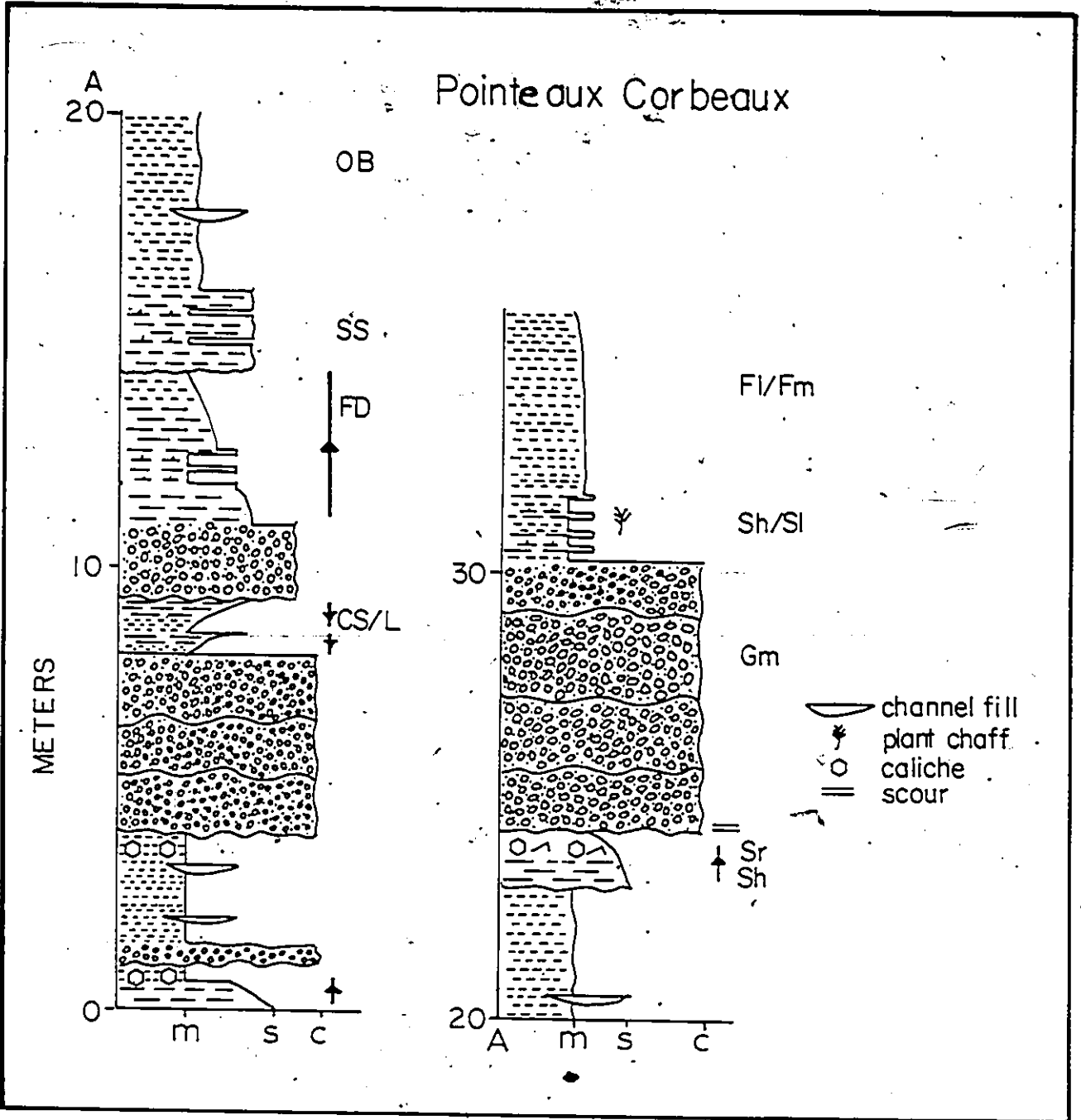


FIGURE 26: Pointeaux Corbeaux Section

These grade upward into relatively thick Fl or Sh/Fl deposits with disseminated plant and caliche material.

The middle and upper portions of some cycles contain sheetflood sandstones that can include pebbly and rip up clast bearing zones and large scale dune bedding (Plate 13). Again, plant and caliche material may be ubiquitous. No evidence of channel or channel fill was seen in the finer-grained zones, but in areas where Gp was present, channels were observed.

These cycles represent deposition near the toe of the alluvial fan complex or in the proximal position of a braidplain (McGowan and Groat, 1971). The lack of internal erosional surfaces within Gm sequences, and the fining-upward nature of the deposit may indicate deposition as one "event". The internal truncation within the Sh and Fl units indicates successive (ephemeral ?) depositional events, on a short time scale. The cycle as a whole appears to be the result of one event, i.e., an allocyclic event overprinted by autocyclic controls.

Three possible interpretations of the cyclic nature exhibited within the Pointe aux Corbeaux section are:

1. pluvial flood episodes that resulted in cyclic fluctuations in flow conditions and the ability to move different sized material,
2. periodic syndepositional tectonic uplifts resulting in the elevation of source and subsequent erosion and return to base level, and

3. autocyclic switching within the dispersal system.

The writer prefers a combination of all three hypotheses.

The deposits are representative of the Scott/Donjek/S. Saskatchewan model of Miall (1977, 1978b); or of a G2/S1-2 models of Rust (1978b). In this case the models of Rust (op. cit.) are more flexible in determining a depositional model than those of Miall.

4.3.1.6 Pit Section- Dalhousie Junction

The Pit section (Figure 27) located approximately 11 km west-south-west of Dalhousie, consists of an 11.5 m quarry exposure of Gm- (and Gms-) dominated Bonaventure Formation.

The section can be subdivided into:

1. a lower 5 m section composed of ill-sorted, massive, open-framework matrix-supported Gms deposits fining-upward into Gm, Gp or Sp type deposits.
2. an upper 6.5 m with massive to horizontally bedded, well-imbricate Gm with minor amounts of Sp and St deposits.

The lower unit contains conglomeratic deposits that resemble Gms but do not contain more than 50 % matrix. In zones the conglomerates are supported by a muddy matrix, and may therefore be of debris flow origin. Deposits of this kind may be interpreted as grain flows (Lowe, 1979).

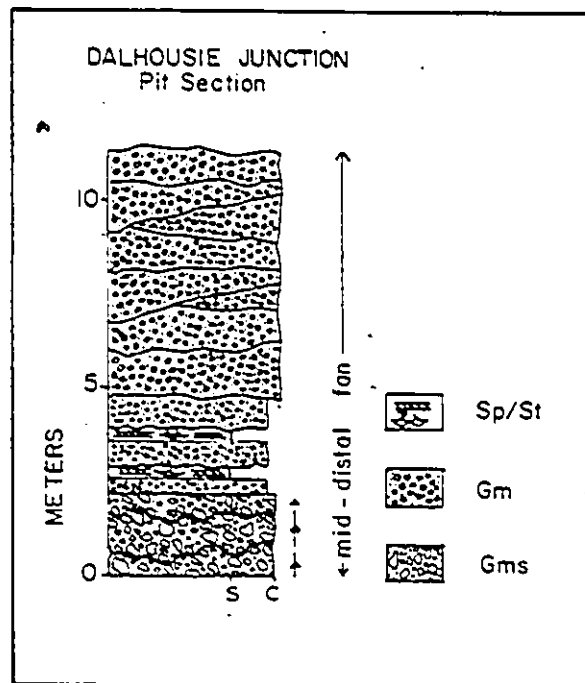


FIGURE 27: Dalhousie Junction- Pit Section

The upper unit is composed of massive to horizontally bedded and well-imbricate Gm deposits. These units have abundant internal erosional surfaces and minor amounts of Sp-St channel fill sandstones. AB-planes dip upstream and the A-axis is transverse to paleoflow direction, indicative of fluvial transport (Rust, 1972_a). Indistinct zones of Gp may also be present. These types of deposits resemble coalesced longitudinal bars in the proximal braided fluvial tract (Church and Gilbert, 1975). A Scott or G2 model best typifies this succession.

The Pit section is an example of the distal alluvial fan in which debris flows are still active, to the proximal braided fluvial tract on either the fan complex or the braided plain.

4.3.1.7 Charlo

The Charlo section, located along a 2 km stretch of coast at Charlo, N.B., is a gently dipping (< 3 degrees) 46 m succession similar to Pointe aux Corbeaux (Figure 28). The section consists of fining-upward cycles of Gm(s)- Gm- Sp; Gm- Sp- St; Sh- Fl and Fl/Fm deposits.

The conglomerates are essentially composed of cobble to pebble well-imbricate deposits with minor interbedded Gp and Gt facies. The Gm deposits are laterally extensive and show moderate vertical and horizontal facies changes. They ap-

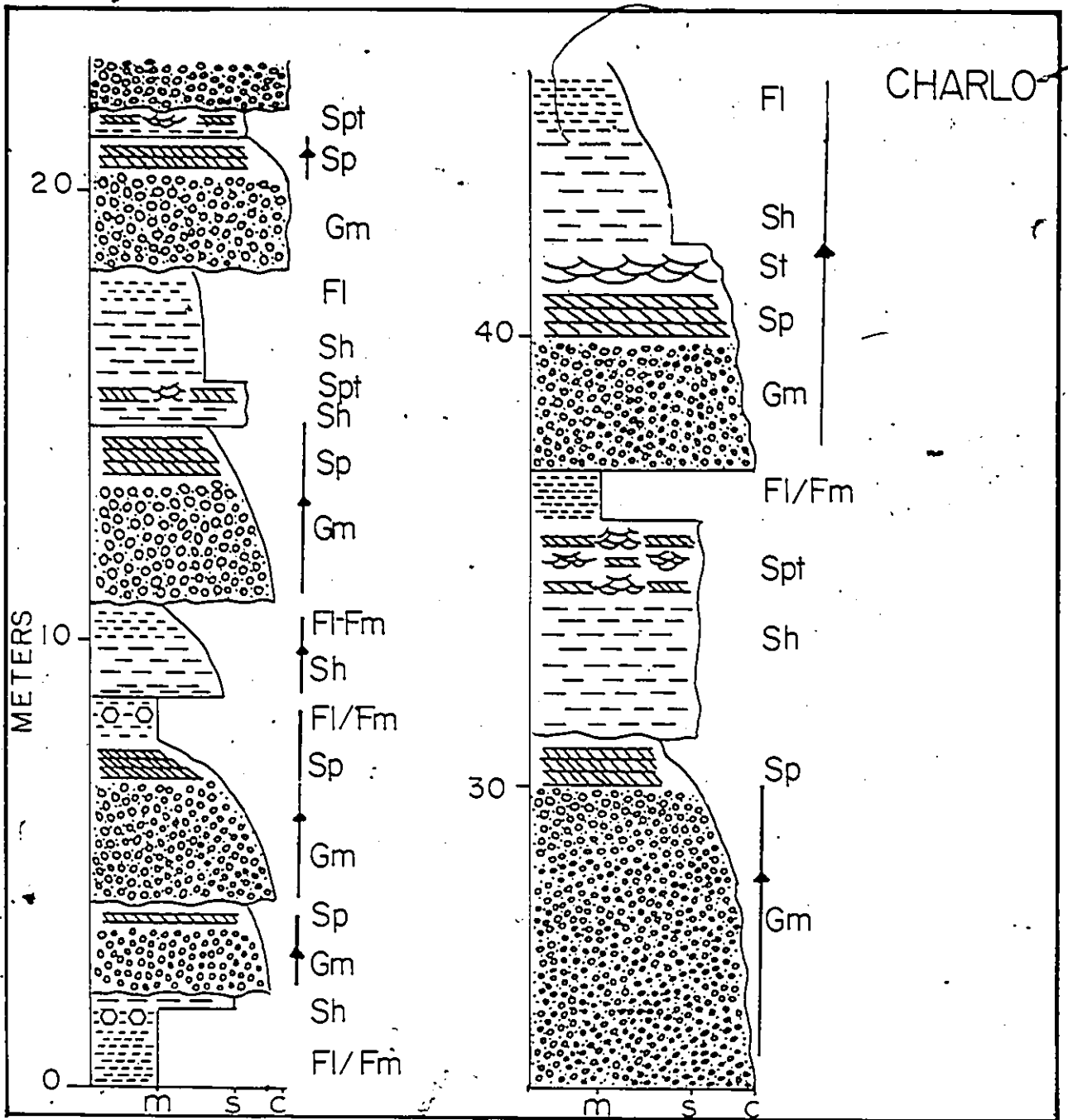


FIGURE 28: Charlo Section

pear to represent the formation of longitudinal bars in stream flood deposits.

The finer units (Sh-F1 and F1/Fm) appear to be of over-bank origin. The occasional coarsening-upward succession may be due to crevasse splay or levee formation.

Plate 12 shows a coarsening-upward, fining-upward, coarsening-upward succession. Overlying the caliche horizon are St sandstones that have cut a minor scour or channel into the deposits. The lower unit represents a near proximal flood event while the overlying deposit represents a mid-flood event.

Cycles in the Charlo section are less distinct than in other sections, but appear on a 3 to 5 m fining-upward scale. The lack of internal erosional surfaces within these deposits and their gradational contacts indicate that they are the result of one depositional event. The scale of the cycle may indicate a climatic, seasonal or avulsion mechanism, but tectonic control is not favoured. The section as a whole may have been deposited on the proximal to mid reaches of the braidplain. Paleocurrent data for Gm show a paleo-flow direction that is parallel to the proposed bajada, so a position in close proximity to the fan is indicated. The section can be modelled as a transitional sequence between the Scott and Donjek models of Miall (1977, 1978b), or the G2 model of Rust (1978b).

4.3.1.8 Armstrong Brook

The Armstrong Brook section (Figure 29) located midway between Charlo and Belledune Point, is a discontinuous section of 20 plus m within a 1.5 km section of beach. The section possesses a very shallow dip and is composed predominantly of fining-upward cycles of Sh, Sh- Fl, and Gm- Sp- St deposits. Very little Fl or Fl/Fm deposits are present except for a few minor interbeds that contain caliche zones.

The discontinuous nature of the outcrop makes it difficult to propose an interpretation. The section seems to represent a transition between deposits seen at the lower section at Anse aux Corbeaux and Charlo, i.e., mid to distal braided fluvial deposits on a braidplain. A Donjek or G3 model of deposition is the most likely interpretation.

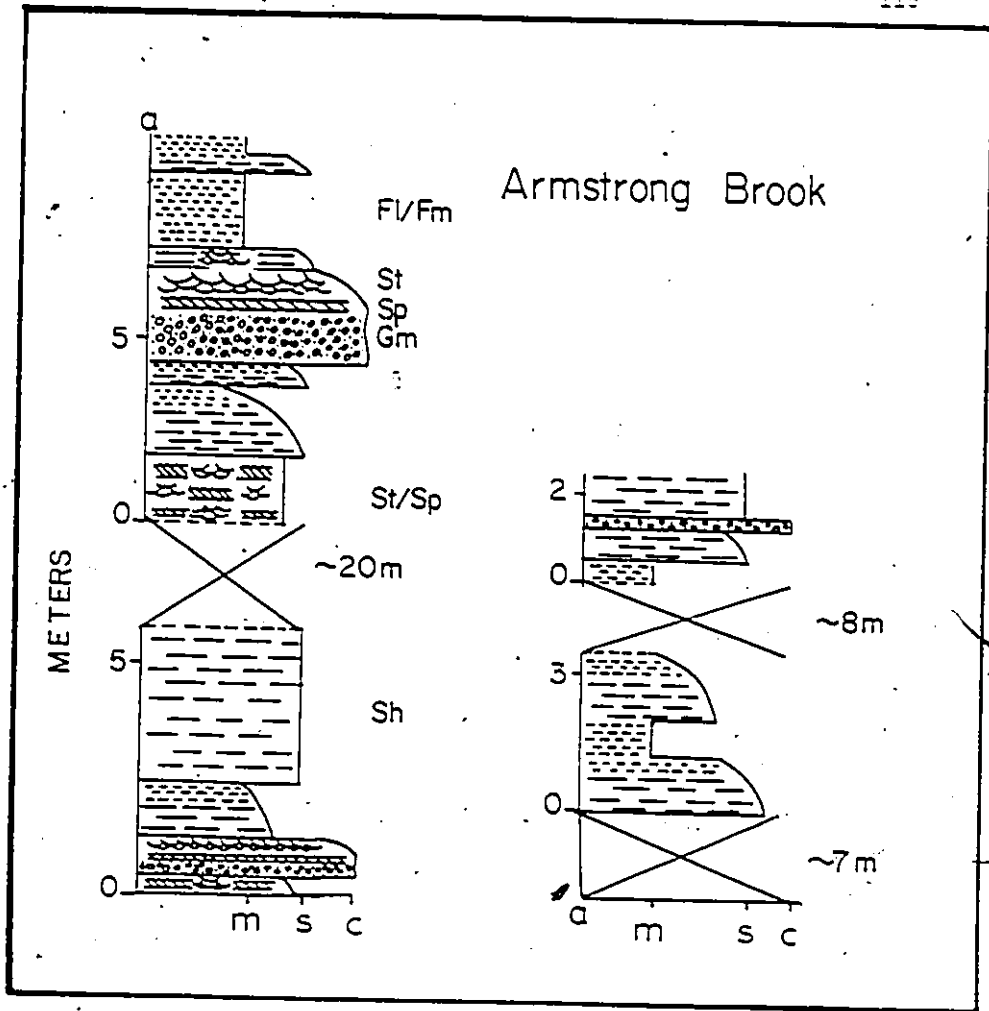


FIGURE 29 : Armstrong Brook Section

4.3.1.9 Belledune

The Belledune section (Figure 30) is the most easterly section of the Bonaventure visited. The section rests unconformably upon tilted Siluro-Devonian carbonates. The section is only 3 m thick in the area and consists of a pebble to small cobble, massive Gm, filling in the paleohollows overlain by Sh and St sandstones. The sandstones are themselves overlain by Fl deposits that are rippled and contain well-developed caliche.

The Belledune section is interpreted to be representative of the alluvial braidplain. Locally, coarse grained material fills in the original paleohollows, but once a level gradient was reached deposition consisted of Sh (ephemerally derived) sandstones. Caliche is evidence of protracted breaks in sedimentation.

The Belledune section would best resemble the S₂ /silt model of Rust(1978b). The lack of section, and the inability to determine cyclicity make it difficult to ascribe to one of the models of Miall (1977, 1978b).

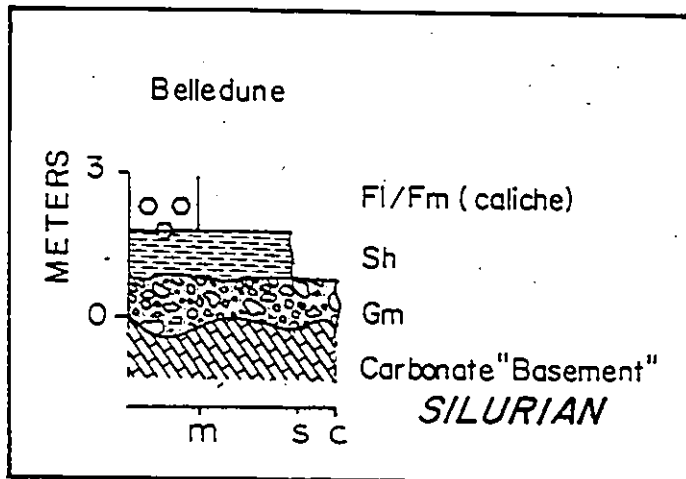


FIGURE 30: Belledune Section

4.4 DRILL HOLE DATA- HERON ISLAND

Heron Island, situated approximately 1.6 km off the northern New Brunswick coast, was drilled in the fall of 1973 as part of a site investigation project for a nuclear power plant by the N.B.E.P.C. . The solid core from the project was discarded prior to 1979, but the drill hole logs recorded by A.D.I Consultants, Ltd (1974) were made available for study.

The island is composed entirely of the Bonaventure Formation except where overlain by a thin cover of glacial drift. The Bonaventure strikes approximately NW-SE , with a gentle NE to E dip (A.D.I.,1974.). The thickest hole through the Bonaventure reached 44 m without reaching basement (DH-D). Figure 31 is the schematic representation of the four drill holes.

The logs were difficult to decipher, due to the lack of sedimentary structural information . Six lithofacies based solely on lithotype were discerned:

1. G- conglomerate
2. S- sandstone
3. Sfl- interbedded sandstone and shale
4. Fl - interbedded siltstone and shale
5. Fcl- red claystone
6. Fe - caliche, seat earth, and nodular breccias. (The poor quality of the log descriptions, and the absence

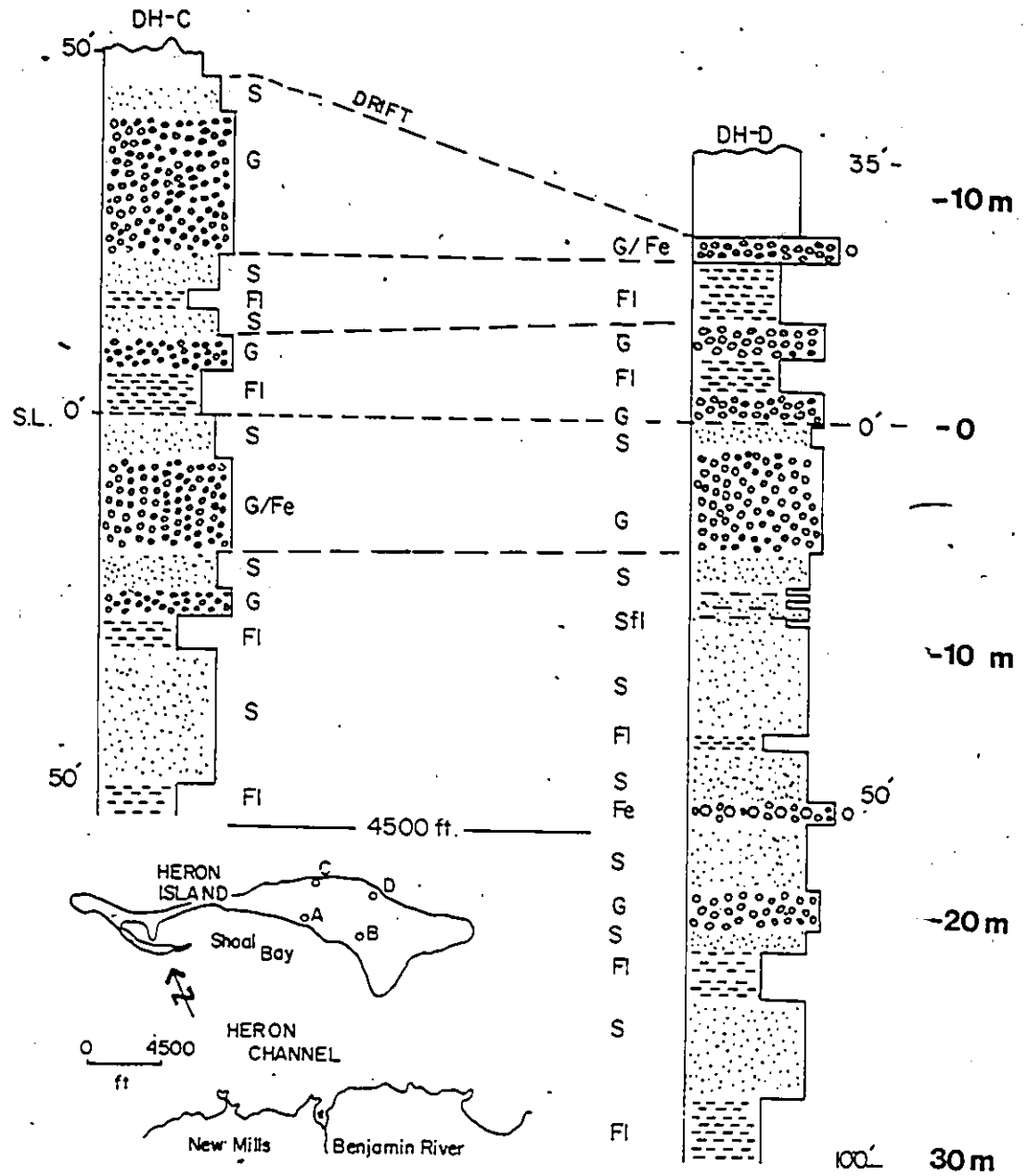


FIGURE 31 : Heron Island Drill Core - Locations and Sections
 (after A.D.I. Ltd, 1974)

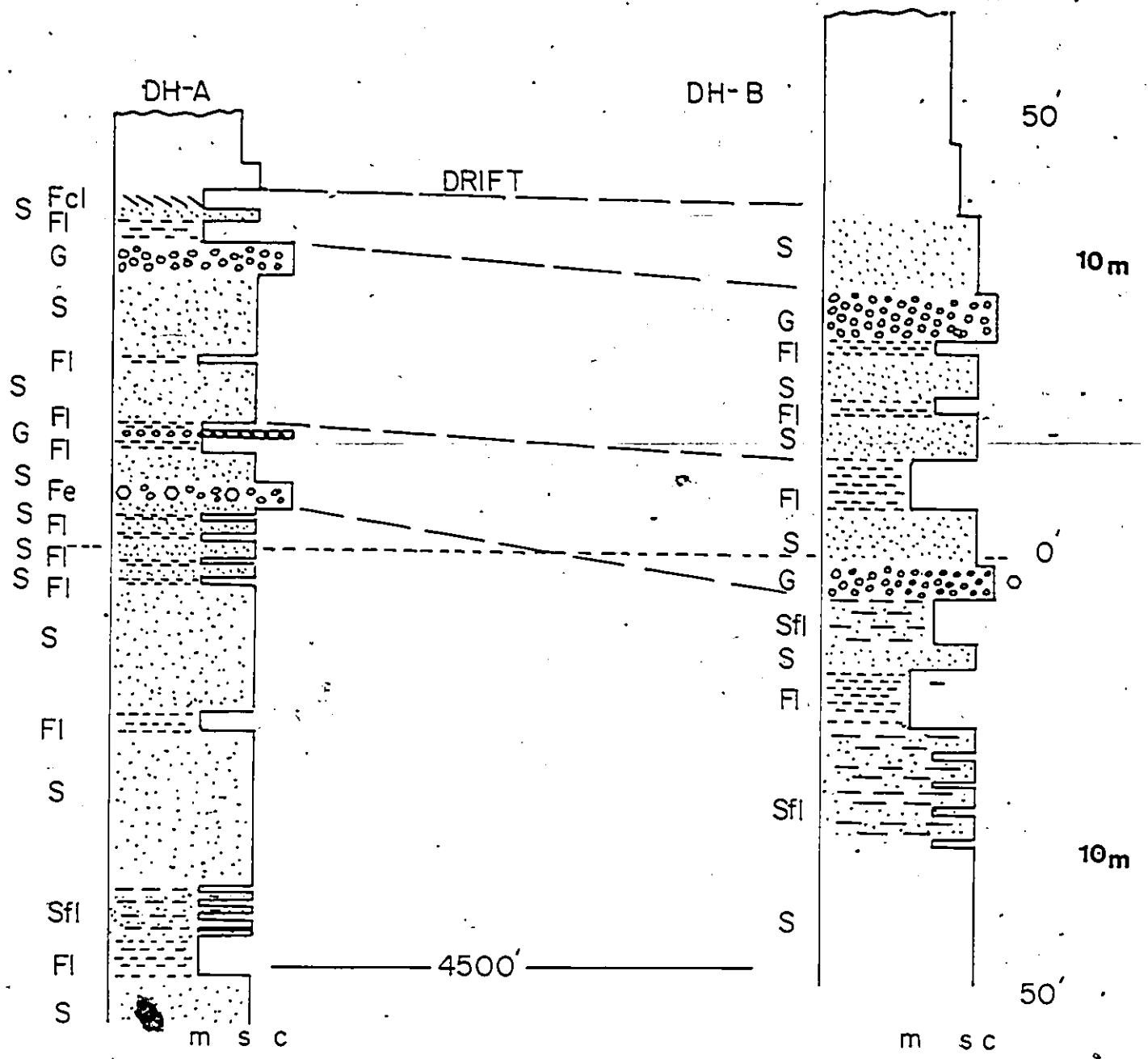


FIGURE 31 con't

of any type of "breccia" deposit within the sand-dominated braidplain, led to the grouping of the 'carbonate nodular breccia' with caliche and seat earth units).

Markov Analyses on each drill hole were combined for an analysis of the entire drilled thickness. Appendix B contains the derived matrices, and Figure 32 summarizes the results.

The individual drill holes show distinct cycles from :

1. G- Sfl- S ; G- S- Sfl- Fl; G- S- Fl and that the finer material is usually erosionally overlain by coarser material
2. Fe- S; Fl- S; in coarsening-upward cycles

The composite analysis of all four drill holes (n=71 transitions) shows a lack of cyclicity except that Fe is usually overlain by S. The four possible model cycles obtained from the analysis of the drill holes are presented in figure 32. The first is typical of overbank deposits while the second and third may represent flood incursions of coarser detritus or sheetfloods respectively. These last two are combined together to form what may be termed a fining-upward (splay?) deposit.

The lack of cyclicity in the drill data, and the lateral and vertical facies changes noted by the authors of the A.D.I. report (A.D.I., 1974) may indicate that the Heron Island deposits are of the sand dominated braided fluvial

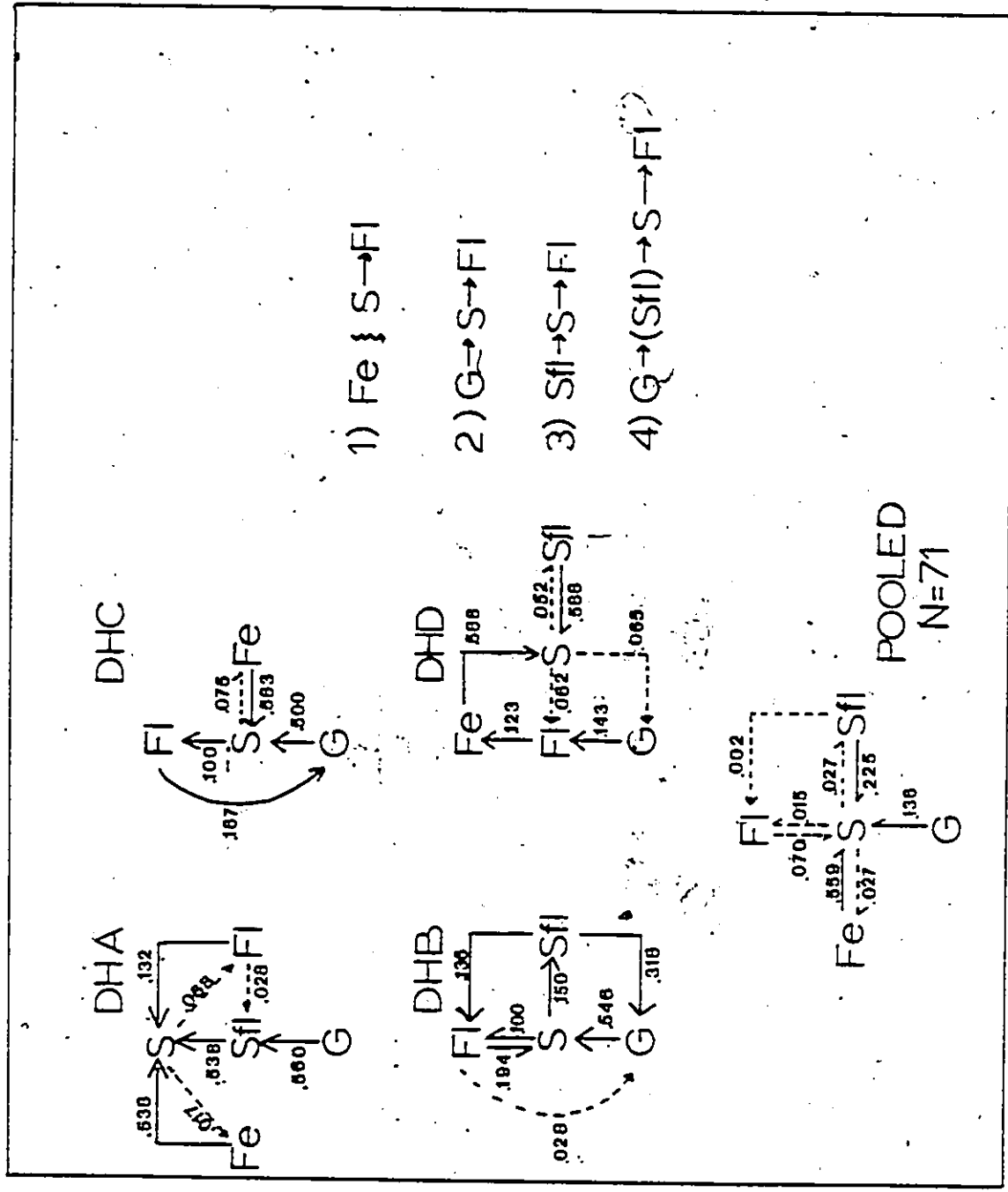


FIGURE 32: Cycles obtained from Markov Analysis of Drill Hole Data, Heron Island Bonaventure Formation

Platte or S2 type of Miall (1978b) and Rust (1978b) respectively. The eastward dip of the bedding probably indicates the original paleoslope and is regarded as such in the later reconstruction of the Bonaventure depositional environment. The absence of solid core and the lack of access to Heron Island make it difficult to be more precise about depositional environments.

4.5 PALEOCURRENT AND CLAST COMPOSITIONAL DATA

The paleocurrent measurements obtained from the Bonaventure Formation are summarized in Table 9 and Figure 33. The data from the Quebec portion of Baie des Chaleurs show a strong north to south and/or northwest to southeast transport direction. The values obtained from New Brunswick show a strong south to north and/or southwest to northeast paleocurrent direction. These opposed directions strongly suggest that the Bonaventure Fm. occupies a paleovalley exhumed by recent erosion to form the Baie des Chaleurs. Hence it is reasonable to interpret the eastward dip of the Bonaventure on Heron Island as the original paleoslope direction which suggests a west to east paleodrainage direction down the axis of the Baie des Chaleurs. Figure 33 shows the proposed model of paleodrainage during the deposition of the Bonaventure Formation.

IMBRICATION							
Station	N	Vector Mean \bar{O}	Arithmetic Mean \bar{X}	Vector Magnitude \bar{X}	Significance P	Mean Dip Angle \bar{Y}	Comments
P	20	138.20	138.0	93.79	2.74×10^{-31}	21.40	Point aux Corbeaux
X	15	174.03	175.07	93.12	2.50×10^{-23}	24.47	Hugh Miller Cliffs
Y	15	214.62	213.60	95.12	2.60×10^{-24}	25.07	Hugh Miller Cliffs
Pooled X-Y	30	194.50	194.30	88.51	1.49×10^{-41}	25.17	
CHA	20	164.48	--	94.56	8.63×10^{-32}	27.55	Charlo
CHB	20	20.44	--	94.32	1.23×10^{-31}	26.90	Charlo
CHC	20	38.58	--	94.37	1.19×10^{-32}	32.45	Charlo
Pooled	60	25.77	--	94.06	6.21×10^{-93}	28.97	
Pit A	20	22.63	--	93.61	2.69×10^{-31}	22.90	Pit H.B.
Pit B	20	348.79	--	95.07	1.17×10^{-32}	14.15	Pit H.B.
Pooled	40	355.52	--	94.12	2.78×10^{-62}	18.53	

Clast Imbrication Data--Bonaventure Formation

Station	N	Vector Mean \bar{O}	Arithmetic Mean \bar{X}	Vector Magnitude \bar{X}	Significance P	Mean Dip Angle \bar{Y}	Comments
M	12	49.18	--	93.61	--	--	Point aux Corbeaux
H	10	136.54	--	97.53	--	--	Point aux Corbeaux
R1	3	270.30	--	100.00	--	--	Yacta Point
R2	4	210.50	--	99.99	--	--	Yacta Point
S	5	262.52	--	98.54	--	--	Yacta Point
T	5	206.54	--	99.02	--	--	Yacta Point
Y	10	110.50	--	100.00	--	--	Anse aux Corbeaux
V	10	176.47	--	98.72	--	--	Anse aux Corbeaux
Current Initiations		Trend					
Q	10	262.62	--	93.79	--	--	Yacta Point
Trough X-Beds							
W	12	150.50	--	95.98	--	--	Anse aux Corbeaux

TABLE 9: Paleocurrent Data, Bonaventure Formation (N- no. of readings per station)

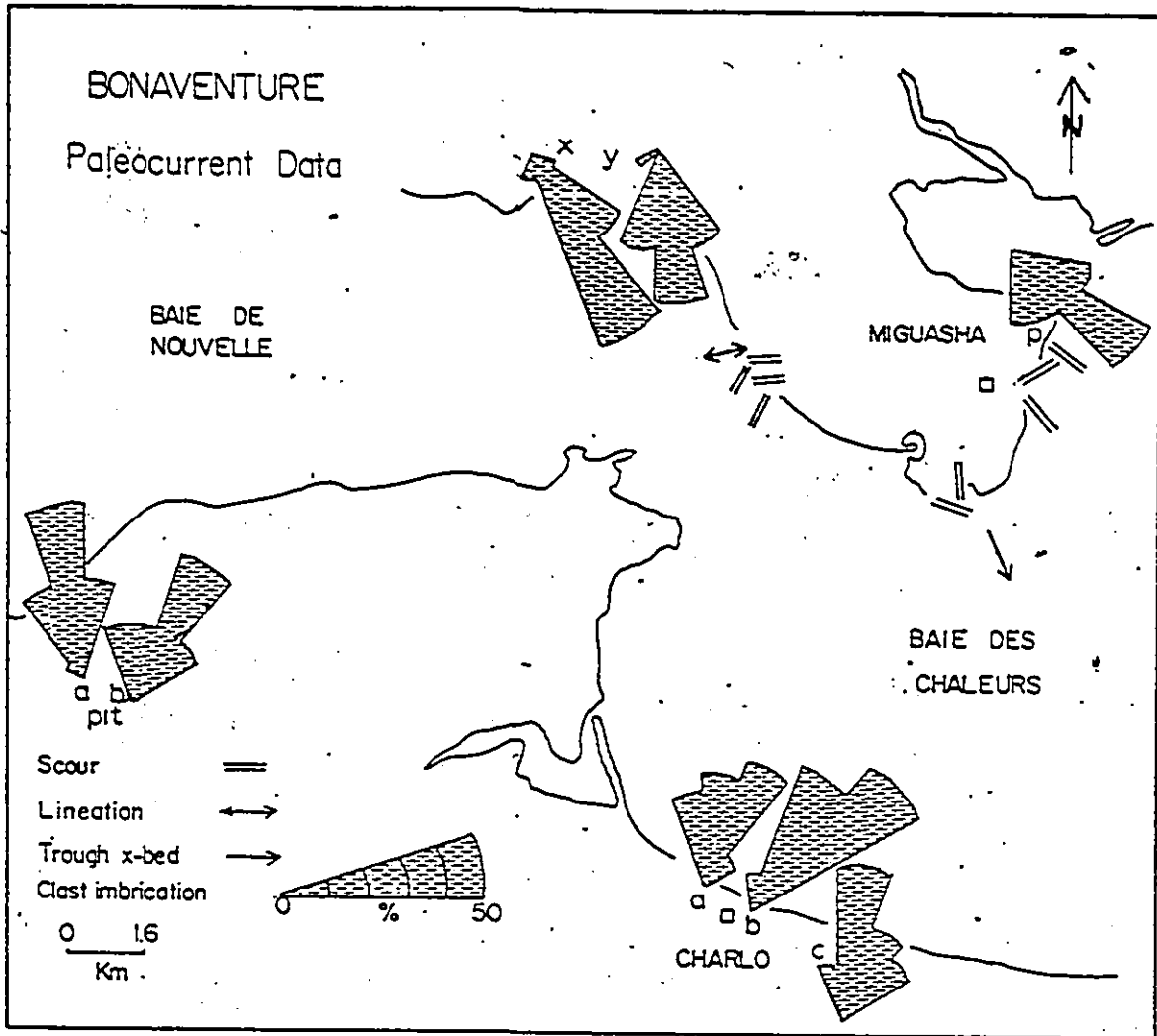


FIGURE 33: Paleocurrent Data, Bonaventure Formation
(Location points refer to Gm imbrication, Table 9)

The clast counts for the Bonaventure Fm are presented in Figure 34. The Gaspé portion is still dominated by carbonates, with lesser amounts of volcanics and sandstones most probably derived from the Restigouche and Matepédia Groups. The N.B. portion is dominated by andesitic volcanics of probable oceanic crust derivation from the New Brunswick Highlands (Tetagouche Group) to the south. The differences in clast composition within the Bonaventure from the Gaspé and New Brunswick areas confirm the paleocurrent data, and show that the Bonaventure was draining areas to the north, northwest, west, southwest and south of the study area. The west to east postulated drainage flow direction from Heron Island, in conjunction with the geometric distribution of the lithofacies indicate that the Bonaventure was deposited in an enclosed basin opening eastward, draining highlands to the north, west, and south; that flowed in a trunk river system, eastward down the axis of the Baie des Chaleurs. It is postulated that the Bonaventure eventually debouched onto the New Brunswick Platform.

CLAST COMPOSITION
BONAVENTURE FM.

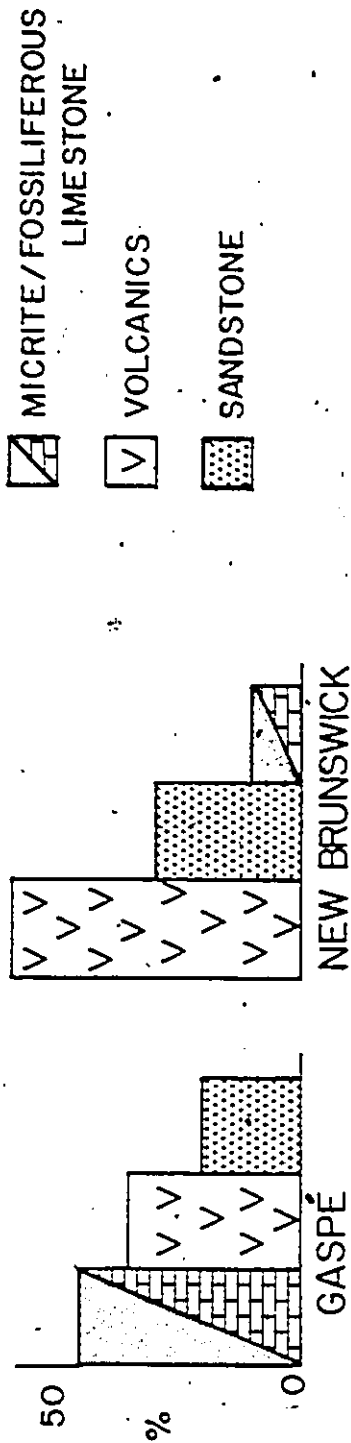


FIGURE 34 : Clast Composition, Bonaventure Formation (approx. 200 clasts per histogram)

4.6 CALICHE

Calcrete (or caliche) is defined as a "hard mass of calcium carbonate precipitated from solution and redeposited through the agency of infiltrating waters in the soil zone, or deposited by the escape of carbon dioxide from vadose waters" (A.G.I. Glossary, 1972, p. 100). Caliche is found in areas of arid to semi-arid terrestrial deposition and as surficial crusts on modern or ancient carbonate successions (Reeves, 1970; Williams, 1973; Siesser, 1973; and many others).

Recent work on caliche has dealt with the textural zonation of the pedogenic profiles within modern environments (Reeves, 1970; Gardner, 1970). The few studies to date on the geochemistry of caliche have dealt with the major and trace element distribution within the profile. The aims of this study of three caliche profiles were to determine:

1. the concentrations of Ca and Sr from the leachable carbonate fraction
2. the mode of formation of the caliche and to determine the composition of the natural waters that controlled caliche development .

Caliche is present in the Bonaventure Formation within the proximal alluvial fan/ braidplain facies and the transitional braided/meandering facies. Three caliche profiles from the upper braided or transitional braided/meandering

facies were chosen for chemical analysis by Atomic Absorption.

The samples of caliche were obtained from the top(A), middle(B) and bottom(C and D) of the profiles located at Yacta Point (C-Y-); Belledune (C-B-); and Charlo (C-C-). The results are listed in Table 10 .

The values obtained show mSr/mCa ratios between .11 - .40 $\times 10^{-2}$. According to Kinsman (1969) values approaching .32 $\times 10^{-2}$ are diagnostic for normal ground waters. The ppm values obtained for Sr (.19- .70) are within the range of .2 to 50 ppm for Sr concentrations found in ground and near surface waters by Skougstard and Horr (1963). This indicates that the Sr concentration found within the soluble portion of the caliche was controlled by the chemistry of the ground and near surface waters.

The water table in semi-arid ephemeral deposits is usually deep in relation to the topographic surface (Walker, 1967,1976). This is the case near the active scarp, whereas the water table may approach surface within the braidplain. The analyzed caliche is thought to have developed in areas of elevated water table near crevasse splays and/or levees. It is postulated that at certain times of the year the water table was charged, or flood conditions prevailed and the dissolution of carbonate was enhanced. As the season became arid the water table was depressed, pedogenic processes took over and carbonate was precipitated.

Sample	Ca	Sr	$\left(\frac{^{87}\text{Sr}}{^{86}\text{Sr}}\right)_{\text{Kc}}$	$\left(\frac{^{87}\text{Sr}}{^{86}\text{Sr}}\right)_{\text{H}_2\text{O}}$	Sr*
	ppm	ppm			ppm
C-B-A	337395	127	$.17 \times 10^{-3}$	$.12 \times 10^{-2}$.21
C-B-B	396566	171	.19	.14	.25
C-B-C	369082	128	.16	.11	.19
C-B-D	361682	155	.19	.14	.25
C-Y-A1	383382	340	.41	.29	.51
C-Y-A2	363569	324	.41	.29	.49
C-Y-B	366873	313	.39	.28	.37
C-Y-C	341237	216	.29	.21	.39
Y-P	350849	236	.31	.22	.49
C-C-A1	358316	322	.41	.29	.51
C-C-A1	371723	358	.44	.31	.54
C-C-B	213229	265	.56	.40	.70

TABLE 10: Partial Chemical Analysis of Caliche Samples (leachable fraction)
Sr* values for precipitating solution (Kinsman, 1969)

4.7 RECONSTRUCTION AND INTERPRETATION

The Bonaventure Formation has been deduced to encompass the three following depositional environments from the analysis of the measured stratigraphic sections:

1. proximal alluvial fan
2. proximal to distal gravel- and/or sand-dominated braided fluvial deposits from the distal fan and braidplain environments
3. sand- and silt-dominated transitional deposits from between the distal braidplain and the meandering alluvial plain

Figure 35 represents the proposed distribution of the above depositional environments about the western Baie des Chaleurs region.

The Bonaventure is attributed to deposition in a restricted, west to east trending basin within the western Baie area. This basin or paleovalley is now exhumed and forms the present Baie des Chaleurs drainage basin. East of the line made by Belledune-Cape Noir the Bonaventure basin may have opened out onto the New Brunswick Platform. Data to confirm or refute this was not collected, as it was outside the study area.

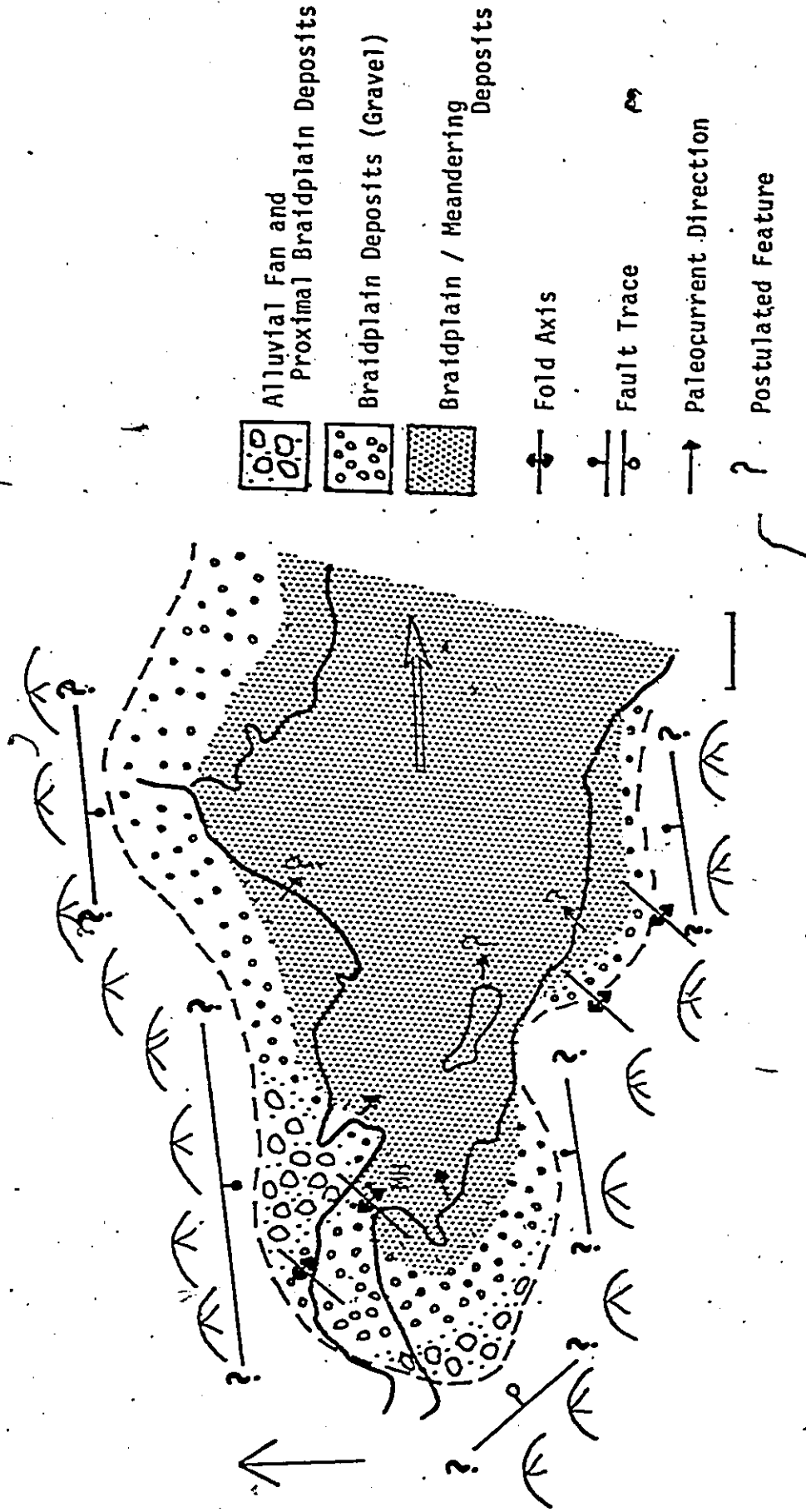


Figure 35: Paleogeographic Reconstruction, Bonaventure Formation.
(MH- Miguasha Hinge)

The major source areas for the western Baie region were to the north, west and south. Clast compositions from the Gaspé contain carbonate from the Restigouche and/or Matapédia Groups to the north and northwest and in New Brunswick are characterized by volcanics of the Tetagouche Group to the south.

The bajada to alluvial plain succession is deduced from the measured sections. The only continuous section is at Yacta Point, but the other sections provide specific depositional information. Proximal alluvial fan deposits (ie. containing Gms) are present at Yacta Point and the Pit section at Dalhousie Junction. Proximal gravel-dominated braided fluvial deposits representing mid to distal fan to proximal braidplain (ie. containing longitudinal bars) are present at Yacta Point, lower Hugh Miller Cliffs, upper Anse aux Corbeaux and Pit section. Areas of more distal gravel dominated braided fluvial conditions that have both dissected longitudinal and traverse bars were the upper portion of the Hugh Miller Cliffs, Miguasha Road and Pointe aux Corbeaux section. The remaining sections represented sand dominated alluvial braidplain to transitional deposits (at Yacta Point).

The ephemeral nature of the deposits, red bed development and the presence of well-developed caliche indicate that the Bonaventure was deposited under semi-arid climatic conditions.

Chapter V

TECTONIC CONTROLS ON THE LOWER/MIDDLE DEVONIAN - CARBONIFEROUS TERRESTRIAL SUCCESSION, WESTERN BAIE DES CHALEURS AREA.

5.1 INTRODUCTION

Lower/Middle Devonian to Carboniferous terrestrial deposits in the northern Appalachians have been attributed to molasse deposition as the result of the Acadian-Appalachian tectonic events (Belt, 1968b; Poole, 1976). Molasse, though, is defined as "a distinctive sedimentary facies consisting of alluvial and shallow marine deposits derived from source areas undergoing rapid uplift and erosion" (Miall, 1978c, p1613). The L/M Devonian near the eastern tip of the Gaspé (consisting of the York River, Battery Point, and Malbaie Fms.) most probably represents "classical" molasse (McGerrigle, 1950; Rust, in press (b)). Rocks of similar age studied in the western Baie des Chaleurs region do not represent the transitional sequence from marine to non-marine infill. Deposits of this type are termed molassoid (Miall, 1978c).

The Devonian/Carboniferous deposits of the western Baie area have been attributed to deposition in successor basins (Poole, 1976; Zaitlin, 1981). A classification of non-marine paralic sedimentary basins by Miall (1978c, Table 1) places

molassoid deposits in "late orogenic to post-orogenic (superimposed ?) intermontane basins" . Miall (op.cit., pl614) states that basins of this type are present in tectonically active areas and are characterized by :

1. pronounced fault scarps
2. coalescing alluvial fans (bajada) .
3. the occurrence of landslides and debris flows.

Such basins can also be subdivided into internal and external basins, subject to their position relative to the orogenic belt.

Miall (1978c) notes that while the characteristics of molasse are distinctive, the lithofacies attributed are not exclusive to molasse sequences. No mention is made of the type of tectonic regime needed to form molasse (-oid) basins, but that only sharp relief is needed to produce coarse detritus. Both normal (dip-slip) and strike-slip faults can produce the necessary vertical relief.

Relief can form due to 1) compressional, 2) tensional, or 3) horizontal movement. All three can produce dip-slip components . Tectonically active areas, that are normally associated with basin development, are found in active continental margin and/or interior rift areas.

5.2 APPALACHIAN TECTONIC MODELS

The regional geology and tectonics of the Maritimes was briefly summarized in section 1.3. There are two main schools of thought concerning the tectonic events affecting the northern Appalachians during the Devonian and Carboniferous. The first school believes that subduction and transcurrent motion were active during all tectonic events (Bird and Dewey, 1970; Poole, 1976; Schenk, 1978). According to this hypothesis the Appalachians would have undergone compressional and/or tensional stress dependant on the nature (straight or oblique) of the associated collision.

The second school believes subduction, which began in the Ordovician, stopped prior to the Devonian Acadian Event. The Acadian was thought to have developed solely due to compression. The absence of ophiolites is cited as negative evidence to discount subduction during the Acadian (H. Williams, 1979). Rust (in press (b)) notes that the period between the Taconic and Acadian events is such that it is difficult to attribute the warping in the Devonian to a continuation of the Taconic Event. A more probable explanation is that Taconic zones of weakness were reactivated during the Devonian by the postulated oblique collision between Laurentia and Baltica (Scotese et al., 1979).

Continental collision to the SE therefore caused renewed motion along preexisting zones during the Carboniferous.

Webb (1969) and Belt (1968 b) noted strike-

slip displacement along major faults in the Maritimes. The sense of displacement along faults differs between left and right lateral, with some faults possessing both senses of movement during different periods of their history, but dextral movement appears dominant. Kent and Opdyke (1978) and Morris (1976) noted portions of southern Nova Scotia have been displaced 10-15 degrees relative to North America, and obtained their present position during the Carboniferous. This is definitive evidence of transcurrent motion during the Appalachian event.

5.3 MAJOR SEDIMENTARY FEATURES IN THE WESTERN BAIE DES CHALEURS MOLASSOID DEPOSITS

The Pirate Cove and Bonaventure Formations are characterized by alluvial fan deposits (with Gms) that grade laterally into proximal to distal alluvial (braid-) plain deposits. The Pirate Cove appears to have formed in an asymmetric basin, with its braidplain draining longitudinally NE to SW, parallel to a major (postulated) fault scarp to the NW. The alluvial fans of the Pirate Cove appear to coalesce, forming a bajada that drains transversely from the fault scarp. The Fleurant Formation, a proximal gravel-dominated braidplain deposit, also drains transversely from a NE-SW trending fault scarp to the NW.

The Bonaventure Formation in the western Baie area is characterized by a W to E trending longitudinal drainage system, girdled to the N., S., and W. by fan complexes that drain transversely from postulated fault scarps.

The L/M Devonian to Carboniferous terrestrial deposits in the western Baie area can be subdivided into two distinct packages based on their sedimentological and tectonic styles. The Devonian sequence, composed of the La Garde, Pirate Cove, Fleurant and Escuminac Formations appear to have been deposited into NE-SW elongate basins, controlled by a major fault system trending NE-SW, to the NW of the present outcrop area. Drainage was transverse to the faults in a NW to SE direction, with a longitudinal drainage system parallel to the scarps from NE to SW.

Only the NW side of the basins outcrops. The SE portion of the basins should outcrop in the Baie des Chaleurs when the synclinal E-W trending Chaleur Trough is taken into account. If the basins were symmetrical, the SE portion should consist of marginal coarse clastics, and the resistant nature of the sediments should cause the formations to outcrop. It is based on this weak evidence, and the structural setting of the area, that the Devonian basins are assumed to be asymmetric.

The depositional basin for the Bonaventure Formation opens outward from the west to the east. Coarse fan deposits with associated debris flow deposits are better developed in the N and N.W. of the basin. In the S and SW the conglomerates are less extensive, finer and lack well developed Gms. Major fining-upward cycles are present in the N

and NW., in the Yacta Point and the Hugh Miller Cliff sections. In this respect the Bonaventure Basin is asymmetric at the western end of the Baie des Chaleurs, though it may be a function of exposure. Its lithofacies distribution, drainage and overall shape closely resemble the Hornelen Basin of Norway (Steel et al., 1977; Steele and Aasheim, 1978).

5.4 RECOGNITION OF ANCIENT SEDIMENTARY BASINS

5.4.1 Introduction

The tectonics of modern depositional basins are relatively easy to deduce because of the available information on continental margin setting, active fault systems, outcrop distribution etc. . . The most important feature, however, is that the entire record is available and has not been affected by later tectonic events.

Ancient basins are more difficult to place in a tectonic setting because the entire record may not be present; or has been altered by later faulting, erosion or masked by overlying material.

In reconstructing ancient sedimentary basins the regional context is an important aid. It is for this reason, based on the studies of Belt (1968a,b), Webb (1969) and Poole (1967, 1976), that the sediments within the Baie area are assumed to have been deposited in half-graben and strike-slip basins during this time. The tectonic setting for the Devonian-Carboniferous molassoid deposits will be modeled from that premise, although other interpretations that include normal

dip-slip faulting may equally well explain certain of the features. It is of my opinion, however, that strike-slip tectonics best explain the overall features of sedimentation in the Western Baie des Chaleurs area during the Carboniferous.

5.4.2 Recognition of Ancient Strike-Slip Basins- a discussion

5.4.2.1 Shear Couples vs. Compression

Strike-slip motion associated with major shear couples produced a variety of structural components that control sedimentation. Figure 36a represents a stress ellipsoid that has undergone a NW-SE dextral shear couple producing:

1. E-W en echelon fold axes
2. conjugate synthetic and antithetic strike-slip faults
3. normal faults
4. thrust faults

Figure 36b represents N-S compression, and the resulting structural components:

1. fold axis (possibly en echelon).
2. sinistral strike-slip faults
3. dextral strike-slip faults
4. normal faults
5. thrust faults

It is important to note that certain compressional elements are equivalent to shear couples. Normal dip-slip faults and dip-slip components to transcurrent faults are produced under both types of stress, forming the needed vertical movement for molasse or molassoid deposits.

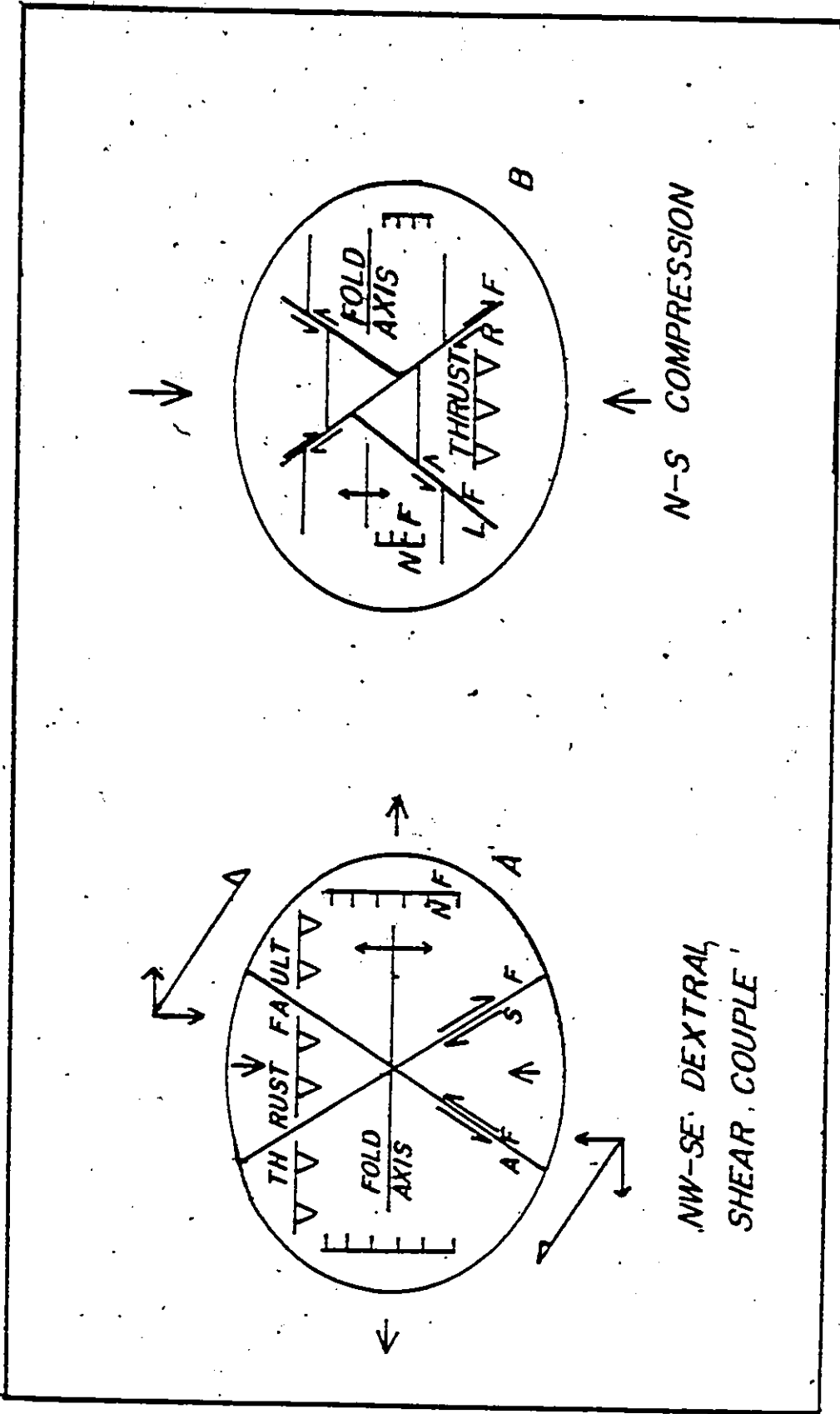


FIGURE 36 : Structural Elements Generated by a) Dextral Shear Couple and b) Compressional Stress (modified from Wilcox et. al., 1973)

AF- Antithetic strike-slip fault; SF- Synthetic strike-slip fault; NF- Normal fault

√RF- Dextral strike-slip fault; LF- Sinistral strike-slip fault

5.4.3 Criteria for the Recognition of Strike-Slip Basins

Steel and Gloppen (1980) and Reading (1980) proposed criteria for recognizing ancient strike-slip basins. Although overlap existed in both sets of criteria, 11 basic points are deemed to be helpful in distinguishing strike-slip basins:

1. overall elongate basin shape delimited by fault scarps or major fold axes.
2. rapid sedimentation rate
3. quick lateral facies changes and/or extensive thin deposits
4. thick deposits in relation to lateral extent
5. proximal onlap of subsequent deposits (that follow one of 4 possible models for lithofacies distribution by Ballance (1980)).
6. basin asymmetry
7. longitudinal mode of sediment dispersal
8. mismatch with postulated provenance of either clast size or composition
9. coarse marginal fan conglomerates including debris flow deposits.
10. strike-slip fault structural system
11. scarce igneous and metamorphic activity

Criteria 5,8 and 10 are solely attributed to strike-slip basins, while the other features, though found in strike-slip

settings, can form or be produced in settings having a dip-slip component.

Other features presented by Steel and Gloppen (1980), and Reading (1980) appear to have dealt with specific basins. An example of this is the coarsening-upward criteria postulated by Steel and Gloppen (op. cit.) from the Hornelen Basin. Bluck (1980) noted that his postulated strike-slip basin sediments fine upward (similar to the Bonaventure). Balance (1980) explained how strike-slip basins can generate either fining- or coarsening-upward deposits dependant on the sense of displacement along the fault and drainage within the basin. If longitudinal drainage parallel to the fault zone is in the sense opposite to fault movement, then the coarse sediments will "prograde" over the finer sediments, producing a coarsening-upward sequence.

5.4.4 Strike-Slip Basin Criteria Applied to the Devonian-Carboniferous Sediments, Western Baie des Chaleurs Area

Table 11 summarizes 12 criteria for both the Devonian and Carboniferous Basins in the western Baie area. It is important to note that both successions have elongate basin shape, abrupt lateral facies changes, basin asymmetry(?), and coarse marginal "fanglomerates". Neither succession shows well-developed proximal onlap. The overall minor thickness and calculated sedimentation rates are slow, in contrast to quick rates and thick sediment piles postulated for other strike-slip basins. The Pirate Cove Fm. of the Devonian

Criteria	Devonian	Carboniferous
Sedimentation Rate	slow - .02m/1000y	slow - .01m/1000y
Sparse Igneous and Met. Activity	yes	yes
Marginal "Fanglomerates"	yes	yes
Wrench Fault Pattern	no?	yes?
Mismatch of Clast Size +/- Composition	yes?	?
Longitudinal Mode of Sediment Dispersal	yes	yes
Basin Asymmetry	yes	yes?
Proximal Onlap	no?	no
Thickness	2.2 km	200m
Extensive, thin deposits	yes?	yes?
Rapid lateral + vertical Facies change	yes?	yes
Elongate Basin Geometry	yes NE-SW 4 x 20km	yes W-E 10 x 70km

Table 11: Criteria for the Recognition of Strike-Slip Basins Applied to the Devonian (incl. La Garde, Pirate Cove, Fleurant and Escuminac Fms.) and Carboniferous (Bonaventure Fm) Successions of the Western Baie des Chaleurs Area.

succession has a longitudinal mode of sediment dispersal, as does the Bonaventure. Other formations in the Devonian succession do not appear to possess such a discharge system.

The Devonian succession may show a mismatch in regard to the presence of Gms, coarse clasts and angular clasts in unit 2 of the Pirate Cove. B. Skidmore (per. comm., 1980) noted the lack of fit between the clast size of unit 2 in relation to its closest source area. Limestones of the Restigouche Group outcrop approximately 10 km to the N and NW of unit 2. Unit two does not have a high depositional gradient, suggesting that the slope needed to generate debris flow deposits and cobble to small boulder sized limestone clasts had to be relatively close. Limestone clasts abrade rapidly in transport (Abbott and Peterson, 1978). All these lines of evidence appear to indicate that during deposition the fault scarp (in a NW direction from analysis of paleocurrents) must have been close by. Since the present outcrop area is approximately 10 - 15 km to the SE of the postulated source, two possibilities exist:

1. Either the outcrop distribution has been modified by erosion to their present position, or
2. the sedimentary basin has shifted 10 km to the SW.

Analysis of the aeromagnetic maps for the Baie area show little offset between units. However, offset would bring limestone against limestone, which would not show up well in aeromagnetic maps.

The presence or absence of a mismatch between clast size and expected lithofacies distribution is therefore problematic for Unit 2 of the Pirate Cove Formation.

Features of a wrench fault system (i.e. en echelon folds , conjugate faults , etc.) were not discerned for the Devonian Succession. The Carboniferous Bonaventure Formation , however , may contain wrench fault features. The Miguasha Hinge (named by B. Skidmore, per. comm., 1980), is a NE-SW trending syncline whose axis is approximately 30-40° off the major E-W trend of the depositional basin (Figure 35). Other less apparent NE-SW trending open flexures occur along the Gaspé and northern New Brunswick coasts. These structures are seen to form part of a NW-SE en echelon fold system. In this arrangement the fault scarps that controlled basin development trend eastward, as expected by the lithofacies distribution. Subsidiary normal faults may also be present normal to the trend of the fold axes. These structural elements may define a NW-SE compression across the folds with a transcurrent component.

The faults and folds postulated could have formed due to a regional dextral shear system that is assumed to have existed in the Maritimes at this time (Arthaud and Matte , 1978) . The associated features cited above , however , can also be explained by simple compression. The choice of one model over the other is based solely on the regional setting. The

lack of structural data available makes it difficult to choose one or the other model.

5.5

A POSSIBLE DEPOSITIONAL MODEL

The information presented in sections 5.3 and 5.4 makes it problematic to choose a specific model for deposition of the Devonian and Carboniferous deposits in the Baie des Chaleurs area. Certain assumptions can be made with confidence, however, when the regional tectonic setting is used to limit the choice of model.

First, we have divided the Devonian-Carboniferous terrestrial succession into two "Packages":

1. A L/M to Upper Devonian Sequence
2. A Lower Carboniferous Sequence

The Devonian sequence is correlative to the L/M Devonian Battery Point and Malbaie Formations of the Eastern Gaspé. As mentioned previously, the major difference between the two L/M Devonian Sequences is the presence of fan deposits in the Pirate Cove Formation. Two possible mechanisms for the development of the fan deposits are 1) strike-slip faulting associated with a dextral shear or 2) normal faulting solely due to compression. The Fleurant and Escuminac Formations have the same laterally extensive and uniform style as the Battery Point and Malbaie Fms.. Rust (in press (b)) postulates a shallow subduction zone causing upwarping due to compression. The continental collision occurring to the

SW during Acadian time surely had a component of compression.

Therefore, despite the lack of definitive evidence, the Devonian molassoid succession is thought to have formed in successor basins that developed due to compression, forming asymmetric basins as the result of normal dip-slip faulting. One possible model to develop such basins would be a shallow NW dipping subduction zone in the SE Maritimes causing broad, compressional warping.

The Bonaventure Formation, composing the Carboniferous "package", appears to have developed under different tectonic style. The Maritimes are thought to have undergone dextral shearing in the Carboniferous (Poole, 1976). It is not important in this case whether the shear was dextral or sinistral, because the structural elements developed will control sedimentation in a similar manner. Many basins in the Maritimes are thought to have formed due to shear couples related to transcurrent movement (ex. Fundy Basin).

The Bonaventure Formation may possess the structural elements (ex. echelon folds, conjugate and normal faults) to be classed as a strike-slip basin. Its sedimentological characteristics do not contain any features (diametrically) opposed to such an interpretation, except for its low rate of sedimentation. The low rate of sedimentation may be due to its position removed from the major shear zones in southern New Brunswick and Nova Scotia. The fining-upward nature is

similar to strike slip basins studied by Bluck (1980) and its facies distribution is similar to basins studied by Steel et al. (1977), Steel and Aasheim (1978).

The Bonaventure Formation therefore is thought to have developed in a strike-slip successor basin as a result of transcurrent motion during the Appalachian Disturbance.

Chapter VI

CONCLUSION

6.1 SUMMARY

The Lower to Middle Devonian - Lower Carboniferous terrestrial succession located at the western end of the Baie des Chaleurs is interpreted to have developed as a variety of alluvial fan and braided fluvial deposits in restricted, asymmetric successor basins. Sedimentary and tectonic style changed at the Upper Devonian / Lower Carboniferous boundary due to the the postulated change from dominantly compressional stress resulting from a shallow dipping subduction zone to the SE to compression and tensional stress resulting from oblique transcurrent motion and resulting from a dextral mobile zone.

The Devonian succession is composed of the La Garde, Pirate Cove, Fleurant and Escuminac Formations. The Pirate Cove Formation consists of five informal members (called units) that represent:

1. Alluvial fan deposits with distal Gms (unit 2)
2. distal alluvial fan and proximal gravel-dominated braided fluvial deposits (units 3 and 5)
3. sand-dominated alluvial braidplain deposits (unit 4)

4. alluvial braidplain and / or interlobe area ephemeral deposits (unit 1).

The Pirate Cove Formation was deposited into a NE-SW asymmetric elongate basin with a prominent fault scarp to the NW trending NE-SW. Drainage within the basin consisted of a NE-SW trending longitudinal "trunk" river system, parallel to the scarp, being fed from a coalesced fan complex draining transversely NW-SE across the fault scarp.

The Fleurant Formation (Upper Devonian) consists predominantly of a coarse cobble to boulder, proximal braided fluvial deposit. Drainage was transverse (NW to SE) across a NE-SW trending fault scarp. The Fleurant was deposited on a relatively gently sloping NW-SE braidplain.

The Fleurant and Escuminac Formations form the Miguasha Group. The Group was deposited in a NE-SW trending basin that was tilted East-West between the deposition of the Fleurant and lacustrine-turbiditic Escuminac Formation.

The Bonaventure Formation is the most widely developed unit in the Baie des Chaleurs area, and was deposited into a East-West trending asymmetric basin similar in facies organization to the Hornelen Basin of Norway. Alluvial fan sediments including debris flow deposits are present along the margins of the basin, which had transverse drainage. Longitudinal proximal to distal alluvial braidplain deposits are transitional to postulated braided meandering deposits. The Bonaventure is composed of a large variety of braided fluvial deposits.

6.2 CLIMATE

Climatic changes from arid/semiarid to temperate to semiarid are postulated to occur between the deposition of the Pirate Cove, Fleurant, and Bonaventure Formations. The Pirate Cove Fm., a red bed sequence, contains incipient caliche, pseudoanticlinal development and ephemeral/sheet-flood deposits that are characteristic of a semi-arid environment.

The Fleurant Formation is an olive-green coarse clastic deposit which lacks caliche and is characterized by large scale coalesced bar forms, well-developed imbrication and a paucity of sand and silt facies. These features all tend to indicate a more temperate climate that have more frequent and powerful flood events.

The Bonaventure Formation is a well-developed redbed formation with thick zones of caliche. Sr values for the caliche indicate formation from percolating ground waters in a semi-arid environment. Alluvial fans, debris flow, sheetflood deposits and the large amount of low-angle trough cross-stratification in conjunction with caliche are indicative of a semi-arid climate.

6.3 BRAIDED FLUVIAL MODELS

Models for gravel and sand sized braided alluvium proposed by Miall (1977,1978b) and Rust (1978b) were successfully applied to the deposits in the Baie des Chaleurs area. The models proposed by Miall have two serious drawbacks:

1. the connotations of the original model in terms of its tectonic/geographic setting in relation to the deposits under study, and
2. the lack of flexibility in transitional cases between models.

The models proposed by Rust are considered superior due to their greater flexibility. Both model sets are invaluable in determining the type of depositional environment only when used in its lateral and vertical facies context.

6.4 SUGGESTIONS FOR FURTHER WORK

1. The continuation of the sedimentological study of the Bonaventure Formation to the east to determine if it was deposited into one or more basins,
2. Structural study of the Baie region to determine more precisely if a strike-slip tectonic model is correct, and to determine whether the strike-slip tectonics affected the Devonian sediments
3. Correlation of the Devonian-Carboniferous basins in Newfoundland, Gaspé, N. New Brunswick and New England states to determine more about the tectonic history of the area.

REFERENCES

- Abbott, P.L., and Peterson, G.L., 1978. Effects of Abrasion Durability on Conglomerate Clast Populations: Examples from Cretaceous and Eocene Conglomerates of the San Diego Area, California. *J. Sediment. Petrol.*, vol. 48, p31-42.
- A.D.I. Ltd., 1974. New Brunswick Electrical Power Commission Site Investigation of Pennsylvanian Strata in Northwestern New Brunswick: by D.O. Downing, Resource Associates Ltd., Fredericton, New Brunswick.
- A.G.I. Glossary, 1972: American Geological Institute, Washington, D.C..
- Alcock, F.J., 1935, Geology of the Chaleur Bay Region: *Geol. Surv. Can. Mem.* 183, 146p. .
- Allen, J.R.L., 1964. Studies in fluvial sedimentation: six cyclothems from the Lower Old Red Sandstone, Anglo-Welsh Basin; *Sedimentology*, vol. 3, p. 163-198.
- Allen, J.R.L., 1965. The sedimentation and paleogeography of the Old Red Sandstone of Anglesey, North Wales; *Yorks. Geol. Soc. Proc.*, vol 35, p.139-185.
- Allen, J.R.L., 1970. Studies in fluvial sedimentation: a comparison of fining-upward cyclothems, with special reference to coarse member composition and growth; *J. Sediment. Petrol.*, vol. 40, pp298-323.
- Allen, J.R.L., 1974. Studies in fluvial sedimentation; Implications of pedogenic carbonate units, Lower Old Red Sandstone, Anglo-Welsh outcrop; *Geol. J.*, vol.9, Pt. 2, pp 181-208.
- Allen, J.R.L., Dineley, D.L., and Friend, P.F., 1967. Old Red Sandstone Basins of North America and Northwest Europe. In: *Proceedings of the International Symposium on the Devonian System, Calgary, Alberta, 1967*, vol. 1, pp. 69-98. D.H. Oswald, editor.
- Arnold, C.A., 1936. Observations on fossil plants from the Devonian of eastern North America; *Mich. Univ. Mus. Paleont. Contr.*, v. 2, no. 2.

- Arthaud, F., and Matte, P., 1977. Late Paleozoic strike-slip faulting in southern Europe and northern Africa: Result of a right-lateral shear zone between the Appalachians and the Urals.; Geol. Soc. Amer. Bull., v. 88, p1305-1320.
- Aryton, W.B., 1961. Preliminary Report on the Chandler-Port Daniel Area, Bonaventure and Gaspé-South Counties; Que. Dept. of Nat. Res., Mines Branch, Prelim. Rept. 447.
- Aryton, W.B., 1967. Chandler-Port Daniel Area, Bonaventure and Gaspé-South Counties; Que. Dept. of Nat. Res., Mines Branch, Geol. Rept. 120.
- Badgley, P.C., 1956. New Carlise Map Area, Electoral District of Bonaventure; Que., Dept. of Nat. Res., Geol. Rept. 70.
- Ballance, P.F., 1980. Models of sediment distribution in non-marine and shallow marine environments in oblique-slip fault zones. In: Sedimentation in Oblique-slip Mobile Zones, eds. P.F. Ballance and H.G. Reading, Internat. Assoc. Sedimentologists Spec. Pub. No. 4, p229-236.
- Béland, J., 1958. Preliminary Report on the Oak Bay Area, Electoral District of Matapedia and Bonaventure; Que. Dept. of Nat. Res. Prel. Rept. 375.
- Belt, E.S., 1968a. Carboniferous Continental Sedimentation Atlantic Provinces. In: Late Paleozoic and Mesozoic Continental Sedimentation, Northeastern North America, ed. G. de V. Klein, Geol. Soc. Amer. Spec. Paper 106, p.127-176.
- Belt, E.S., 1968b. Post-Acadian rifts, and related facies, Eastern Canada. In: Studies in Appalachian Geology, ed. E-an Zen, W.S. White, J.B. Hadley and J.B. Thompson. Wiley Interscience, New York, New York, p.95-113.
- Blank, H.R. and Tynes, E.W., 1965. Formation of caliche in situ: Geol. Soc. Amer. Bull. v.76, p1387-1392.
- Bluck, B.J., 1980. Evolution of a strike-slip fault controlled basin, Upper Old Red Sandstone, Scotland. In: Sedimentation in Oblique-slip Mobile Zones, eds. P.F. Ballance and H.G. Reading, Internat. Assoc. Sedimentologists Spec. Pub. No. 4, p63-78.
- Bird, J.M. and Dewey, J.F., 1970. Lithosphere plate continental margin tectonics and the evolution of the Appalachian orogen; Geol. Soc. Amer. Bull. v.81, p1031-1060.

- Boothroyd, J.C. and Ashley, G.M., 1975. Processes, Bar Morphology and Sedimentary Structures on Braided Outwash Fans, Northeastern Gulf of Alaska. In: Glacial Fluvial and Glaciolacustrine Sedimentation, ed. A.V. Jopling and B.C. McDonald, Soc. Econ. Paleont. Mineral. Spec. Pub. 23, p193-222.
- Bull, W.B., 1964. Alluvial fans and near surface subsidence in western Fresno County, California. U.S. Geol. Surv. Prof. Paper 437-A.
- Bull, W.B., 1972. Recognition of alluvial fan deposits in the stratigraphic record. In: Recognition of ancient sedimentary environments: eds. J.K. Rigby and W.K. Hamblin, Soc. Econ. Paleont. Mineral. Spec. Pub. 16, p63-83.
- Bull, W.B., 1977. The alluvial-fan environment; Progress in Physical Geography, v.1, p222-270
- Callieux, A., 1945. Distinction des galets marins et fluviatiles; Soc. Géol. France. Bull. v 15, p375-404.
- Cant, D.J. and Walker, R.G., 1976. Development of a braided-fluvial facies model for the Devonian Battery Point Sandstone, Quebec, Can. J. Earth Sci. v13, p102-119.
- Chandler, F.W., 1980. Proterozoic Redbed Sequences of Canada; Geol. Surv. Can. Bull. 311.
- Church, M. and Gilbert, R., 1975. Proglacial fluvial and lacustrine environments. In: Glaciofluvial and glacial lacustrine sedimentation, eds. A.V. Jopling and B.C. McDonald; Soc. Econ. Paleont. Mineral. Spec. Pub. 23, p22-100.
- Clarke, J.M., 1924. The Geological Age of the Bonaventure Formation; N.Y. State Mus. Bull. v. 251, p123-127.
- Dineley, D.L. and Williams, B.P.J., 1968a. Sedimentation and Paleogeology of the Devonian Escuminac Formation, and related strata, Escuminac Bay, Quebec. Geol. Soc. Amer. Spec. Paper 106, p241-264.
- Dineley, D.L. and Williams, B.P.J., 1968b. The Devonian continental rocks of the lower Restigouche River, Quebec. Can. J. Earth Sci. v.5, p945-953.
- Gardner, L.R., 1970. Origin of the Mormon Mesa Caliche, Clarke County, Nevada. Geol. Soc. Amer. Bull. v.83, p143-156.
- Greiner, H., 1978. Late Devonian Facies Interrelationships in Bordering areas of the North Atlantic and their Paleogeographic Implication. Paleogeog., Paleoclimat... and Paleoecol. v25, p 241-263

- Hacquebard, P.A., 1972. The Carboniferous of Eastern Canada
In: Septième Congrès International de Stratigraphie et
de Géologie, du Carbonifère, Krefeld, 23-28 August, 1971.
Compte Rendu.
- Harvey, L.D.D., 1980. Shearing and Kolking Phenomena in
Fluvial Sediments, Old Crow, Yukon Territory, Canada.
J. Sediment. Petrol. v.50, no.3, p787-792.
- Hooke, R. leB., 1967. Processes on arid-region alluvial fans.
J. Geol. v.75, p438-460.
- Hooke, R. leB. and Rohrer, W.L., 1979. Geometry of Alluvial
Fans: Effect of Discharge and Sediment Size. Earth Surface
Processes, v.4, p147-166.
- Howie, R.D. and Barss, M.S., 1963. Basement Features of the
Canadian Appalachians. Geol. Surv. Can. Bull. 89.
- Howie, R.D. and Barss, M.S., 1975a. Upper Paleozoic Rocks of
the Atlantic Provinces, Gulf of St. Lawrence and adjacent
continental shelf. Geol. Surv. Can. Paper 74-30, v.2,
p35-50.
- Howie, R.D. and Barss, M.S., 1975b. Paleogeography and
Sedimentation in the Upper Paleozoic, Eastern Canada.
In: Canada's continental margins and offshore petroleum
exploration, eds. L.J. Yorath, E.R. Parcker and D.J. Glass.
Can. Soc. Pet. Geol. Mem. 4, p45-57.
- Karcz, I., 1967. Harrow Marks, Current Aligned Sedimentary
Structures. J. Geol., v.75, no.1, p113-120.
- Kelley, D.G., 1967. Some Aspects of Carboniferous
Stratigraphy in the Atlantic Provinces. In: Geology of
the Atlantic Region, eds. E.R.W. Neale and H. Williams.
Geol. Assoc. Can. Paper 4, p213-228.
- Kennedy, M.J., 1979. The continuation of the Canadian
Appalachians into the Caledonides of Britain and Ireland.
In: Geol. Soc. Lond. Spec. Pub., eds. A.L. Harris, C.H.
Holland and B.E. Leake., p33-63.
- Kent, D.V. and Opdyke, N.D., 1978. Paleomagnetism of the
Devonian Catskill red beds: Evidence for motion of the
coastal New England - Canadian Maritime Region relative
to cratonic North America.; J. Geophys.
Res., v.83, p4441-4450.
- Kindle, E.M., 1930. Stratigraphic relations of the Upper
Devonian beds and the Bonaventure Conglomerate, at
Escuminac Bay, Quebec; Geol. Surv. Can. Summ. Rept. for
1928, pt.C, p83-89.

- Kinsman, D.J.J., 1969. Interpretation of Sr⁸⁷ Concentrations in Carbonate Minerals and Rocks. *J. Sediment. Petrol.*, v.39, p486-508.
- Koster, E.H., 1977. Experimental Studies of Coarse Grained Sedimentation: unpub. PhD. Thesis, University of Ottawa, 221p.
- Koster, E.H., Rust, B.R., and Gendzwill, D.J., 1980. The ellipsoidal form of clasts with practical applications to fabric and size analysis of fluvial gravels. *Can. J. Earth Sci.*, v.17, no2, p.1708-1724.
- Leeder, M.R., 1975. Pedogenic carbonates and flood sediment accretion rates: a qualitative model for alluvial arid zone lithofacies; *Geol. Mag.*, v.112, p252-270.
- Legun, A.S., 1980. Sedimentology of the Clifton Formation (Upper Carboniferous) of Northern New Brunswick: A semi-arid depositional setting for coal; Unpub. M.Sc. Thesis, University of Ottawa, 97p.
- Legun, A.S. and Rust, B.R., 1981. Coal Accumulation on a Semi-Arid Alluvial Plain: The Carboniferous Clifton Formation of Northern New Brunswick (Abs.): *Geol. Assoc. Can. Program with Abstracts*, v.6, p.A-65.
- Legun, A.S. and Rust, B.R., (in prep)
The Upper Carboniferous Clifton Formation of Northern New Brunswick: Coal-bearing deposits of a semi-arid alluvial plain.
- Logan, W.E., 1846. On the Geology of the Chat and Cascapedia Rivers, Gaspé, and part of Chaleur Bay. *Geol. Surv. Can. Rept. Prog.* 1884.
- Lowe D.R., 1976. Grain Flow and Grain Flow Deposits. *J.Sediment. Petrol.*, v.46, no.1, p188-199.
- Lowe, D.R., 1979. Sediment Gravity Flows: their classification, and some problems of application to natural flows and deposits. *Soc. Econ. Paleont. Mineral. Spec. Pub.* 27, p75-82.
- McGerrigle, H.W., 1950. The Geology of Eastern Gaspé. *Que. Dept. Mines Geol. Rept.* 35.
- McGowan, J.H., and Groat, C.G., 1971. Van Horn Sandstone, West Texas: an alluvial fan model for mineral exploration; Dept. of Investigation 72, Bureau of Econ. Geol., University of Texas, Austin. 57pp.

- McGregor, D.C., 1963. Unpublished report submitted to Quebec Dept. Mines, on spore analysis of samples from Nouvelle and Maria Townships. Geol. Surv. Can. Rept. F-1-1-1963DCM
- McGregor, D.C., 1973. Lower and Middle Devonian Spores of Eastern Gaspé, Canada. 1. Systematics; Paleontographica Abt. B, 142, pl-177.
- McGregor, D.C. and Terasmae, J., 1959. Paleobotanical excursion to Eastern Canada. Internat. Botanical Cong., 9th, Montreal, 1959, 51p.
- McKee, E.D., Crosby, R.J., and Berryhill, H.L., Jr., 1967. Flood Deposits, Bijou Creek, Colorado: June 1965. J. Sediment. Petrol., v. 137, p829-851.
- Miall, A.D., 1973. Markov Chain analysis applied to an ancient alluvial plain succession: Sedimentology, v. 20, p347-364.
- Miall, A.D., 1974. Paleocurrent Analysis of alluvial sediments- a discussion of directional variance and vector magnitude. J. Sediment. Petrol., v. 44, pl174-1185.
- Miall, A.D., 1976. Paleocurrent and paleohydrologic analysis of some vertical profiles through a Cretaceous braided stream deposit, Banks Island, Arctic Canada. Sedimentology, v. 23, p459-483.
- Miall, A.D., 1977. A review of the braided-river depositional environment. Earth Science Rev., v. 13, p.1-62.
- Miall, A.D., 1978a. Fluvial Sedimentology: An Historical Review. In: Fluvial Sedimentology, ed. A.D. Miall, Can. Soc. Pet. Geol. Mem. 5, pl-47.
- Miall, A.D., 1978b. Lithofacies types and vertical profile models in braided river deposits: a summary. In: Fluvial Sedimentology, ed. A.D. Miall, Can. Soc. Pet. Geol. Mem. 5, p597-604.
- Miall, A.D., 1978c. Tectonic Settings and Syndepositional Deformation of Molasse and other Non-marine Paralic Sedimentary Basins; Can. J. Earth Sci., v. 15, pl613-1632.
- Miall, A.D., 1980. Cyclicity and the Facies Model Concept in Fluvial Deposits. Bull. Can. Pet. Geol., v. 28, p59-80.
- Morris, W.A., 1976. Transcurrent motion determined paleomagnetically in the Northern Appalachians and Caledonides and the Acadian Orogeny; Can. J. Earth Sci., v. 13, pl236-1243.

- Orvig, T., 1957. Remarks on the vertebrate fauna of the Lower Upper Devonian of Escuminac Bay, P.Q., Canada, with special reference to the porolepiform crossopterygians.; Arkiv. Für. Zoologie, v.10, p367-426.
- Poole, W.H., 1967. Tectonic Evolution of Appalachian Region of Canada. In: Collected Papers on Geology of the Atlantic Region, eds. E.R.W. Neale and H. Williams, Geol. Assoc. Can. Spec. Paper 4, p9-51.
- Poole, W.H., 1976. Plate Tectonic Evolution of the Canadian Appalachian Region; Geol. Surv. Can. Paper 76-1b, Rept. of Activities, p113-126.
- Reading, H.G., 1980. Characteristics and recognition of strike-slip fault systems. In: Sedimentation in Oblique-slip Mobile Zones, eds. S.P.F. Ballance and H.G. Reading, Internat. Assoc. Sedimentologists Spec. Pub. No. 4, p.7-26
- Reeves, C.C., Jr., 1970. Origin, Classification and Geologic History of Caliche on the Southern High Plains, Texas and Eastern New Mexico. J. Geol., v. 78, p 352-262
- Roy, J.L., 1966. Désaimantation thermique et analyse statistique des directions de sédiments Carbonifères et Permians de l'est du Canada. Can. J. Earth Sci., v3, p139-161.
- Roy, J.L., 1969. Paleomagnetism of the Cumberland Group and other Paleozoic Formations. Can. J. Earth Sci., v.6, pt1, p663-669
- Rust, B.R., 1972a. Pebble Orientation in Fluvial Sediments. J. Sediment. Petrol., v.42, no.2, p384-388.
- Rust, B.R., 1972b. Structure and Process in a Braided River. Sedimentology, v.18, no.3, p221-246.
- Rust, B.R., 1975. Fabric and structure in glacial fluvial gravels: In. Glacial-Fluvial and glaciolacustrine sedimentation, eds. A.V. Jopling and B.C. McDonald, Soc. Econ. Paleont. Mineral. Spec. Pub. 23, p238-248
- Rust, B.R., 1976. Stratigraphic Relationships of the Malbaie Fm. (Devonian), Gaspé, Quebec. Can. J. Earth Science, v.13, p1556-1559.
- Rust, B.R., 1977. The Interpretation of Ancient Alluvial Successions in Light of Modern Investigations. In: Fluvial Sedimentology, eds. R. Davidson-Annot and W. Nickling, Proc. 5th Guelph Sympos. on Geomorphology, Guelph, 1977, p67-105.

- Rust, B.R., 1978a. A classification of alluvial channel systems. In: Fluvial Sedimentology, ed. A.D. Miall, Can. Soc. Pet. Geol. Mem 5, p187-198.
- Rust, B.R., 1978b. Depositional models for braided alluvium. In: Fluvial Sedimentology, ed. A.D. Miall, Can. Soc. Pet. Geol. Mem 5, p605-626.
- Rust, B.R., in press(a), The Cannes de Roches Formation: Carboniferous alluvial deposits in Eastern Gaspé, Canada. Comptes Rendus, Int. Carb. Cong., Urbana, I.U.
- Rust, B.R., in press(b). Alluvial deposits and Tectonic Style: Devonian and Carboniferous successions in Eastern Gaspé. Geol. Assoc. Can. Special Paper
- Rust, B.R., in press(c). Sedimentation in an Arid Zone Anastomosing Fluvial System: Coopers Creek, Central Australia. J. Sediment. Petrol.
- Sanschagrín, R., 1963. Preliminary Report on the Grande-Rivière Area, Gaspé South County. Que. Dept. Mines, Prel. Rept.
- Schumm, S.A., 1968. Speculations Concerning Paleohydrologic Controls of Terrestrial Sedimentation. Geol. Soc. Amer. Bull. v.79, p1573-1583.
- Schumm, S.A., 1977. The Fluvial System. John Wiley and Sons, New York, New York, 338p.
- Scotese, C.R., Rambach, R.K., Barton, C., Van de Voo, R., and Ziegler, A.M., 1979. Paleozoic Base Maps. J. Geol., v.87, p217-277.
- Schenk, P.E., 1978. Synthesis of the Canadian Appalachians. In: I.G.C.P. Project 27, Canadian Contribution No. 6, Caledonian-Appalachian Orogen of the North Atlantic Region. Geol. Surv. Can. Paper 78-13, p111-136.
- Siesser, W.G., 1973. Diagenetically formed ooids and intraclasts in South African calcretes, Sedimentology, v.20, p539-551.
- Skougstad, M.W. and Horr, C.A., 1963. Occurrence and Distribution of Strontium in Natural Waters. U.S. Geol. Surv.- Water Supply Paper 1496d, 97p.
- Smith, D.G. and Putnam, P.E., 1980. Anastomosed river deposits: modern and ancient examples in Alberta, Canada. Can. J. Earth Sci., v.17, p1396-1406.

- Smith, D.G. and Smith, N.D., 1980. Sedimentation in anastomosed river systems: examples from the alluvial valleys near Banff, Alberta. *J. Sediment. Petrol.*, v.50, no.1, p157-164.
- Steel, R.J. and A. Aasheim, 1978. Alluvial sand deposition in a rapidly subsiding basin (Devonian), Norway. In: *Fluvial Sedimentology*, ed. A.D. Miall, Can. Soc. Pet. Geol. Mem. No. 5, p385-412.
- Steel, R.J. and Gloppen, T.G., 1980. Late Caledonian (Devonian) basin formation, western Norway: signs of strike-slip tectonics during infilling. In: *Sedimentation in Oblique-slip Mobile Zones*, eds. P.F. Ballance and H.G. Reading, Internat. Assoc. Sedimentologists Spec. Pub. No. 4, p79-104.
- Steele, R.J., Maehle, S., Nilsen, H., Roe, S.L., and Spinnagr, A., 1977. Coarsening upward cycles in the alluvium of the Hornelen Basin (Devonian), Norway: Sedimentary Response to Tectonic Events. *Geol. Soc. Amer. Bull.* v.88, p1124-1134.
- St.-Julien, P., Hubert, C., Skidmore, W.B., and Béland, J., 1972. Appalachian Structure and Stratigraphy in Quebec In: *Geol. Congress (24*th), 1972, Montreal. Excursion A56-C56.*
- Stensio, E.A., 1958. Les Cyclostomes fossiles ou Ostracodermes. En: *Traité de Zoologie*, ed. P.-P. Grasse, 'Poissons', v.3, Masson et Cie., Paris, 924p..
- Turnbridge, I.A., 1980. Sandy high energy flood sedimentation- some criteria for recognition, with an example from the Devonian of S.W. England. *Sedimentary Geology*, v.28, p79-95.
- Walker, T.R., 1967. Formation of Red Beds in Modern and Ancient Deserts. *Geol. Soc. Amer. Bull.*, v.78, p353-368.
- Walker, T.R., 1976. Diagenetic Origin of Continental Red Beds In: *The Continental Permian in Central and South Europe*, D.Reidel Pub. Co., p2540 -282
- Webb, G.W., 1969. Paleozoic wrench faults in Canadian Appalachians. In: *North America- Geology and Continental Drift*, ed. M. Kay, Amer. Ass. Pet. Geol. Mem. 12, p754-786.
- Whiteaves, J.P., 1881. On some remarkable fossil fishes of Scaumenac Bay, P.Q.. *Amer. J. Sci.*, ser.3, v.21, p494-495
- Whiteaves, J.P., 1889. Illustrations of the fossil fishes of the Devonian rocks of Canada. Part 2, *Trans. Roy. Soc. Can.*, v.6, sec.4, pt.2, p77-96.

- Wilcox, R.E., Harding, T.P., and Seeley, D.R., 1973. Basic wrench tectonics. Amer. Assoc. Pet. Geol. Bull. v.57, p74-96.
- Williams, B.P., and Dineley, D.L., 1966. Studies of the Devonian Strata of Chaleur Bay. Maritime Sed., v.2, p7-10.
- Williams, G.E., 1973. Late Quaternary Piedmont Sedimentation, soil formation and paleoclimates of arid South Australia. Z. Geomorph. N.F., v.17, p102-125.
- Williams, H., 1979. Appalachian Orogen in Canada. Can. J. Earth Sci., v.16, pt.2, p.792-807.
- Williams, H., Kennedy, M.J., and Neale, E.R.W., 1972. The Appalachian Structural Province. In: Variations in Tectonic Styles in Canada, eds. R.A. Price and E.J.W. Douglas. Geol. Assoc. Can. Spec. Pub. no.11, p181-262.
- Williams, P.F., and Rust, B.R., 1969. The Sedimentology of a Braided River. J. Sediment. Petrol., v.39, p.649-679.
- Zaitlin, B.A., 1981. Sedimentology and Tectonics of the Devonian/Carboniferous Terrestrial Deposits, Baie des Chaleurs Region, S. Gaspé and N. New Brunswick (Abs.). Geol. Assoc. Can. Program with Abstracts, v.6, p A-63.
- Ziegler, A.M., Scotese, C.R., McKerrow, W.S., Johnson, M.E. and Bambach, R.K., 1979. Paleozoic Paleogeography. Ann. Rev. Earth Planet. Sci., v.7, p.473-502.
- Zingg, T., 1935. Beitrage zur schotteranalyse: Schweiz. min. pet. Mitt., v.15, p39-140.

Addendum

- Dineley, D.L. and Williams, B.P. J., 1968a. Sedimentation and Paleogeology of the Devonian Escuminac Formation and related Strata, Escuminac Bay, Quebec. Geol Soc. Amer. Spec. Paper 106, p241-264.

PLATE 1

- A) Fining-upward Gm-Sp-St cycle, bounded by erosional surfaces
(Unit 2, Pirate Cove Formation)

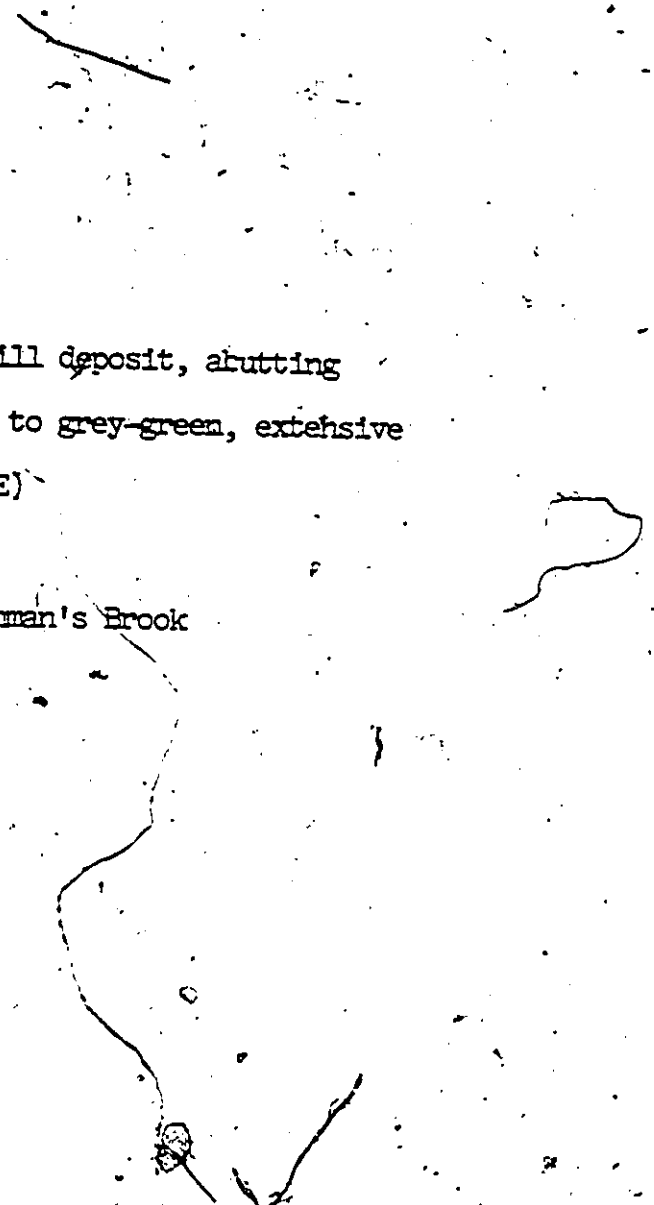
Location: Escuminac Point

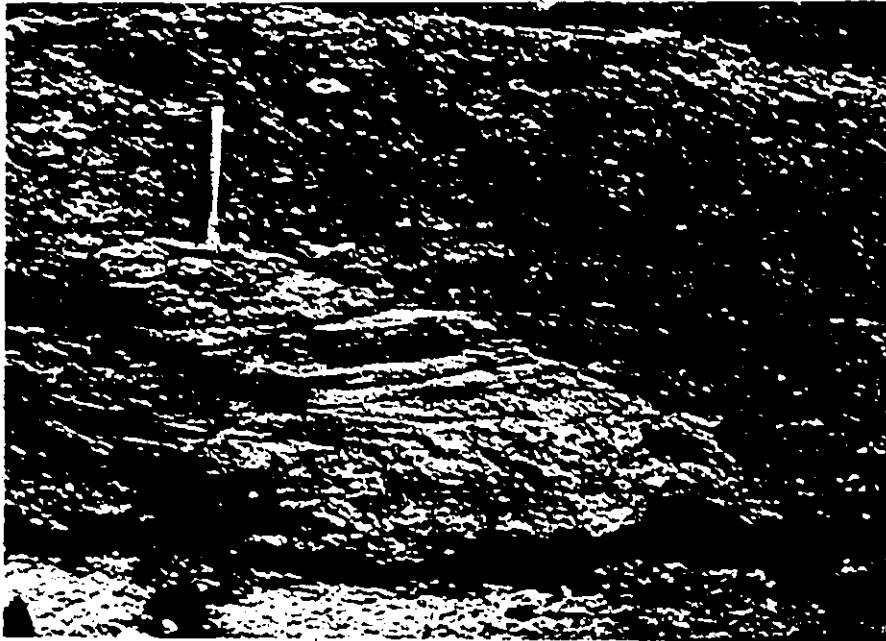
Scale: Hammer (approx. 30 cm)

- B) Edge of laterally extensive channel fill deposit, abutting
overbank deposits (C). Below are grey to grey-green, extensive
fining-upward sheetflood sandstones (E)

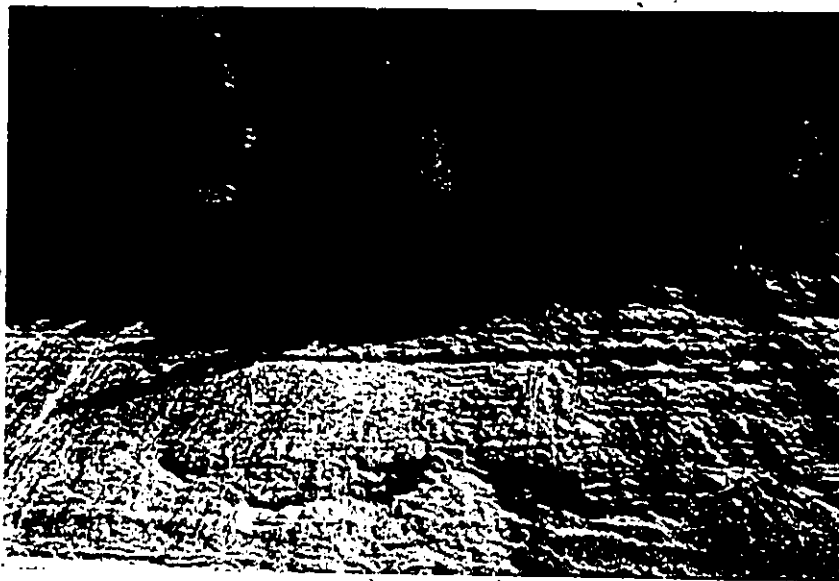
(Unit 4, Pirate Cove Formation)

Location: approx. 50 m east of Englishman's Brook





1A



1B

COLOURED PICTURE.

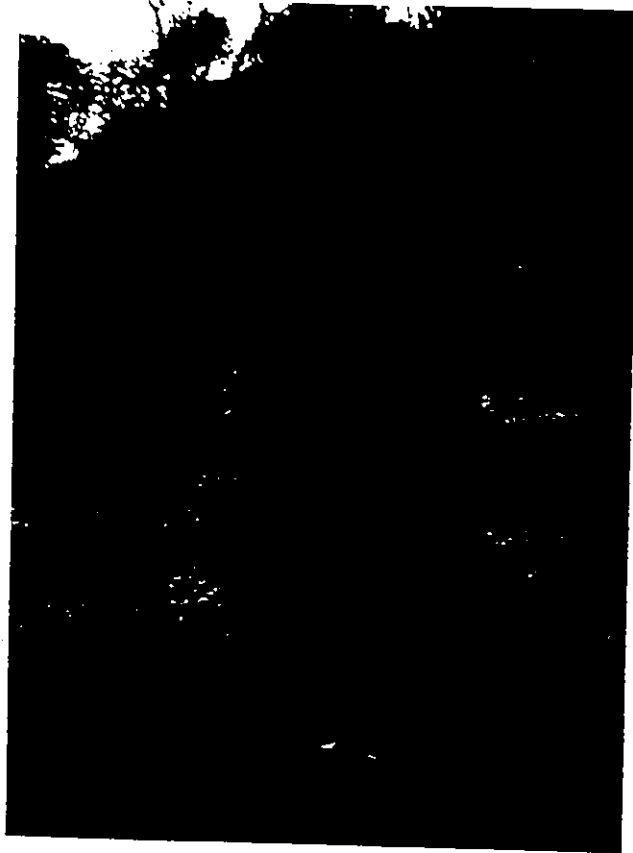
PLATE 2

A) Repetitive, fining-upward cycles of pebble to cobble Gm-Sp-St
(.25-1.5 m cycles).

(Unit 5, Pirate Cove Formation)

Location: 20 m west of Englishman's Brook

Scale: Packsack (approx. 50 cm)



2A

COLOURED PICTURE.

PLATE 3

- A) Unconformable contact between the Pirate Cove and Fleurant Formations (note that unit 5 is cut out to the east (right side of photograph))

Location: approx 2.2 km east of Englishman's Brook



3A

COLOURED PICTURE.

7

PLATE 4

A) Contact between the conglomeratic Fleurant Formation and the overlying St-dominated Escuminac Formation.

Note the indistinct, red mudstone horizon that follows the contact between Formations.

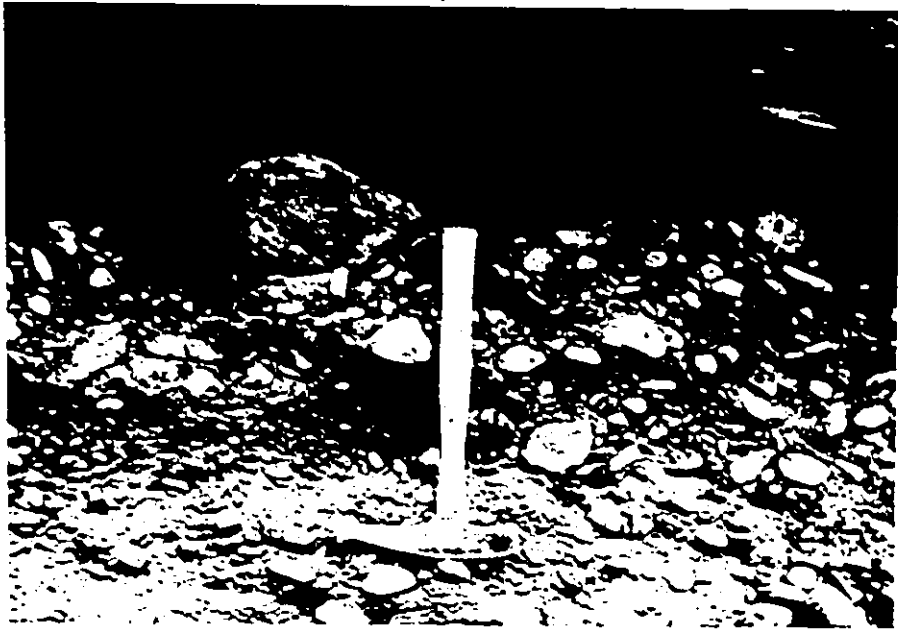
Location: approx. 35m west of Miguasha Pier.

Scale: Hammer (approx 30 cm)

B) Conformable contact between the Fleurant and overlying Escuminac Formation. Note well developed imbrication and sandstone wedge within the Fleurant Formation.

Location: approx. 60 m west of the Miguasha Pier

Scale : Hammer (approx. 30 cm)



4A



4B

COLOURED PICTURE.

PLATE 5

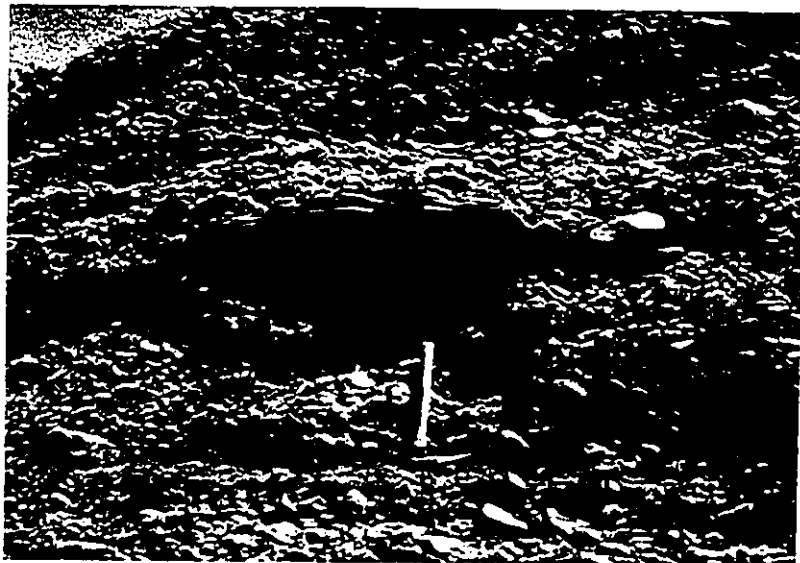
- A) Well developed, horizontally bedded ("sheeted") Gm conglomerates of the Fleurant Formation. Note low angle of dip to the bedding, and the 1-5 m thick depositional units.
Location: Fleurant Point
- B) Massive to thick, horizontally bedded, fining-coarsening-fining upward Gm of the Fleurant Formation in sea cliff exposure. Note the paucity of fine material and the occasional boulder sized clast.
Location: approx 3 km east of Englishman's Brook
- C) Minor Sp-St sandstone body within massive to thickly bedded, very well imbricate Gm of the Fleurant Formation.
Location: Fleurant Point
Scale: Hammer (approx 30 cm)



5A



5B



5C

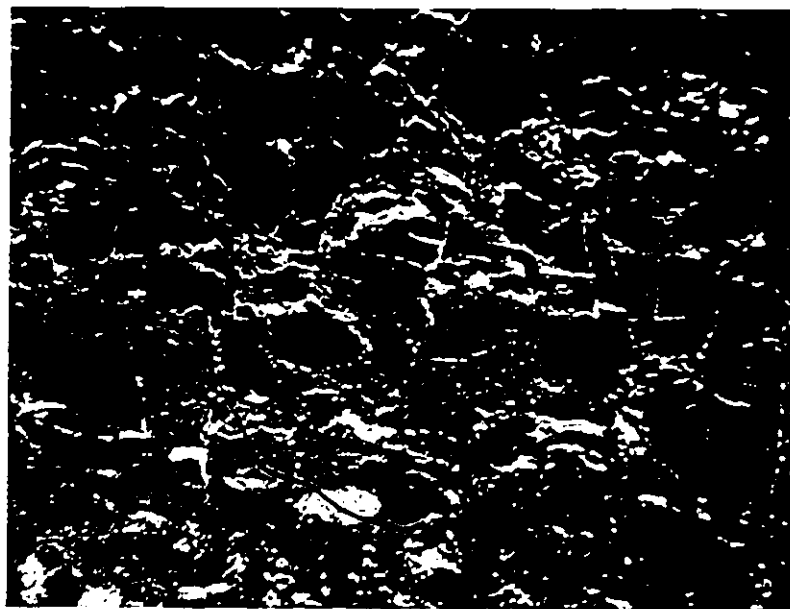
PLATE 6

- A) Well developed caliche horizon in the upper third of the Yacta Point Section. Note the nodular and honeycomb textures present in the lower portions of the profile, coalescing upward into nodular and hardpan caliche. (Bonaventure Formation)
Location: approx 1.5 km east of Miguasha Pier.
Scale: Hammer (approx 30 cm)

- B) Closeup of "honeycomb" texture within caliche
Scale: lenscap (approx 4 cm)



6A



6B

COLOURED PICTURE.

PLATE 7

- A) Unconformable contact between the Escuminac and overlying Bonaventure Formation. Note stepped relief from left to right in photograph, and the large, sub-horizontal blocks of the Escuminac "caught" up into the lower portion of the Bonaventure Formation.

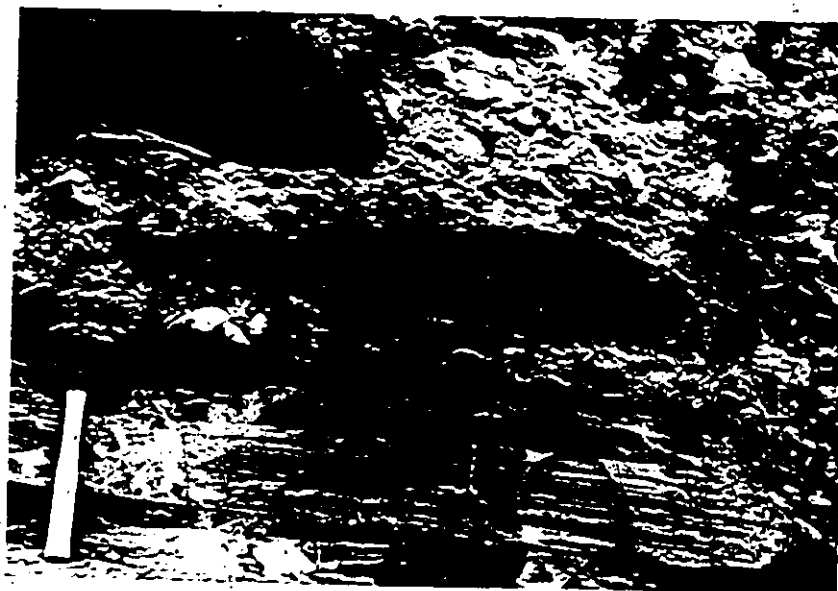
Location: approx 3/4 Km east of the Miguasha Pier

Scale: Hammer (approx 30 cm)

- B) Close up of Plate 7A. Large clasts of Escuminac appear to float in a muddy-matrix, with poorly sorted, angular cobble to boulder clasts.



7A



7B

PLATE 8

- A) Channel fill sandstone with lateral accretion surfaces in lower left hand portion of the photograph. Coarsening upward "splay(?)" deposit with large (up to 2.5 m) calcrete filled desiccation features within the mid portion of the Yacta Point Section. (Bonaventure Formation)

Location: approx 1 km east of Miguasha Pier

Scale: largest desiccation feature approx 2.5 m

- B) Large channel fill sandstone within overbank deposits in upper portion of the Yacta Point Section. Note indistinct lateral accretion surfaces and asymmetric morphology

Location : approx 3.25 km east of Miguasha Pier



8A



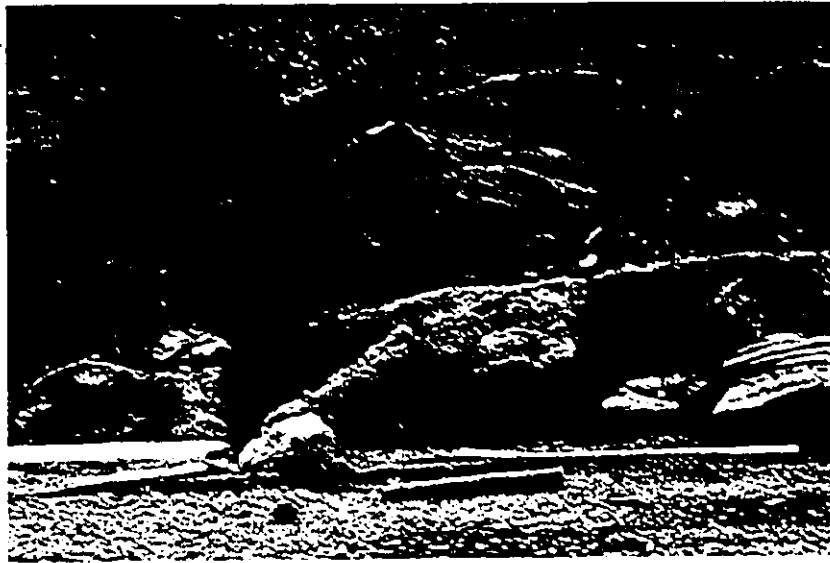
8B

COLOURED PICTURE.

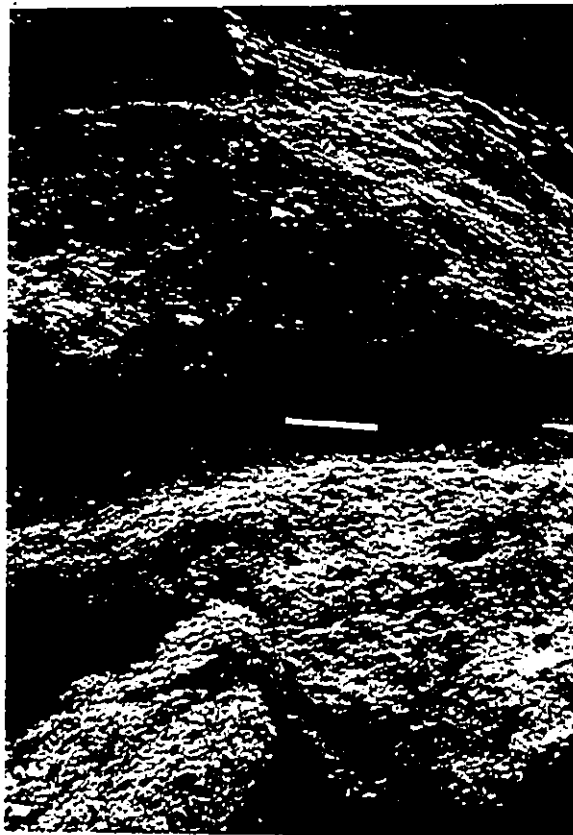
PLATE 9

- A) Asymmetrically stacked channel fill sandstones and pebble conglomerates within the upper portion of the Yacta Point Section. Note kolking structures at the base of middle fill.
Location: approx 3 km east of Miguasha Pier
Scale: Hammer (approx 30 cm)

- B) Close up of Plate 9A. Note radiating pattern and consistent spacing of Kolking structures at base of channel fill.



9A



9B

A

PLATE 10

A) Interbedded St, Sh and Sl sandsstones, with small pebble and single pebble horizons. Note scour filled with calcrete fragments and small pebbles. Features of this type are indicative of high energy ephemeral deposition.

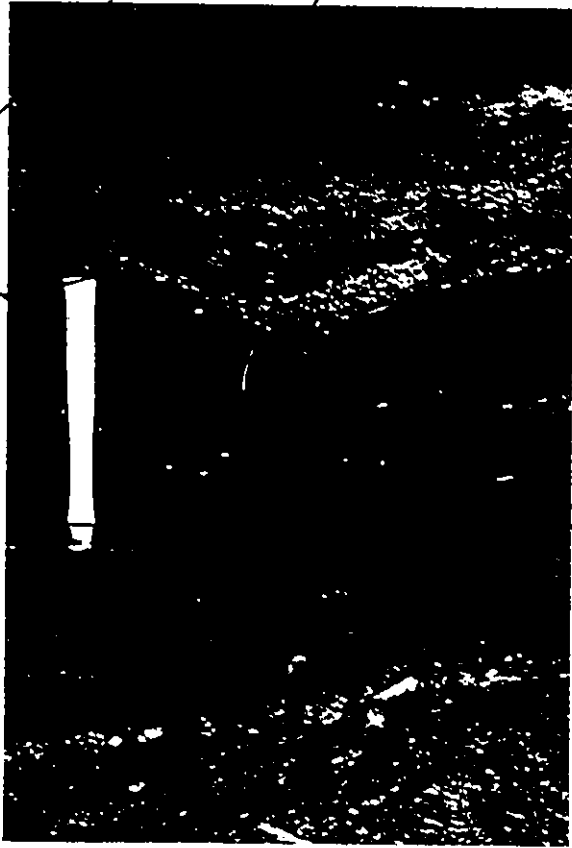
Location: Anse aux Corbeaux West

Scale: Hammer (approx 30 cm)

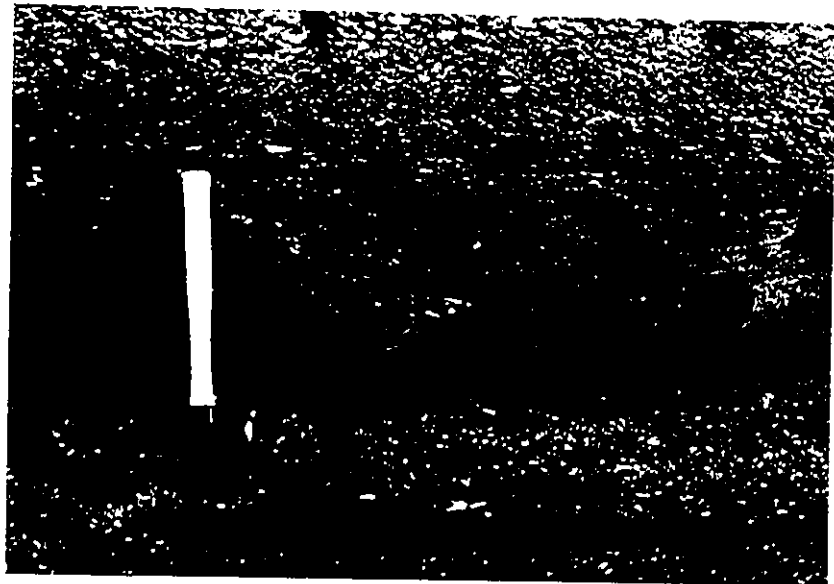
B) Sl and Sh deposits interbedded with "massive" pebble conglomerates that show sub-horizontal orientation to clasts. Asymmetric scour fill of coarsening upward upper pebble conglomerate. Features of this type are indicative of ephemeral deposition.

Location: Anse aux Corbeaux East

Scale: Hammer (approx 30 cm)



10 A



10B

PLATE 11

- A) Single and multiple pebble horizons and mudchip conglomerate, low angle Sh and Sl deposits all indicative of ephemeral, high energy flood deposits.

Location: Anse aux Corbeaux East

Scale: Hammer (30 cm)

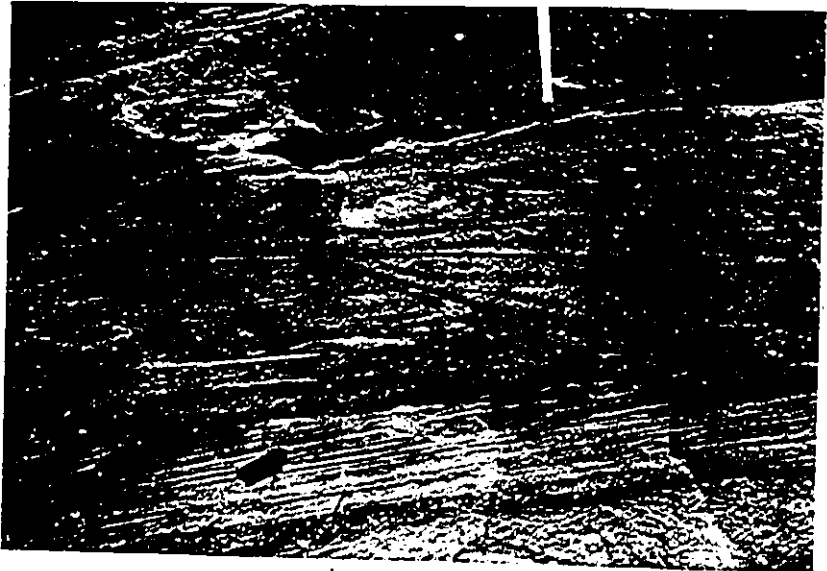
- B) Well developed Sl and Sh deposits. Note abundant erosional surfaces within beds.

Location: Anse aux Corbeaux East

Scale : Hammer (approx 30 cm)



11A



11B

PLATE 12

- A) Sheeted, horizontally bedded (imbricate) Gm deposits thought to form on the proximal braidplain under unconfined flood conditions. Deposits of this type are similar to Unit 3 of the Pirate Cove Formation. Location: 3/4 km west of Point aux Corbeaux.

Bonaventure Formation

- B) Splay deposit showing increased development of caliche upward, truncated by overlying St flood sandstones. Note symmetrical scour infilled by St sandstone.

Calcrete filled desiccation structures similar to Yacta Point are present.

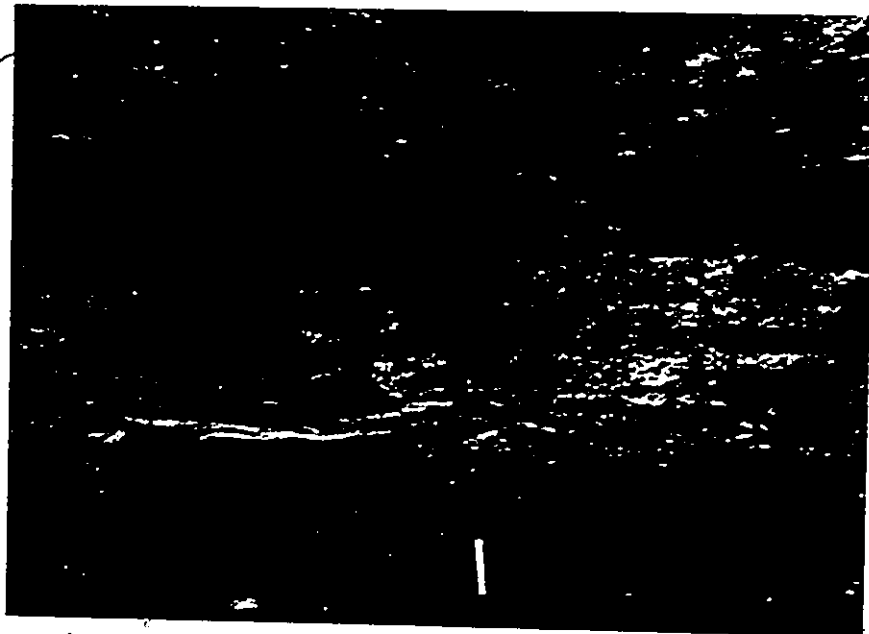
Location: Charlo

Scale: Hammer (approx 30 cm.)

Bonaventure Formation



12A



12B

COLOURED COVER

PLATE 13

A) Dune bedding present within Sp, St and Fl sandstones

Location: Point aux Corbeaux

Scale: Hammer (approx 30 cm)

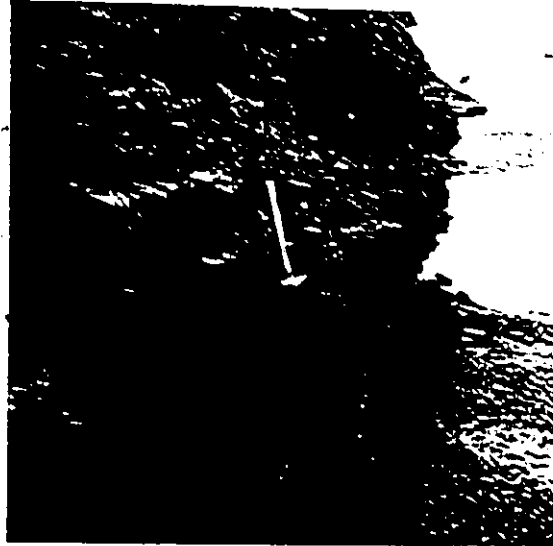
Bonaventure Formation

B) Large scale desiccation features in a silty mudstone.

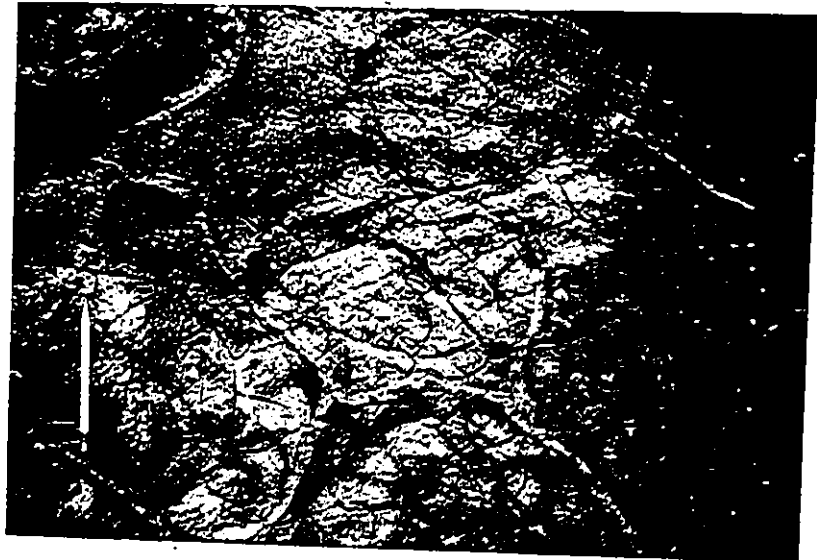
Note the rainprint impressions in the upper left of
the photograph.

Location: Pointe aux Corbeaux

Scale: Pencil (approx 10 cm)



13A



13B

APPENDIX A
Drill Hole Data
Pirate Cove Formation

UNIT 4

	Fl	Fm	St/S...	SP	Sh,l	Sr	St	Sp/Sr	Total
TRANSITION	0.000	0.000	1.000	0.000	1.000	0.000	3.000	0.000	5.000
COUNT	0.000	0.000	1.000	0.000	2.000	3.000	0.000	1.000	7.000
MATRIX	Fl/S...	0.000	0.000	0.000	0.000	0.000	1.000	0.000	4.000
	SP	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.000
	Sh/L	3.000	1.000	0.000	0.000	0.000	0.000	0.000	6.000
	Sr	1.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
	Sl	2.000	1.000	2.000	0.000	0.000	0.000	0.000	5.000
	SP/Sr	0.000	0.000	1.000	0.000	0.000	0.000	0.000	1.000
									<u>31.000</u>

	Fl	Fm	St/S...	SP	Sh,l	Sr	St	Sp/Sr
TRANSITION	0.000	0.000	0.200	0.000	0.200	0.000	0.600	0.000
PROBABILITY	0.000	0.000	0.143	0.000	0.286	0.429	0.000	0.143
MATRIX	Fl/S...	0.750	0.000	0.000	0.000	0.000	0.250	0.000
	SP	1.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sh/L	0.333	0.167	0.000	0.000	0.000	0.000	0.000
	Sr	1.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sl	0.400	0.200	0.400	0.000	0.000	0.000	0.000
	SP/Sr	0.000	0.000	1.000	0.000	0.000	0.000	0.000

APPENDIX A cont.

Pirate Cove Formation

UNIT 4

INDEPENDANT TRIALS PROB. MATRIX	Fl	Fm	St/S...	SP	Sh,l	Sr	St	SP/Sr
Fl	0.000	0.269	0.154	0.077	0.231	0.038	0.192	0.038
Fm	0.208	0.000	0.167	0.083	0.250	0.042	0.208	0.042
Fl/s	0.185	0.259	0.000	0.074	0.222	0.037	0.185	0.037
SP	0.172	0.241	0.138	0.000	0.207	0.034	0.172	0.034
Sh/L	0.200	0.280	0.160	0.080	0.000	0.040	0.200	0.040
Sr	0.167	0.233	0.133	0.067	0.200	0.000	0.167	0.033
Sl	0.192	0.269	0.154	0.077	0.231	0.038	0.192	0.038
SP/Sr	0.167	0.233	0.133	0.067	0.200	0.033	0.167	0.000

DIFFERENCE MATRIX	Fl	Fm	Fl/s	SP	Sh,l	Sr	St	SP/Sr
Fl	0.000	-0.269	0.046	-0.077	-0.031	-0.038	0.408	-0.038
Fm	-0.208	0.000	-0.024	-0.083	0.036	0.387	0.208	0.101
Fl/s	0.565	-0.259	0.000	-0.074	-0.222	-0.037	0.065	-0.037
SP	0.828	-0.241	-0.138	0.000	-0.207	-0.034	-0.172	-0.034
Sh/l	0.133	0.220	0.007	-0.080	0.000	-0.040	-0.200	-0.040
Sr	0.833	-0.233	-0.133	-0.067	-0.200	0.000	-0.167	-0.033
Sl	0.208	-0.269	0.046	0.323	-0.231	-0.038	0.000	-0.038
SP/Sr	-0.167	-0.233	-0.133	0.933	-0.200	-0.033	-0.167	0.000

APPENDIX A

HERON ISLAND DRILL CORE

Drill Hole A

Transition Count Matrix

	Fe	Fl	Sfl	S	G	Total
Fe	0.000	0.000	0.000	1.000	0.000	1.000
Fl	0.000	0.000	1.000	9.000	1.000	11.000
Sfl	0.000	0.000	0.000	1.000	0.000	1.000
S	1.000	10.000	0.000	0.000	1.000	12.000
G	0.000	2.000	0.000	0.000	0.000	2.000
						<u>27.000</u>

Independent Trials Prob. Matrix

	Fe	Fl	Sfl	S	G
Fe	0.000	0.423	0.038	0.462	0.077
Fl	0.063	0.000	0.063	0.750	0.125
Sfl	0.038	0.423	0.000	0.462	0.077
S	0.067	0.733	0.067	0.000	0.133
G	0.040	0.440	0.040	0.480	0.000

Transition Probability Matrix

	Fe	Fl	Sfl	S	G
Fe	0.000	0.000	0.000	1.000	0.000
Fl	0.000	0.000	0.091	0.818	0.091
Sfl	0.000	0.000	0.000	1.000	0.000
S	0.083	0.833	0.000	0.000	0.083
G	0.000	1.000	0.000	0.000	0.000

Difference Matrix

	Fe	Fl	Sfl	S	G
Fe	0.000	-0.423	-0.038	0.538	-0.077
Fl	-0.063	0.000	0.028	0.068	-0.034
Sfl	-0.038	-0.423	0.000	0.538	-0.077
S	0.017	0.100	-0.067	0.000	-0.050
G	-0.040	0.560	-0.040	-0.480	0.000

Drill Hole B

Transition Count Matrix

	Fl	Sfl	S	G	Total
Fl	0.000	0.000	3.000	1.000	4.000
Sfl	1.000	0.000	0.000	1.000	2.000
S	3.000	2.000	0.000	0.000	5.000
G	0.000	0.000	2.000	0.000	2.000
					<u>13.000</u>

Independent Trials Prob. Matrix

	Fl	Sfl	S	G
Fl	0.000	0.222	0.556	0.222
Sfl	0.364	0.000	0.455	0.182
S	0.500	0.250	0.000	0.250
G	0.364	0.182	0.455	0.000

Transition Probability Matrix

	Fl	Sfl	S	G
Fl	0.000	0.000	0.750	0.250
Sfl	0.500	0.000	0.000	0.500
S	0.600	0.400	0.000	0.000
G	0.000	0.000	1.000	0.000

Difference Matrix

	Fl	Sfl	S	G
Fl	0.000	-0.222	0.194	0.028
Sfl	0.136	0.000	-0.455	0.318
S	0.100	0.150	0.000	-0.250
G	-0.364	-0.182	0.545	0.000

Drill Hole C

Transition Count Matrix

	Fe	Fl	S	G	Total
Fe	0.000	0.000	1.000	0.000	1.000
Fl	0.000	0.000	2.000	2.000	4.000
S	1.000	3.000	0.000	1.000	5.000
G	0.000	0.000	3.000	0.000	3.000
					<u>13.000</u>

Independant Trials Prob. Matrix

	Fe	Fl	S	G
Fe	0.000	0.333	0.417	0.250
Fl	0.111	0.000	0.556	0.333
S	0.125	0.500	0.000	0.375
G	0.100	0.400	0.500	0.000

Transition Probability Matrix

	Fe	Fl	S	G
Fe	0.000	0.000	1.000	0.000
Fl	0.000	0.000	0.500	0.500
S	0.200	0.600	0.000	0.200
G	0.000	0.000	1.000	0.000

Difference Matrix

	Fe	Fl	S	G
Fe	0.000	-0.333	0.583	-0.250
Fl	-0.111	0.000	-0.056	0.167
S	0.075	0.100	0.000	-0.175
G	-0.100	-0.400	0.500	0.000

Drill Hole D

Transition Count Matrix

	Fe	Fl	Sfl	S	G	Total
Fe	0.000	0.000	0.000	1.000	0.000	1.000
Fl	1.000	0.000	0.000	3.000	1.000	5.000
Sfl	0.000	0.000	0.000	1.000	0.000	1.000
S	1.000	2.000	1.000	0.000	3.000	7.000
G	0.000	2.000	0.000	2.000	0.000	4.000
						<u>18.000</u>

Independant Trials Prob. Matrix

	Fe	Fl	Sfl	S	G
Fe	0.000	0.294	0.059	0.412	0.235
Fl	0.077	0.000	0.077	0.538	0.308
Sfl	0.059	0.294	0.000	0.412	0.235
S	0.091	0.455	0.091	0.000	0.364
G	0.071	0.357	0.071	0.500	0.000

Transition Probability Matrix

	Fe	Fl	Sfl	S	G
Fe	0.000	0.000	0.000	1.000	0.000
Fl	0.200	0.000	0.000	0.600	0.200
Sfl	0.000	0.000	0.000	1.000	0.000
S	0.143	0.286	0.143	0.000	0.429
G	0.000	0.500	0.000	0.500	0.000

Difference Matrix

	Fe	Fl	Sfl	S	G
Fe	0.000	-0.294	-0.059	0.588	-0.235
Fl	0.123	0.000	-0.077	0.062	-0.108
Sfl	-0.059	-0.294	0.000	0.588	-0.235
S	0.052	-0.169	0.052	0.000	0.065
G	-0.071	0.443	-0.071	0.000	0.000

Drill Holes-A-D

Pooled

Transition Count Matrix

	Fe	Fl	Sfl	S	G	Total
Fe	0.000	0.000	0.000	3.000	0.000	3.000
Fl	1.000	0.000	1.000	17.000	5.000	24.000
Sfl	0.000	1.000	0.000	2.000	0.000	3.000
S	3.000	18.000	3.000	0.000	6.000	30.000
						<u>71.000</u>

Independent Trials Prob. Matrix

	Fe	Fl	Sfl	S	G
Fe	0.000	0.353	0.044	0.411	0.162
Fl	0.064	0.000	0.064	0.638	0.234
Sfl	0.044	0.353	0.000	0.441	0.162
S	0.073	0.585	0.073	0.000	0.268
G	0.050	0.400	0.050	0.500	0.000

Transition Probability Matrix

	Fe	Fl	Sfl	S	G
Fe	0.000	0.000	0.000	1.000	0.000
Fl	0.042	0.000	0.042	0.708	0.208
Sfl	0.000	0.333	0.000	0.667	0.000
S	0.100	0.600	0.100	0.000	0.200
G	0.000	0.364	0.000	0.636	0.000

Difference Matrix

	Fe	Fl	Sfl	S	G
Fe	0.000	-0.353	-0.044	0.559	-0.162
Fl	-0.022	0.000	-0.022	0.070	-0.026
Sfl	-0.044	-0.020	0.000	0.225	-0.162
S	0.027	0.015	0.027	0.000	-0.068
G	-0.050	-0.036	-0.050	0.136	0.000

Appendix B

Petrographic Data Based on Representative Specimens

Pirate Cove Formation			
Unit	1	2	4
Lithofacies	Sh/1	Sp	Sp
Sample No.	Z-80-2	Z-80-8	Z-80-15
Roundness	angular-subangular	angular-subangular	angular-subrounded
Size Range	.05-.35 mm	.05-.2 mm	.1-.25 mm
Mean Size	.2mm	.15 mm	.15 mm
Sorting	poor to moderate	moderate	poor to moderate
Cementation	moderate	moderate	moderate
Grain Type			
Quartz	28	35	25
Quartzitic	12		8
Micritic	8	<5	<5
Volcanic	<2		
Other		7	20
Clay Sized Groundmass	10	23	15
Feldspar	5	<5	<3
Opaque	5	3	<5
Carbonate	17	10	8
Fe Oxide	13	12	12
Type	Lithic Arkose	Lithic Arkose	Lithic Arkose
Comments	clay and carbonate infills voids; secondary mica and Fe oxide	preferred orientation of grain axis to Sp stratification	Sp and Sh stratifi- cation marked by clay bands.

(N.B. : all percentages via visual estimate)

Fleurant Formation		Bonaventure Formation	C (Yacata Point)
Lithofacies	Gm	Sh (Yacata Point)	
Sample No.	E-80-23	E-29-2	C-V-B
Roundness	angular to subrounded.	subangular	---
Size Range	.05-50 mm	.2-1 mm	.05-1.3 mm
Mean Size	bimodal-.35 mm 2 mm	.4 mm	.3 mm
Sorting	poor	moderate	moderate
Cementation	moderate	moderate	good
Grain Type	%	%	%
Quartz	5	12	35
Quartzite	15	30	
Micritic	40	10	
Volcanic	8		10
Other		10	
Clay Sized Groundmass	2	5	15
Feldspar		13	3
Opaque			2
Carbonate	30	15	30
Fe Oxide		5	5
Type	Conglomerate matrix	Lithic Arkose	Caliche
Comments	At least 2 generations of carbonate cement, with grains "floating" in cement	very immature	carbonate vlenlets cross- cutting lithic fragments, carbonate nims and rhizo- cretions along with "nodular" and massive cement.

(N.B.: all percentages via visual estimate)