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NOTES ON THE GEOLOGY OF EAST CENTRAL GASPE PENINSULA

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NOTES ON THE GEOLOGY OF EAST CENTRAL

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by

H. D. KNIPPING

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## C O N T E N T S

	<u>Page</u>
Introduction .....	1
Operations, Work and Terrain Conditions .....	1
Acknowledgements .....	2
Previous Work .....	3
Purpose and Content of the Report .....	3
Stratigraphy, Sedimentation and Geological History ..	5
General Statement .....	5
Precambrian, Cambrian and Ordovician .....	6
Silurian .....	7
Silurian and Lower Devonian .....	18
Cap Bon Ami Formation .....	18
Lower Devonian .....	21
Grand Greve Formation .....	21
Lower and Middle Devonian .....	23
York River Formation (incl. York Lake facies) ..	23
Lower Devonian .....	25
Fortin Series .....	25
Lower and Middle Devonian .....	27
Battery Point Formation .....	27
Middle and/or Upper Devonian .....	29
Malbaie Formation .....	29
Igneous Geology .....	30
Structural Geology .....	30
General Statement .....	30
Regional Structure and Structural History .....	31
Origin of Acadian Structures .....	32
Faults .....	33
Wrench Faults .....	33
Thrust Faults .....	41
Normal Faults .....	43
Folds .....	45
Selected References .....	50
Additional Bibliography .....	57

ILLUSTRATIONS

		<u>Page</u>
Table 1	Table of Formations (Simplified and Schematic).....	4
Figure A	Diagram of Devonian Facies Changes from Fortin to Power townships.....	26
Figure B	Wrench fault terminology.....	34
Figure 1	Geological Map East Central Gaspe - North and South sheets - Scale 1:50,000 showing location of Cross- sections.....	in pocket
Figure 2	Silurian Isopach and Facies Map.....	in pocket
Figure 3	Map No. 1000 Geological Map Gaspe Peninsula.....	in pocket
Cross-section 1	Madeline River-York Lake-St. John River-Mount Alexander area.....	in pocket
Cross-section 2	Patch Brook-York River (Bald Mountain and Mississippi anticlines).....	in pocket
Cross-section 3	Bald Mountain-Mississippi Brook.....	in pocket
Cross-section 4	Dartmouth River-Galt Brook-York River- Owl Capes-St. John River-Power Joncas Structure-Grande Riviere Ouest.....	in pocket
Cross-section 5	Renard River-Hay Creek Structure-York River-St. John River-Little Fork Brook- Malbaie River-Grande Riviere Est.....	in pocket

NOTES ON THE GEOLOGY OF EAST CENTRAL

GASPE PENINSULA, QUEBEC

by

H. D. Knipping

INTRODUCTION

In the field season of 1958 The British American Oil Company Limited conducted geological field investigations in east central Gaspé Peninsula, Province of Quebec. The assigned area covers the east central belt from the east coast at about  $64^{\circ}10'$  west longitude to  $65^{\circ}40'$  west longitude in Bonnacamp township. The investigated area lies between  $49^{\circ}05'$  and  $48^{\circ}35'$  north latitudes, and contains approximately 2,200 square miles. Minor work outside the project area was done near Port Daniel on the Chaleur Bay. The work included structural and stratigraphic observations.

OPERATIONS, WORK AND TERRAIN CONDITIONS

Transportation within the project area was provided by a Willy's 4-wheel drive jeep which could be used on roads and on most of the lumber trails. The field work was carried out from June 1 to September 20. A total of 90 days was spent in actual field geology and reconnaissance.

Base camps were established at Baker's Hotel, Gaspé and for August only at Copper Mountain Hotel in Murdochville. Access to the area is provided by the Perron Boulevard, which circles the entire Gaspé Peninsula and a new Anse Pleureuse, Murdochville - Gaspé Highway. Numerous old and new lumber roads exist in the area and provided, with few exceptions, sufficient access. These roads expose abundant structural and stratigraphic detail. By far the largest amount of information was obtained from stream traverses. Since timber and bush growth are profuse walking in the water was necessary. Cross-country traverses

were made in a few instances.

About 870 locations were coded, plotted on aerial photographs and studied. The codes consist of the letters A to K and the numbers 1 to 100. Later the coded locations were transferred to a 1:50,000 base map and the attitudes of beds and faults were constructed.

#### ACKNOWLEDGEMENTS

The field work was carried out under the supervision of Mr. D.J. Mott, Head Office, Toronto, who visited the field party for several days in July and September. Mr. R.P. Lockwood visited the Gaspé region in September and provided valuable advice during this visit and later during discussions in Calgary. Mr. Lockwood also contributed greatly to the structural interpretation contained in this report. Mr. M.J. Melnyk assisted the writer very ably during the field work and during the initial stages of the compilation of the data. In the field Mr. Melnyk carried out many surveys independently and also did most of the reconnaissance work. Drs. I.W. Jones and H.W. McGerrigle of the Quebec Department of Mines contributed general information about working conditions and geology. Both have done pioneer work in the Gaspé and laid the basis for other workers. Their help is gratefully acknowledged. Mr. Kieffer of the Quebec Department of Land and Forests gave permission to enter the forests and Mr. L.P. Gagnon of the Quebec Department of Parks and Reserves gave permission to enter the park areas of the Gaspé.

In Gaspé Mr. Jones of the Canadian International Paper Company and Mr. Coffin of Howard-Smith Paper Company granted permission to enter their pulp and paper concessions.

The report was written in Calgary and edited by Drs. O.A. Erdman and A.D. Baillie, who also discussed several structural problems with the writer.

#### PREVIOUS WORK

The Gaspé Peninsula has been a centre of geologic activity for more than a century. A large amount of geologic literature is available, part of which has been listed in the bibliography of this report. McGerrigle (1950, pp. 17 and 18) gives a short history of geologic research in the Gaspé Peninsula and the reader is referred to his paper for further information.

#### PURPOSE AND CONTENT OF THE REPORT

The profuse geologic literature concerning the Gaspé Peninsula treats mainly its stratigraphic and palaeontologic aspects. Since the geology of the area is inherently very complicated much of the older literature is rather confusing. Particularly the arguments of different palaeontologists have to be considered to show the proper age relations of the sediments.

In the following report only the gross stratigraphic features are discussed. Consideration of purely academic questions as exact time lines and correlations to standard areas, e.g., in this case the main Appalachian basin, are beyond the scope of this report. The structural work is considered economically most important and this report is focussed on the structural geology of the project area.

The solution of important structural problems has been neglected in previous publications. This is understandable, however, since many structural features can be interpreted better by use of aerial photography than by field work alone.

TABLE 1  
TABLE OF FORMATIONS ( Simplified and Schematic)

Area Time	Project Area	Chaleur Bay	Matapedia V.	
Carboniferous	Bonaventure (Conglomerate) Cannes-de-Roche (Sandst.&Conglom.)	<div style="border: 1px solid black; padding: 5px;">                     Ministère des Richesses Naturelles, Québec                      SERVICE DE LA DOCUMENTATION TECHNIQUE                       Date: .....                      No GM: <u>16470</u> </div>		
Upper Dev?	Acadian Orogeny Malbaie (Sandst.&Congl.)			
Middle	Battery Point (Sandst.& Conglom.)			
Devonian	York River (Shale, Sandst.& Conglom.)			
Lower	York Lake (ss.& limest.)	<div style="border: 1px solid black; padding: 10px; font-size: 2em; font-weight: bold;">PUBLIC</div>		
Devonian	Fortin (limy clastics) Grande Greve (Limest.& Shale, silty)			
?	Cap Bon Ami (Limest.& Shale, silty)			
Middle	Silurian (formerly St. Alban)			
Silurian	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px dashed black; padding: 5px; text-align: center;">                     Facies A (Congl. &amp; Sandst)                 </div> <div style="border: 1px dashed black; padding: 5px; text-align: center;">                     Facies B (Cong &amp; sandst)                 </div> </div>	St. Leon (Siltst.) Gascons (Shale & Siltst.) La Vieille (Shale & bioclastic-biostromal ls) (Facies C&D)	Indian Point West Point Bouleaux Gascons La Vieille Anse Gascon Clemville	St. Leon Sayabec Val Brillant
Ordovician & older	Taconic Orogeny Slate, Quartzite, Intrusives & Extrusives			

STRATIGRAPHY, SEDIMENTATION AND

GEOLOGICAL HISTORY

GENERAL STATEMENT

The east central belt of the Gaspé Peninsula, treated in this report, forms a minute part (near the northeast margin) of the large Appalachian mobile belt, which in older publications is named the Appalachian geosyncline. A particular feature of the project area is the change in trend of the orogen from an east-northeast direction to a southeast trend which coincides with a special set of structural complications described in the chapter on Structural Geology. Construction of a palinspastic map which would show the restoration of the folded and faulted sediments to original relative geographic position was not attempted as the original geographic area of deposition for all Palaeozoic sediments is at an undetermined distance south or south-southeast of the present project area. Depositional conditions varied strongly during the Palaeozoic era in this area. Deposition was intermittent, rock units changed thickness and facies rapidly indicating an unstable sea floor and active source areas. Source of the clastics up to Middle Devonian probably was a borderland to the south, the New Brunswick geanticline, a feature which is still under discussion in the geological literature. A post-Middle Devonian fast emerging and rising mass of acid igneous rocks east and/or north of the project area is postulated as a source of post-Middle Devonian strata.

A large amount of basal Silurian sediments was apparently derived from topographic highs within the depositional area which indicates division of the active basin into sills\* and troughs with their concomittant sill and trough facies. sill - a submarine ridge or rise separating partially closed basins from one another or from the adjacent ocean.

The troughs subsided more rapidly than the sills, therefore, accumulation of sediments in the troughs was greater than on the sills.

Due to lack of subsurface information in the project area exact thicknesses of rock units are known only in structurally simple outcrop areas. However, the trend of thickness variations is recognizable and thickness values given are calculated from the structural cross-sections 1 to 5.

#### PRECAMBRIAN, CAMBRIAN AND ORDOVICIAN

The pre-Silurian sediments were not studied during the 1958 field season. Their stratigraphic sequence is little known as they were strongly folded, faulted and partly metamorphosed during the Taconic revolution near the end of the Ordovician. The intensity of the Taconic orogeny considerably dims the prospect of finding economical hydrocarbon accumulations in these early Palaeozoic strata.

The nearest outcrops of Precambrian rocks, chiefly metamorphosed sediments, occur southwest of Chandler on the Chaleur Bay about 20 miles south of the project area. These beds, the Maquereau group, are definitely pre-Middle Ordovician and most writers suggest a Precambrian age.

The Palaeozoic sedimentation in the Appalachian belt of southern Quebec commenced with the transgression of the Lower Cambrian over the Precambrian erosional surface. Questionable Lower Cambrian limestone and shale are present in the southeast corner of the project area along Murphy Creek west of Perce. Definite Upper Cambrian limestone, oolitic limestone and minor shale are present at the same locality overlain by quartz conglomerate of the Upper Ordovician. Cambrian sediments may be more widespread in outcrops than hitherto recognized. If that is true, Cambrian beds are contained in the strata mapped as Ordovician.

The Taconic orogeny in eastern Gaspé was less severe than further southwest and west. The Cambrian beds which blanket the Precambrian erosion

surface have been elevated to the Taconic unconformity only in a few places. The subsistence of the basin floor or the maintenance of a topographic low during the Cambrian period in eastern Gaspé was moderate and at the end of the Cambrian a reversal of this trend resulted in emergence and subsequent erosion of some of the Cambrian beds.

During the Ordovician period the negative trend recurred and the downward movement of the basin floor reached greater proportions than during the Cambrian period.

Grey and dark grey shale, minor sandstone, conglomerate and limestone characterized Lower and Middle Ordovician sedimentation. The Middle Ordovician Mictaw series north of Port Daniel on the Chaleur Bay 20 miles south of the project area contains a thick succession of greywackes indicating a pronounced downward movement of the trough floor and a rapid pouring-in of debris from the source area.

A migration of the trough axis and an undulation of the sea floor during the Ordovician is anticipated but the pattern has not been ascertained.

Near the close of Ordovician, emergence accompanied by volcanic activity marked the beginning of the Taconic orogeny. The pre-Silurian sediments were dislocated, folded and faulted. The trend of the Taconic fold axes generally parallels that of the later super-imposed Acadian axes.

The erosian interval during which the Taconic relief was destroyed continued through the Lower Silurian epoch.

#### SILURIAN

After the peneplanation of the Taconic Mountains the area which received basin sediments during the early Palaeozoic again became a topographic low. Figure 2 shows the general isopach pattern of the Silurian and some facies aspects of this economically most important group. Although the Silurian has been the object of palaeontological discussions for many years it is only lately

that the problems of the Silurian stratigraphy in the project area have been successfully attacked. The Silurian succession on the Chaleur Bay (Northrop, 1939, Alcock, 1935, and others) and in the Matapedia Valley at the western margin of Gaspé Peninsula had been solved successfully by many workers. But in east central Gaspé Peninsula some Silurian beds had been originally assigned to the Devonian under the name of the St. Alban formation. L.M. Cumming (G.S.C., personal communication), however, investigated the St. Alban problem and found that all of the St. Alban beds belong to the Middle Silurian. The Silurian/Devonian boundary in eastern Gaspé, therefore, should be drawn in the overlying Cap Bon Ami formation since Middle Silurian fossils were found in basal Cap Bon Ami beds (L.M. Cumming). The work of C.F. Burk (Northwestern University, personal communication) in 1957 and 1958 showed that Silurian formations from the Chaleur Bay and Matapedia Valley can be correlated to east central Gaspé Peninsula. The work of Mr. C.F. Burk will soon be available in thesis form.

Of all formations and groups in eastern Gaspé the Silurian sedimentation is marked by the strongest facies differentiation. This is particularly evident for the basal Silurian beds. The facies pattern is shown on Figure 2. Since only very few outcrops outlining this facies pattern have been observed, the facies map is interpretative only.

Since the Middle Silurian sea transgressed over topography produced by the erosion of the Taconic orogen the sediments should reflect this topography.

The subsidence of the area which caused the transgression also continued dividing the sedimentation area into faster sinking troughs and slower sinking sills.

On figure 2 the four most important facies areas, designated Facies, A, B, C and D have been outlined. These four facies concern only the basal Silurian beds in the area since later sedimentation conditions become more uniform in the project area.

Facies A is a typical sill sediment. It is postulated that an Ordovician or Lower Silurian submarine sill or ridge extended in a northwest-southeast direction from the centre of De Beaujeu township possibly to the Hay Creek structure. The sediments of Facies A (Figure 2) were derived from this sill and are different in composition from Silurian sediments north and south of the postulated sill, here designated "Lady Step Sill". The thickness of the beds of Facies A is also much thinner than that north and south of "Lady Step Sill". A detailed section of facies A beds is exposed in Salmon Hole brook (location H100) where the entire sedimentary Silurian below the Cap Bon Ami formation is only 400 to 450 feet thick. The lower Silurian and/or Ordovician igneous rocks, designated by McGerrigle (1950) the Lady Step Igneous Series is composed of diverse types. Altered andesitic tuffs and flows are described by McGerrigle (1950) and I.W. Jones (1935, Dartmouth River map area). Dioritic and gabbroid rocks are also present. Some of the intrusives are definitely post-Middle Devonian, since at one locality they cut Middle Devonian limestone. At the Salmon Hole brook the igneous rocks underlying the Silurian sediments are gneisses. Orthoclase, quartz and accessories make up the gneiss bands separated by thin layers of large muscovite and subordinate biotite and chlorite.

The basal 100 to 150 feet of the Silurian beds are covered but the lithology is probably the same as the following 30 feet which consists of a well rounded conglomerate with boulders, up to 6 inches in diameter but averaging 1 to 1½ inches, floating in a well rounded sand matrix. The composition of the pebbles is the same as that of the underlying gneisses and they are certainly derived from this substratum. This 30-foot sandy conglomerate is overlain by 30 feet of greenish sandstone with conglomerate layers and abundant chlorite flakes, which give the rock the greenish grey colour. Large calcite crinoid ossicles increase in number toward the top of this unit. A coarsely

fragmental limestone (calcarenite) with floating pebbles of the igneous substratum, strongly sandy with some small coral stocks of Favosites aff. and abundant crinoid ossicles follow. Overlying the calcarenite is 50 feet of medium grey, very fine grained sandstone with strongly calcareous sandstone lenses, lensing beds and slight angular bedding. In the sandstone abundant floating crinoid ossicles are present and some beds consist of calcarenite. Another 35 feet of similar sandstone follows but is separated from the lower sandstone by 5-foot biostromal band composed of bryozoa, isolated cup corals, many fist size Heliopora and a few algal patches. Stromatopora is not present. The highest exposed beds consist of 60 feet of light grey to white fragmental limestone (Calcarenite) with high quartz content. Grains are medium to coarse but poorly sorted and sub-rounded. Presumably similar lithology occupies the fifty-foot covered interval up to the basal beds of the Cap Bon Ami formation.

In the predominantly coarse clastic lithology of the above described Silurian facies strong lateral thickness and facies changes are to be expected. Since the basal conglomerate was derived from the sub-stratum it is assumed that shore lines during the Silurian were present over this igneous ridge, the "Lady Step Sill". The extent of Facies A is governed by the extent of the postulated "Lady Step Sill". Figure 2 shows the probable extent of Facies A. Porosity in the Silurian clastics of Salmon Hole brooks is poor. However, this could be a surface feature only. Much of the originally high porosity is eliminated by secondary lime deposits. The clastics of Facies A theoretically should have excellent porosity development in the subsurface. Beds of Facies A are considered to be excellent possible reservoir beds at depth.

Facies A includes all Silurian beds from the Taconic unconformity to the base of the Cap Bon Ami formation. The age determination of Facies A is dependent

on identification of a few significant fossils. McGerrigle (1950, P.38) discusses this question. Facies A beds are most probably Middle Silurian, but Upper Silurian age is not excluded.

The Silurian beds of Facies B (see Figure 2) are similar in origin to Facies A but they differ in lithologic composition. The economic importance of beds of Facies B is also much less owing to structural considerations. The clastics of Facies B are derived from a postulated submarine sill, designated the "St. John River Sill". It is assumed that the "St. John River Sill" was present geographically congruent with that feature known today as the St. John River Ordovician belt (Map 1000). Shore line conditions probably occurred near its present eastern end at the Owl Capes. Structural conditions are rather complex in the Owl Capes area (structural cross-section No. 4). The entire Silurian thickness from the Taconic unconformity to the base of the Cap Bon Ami is estimated to be about 2,000 feet.

The unconformity is not exposed at Owl Capes (locality B51). It is estimated that 100 to 150 feet are concealed at the base of the Silurian, but the lithology is probably similar to the overlying exposed 200 feet of limestone pebble conglomerate, coarsely fragmental angular limestone (calcarenite) with floating well-rounded quartz grains and a few greenish grey limy shale beds. These lithologies are interbedded and more variations in its composition occur. Green pebbles of volcanics and/or intrusives are present near the base. Above this variable clastic sequence lies a 800 to 1,200 foot thick conglomerate with pebbles from one half inch to 6 inches of green diabase, light grey limestone, and milky quartz. The matrix is strongly limy and enriched in grains of green volcanics or intrusives. There is also fragmental limestone as pebbles in the conglomerate. The coarse conglomerate is overlain by light greenish grey limy and silty shale and shaly siltstone. The contact between the Silurian and the

Cap Bon Ami formation is not exposed, but the upper Silurian beds are assumed to be greenish grey, limy and silty shale and shaly siltstone as observed in Wooden Bottom brook 4 miles east of the Owl Capes locality. The same conglomerate is present south of Owl Capes and south of St. John River, east of Burnt Jam brook. At this latter location an oblique wrench fault cuts through the conglomerate and its thickness is probably greater than the 400 feet given by McGerrigle (1950). This coarse conglomerate is a local occurrence only, as it is not present 4 miles east of Owl Capes along Wooden Bottom brook. At Wooden Bottom brook the basal Silurian beds contain conglomeratic bands and a 30 foot greenish grey conglomerate with unsorted pebbles of light grey (Ordovician) limestone, green igneous rock (diabase) and possibly andesite and quartz in limy and silty shale matrix. Pebbles are 1/8 inch to 3 inches long. Limy and argillaceous arkosic sandstone bands with a light green plagioclase (Labradorite?), are present in this basal coarse clastic zone which is about 300 to 500 feet thick. A thin 3 to 5 foot bioclastic-stromatoporoidal limestone bed occurs in the middle of the basal coarse clastic sequence. The conglomeratic facies B probably disappears rapidly eastward as shown in Figure 2. Silurian beds cannot be observed in Little Fork brook and brooks farther east, since the St. John River anticline plunges eastward and the brooks do not cut the Silurian.

Facies B is also present at the northwest side of the postulated "St. John River Sill". It was observed in Sirois township on the north flank of the St. John River anticline. The entire Silurian thickness is 3,600 feet. Limy conglomerate, conglomeratic sandstone, greenish grey limy and shaly siltstone with conglomerate bands make up the lower third of the Silurian sequence. This was described as limestone grit by McGerrigle (1950). Pebbles of green igneous rocks are common but are not as dominant as in the Owl Capes conglomerate 20 miles east. Facies B is also present around the area of the west plunge of the St. John River anticline in southwest Gastonquay township. Outcrops are

extremely poor and only a thin bed of coarsely fragmental limestone (calcarenite) and limestone conglomerate (calcirudite) with prolific bryozoa growth was seen. Beds of Facies B might be more extensive in this area.

The lithologic composition and thickness variations of Facies B undergo strong changes laterally over short distances. There probably was an emergent area near the east end of "St. John River Sill", the erosion of which supplied the Owl Capes conglomerate. The extent of Facies B beds is governed by the extent and shape of the "St. John River Sill", which can only be inferred from the information available. The St. John River anticline with its exposed Ordovician core is also the approximate location of the submarine sill or ridge.

Beds of Facies B are poorly or non-porous in the outcrops visited, however, they are potential reservoir beds in the subsurface. Unfortunately Facies B beds do not occur in favourable structural position and are consequently less important economically than beds of Facies A.

The bioclastic-reefoid deposits of Facies C are of economic importance (Figure 2). The east-west extent of Facies C is fairly well known but the south boundary is largely inferred. Facies C beds have been observed in Lefrancois township along Madeleine River and in north central Champou township south of Grande-Vallee village. West and east of Facies C, Facies D is present, which is lithologically similar to Facies C but much thinner. The classification of Facies C beds is difficult. Facies C is a mixture of crinoidal fragmental limestone, limestone conglomerate and reefal beds. On Madeleine River (location F47) the exposed thickness of Facies C beds is 85 feet. Since the Taconic unconformity is not exposed along Madeleine River the exact position of Facies C beds in the Silurian sequence is not known. Structural considerations place the Facies C beds in the basal 500 to 800 feet of the Silurian.

The basal 45 feet of Facies C on Madeleine River (locality F47B3) consist of a very coarse conglomerate or breccia with angular boulders up to 3 feet in diameter. The lithology of the boulders is quartz sandstone, crinoidal fragmental sandy limestone, pockets with small pieces of shale, sandstone with detrital Stromatopora sp. The conglomerate is overlain by 25 feet of coarse fragmental crinoidal limestone with large Stromatopora fragments and some large cup corals. The fossils are not in place of growth but broken and transported a short distance (locality F47B2). The uppermost exposed 15 feet (locality F47B1) are similar to the basal conglomerate, but with abundant detrital cup corals and Stromatopora. This conglomerate probably represents deposition directly below wave base. Banks of crinoidal fragmental limestone with sandstone patches and local knolls of reef growth of Stromatopora were broken by wave action and after short transport re-deposited. The cementation by algae consolidated the deposit. Thickness variations in this type of deposit are to be expected.

South of Grande Vallee village large boulders of the same material were found at or near the unexposed Silurian base. Reefoid patches of bryozoa and Stromatopora are common and 2 specimens of the Silurian Monograptus sp. were found. The graptolites are probably not indigenous.

The thickness of Facies C beds between Madeleine River and upper Grande Vallee River is about 100 feet, and thicknesses greater than 200 feet are not expected. The bioclastic-biostromal beds of Facies C are a potential reservoir rock. Beds of Facies C and D have been called "La Vieille formation" by C.F. Burk (personal communication). A correlation to the Sayabec formation at Matapedia Lake, however, appears also probable.

Beds of Facies D (Figure 2) are similar to Facies C, but they are much thinner. The regional extent of Facies D is the greatest of the Silurian facies. It is probably present in the subsurface of the entire area between Forillon

Peninsula and Malbaie River. Facies D interfingers with Facies B at the east plunge of the St. John River anticline in the area between Wooden Bottom and Ascah brooks. On upper Ascah brook is an exposed part of a reefoid patch, built up of crinoidal fragmental limestone and fist-sized *Stromatopora*. Coarse fragmental crinoid ossicles and other fragments with a strong petroleum odour on fresh surface make up the largest part of the 12 foot outcrop. Very few small cup corals are present, some large *Stromatopora* are scattered. In the southwest end of the outcrop there are many bands of fist-sized *Stromatopora*, obviously in place of growth, separated by bands of fragmental crinoidal limestone. The concentric laminae of the *Stromatopora* are often impregnated with a black oil and fractures in the entire outcrop are lined with black hardened (inspissated) petroleum. Permeability obviously is very low and the oil appears to be indigenous. The bioclastic-biostromal limestone on Ascah brook is capped by micaceous, limy and argillaceous greenish grey siltstone and shale with a few isolated crinoid fragments, brachiopods and floating small *Stromatopora*.

Facies D beds are present in greater but strongly variable thickness in the southern parts of townships Joncas, Fortin and Malbaie in the Grand River Portage River outcrop belt. Many north tributaries of Grande Riviere Est expose the beds of Facies D. Crinoidal fragmental, sandy and silty limestone with brachiopod fragments and some bryozoa layers are present at K3 locality. The Facies D beds are 40 feet thick and have a slight petroleum odour on fresh surfaces. *Stromatopora* and corals are not present. At locality K8 about 1 mile east of K3 in another creek 30 feet of the bioclastic limestone are present. Prolific coral growth (*Heliopora* type) is present interspersed with bryozoa, crinoids and rare brachiopods. Many beds are greenish grey, strongly argillaceous and micaceous. Bands of coarsely fragmental sandy limestone with cup corals have a faint petroleum odour. A few large isolated *Stromatopora* grew in this environment.

On Portage River near the Baie de Malbaie (locality K13) a 100-foot outcrop of greenish grey limy and argillaceous siltstone contains several beds with prolific coral content. The beds are from one foot to six feet thick. About 20 to 30 per cent of these beds consist of argillaceous and limy siltstone and 70 to 80 per cent are composed of long cup corals, fist size coral colonies, mostly Favosites and some large Stromatopora up to 2 feet in diameter. This is typical "La Vieille" lithology, known from the "La Vieille formation" near Port Daniel on the Chaleur Bay.

On Forillon Peninsula south of Cap-des-Rosiers Facies D beds, are observed as directly overlying the Taconic unconformity. McGerrigle (1950) and all previous workers of this classical location designated these beds between the Taconic unconformity and the base of the Cap Bon Ami formation, the St.Alban formation and of the Lower Devonian. The St.Alban is now considered Middle Silurian (L.M. Cumming G.S.C.) and is divided in three formations which are in ascending order the La Vieille formation, the Gascons formation and the St.Leon formation. The boundaries have been exactly defined by C.F. Burk (1959/60), who investigated the Gaspé Silurian during the field seasons 1957 and 1958. Facies C and D of this report belong to the La Vieille formation of C.F. Burk or the basal St.Alban of previous workers. However, a correlation to the Sayabec formation of the Matapedia Lake area should be considered.

On Forillon Peninsula Facies D is from 100 to 120 feet thick, however, it thins rapidly westward. The upper boundary is transitional. Light greenish grey, medium to coarse fragmental, poorly sorted limestone (calcarenite) is the main constituent. The unit is strongly sandy with abundant floating sand grains. The coarse fragmental parts are nodular and separated by more argillaceous fragmental limestone. The fossils are concentrated in the strongly argillaceous bands and consist of large cup corals, fist sized colonies of cf. Heliopora, a few Stromatopora

and near the top many brachiopods like Stromphomena and Atrypa. This is also typical La Vieille Lithology as known from the Chaleur Bay.

Farther west along Renard River only thin bands of Facies D occur near the base of the Silurian. The thickest band is a 3 foot dark grey argillaceous limestone with abundant fossil debris. Some of these bands contain Stromatopora and long cup corals. Argillaceous siltstone separates these bands of Facies D.

On Sydenham River Facies D is represented by 30 feet of argillaceous and silty fragmental limestone with a few cup corals and algae lamination. On Dartmouth River talus of silty crinoidal fragmental limestone with local Stromatopora growth and some cup corals are present near the base. The thickness is estimated to be under 30 feet. West of Dartmouth River the bioclastic build-up seems to increase in thickness and Facies C replaces Facies D between upper Grande Vallee River and Madeleine River, north of York Lake. Between the west border of Lefrancois township and Lac Madeleine, Facies D again is present. North of Murdochville along the new highway, boulders of coarse fragmental crinoidal limestone with broken Stromatopora, bryozoa fragments and a few cup corals are present about 100 feet above the Taconic unconformity. It is expected that not more than 30 feet of D Facies beds is present and that this facies continues to the west border of the project area. Thin Facies D beds probably also underlie the Bonnacamp structure and render this excellent structure less attractive economically than the Bald Mountain culmination at Patch brook.

The above described four facies of the basal Silurian in east central Gaspé are ample evidence of the transgressive character of the Silurian sea over an eroded surface, which has not reached full maturity. It is not difficult to correlate the bioclastic and partly biostromal limestone of Facies C and D with the La Vieille formation of the Chaleur Bay region, however, Facies A and B are

sediments which cannot be correlated with other Gaspé occurrences because of their dependence on local conditions, which were also similar to Sayabec type conditions of Matapédia Lake.

During the Middle Silurian period subsidence of the sedimentation area continued in a pattern best shown by the Isopachs of Figure 2. "St. John River Sill" and "Lady Step Sill" were areas of little or no subsidence or sedimentation during Middle Silurian and, therefore, Cap Bon Ami sediments rest on thin Silurian. But other areas sank rapidly and received a great thickness of sediments. North of St. John River and west of upper Dartmouth River a southwest trending trough formed after the deposition of Facies C and D probably parallel to regional structure. Farther east the downward movement probably was not very intense and only small basins with post-facies D sediments were formed. Greenish grey silty shale, mostly limy overlies Facies D and is named the Gascons formation by Burk. The topmost beds of the pre-Cap Bon Ami Silurian sedimentation are argillaceous siltstone beds correlated with the St. Leon formation of the Matapédia valley in western Gaspé Peninsula. Gascons and St. Leon beds overlap Facies A and B deposits on the flanks of the "St. John River Sill" and the "Lady Step Sill" but do not occur on the crest of the sill.

Figure 2 shows the Silurian isopachs between the Taconic unconformity and the base of the Cap Bon Ami formation. The Gascons and St. Leon formations contribute the largest part of the given thicknesses since Facies C and D are relatively thin.

#### SILURIAN AND LOWER DEVONIAN

##### Cap Bon Ami Formation

The relief of the sea floor, which had played such an important role in the facies distribution of the Silurian beds was not as effective during Cap Bon Ami

deposition as the entire basin was sinking. The extent of the basin is not known but the south margin of the Cap Bon Ami outcrops are believed to be near the trough axis. If that is true, only the northern part of the basin, which received Cap Bon Ami sedimentation is preserved.

L.M. Cumming (G.S.C. personal information) established the Silurian-Lower Devonian contact as being within the Cap Bon Ami formation.

Macroscopically the Cap Bon Ami lithology consists of medium grey, silty and argillaceous limestone with beds from 6 inches to 4 feet thick. Limy and silty, medium dark and dark grey shales are present within the formation in Bonnacamp township and other places. Microscopic examination discloses the presence of beds of crystal tuffs, microcoquina layers composed of sponge spicules, shell fragments, detrital quartz grains and ostracod shells (Brummer, 1955). The base of the Cap Bon Ami formation is not difficult to map except in areas of extreme facies change as at Burnt Jam brook, treated later in this chapter. The upper contact with the overlying Grande Greve formation is difficult to pick. In the field the recognition of Cap Bon Ami beds is facilitated by the fact that the bedding and fracturing is even, the limestone is soft and has a dull lustre (Brummer, 1955). Cross-sections 1 through 5 show the thickening of the Cap Bon Ami formation from the northern outcrop margin to the southern border. In the direction of thickening a gradual facies change also takes place. The rock unit becomes strongly silty and sandy southward and south of St. John River, arkosic sandstone and conglomerate are present.

North of the Owl Capes, Cap Bon Ami lithology is dominated by strongly silty limestone and limy siltstone. South of the Owl Capes along Burnt Jam brook structural conditions are very complicated on account of a multitude of northwest striking wrench faults (strike-slip faults). The basal 200 feet of Cap Bon Ami consists of greenish grey limy, very fine grained, arkosic sandstone with plagioclase. Intercalated is reddish and light grey limy siltstone with intermixed fragmental

limestone. Some conglomeratic bands with crinoid ossicles and slight angular bedding are present. Overlying is greenish grey conglomeratic sandstone with well rounded pieces of amygdaloidal green volcanics (andesitic composition) up to 5 inches in diameter. Associated is greenish grey arkosic sandstone with grey felspar. Rare fragmental crinoidal limestone bands are present. The sequence and thickness of Cap Bon Ami are difficult to determine owing to the complicated structure which along Burnt Jam brook consists of reverse and normal faults dominated by wrench faults.

South of the Power-Joncas structure Miller (1946) carried out a detailed survey of the post-Taconic sediments. In cross-section No. 4 his measurements and photogeologic study has been used to determine the thicknesses of the formations involved. McGerrigle (1950) and Miller place the thickness of the Cap Bon Ami there at 6,000 feet. Cross-section No. 4 shows a thickness of 5,500 feet, which is believed to be more correct.

South of Power-Joncas structure four zones have been established in the Cap Bon Ami by A. Miller (1946). The lower Cap Bon Ami boundary might not be correlative with the Cap Bon Ami boundary elsewhere. Zone 4 at the base consists of 1,700<sup>+</sup> feet of calcareous shale and limestone overlain by Zone 3 consisting of 1,300<sup>+</sup> feet of silty dark grey limestone. Zone 2 is made up of 1,000<sup>+</sup> feet of dark brownish grey limestone and Zone 1 of 2,500<sup>+</sup> feet of calcareous shale, limestone, sandstone and conglomerate. Conglomerate and sandstone are present in the upper part of the Cap Bon Ami formation south of the Power-Joncas structure. Only in this area and at Burnt Jam brook has this lithology been observed in the Cap Bon Ami. In these areas they add considerably to the general thickness of the Cap Bon Ami formation.

The Cap Bon Ami formation is not attractive economically, since it does not contain possible reservoir rocks north of St. John River.

LOWER DEVONIAN

Grand Greve Formation

The topmost formation of the "Gaspe limestone" of Logan (McGerrigle, 1950), named the Grande Greve formation contains only a few facies variations similar to the underlying Cap Bon Ami formation. The exact age of the Grande Greve has not been determined despite the work of numerous palaeontologists. It is generally agreed that the Grande Greve formation belongs to the Lower Devonian epoch. The sea floor continued to sink as during the Cap Bon Ami sedimentation, without showing the effect of sills and troughs, which characterized the Silurian sedimentation.

During the Grande Greve, the sedimentary trough axis was a short distance north of St. John River, where the maximum thickness of 4,000 feet in the project area is attained. It should be noted here that this description of the trough axis is its present structural position. Its relative geographic position during sedimentation was to the south of its present position at an undetermined distance. Structural cross-sections 1 through 4 show the north-south thickness variations of the Grand Greve formation. The Grande Greve formation consists of bluish grey thin bedded siliceous limestone and limy, partly siliceous siltstone. The fracture is conchoidal and the lustre is vitreous. The bedding is uneven with thin lenticular bands. Many of the siliceous limestone beds contain a very fine lamination, which shows minute angular bedding. It can generally be stated that the Grande Greve is a very fine clastic unit, the clastic character of which is later obliterated by silicification. Geologists at Gaspe Copper Mine in Murdochville have correctly designated the Grande Greve as a "limy quartzite". Detailed stratigraphic investigation of the Grande Greve formation probably will show many more lithologic variations. Bentonite and glauconite beds are present within the Grande Greve on Forillon Peninsula. Correlation to Grande Greve deposits near the trough axis could

not be established. Coarse clastic beds similar to the underlying Cap Bon Ami formation south of St. John River are not present in the Grande Greve formation except in an area of facies change near York Lake, described later in this chapter. The relations of the Grande Greve to other formations south of St. John River and west of the Power-Joncas structure are not known. Government geologists, pioneer workers in this area, (McGerrigle and I.W. Jones) have indicated solutions to this problem but much more work has to be done to clarify the relations of the Grande Greve to the Fortin series. In this report it is postulated that the Grande Greve formation disappears completely westward of the Power-Joncas structure and its time equivalent is present in the rocks of the Fortin series. An indication of this postulate has been given by McGerrigle (1950). If this facies change is not postulated a normal fault of great magnitude to the south of St. John River has to be assumed as shown on Map No. 1000 of the Quebec Department of Mines. A fault of this magnitude should have a photogeological trace as many smaller faults are identifiable on photos in the Murdochville area. No such fault trace, however, is present in the area as shown on Map No. 1000, which suggests that the Grande Greve formation changes facies completely to Fortin type sediments west of Power-Joncas structure.

Oil shows have been noted in wells north of York River in the upper part of the Grande Greve formation. R.V. Johnson (1945) observed porosity in outcrops of the Grande Greve near the axial plane of the Mississippian anticline along Galt brook. This porosity was not observed in the 1958 field season. Some of the laminated siliceous limestone is very finely pitted at the surface, having the appearance of porosity. The pitting, however, is a weathering phenomenon and not present below the weathered surface.

The siliceous character of the Grande Greve formation caused extensive fracturing during the Acadian movements. In all areas, where the Grande Greve formation was observed, the rocks are strongly broken by closely spaced fractures. In many places the fractures are healed by secondary calcite and quartz, but mostly the

fractures are open. Oil seeps in this area are evidence of migration along open fractures of the Third Lake fault.

Fracture porosity in the Grand Greve formation is probably the only type of porosity in the subsurface.

#### LOWER AND MIDDLE DEVONIAN

##### York River Formation (including York Lake facies)

During the late Lower Devonian the sedimentary pattern changed abruptly and deposition of clastics became dominant particularly in the eastern part of the project area.

The downward movement of the basin floor seems to have been intensified at least in the eastern part of the project area after the deposition of the Grande Greve formation. But synchronous with this development was the creation of a new source area at an undetermined distance possibly east or southeast of the project area. A tremendous amount of coarse clastic material with many unstable minerals was poured into the basin and rapidly buried indicating the advent of Acadian movements, which culminated in the Acadian orogeny in the late Devonian.

The relief of the new and probably fast rising source area must have been great. The source area was probably igneous or metamorphic terrain and covered with vegetation.

In the eastern area around lower York River and the coast the York River formation was deposited abruptly over the siliceous limestone and limy siltstones of the Grande Greve formation. The lithology consists of greenish grey, sandy and silty shales with carbonaceous plant debris and argillaceous, fine to medium grained arkosic sandstone with grey plagioclase. Angular bedding of varying degree can be observed in almost every sandstone outcrop. It has been stated (McGerrigle, 1950) that the boundary between the Grande Greve and the York River formations is a slightly angular unconformity, which would indicate that the Grande Greve was eroded prior to York River deposition. Differences of bed attitudes above and

below this junction have been cited as an indication of angular relations between the formations in question. It should be pointed out, however, that the angular bedding of the basal York River does not necessarily indicate an angular unconformity but could be merely angular bedding on the erosional Grande Greve surface, a purely sedimentary feature. The unconformity probably is more like a diastem, many of which are observable within the York River and the overlying Battery Point formation. Furthermore, no pebbles or grains of the eroded Grande Greve formation were observed in the basal York River sediments. The York River formation increases in thickness from 1,400 feet to more than 4,000 feet from the northern outcrop belt near St. Majorique to the York River syncline, a distance of five miles (cross-section 5). The upper part of the York River formation is eroded in the project area west of Gaspé village and its true depositional thickness is not known.

Farther west in the York Lake area the lower 1,500 feet of the York River formation consist of interbedded York River type clastics and siliceous limestone and limy siltstone of Grande Greve lithology. This facies has been designated the York Lake facies (or series) by I.W. Jones (1935). In this report the York Lake facies is mapped with the York River formation for practical reasons. York Lake facies is transitional between the Grande Greve and the York River and shows relative conformity between these two formations in the York Lake area. Southeast of York Lake in the Oat Cake Lake area the basal York River formation is partly limy indicating the proximity of the York Lake facies.

White quartzose sandstone about 30 feet thick is present in the York River a few hundred feet above the Grande Greve top between Galt and Patawegia brooks. These sandstones are the best possible reservoir rocks in the York River formation. Unfortunately they do not occur in the subsurface on attractive structures. Very poor porosity in argillaceous sandstones of the York River formation was observed in some outcrops. Some porosity is obviously present in the subsurface on Galt

anticline and York River syncline, since many wells obtain very small flows of oil from these zones. Porosity and permeability apparently are very low.

## LOWER DEVONIAN

### Fortin Series

The relation of the Fortin series to other strata present the most formidable problem in the project area. This problem will be treated in the chapter on structure.

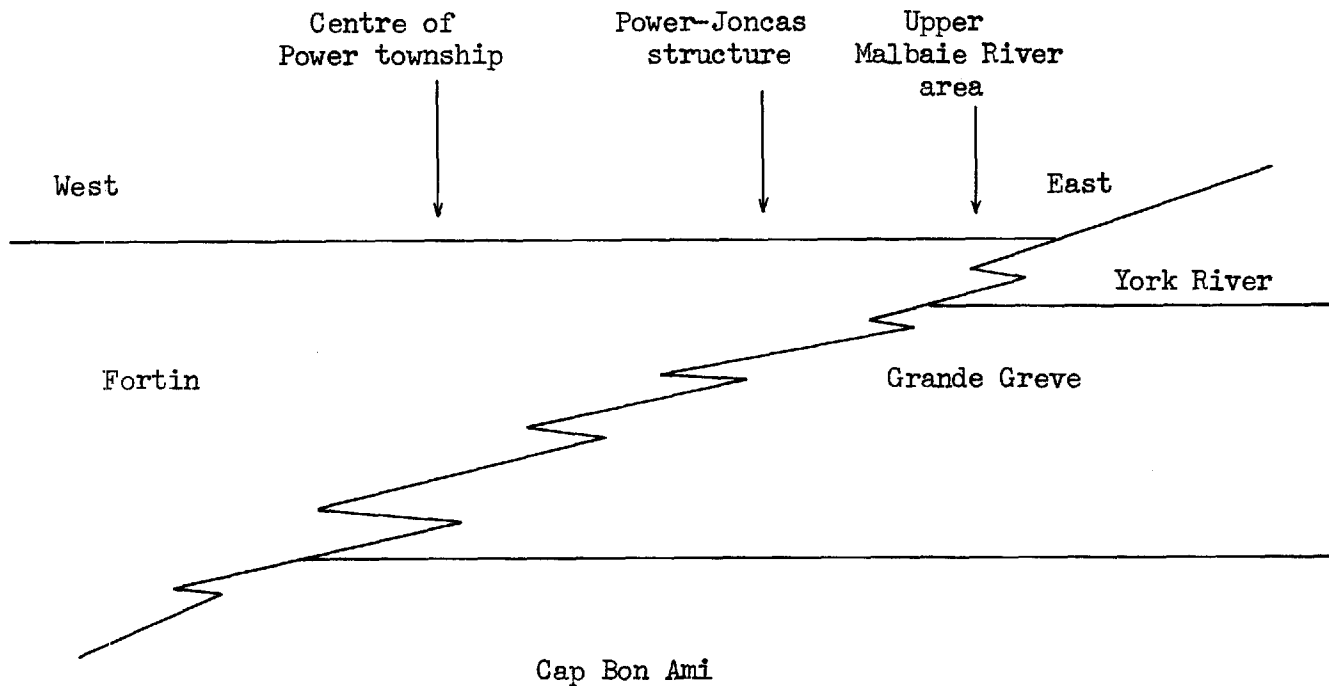
The stratigraphy of the Fortin series is of little or no economic importance and only a limited discussion is given here.

The "St. John River Sill", which influenced to a strong degree the Silurian sedimentation became active again some time during the Grande Greve deposition separating the Gaspé Basin into two separate troughs. South of the St. John River barrier the Fortin series was deposited. The Grande Greve formation was deposited north of St. John River and east of Power township. Fortin type sediments were deposited west of Power township but south of St. John River. At the Power-Joncas structure only the upper part of the Grande Greve is replaced by Fortin clastics and in the upper Malbaie River area the Fortin series grades into the lower part of the York River formation. Figure A is a diagram of the Devonian facies changes. The Fortin series increases in thickness westward and probably grades laterally into the Cap Bon Ami formation. On Map No. 1000 in the south corner of Deville township Fortin and Cap Bon Ami sediments are shown as being laterally related.

Fortin sediments are medium grey and medium dark grey. Silty, laminated shale with carbonaceous debris and mica and strongly limy and argillaceous siltstone make up most of the lithology. A strong fracture cleavage is imposed upon the fine clastic beds of the Fortin series and the attitude of bedding is recognizable only in laminated or banded parts. Basal and intraformational conglomerates are common. Arkosic sandstone beds with grey plagioclase grains have been seen in Joncas and

FIGURE A

Diagram of Devonian facies change from Fortin to  
Power townships



Baillargeon townships. On Wooden Bottom brook conglomeratic sandstone and conglomerate with greenish grey colours overlie the Grande Greve. These conglomerates consist of a matrix of coarse grained arkosic (plagioclase only) sandstone, with well rounded pebbles of quartz, green igneous rocks, black chert and dark grey limestone. More conglomerate bands occur higher in the stratigraphic sequence. McGerrigle (1950, P.76) indicates that the limestone pebbles in the basal conglomerates were derived from the Grande Greve formation. Since, however, the typical Grande Greve lithology is not represented, the limestone pebbles could very well be derived from Ordovician formations south of the project area. The lithologic association of limestone and green igneous rocks in the basal conglomerate is very similar to that of the basal Silurian of Facies B as described before.

The Fortin series contains Grande Greve as well as York River forms (McGerrigle, 1950). It is expected that west of Vondenvelden township Cap Bon Ami fossils also are present in the Fortin series.

The Fortin series is of little economic value due to the strong superimposed slaty cleavage.

Work in the Fortin series west of the project area has been done in the last few years by geologists of the Quebec Department of Mines. The publication of their work should solve particularly the age problem of the Fortin and also the facies relations to York River, Grande Greve and Cap Bon Ami formations.

## LOWER AND MIDDLE DEVONIAN

### Battery Point Formation

Facies relations similar to those discussed in the chapter on the Fortin series are present between the Battery Point and York River formations. The York River formation, discussed previously, was deposited in a marine environment. The

Battery Point formation contains both terrestrial and marine elements.

The Battery Point formation has limited areal distribution in the project area and is present only in the east and northeast part. Battery Point lithology has been mapped (Map No. 1000) west of the project area in Deville township and farther southwest.

A detailed discussion of the Battery Point formation and its age is given by McGerrigle (1950, p.84 et cetera). In general, the Battery point formation overlies the York River in the eastern and northeastern outcrop area, however, in places the upper York River beds are time equivalents of the lower Battery Point beds.

According to A.J. Boucot (1958) "the Acadian orogeny starts in the late early and early Middle Devonian with the transition from marine to non-marine conditions". In Gaspé this transition is directly above beds containing Etymothyris, i.e., above the York River sandstone. The Battery Point formation has the appearance of a delta sediment. Marine fossils are present in the Malbaie River area and non-marine facies is present north of Gaspé village (Peninsula facies). The main differences between the Battery Point and the York River formations are the presence of red felspar and the predominance of conglomerates and sandstones in the Battery Point.

The entire formation is strongly cross-bedded and contains some green shale beds. Logan (reported in McGerrigle, 1950, p.84) measured 7,036 feet in the shore section. This measurement is minimum thickness, since the formation top is eroded.

The composition of the Battery Point is very diverse. Arkosic sandstone, shaly sandstone, conglomerate and conglomeratic sandstone are the main lithologies. Angular to subangular quartz, orthoclase (?), plagioclase, jasper, black minerals and mica are the main minerals. Layers of carbonaceous plant debris are present almost everywhere. Floral microfossils are present and detail work should support age indications, obtained by other means. The uppermost beds are brick-red coloured

and give the soil its characteristic red colour. Small disconformities are abundant, and are indicated by irregular erosion of a coarse clastic bed and infilling of similar material.

The porosity in the Battery Point formation is poor and similar to that in sandstones of the York River formation. However, minor water flows and oil shows have been obtained from the Battery Point in wells and bituminous sandstone beds are present in outcrops along the coast.

#### MIDDLE AND/OR UPPER DEVONIAN

##### Malbaie Formation

The youngest formation involved in the Acadian orogeny is the Malbaie formation in the southeast corner of the project area. This formation has no economic importance and was examined incidentally only. McGerrigle (1950) treats the Malbaie extensively.

The Malbaie consists of Battery Point lithology with the addition of thick limestone pebble conglomerates, presumably derived from the south from the Ordovician Whitehead limestone. Boulders and pebbles of the Grande Greve formation are also present together with numerous pebbles from Battery Point sediments. The Malbaie sediments are strongly cross-bedded and contain numerous small disconformities.

Most of the Malbaie formation is probably younger than the Battery Point, but a facies relation exists similar to the York River-Battery Point relation as described previously. The upper Battery Point beds are probably time equivalent to the lower Malbaie beds. The Malbaie appears to be a delta deposit.

Sedimentation in the project area ceased completely after the deposition of the Malbaie formation and the project area was folded and faulted during the Acadian orogeny. The erosion products of the Acadian orogen later furnished the sediments of the Mississippian and/or Pennsylvanian Cannes de Roche and Bonaventure formations, deposited southeast of the project area.

## IGNEOUS GEOLOGY

McGerrigle (1950) gives a summary account of the igneous rocks in the project area. The investigations in the 1958 field season did not point out additional or contrary evidence to McGerrigle's interpretation.

## STRUCTURAL GEOLOGY

### GENERAL STATEMENT

Previous geological publications in the project area and for the entire Gaspé Peninsula stress the stratigraphical and palaeontological aspects of the geology. Only recently (McGerrigle 1950, Roliff 1952, Johnson and Miller, Reports to Payette companies) has structural geology received some attention.

The density of visited locations during the 1958 field season does not permit construction of a complete structural map, however, an attempt was made to study outcrops along several north-south lines in order to construct structural cross-sections. Five structural cross-sections have been constructed with a horizontal and vertical scale of 1 mile to 3 inches. The lines of the cross-sections are perpendicular to the fold axes and close to the traverses. These lines are offset in several places in order to maintain proximity to measured detail. The bed and fault attitudes were projected on the cross-sections at elevations taken from available topographic maps.

Thicknesses of the units were obtained in undisturbed outcrop areas, mostly on the northern and southern outcrop margins and on the flanks of the St. John River anticline.

Thickness variations of the stratigraphic units are large. The effect of the thickness changes on structural interpretation is significant and its importance can clearly be seen on the cross-sections.

In many instances it was necessary to assume unit thicknesses. Due to sparse outcrop and local facies changes within the Silurian, unit thickness of the Silurian must be considered approximate only. Figure 1 is the geological map constructed from the field observations. In the York Lake-Murdochville area some measurements of Brummer (1955) were used. Air photo study was used extensively particularly for the mapping of oblique wrench faults (strike-slip faults).

#### REGIONAL STRUCTURE AND STRUCTURAL HISTORY

The regional structural trend in western Gaspé trends east-northeast to northeast west of  $65^{\circ}30'$  west longitude. This is the predominant trend for the features of the Taconic and the Acadian orogenies. Between west longitudes  $65^{\circ}30'$  and  $64^{\circ}30'$  the regional structural trend changes from a northeast direction in the west to predominantly a southeast direction in the east. The bending of the orogen occurs within 45 to 50 miles and entirely within the east and west boundaries of the project area. To accommodate this bending a set of northwest striking dextral wrench faults were formed. There is no regional evidence to suggest that the trends of Taconic and Acadian orogenies are not parallel. The Taconic orogeny near the end of the Ordovician folded and faulted the pre-Silurian sediments. Intrusions are present but cannot be dated exactly. A significant intrusion occurred prior to the deposition of Silurian sediments on "Lady Step Sill" (Figure 2).

After erosion of the Taconic orogen and the deposition of the Silurian and Lower Devonian the Acadian orogenic movements started in late early and early Middle Devonian with the transition from marine to non-marine conditions in the project area (Boucot, 1958).

The structural features shown on the geological map (Figure 1) and the five structural cross-sections indicate the result of the Acadian orogeny.

Apparently there were definite pre-Taconic trends that controlled the orientation of the pre-Taconic sediments, the Taconic orogeny, the orientation

of pre-Acadian and the Acadian orogenic trend. Post-Acadian sedimentation (Mississippian and/or Pennsylvanian) occurred only in the southeast corner of the project area. The terminal Appalachian folding phase, the main orogenic phase of the Appalachian farther southwest, had only marginal effects on the project area. Tilting of Carboniferous strata by faulting is common in the Perce area. Dykes composed of basic igneous rocks and normal faults in east central Gaspé could possibly have occurred during the late Permian, the time of the terminal Appalachian deformation.

#### ORIGIN OF ACADIAN STRUCTURES

The Acadian structures west of the project area have been caused by compressive stress acting along northwest-southeast lines. Within the boundaries of the project area the stress direction apparently rotated from a northwest-southeast direction over a north-south direction to a northeast-southwest direction, causing the orogen to bend convex to the north. The large Precambrian block of the Maquereau group 20 miles south of the project area in Newport and Daniel townships on Chaleur Bay may have had a causative effect on the location of the curvature of the orogen (Mr. R.P. Lockwood, personal information, Map No. 1000).

It is not known if the curvature of the orogen was already present to a lesser degree at the termination of the Taconic orogeny or even earlier. It is conceivable that some of the wrench faults e.g., the Third Lake dextral wrench fault and the large wrench fault north of Mount Alexander were active during the Taconic orogeny and the late Ordovician movement occurred in the same direction as before along these old planes of weakness during the Acadian orogeny. The solution of this problem, however, is of little importance for this report, since only the deformation of the post-Ordovician sediments during the Acadian orogeny has a bearing on the economic evaluation of the project area. Further work may result in establishing Acadian arcuate structures with frontal thrusts and lateral strike-slip faults.

## FAULTS

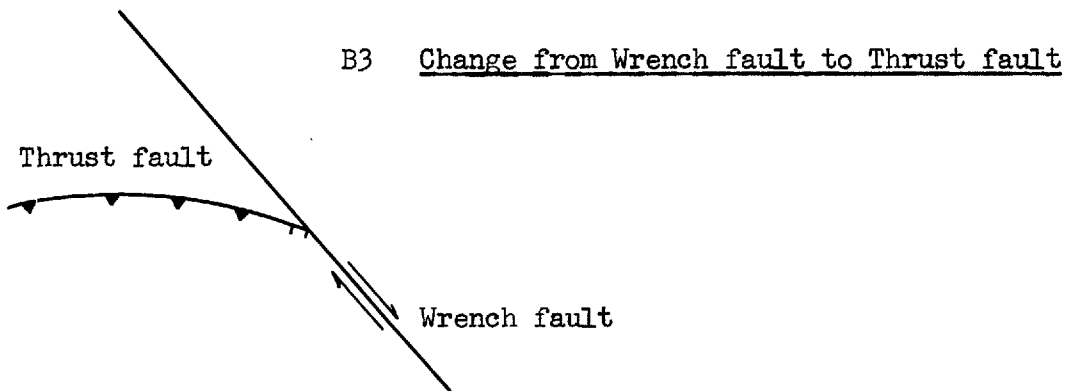
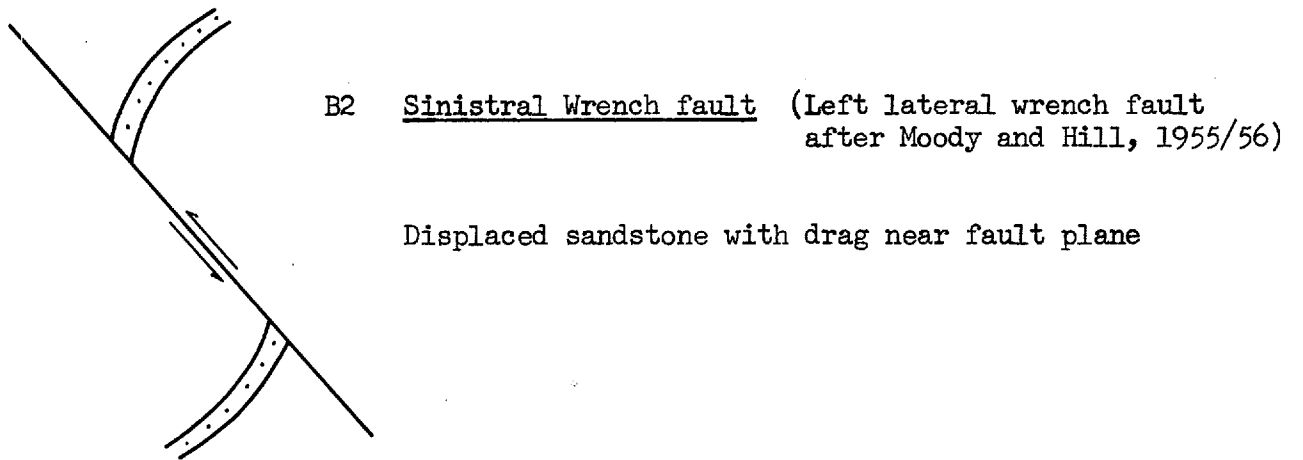
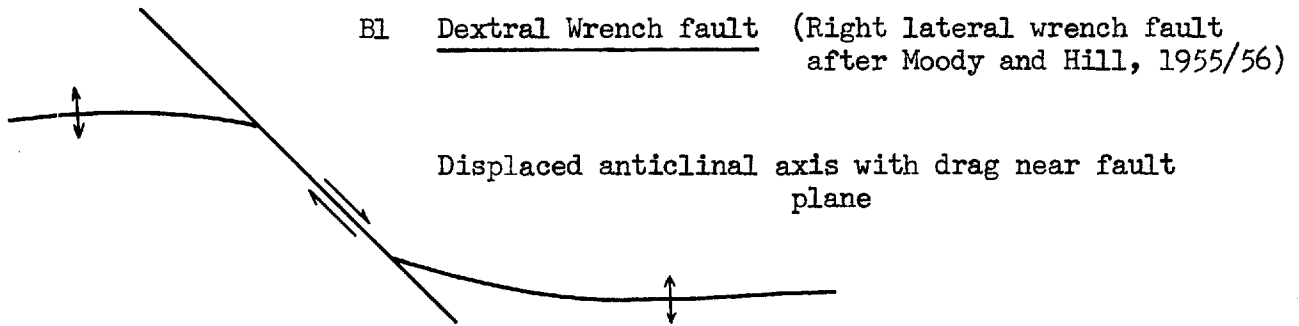
### Wrench Faults

The term "Wrench fault" was first used by E.M. Anderson (1951). The usage of this term was continued by Moody and Hill (1955/56) and De Sitter (1956). M.P. Billings (1954) uses the term "Stike-Slip fault" for the same features and this term seems to be in general usage in North America. The names "Transcurrent fault" and "Transverse fault" are used in older literature previous to 1951. The expression "Tear Fault" is used for strike-slip faults with small displacements. A wrench fault denotes a more or less vertical fault, perpendicular or oblique to the fold axes along which a horizontal movement occurred. The blocks on both sides of the fault plane or fault zone have moved horizontally relative to each other. Figure B has been drawn to explain wrench fault terminology. When observed normal to the wrench fault plane two possible horizontal movements are discerned. If the block behind the fault plane moves to the right the fault is termed a "dextral wrench fault", in the reverse case it is a "sinistral wrench fault". These terms are synonymous with "right lateral" and "left lateral" wrench faults of Moody and Hill (1955/56).

Wrench faults and thrust faults are the result of the same compressive stress system. Wrench faults often change to thrust faults along the fault plane. This is particularly true in the case of wrench faults with relatively large horizontal displacement. Figure B (at B3) shows the change from a dextral wrench fault to a thrust fault, along the large Third Lake fault at Patewegia brook. Wrench faults are theoretically oblique to the fold axes and to the stress direction. They are shear planes, which also have been demonstrated experimentally on smaller scale (Billings, 1954, p. 215). Two directions of shear are possible in a north-south directed stress field. One direction is northwest-southeast, the other northeast-southwest. In east central Gaspé only the northwest-southeast direction is of

FIGURE B

in plan



importance. The northeast-southwest shear planes are present in outcrops but horizontal movement has not been discerned.

In the project area a multitude of wrench faults have been mapped (Figure 1). The fault traces have been determined by photogeology. In many places along Burnt Jam and Little Fork brooks the fault planes or zones were seen in outcrops and measured in the 1958 field season. Horizontal slickensides showing horizontal movement were observed. But in most places the fault planes or fault zones of the wrench faults are not exposed and dip and direction of displacement must be determined from aerial photographs. Most wrench fault traces show up sharply on the photos and are only slightly deflected by the topography. The dip of the fault planes is vertical or near vertical, which is also shown in cross-sections 1, 4 and 5. The direction of horizontal movement is dextral (right lateral) in all places where the movement could be determined by drag of beds or structural features (Figure B). Along some wrench faults the direction of horizontal movement could not be determined. This is the case in most small faults, where the fault traces do not continue for more than one mile.

The action of all wrench faults during the orogeny was probably intermittent. DeSitter (1956) points out that wrench faults may have a long period of movement. The movements along wrench faults continued as long as the compressive stress was applied, i.e., during the entire Acadian orogeny.

Much of the bending of the orogen in the project area can be contributed to the differential dextral movements along wrench faults. The amount of horizontal movement along all faults also varies (net slip) along its plane and the actual movement of course consists of cumulative effect of a multitude of movements composed of horizontal and vertical components. Investigations at outcrops of wrench fault planes show only the effect of the terminal movement.

The two largest wrench faults in the project area, both with definite

dextral movement are the Third Lake fault near the centre of the project area and the fault north of Mount Alexander. Both are more or less broad fault zones and show a distinct scar on aerial photos.

The wrench fault north of Mount Alexander was crossed only in two traverses during the 1958 field season. In both traverses there are almost no outcrops and observations of talus served for mapping purposes. It is highly improbable that even detailed field mapping will outline the fault and study of aerial photographs is imperative. The displacement is dextral, the southwest block of the fault moved to the northwest. Drag near the fault plane can be seen northwest of Mount Alexander a short distance south of St. John River. The amount of horizontal displacement cannot be determined in this case, but it appears to be large. It is believed that this wrench fault played a leading role in moving the sediments of the Mount Alexander Silurian belt to their present position from the area of deposition at an undetermined distance southeast of Mount Alexander. The general strike of this large wrench fault is  $N65^{\circ}W$ . Since this wrench fault does not show any deflection caused by recent topography, its dip is assumed to be vertical or near vertical as is shown on the southern end of cross-section No. 2. The presence of this large wrench fault north of Mount Alexander strongly suggests that the postulated sole fault of Roliff (1952, Figure 6) is not present. He postulates a sole fault at the base of the Silurian but over the Mount Alexander Silurian, over which the Fortin and older sediments have been carried far from the south to their present position.

The Third Lake fault was named and mapped by McGerrigle (1950 Map No. 1000 (1953)). This large dextral fault is continuous from the big bend of central Malbaie River in Malbaie township to one and one half miles north-northwest of Bald

Mountain proper (Bald Mountain observation tower). That is an uninterrupted length of 34 miles. This large wrench fault probably extends farther southeast of Malbaie township into the Baie de Malbaie. McGerrigle (1950 and 1953) shows only segments of the Third Lake fault but the continuity of the fault is quite evident on aerial photos and particularly on the photomosaic (Scale 1:1 mile). The fault scar is distinct from Malbaie township to York River with a few associated faults and a general strike of N55°W. North of York River the Third Lake fault trace commences to undulate and a multitude of thrust faults branch-off to the west of the main fault. Patewegia brook follows the general trend of Third Lake fault. The thrust faults to the west of the Third Lake wrench fault cross Patewegia brook and continue a short distance to the west. The fault planes are continuous with Third Lake fault, but change from a northwest strike to a west strike. Near the wrench fault the thrust faults have steep dips and the movement has a large horizontal component. The attitude changes gradually and the vertical component of the movement dominates at the west end of the thrust fault, where the fault planes dip to the south. Several of these fault planes were measured in Patewegia brook outcrops. The Third Lake fault disappears a short distance north-northeast of Bald Mountain proper and there is no evidence to suggest that it continues into the area of the Champou syncline.

The mode and amount of displacement along the Third Lake wrench fault varies considerably. The horizontal displacement between Third Lake and Wooden Bottom brook is 4 miles (4.3 miles), i.e., the southwest block of the fault has moved 4 miles to the northwest. This measurement was taken at the York River-Grande Greve contact. Farther southeast of Wooden Bottom brook the amount of horizontal displacement may be more than 4 miles, but detailed mapping of that area is necessary to ascertain the displacement.

The east end of the St. John River anticline is

displaced by the Third Lake fault in the same manner. North of York River the displacement was taken over partly by the thrust faults, which branch-off to the west from the main wrench fault. Since thrusting achieved the same result, the horizontal displacement along the Third Lake fault is less than it is south of York River. The horizontal displacement of the axis of the Mississippian anticline is somewhat more than 2 miles. The amount of drag of the anticlinal axis is fairly high and the exact location of the axis at the wrench fault requires more detailed mapping.

There are smaller dextral wrench faults closely associated with the Third Lake fault. Some of the fault traces have been shown on Figure 1 and in cross-sections 4 and 5, where the wrench faults are shown as vertical features. Since the wrench fault traces are not deflected by topography, the true attitude (i.e. vertical or subvertical) of the faults does not vary much from the vertical attitude shown on the cross-sections.

McGerrigle (1950, P. 106/107) discussed the Third Lake fault but did not indicate its character as a wrench or strike-slip fault. He apparently assumes a normal fault and states that the northeast block of the fault is downthrown and the maximum displacement is probably 3,000 feet at York River. This apparent normal displacement is present in McGerrigle's cross-section and in cross-section 4 of this report but it was achieved by horizontal movement on a dextral wrench fault and not by movement on a normal fault.

Several dextral wrench faults with small displacements were mapped in the Burnt Jam brook area, Ross Lake and Owl Capes area and between Little Fork and Wooden Bottom brooks. The amount of displacement of these faults is not known since it required detailed mapping, but it is assumed to be minor.

The Northwest Arm thrust fault (McGerrigle, 1950, p.108) is not a true thrust fault but the combination of a dextral wrench fault and a thrust fault. The

Northwest Arm fault is parallel to the Third Lake fault. The Northwest Arm fault continues for a length of 22 miles from Gaspe Harbour, Gaspe village to the confluence of Eden brook and Darmouth River in De Beaujeu township. The Northwest Arm fault consists of a single fault plane between Gaspe village and Roaring Bull brook, about ten and one half miles northwest of Gaspe village. Between Roaring Bull and Eden brooks for a distance of about 11 miles the Northwest Arm fault zone consists of a system of thrust faults and oblique wrench faults, the planes of which are interconnected. Figure 1 contains only fault traces mapped by photogeological methods in the Lady Step-Eden brook area, since that area is almost inaccessible. The Northwest Arm fault was traversed several times and is shown in cross-section 4 and 5. The fault is steeply inclined to the southwest in its southern half, since its trace is deflected by topography. It is a thrust fault in cross-section 5 with a vertical displacement along the fault plane of about 2,000 feet for the Silurian. This amount of thrust displacement is modified by the strong thickness change of the post-Silurian formations. The inferred displacement for each unit can be measured in cross-section 5. A large horizontal component of the movement along the fault plane is readily discerned on aerial photographs and Map No.663 (McGerrigle, 1950). Southwest of the fault plane the strike of beds and several anticlinal and synclinal axes are dragged to the east and southeast on approaching the fault plane. The southwest block of the fault has moved to the northwest and the fault is a dextral wrench fault. This is the same mode of displacement as on the dextral Third Lake wrench fault, previously described, and these two faults are more or less parallel. It is difficult to classify the Northwest Arm fault. It could be designated a dextral wrench fault with large thrust movement or a thrust fault with large dextral strike-slip movement. The amount of horizontal displacement cannot be discerned since structural or stratigraphic features southwest of the fault plane are entirely missing

on the northeast side. However, the amount of horizontal displacement is considered to be large on account of the strong drag present. Billings (1954) named faults of this type "Longitudinal strike-slip faults" and De Sitter (1956) called these faults "Rifts".

Northwest of Roaring Bull brook the Northwest Arm fault gradually assumes the character of a thrust fault. Detailed mapping probably will reveal many thrust faults branching-off to the west from the main fault similar to the Third Lake fault in the Patewegia brook area described previously. Some definite small dextral wrench faults can be seen and identified on aerial photographs a short distance east of Eden brook and their traces are mapped on Figure 1. The fault is also shown in cross-section 4 on Salmon Hole brook. Since at that location (locality H100 et cetera) the fault has more the character of a thrust than that of a wrench fault, the dip of the fault plane in cross-section 4 is shown to be less than in cross-section 5.

The Northwest Arm fault system disappears near the centre of De Beaujeu township a short distance west of Logan brook.

Several wrench faults are present west of York River in the general Tom's brook area ("Ruisseau Tom" on the maps). One medium sized dextral wrench fault is present in southeast Fletcher township 3 miles west of York River. Its trace is a deep broad scar on aerial photographs, indicating a broad fault zone. Definite drag of beds is present, which shows dextral movement along this fault zone.

Dextral wrench faults dominate the structural picture in Sirois township and in the northwest corner of Gastonguay and southwest corner of Holland townships. This area contains an abundance of complicated structural features the solution of which is difficult because of lack of outcrops. Study of aerial photographs discloses the presence of two dextral wrench faults north of York River bend and one dextral wrench fault south of the large bend of the York River. The faults north of the

York River bend are major with distinct drags of beds near its fault plane or zone, indicating dextral movement. The faults strike N75°W and dip steeply south, since the deflection by topography is negligible. The wrench faults have also a large vertical component of movement and their classification is ambiguous. These faults could be designated thrust faults with large dextral movement or dextral wrench faults with large thrust movement similar to the Northwest Arm fault. There is indication that the northern-most wrench fault (between localities F20 and F21) is connected with thrust faults, which branch-off to the west from the main fault as shown on Figure B (B3) and described previously in the Patwegia brook area.

The topmost Silurian beds, Gascons and/or St. Leon formations of C.F. Burk (1959/60) are present at the surface and they show strong cleavage. The boundaries between the Silurian and the Cap Bon Ami formation are highly questionable, since the Cap Bon Ami changes facies to the west. The Silurian occurs entirely between the two wrench faults with thrust movement and is not thrust over the Grande Greve formation as shown on Map 1000 (1953). The relation of the structures there to those southwest of the York and St. John Rivers is not known. It is certainly not a simple anticline as assumed but a more complicated feature in which wrench faults may be important. This area is marginal to the project area and more work in Gastonguay township is required to resolve the structural problems.

#### Thrust Faults

Most if not all thrust faults in the project area are intimately connected with the wrench faults previously described. Most thrust faults in the project area develop from a dextral wrench fault by branching-off to the west (Figure B3). They do not extend very far from the wrench fault, which shows that they are closely

related to the wrench fault. The south border of the project area contains many steeply south dipping thrust faults, on which the Ordovician is thrust northward over the Silurian and in part the Cap Bon Ami. The displacement does not exceed 2,000 feet. Figure 1 shows the thrust faults of the southern border, which also have a distinct trace on aerial photos. The amount of the deflection of the fault trace by topography shows a steep south dip. Cross-section 4 and 5 show the structural relations on the south border of the project area. Roliff's (1952) interpretation requires north dipping fault planes, since in his opinion the Fortin series and parts of older formations are a "Decke" (nappe) carried from a southern area to its present position.

The thrust fault is offset in some places by dextral wrench faults, one of which is shown in Figure 1 south of the Power-Joncas structure. Some minor thrust faults are shown on Figure 1 in Burnt Jam, Wooden Bottom and Little Fork brooks. The traces mapped are distinct on aerial photos but their lateral extension is not known and requires detailed mapping.

One large thrust fault has been mapped by McGerrigle (1950) north of Owl Capes in Baillargeon and Laforce townships in order to explain the absence of the Cap Bon Ami formation, which presumably is faulted out. There is no photogeological evidence for a thrust fault, no fault trace can be seen. However, a broad wrench fault is present between Owl Capes, Ross Lake and Fourth Lake, which complicates the structural relations. A thrust fault of medium displacement is probably present in that area but it is offset by at least one wrench fault. Cross-section 4 shows the vertical structural relations.

A thrust fault with considerable lateral extension is mapped on Map 1000 in the centre of Larocque township. Segments of this thrust fault are mapped in Figure 1. It originates at the Third Lake dextral wrench fault at Patwegia brook and strikes west to the Mississippi River and Lake Dartmouth. The fault zone is

exposed in central Mississippi brook. The amount of displacement there is difficult to judge, since the location of the Cap Bon Ami-Grande Greve contact is questionable. The displacement could be larger as shown in cross-section 3. This thrust fault probably caused the chevron-type fold of the Mississippi anticline north of it (Mr. Lockwood, personal communication).

The thrust fault in southwest Fletcher township mapped between localities F15 and F16 on Figure 1 shows a very deep scar on aerial photos, which continue eastward to the dextral wrench fault mapped in southeast Fletcher township. The thrust is displaced along the wrench fault but probably was originally continuous with the thrust fault of Larocque township. These relations are not shown on Figure 1 since more detailed work on aerial photographs is required to map the fault traces. Many more small thrust faults are mapped in the different traverses. They are of minor importance and their lateral extent requires more detailed mapping either by field work or by photogeology.

The relation of wrench faulting and thrust faulting is of great importance for the clarification of the regional structure. Since every thrust fault mapped in the field or by photogeologic studies originates in or branches off from a wrench fault with continuous fault planes, wrench faulting is considered to be the dominant faulting in the project area.

#### Normal Faults

The presence of normal faults in the project area could be proved only in a few traverses. Along the coastal section at the east border of the project area with its magnificent exposures, however, numerous normal faults are present and in most places the amount of displacement could be measured.

Steeply south dipping normal faults are present in the Forillon section. Displacement is only a few feet and the fault planes are filled with secondary calcite.

Numerous small normal faults were observed along the coast south of the Tar Point anticline. At locality B87 the displacement is 7 feet. At C12 a small graben is present (see sketch sheet at C12). The normal fault with the largest displacement is present at the south end of Cap Rouge (locality C18). The fault dips 70° SW and displacement is about 300 feet. Many more normal faults are present in the coastal section. Calcite veins up to 7 inches wide occur along the fault planes and some of them are filled with black plastic petroleum. A diabase dyke with amygdaloidal texture is present at Tar Point anticline, but it could not be ascertained if that dyke invades a normal fault.

Planes of normal faults were measured in Little Fork brook, Burnt Jam brook and on the traverse over the Power-Joncas structure. They are all steeply south dipping and the south block of the faults was downthrown. On the south flank of the St. John River anticline a normal fault with tremendous displacement was assumed by McGerrigle to explain the absence of the Cap Bon Ami and Grande Greve formations. Cross-section 4 shows one normal fault in the upper Burnt Jam brook area, the trace of which can be discerned faintly on aerial photographs. Since in this area the Fortin series commences to replace the Grande Greve and farther west Cap Bon Ami, the amount of displacement shown is inferred only. Farther west i.e., at the confluence of Indian Brook and the St. John River the trace of a normal fault could not be discovered on aerial photos. Estimation of the displacement along this normal fault cannot be ascertained owing to facies changes within the Grande Greve-Cap Bon Ami and Fortin strata. If a facies change is not present a displacement of more than 10,000 feet must have occurred on the inferred normal fault, which certainly should show some trace on aerial photographs. Three normal faults of small displacement have been mapped by Brummer (1955) south of Needle Mountain. The trace of two of the faults, named faults "A" and "B" was mapped by air photo studies. The traces are distinct and show a fault scarp in the centre

of fault "B". Fault "A" crosses Needle Mountain proper. The maximum displacement along these faults is 400 feet with a downthrown south block. Two more faults are inferred by Brummer, but could not be seen on air photos and are not mapped on Figure 1.

#### FOLDS

The axis of the major anticlines and synclines are correctly mapped on maps 661 through 665 (McGerrigle, 1950), except at those places where wrench faults more or less displace axes. During the field season traverses were concentrated in the anticlinal areas. In many areas it was impossible to show the continuity of the axial traces without more field checking. In these cases McGerrigle's (1950) interpretation has been accepted. The surface detail obtained by McGerrigle and his associates was found to be excellent.

The southernmost structure traversed in the project area is the Power-Joncas dome. It consists of two anticlines with the culminations in the northwest corner of Joncas township. The anticlinal axes are not more than six miles long. As can be seen in cross-section 4 the closure is minor. The axial planes are shown to dip south. The north flanks of both anticlines are disturbed by minor overthrusts (only one is shown in cross-section 4) which probably do not affect the anticlines at greater depth.

Several anticlines are present in Fortin township in the Grande Fourche-Upper Malbaie Rivers area. On map 665 (1950) the anticlinal axes are shown to plunge eastward. Cross-section 5 shows the general structural relations in Fortin township after McGerrigle. This part of the cross-section is simplified.

The St. John River anticline is one of the largest anticlines in the project area. This structure was present as a "high" or submarine sill during the Silurian sedimentation as described in the chapter on Stratigraphy. The location of the axis of the St. John River anticline can be shown only by using the measurements of bed attitudes in the Silurian and younger sediments. No south

dipping Ordovician strata were observed on the south flanks of the anticline at the Burnt Jam brook - St. John River confluence. On the contrary, only north dipping Ordovician beds can be seen on aerial photographs as shown in cross-section 4. The location of the axis of the St. John River anticline between Wooden Bottom and Little Forkbrooks and farther east is obscured by its displacement along many wrench faults shown in Figure 1. The anticline is completely cut off and displaced by the Third Lake fault in the Little Fork brook area. The anticline plunges east into the northwest corner of Malbaie township and probably disappears completely before reaching the coast.

A very gentle anticline with about  $10^{\circ}$  east plunge is present at the coast and designated the Pointe St. Pierre anticline. The strike of the axis of this anticline is very obscure and cannot be mapped with available surface information. Several workers proposed to link the Pointe St. Pierre anticline with the east plunging St. John River anticline. However, the writer concurs with McGerrigle who does not connect the two structures (Map 665, 1950).

The Tar Point anticline in Douglas township is a well defined structure. This anticline extends farther inland from the coast. However, surface information is insufficient to map the axial trace from Douglas township into York township. In cross-section 5 a gentle anticline is postulated between the St. John River and the axis of the York River syncline. The anticline is not present at the surface. Postulation of this anticline was necessary to accommodate the unit thicknesses of the York River.

The economically important Mississippi anticline was studied by several traverses. The axis is continuous on both sides of the Third Lake wrench fault. The dextral displacement of the axis along the fault is about 3 miles but the drag of the axis close to the fault is very strong. East of Third Lake fault, the anticline plunges to the east. A culmination is shown to be present in Galt brook as shown on map 662. The west plunge west of Galt brook cannot be detected. The

writer believes that the culmination is present either at the juncture of Third Lake fault with the Mississippi anticline or due south of Lizard Lake. Thrust faults with minor displacement are present on the north limb of the anticline in Silver brook and probably in Galt brook, where surface evidence is insufficient. A wrench fault of minor displacement parallel to Third Lake fault cuts through Mississippi anticline at Galt brook and may very slightly displace the axis (see also cross-section 4). West of Third Lake fault the Mississippi anticline has the character of a chevron-type fold with very steep flanks. Thrust faults south of the axis may have caused this chevron-type folding (Mr. Lockwood, personal communication). The culmination of this part of the Mississippi anticline is present in the upper Mississippi brook area since the axis plunges to the east toward Third Lake fault and to the west of York River. As is shown in cross-section 3 the amplitude of the anticline is small at depth along Mississippi brook.

A much greater amplitude occurs in an anticline on Mississippi brook about 1 mile south of Mississippi anticline. That structure is accentuated by thrust faults (cross-section 3). Imperial Mississippi No. 1 well near Dartmouth Lake obviously was drilled to test this structure. The lateral extent of this anticline is not known.

In the vicinity of Gaspé village several anticlines are present. On Haldimand Peninsula the Haldimand anticline plunges into Gaspé Bay. The south limb of Haldimand anticline is disturbed by a few minor thrust faults and subsidiary anticlines as shown on Figure 1 at the east shore of Southwest Basin. Haldimand anticline does not have a culmination but is connected to the Hay Creek anticline west-northwest of Gaspé village. The axis of Hay Creek anticline probably is not continuous as shown on Figure 1. The large Northwest Arm fault on the north limb of Hay Creek structure dominates the anticline and detailed mapping is required to show the relation of the anticlinal axis to this large fault.

Galt anticline in Galt and Baie de Gaspé-Sud township is only five to

six miles long. It has a fair amplitude at the surface, which becomes gradually less at depth as shown in cross-section 4. It apparently is not present as an anticline below the Grande Greve-Cap Bon Ami contact, since the formations increase rapidly in thickness from north to south.

Bald Mountain anticline, one of the largest structures in the area, is present only west of Third Lake fault. It has a large culmination on Patch brook in northwest Fletcher township. East of Patch brook the anticline plunges gently to the east but to the west it bifurcates into two anticlines. On Patch brook the Bald Mountain anticline has a high amplitude of more than 5,000 feet. The amount of plunge to the west and east is not known, but the closure at the culmination is estimated to be at least 1,000 feet plus. Since the true Silurian thickness is not known, two interpretations have been made on cross-section 2. If the Silurian thickness is 6,000 to 8,000 feet, the axial plane dips steeply north and the crest of the anticline at the Taconic unconformity is about 2,500 feet north of the crest at the surface. If the Silurian thickness is between 4,000 and 5,000 feet, material on the flanks has to be moved by small faults or flowage to the crestal part of the anticline, increasing the Silurian thickness considerably under the culmination. Silurian beds are non-competent relatively to the hard overlying Cap Bon Ami and Grande Greve formations and the squeezing of soft material from the flanks into the crestal parts of the anticline is conceivable. The South fork of the Bald Mountain anticline continues southwestward to York River and farther west. There is no evidence for a culmination and the plunge is to the southwest.

The north fork of the Bald Mountain anticline continues west to York Lake and farther west probably to Bonnacamp township. A culmination in this north fork is probably present a short distance west of York Lake. A culmination could erroneously be assumed northeast of Holland Lake along Holland brook because Cap Bon Ami formation is exposed in the anticlinal core. This, however, is misleading since the topography

cuts into the Cap Bon Ami formation.

The Holland anticline, eight miles long is present south of York Lake. Peninsular Oil Corporation No. 1 well was drilled near the culmination.

Cross-section 1 shows the Holland anticline and the north fork of the Bald Mountain anticline. Axial planes of both structures dip steeply north. The anticlinal crest of the Holland anticline at the Taconic unconformity is about 3,000 feet north of the surface crest.

The Bonnacamp anticline in the Gaspé National Park at the western margin of the project area is a large ovate structure the core of which exposes red and green limy and shaly siltstone and shale of the Silurian. Outcrop conditions are extremely poor in Bonnacamp township and the location of the axis could be shown only approximately on Figure 1. Much information gained from aerial photos is incorporated in Figure 1. The Bonnacamp anticline apparently has a gentle south limb and a steep north limb. The closure is estimated to be higher than that of the Bald Mountain anticline on Patch brook. It is highly questionable that surface work can outline the Bonnacamp anticline in detail. It can be expected that mapping on aerial photographs will show the geometry of the structure in detail.

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**PUBLIC**

Ministère des Richesses Naturelles, Québec  
SERVICE DES GÎTES MINÉRAUX  
No GM-16470

FIGURE 1  
GEOLOGICAL MAP  
EAST CENTRAL GASPE PENINSULA

Scale: 1:50,000, or approximately 1.25" to 1 mile



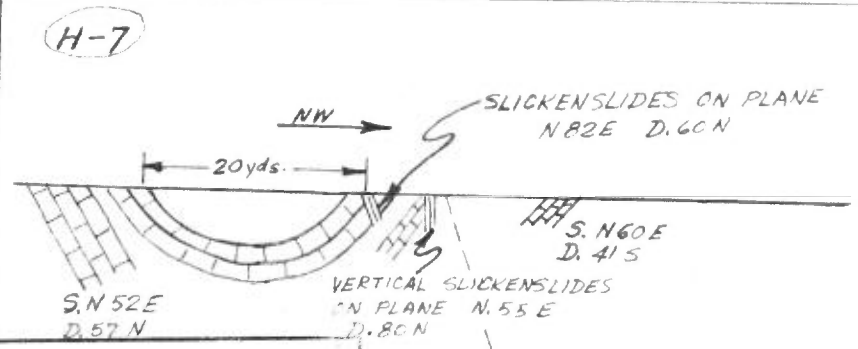
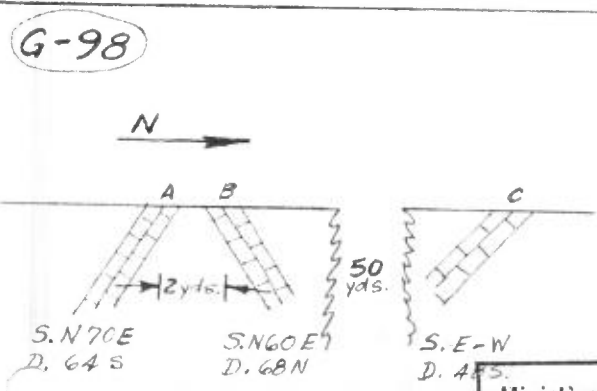
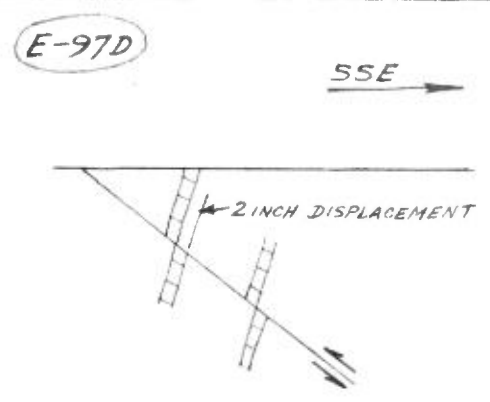
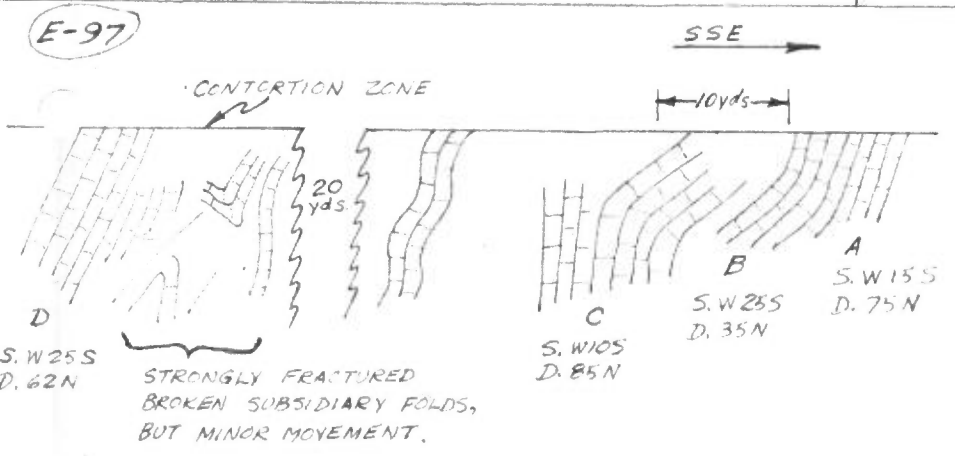
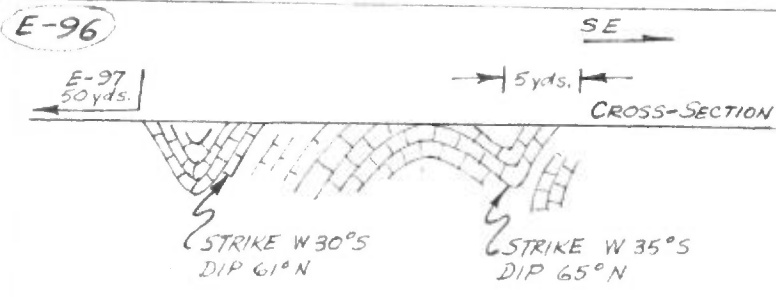
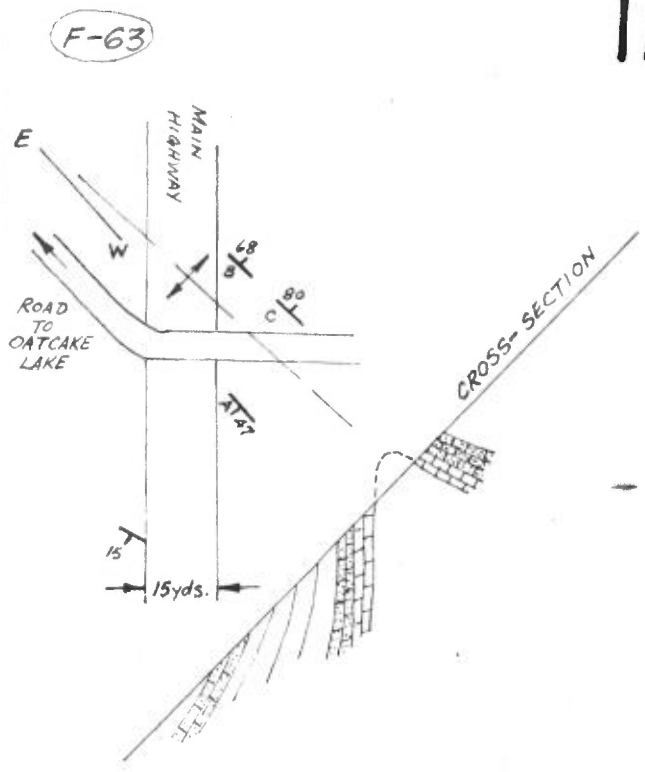
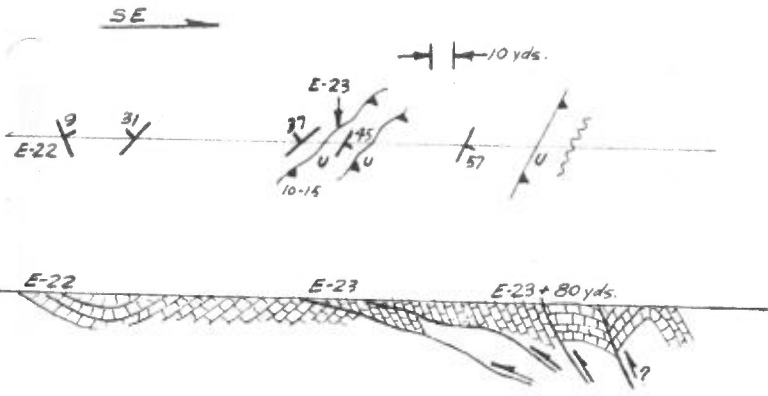
Line of cross section in green with offsets  
Number of cross sections at end of lines

- O - Ordovician
- S - Silurian
- CBA - Cape Bon Ami
- GG - Grande Greve
- YR - York River
- YL - York Lake
- F - Fortin
- BP - Battery Point
- MB - Malbaie
- Road or trail
- C49 - Attitude of beds and location code
- Vertical
- Overturned
- Cleavage
- Dip indication
- D5 - Dip slope measurement
- Horizontal
- A10 - Talus location with locality code
- Attitude without dip amount and code are determined photogeologically
- Attitudes without locality code are copied from McGerrigle (1950) or Brummer (1955)
- G35\* - Localities with asterisk are shown in detail on sketch sheet

- Formation boundary
- Reverse fault, plane dips 75°, u is upthrown side
- Normal fault, plane dips 70°, d is downthrown side
- Dextral wrench fault (strike-slip fault)
- Sinistral wrench fault (strike-slip fault)
- Reverse fault with dip and strike-slip movement
- Change from wrench fault to reverse fault
- Wrench fault, movement not discernible

# SKETCH DIAGRAMS

IA



A STEEP NORTH DIPPING  
THRUST FAULT IS  
INTERPRETED AS BEING  
PRESENT.

**PUBLIC**

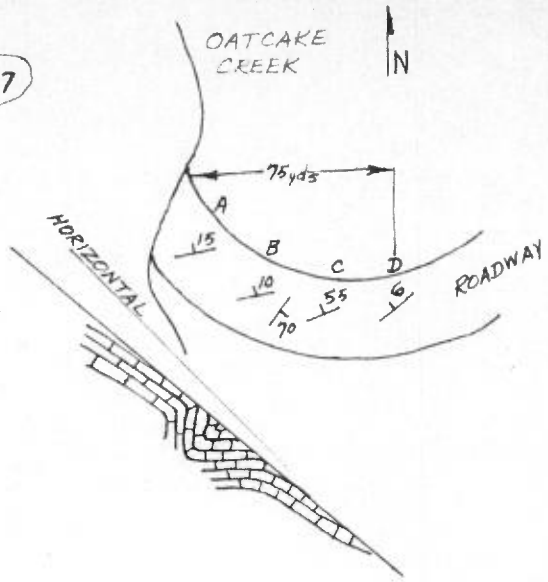
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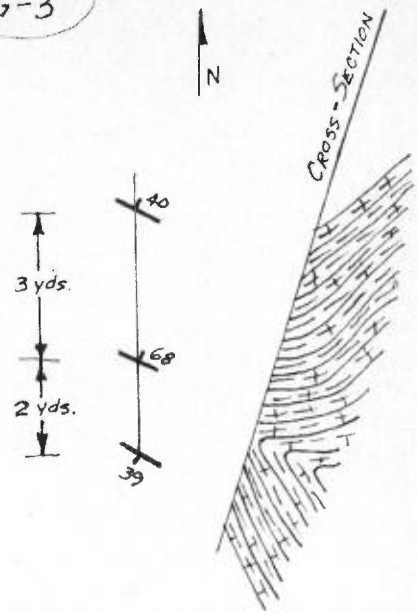
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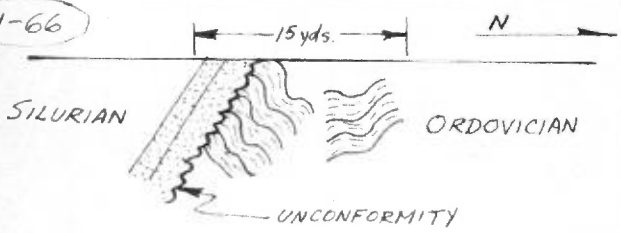
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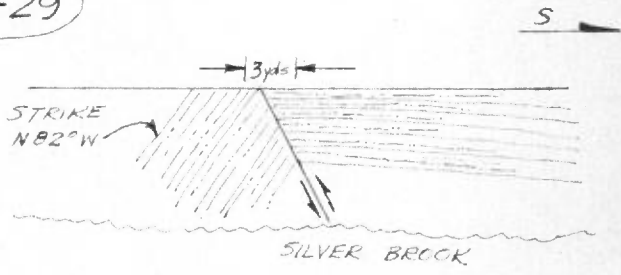
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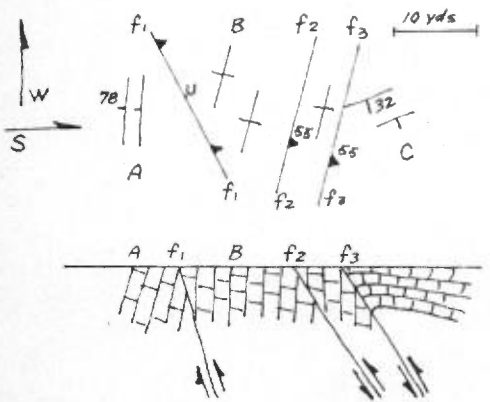
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B-29

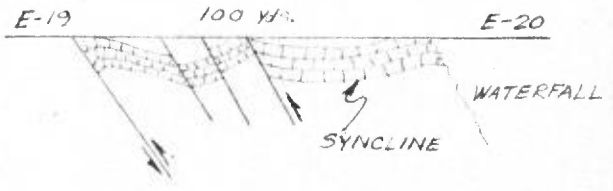


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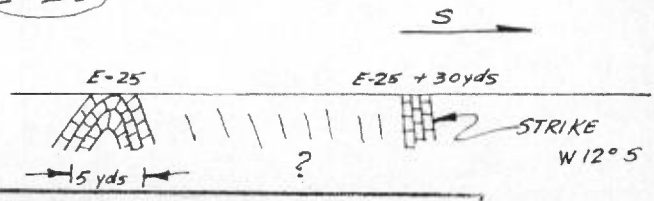


f<sub>1</sub> MINOR ROTATIONAL THRUST  
 f<sub>2</sub> & f<sub>3</sub> MAIN THRUST FAULTS WITH A PROBABLE TOTAL DISPLACEMENT OF 200 TO 500 FEET.

E-19



E-25



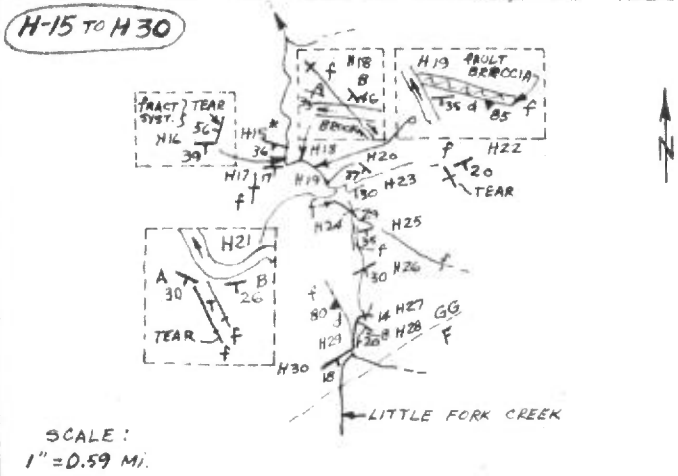
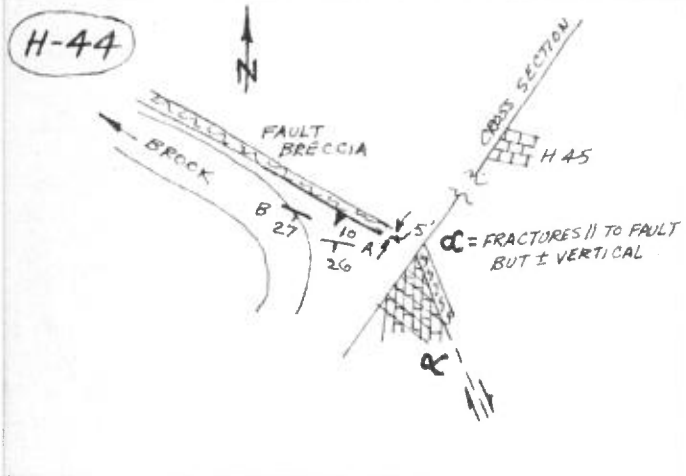
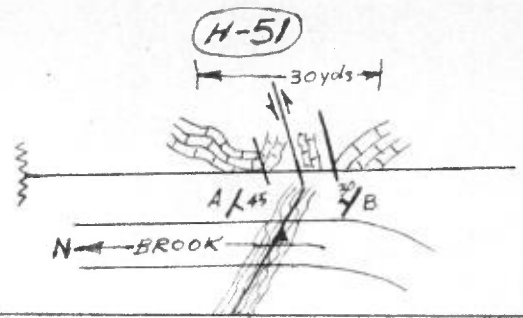
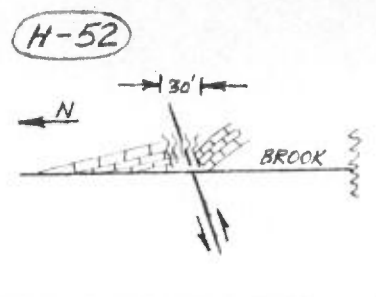
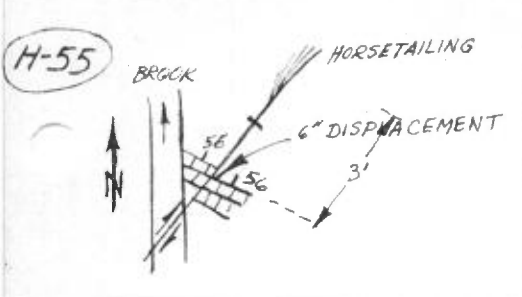
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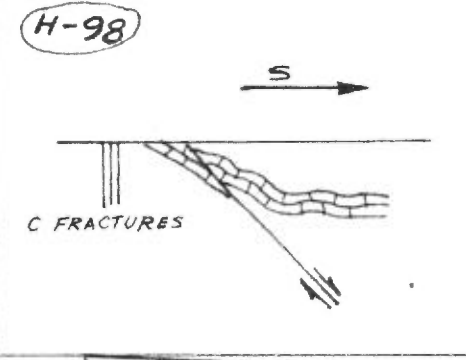
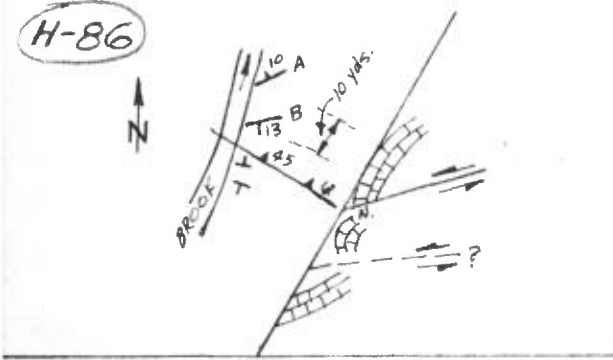
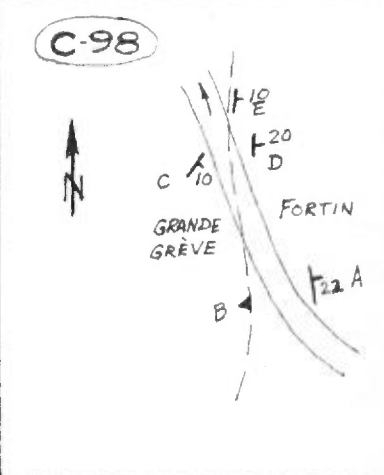
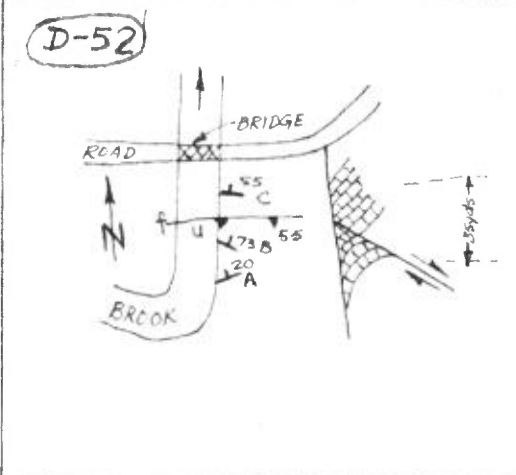
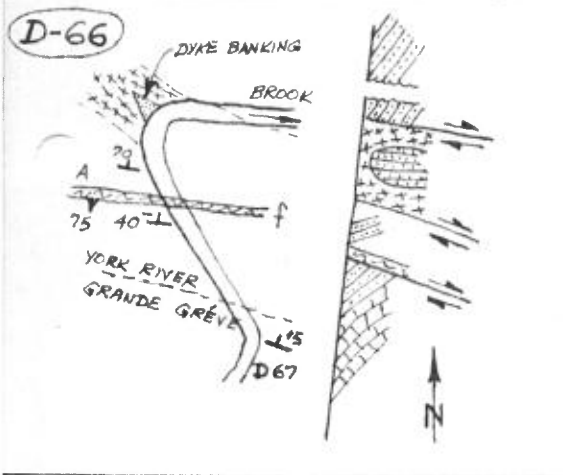
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GM-16470

# SKETCH DIAGRAMS



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1" = 0.59 MI.



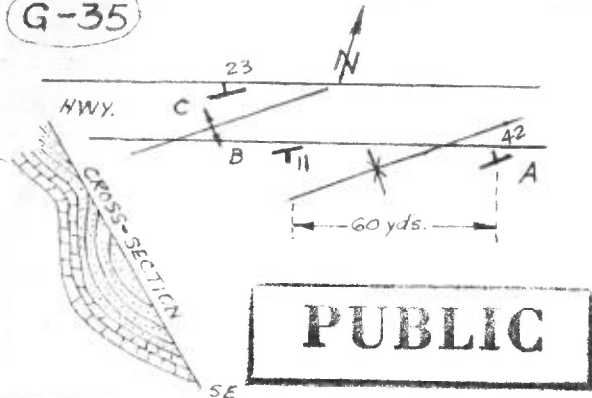
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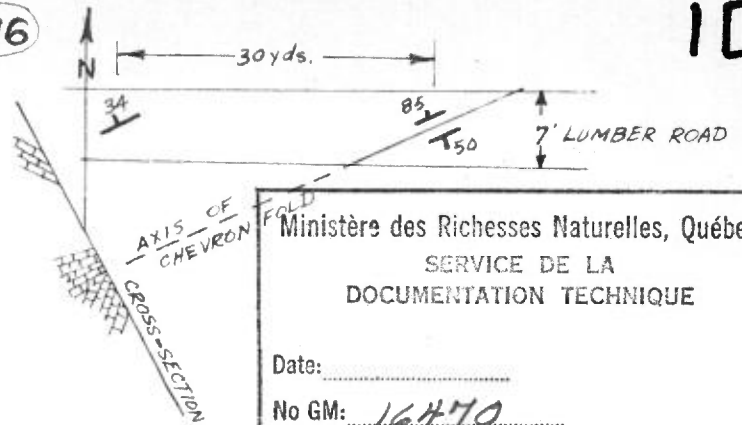
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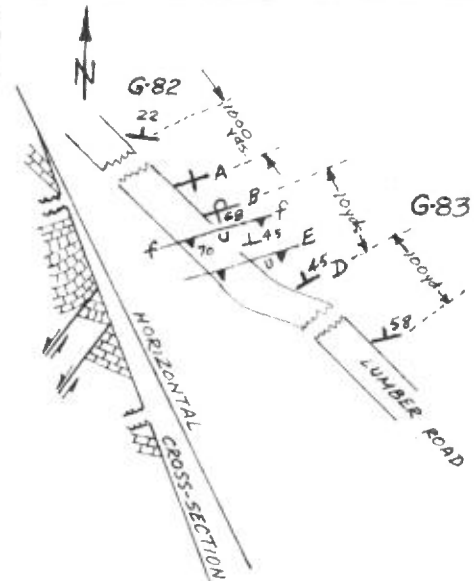
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G-16

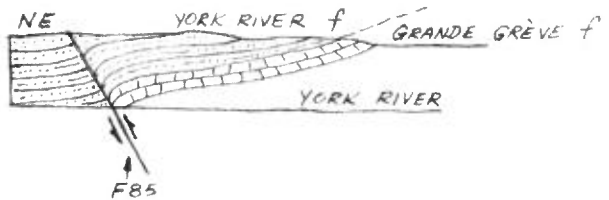


G-82, G-83

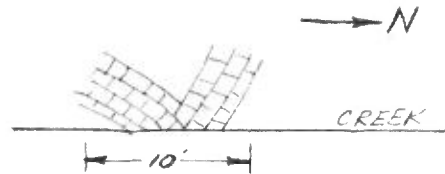


F-85

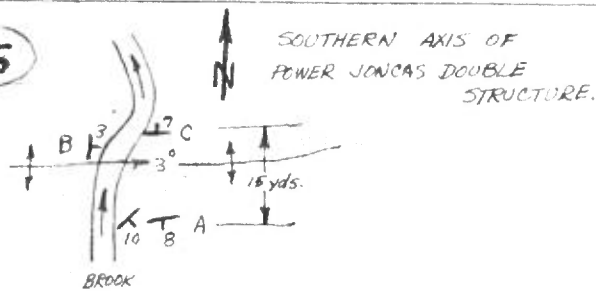
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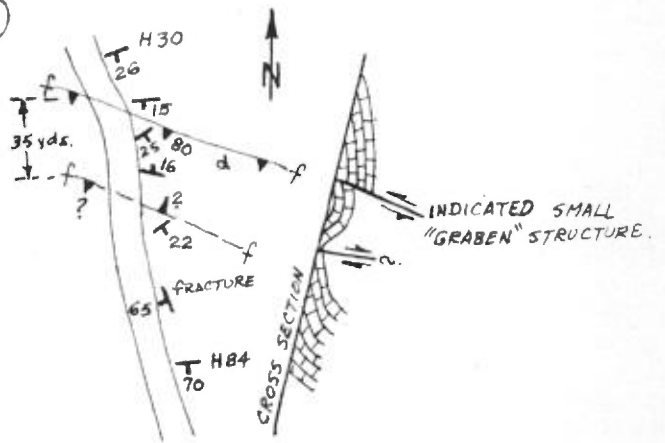
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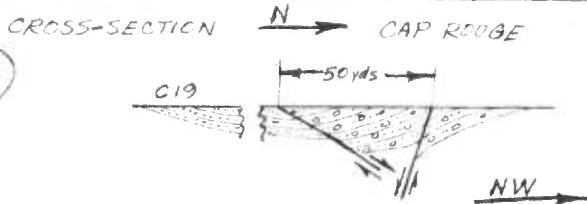
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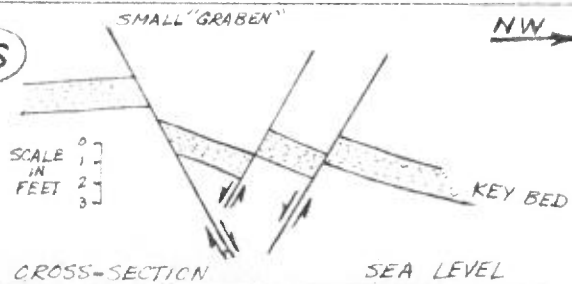
H-31



C-18



C-12 S



H-15

