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GEOLOGICAL RECONNAISSANCE, GASPE PENINSULA AND ADJACENT AREAS

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THE BRITISH AMERICAN OIL COMPANY LIMITED

CALGARY, ALBERTA

# GASPE PENINSULA AND ADJACENT AREAS

## GEOLOGICAL RECONNAISSANCE

PUBLIC

by

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January 1960.

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## ILLUSTRATIONS

(Illustrations cont'd.)

# INTRODUCTION

## OPERATIONS

Geological surface investigations carried out during 1958 in eastern Gaspe by the British American Oil Company Limited were continued in the field season of 1959 from June 3rd to September 26th. Four men constituted the party and the time spent in actual field work is as follows:

| | |
|---|---|
| June | 88 man days |
| July | 88 man days |
| August | 93 man days |
| September | 53 man days |
| Total | 322 man days |

Detailed traverses were carried out in the Fortin belt between west longitudes 65° 00' and 67° 20'. The remainder of Gaspe Peninsula and the adjacent area to the west including Temiscouata Lake and the St.John River valley between Edmunston and St.Leonard were investigated in reconnaissance fashion. The party established its base of operations alternately in New Richmond, Pointe a la Garde, Causapscal and Gaspe town, from where the field districts were reached by a 4-wheel-drive Willys, rented locally. The project area contains approximately 10,000 square miles of which 7,000 square miles were mapped in reconnaissance fashion and 3,000 square miles received close geological attention.

Outcrops were studied on roads, lumber trails and along rivers. Special travelling permits for private roads were obtained from lumber companies in New Richmond, Nouvelle, L'Alverne Depot, Causapscal, Price Brothers Depot on the Matane River and other places.

From the Forest Protection Service of the Department of Lands and Forests in the Parliament Buildings in Quebec City four forest circulation permits were obtained. In the 1959 field season the forest fire hazard was fairly high and for several weeks in July the forests were closed on account of extreme dryness and raging forest fires near Ste. Anne des Monts, Causapscal and Mount Alexander.

## ACKNOWLEDGEMENTS

The writer was very capably assisted in the field and during the initial office interpretation by Mr.M.J.Melnyk, who conducted independent field mapping and traverses. Messrs. B.Blasdale of Burlington, Ontario and F.Charlton of Toronto provided able and cheerful assistance during all phases of the field work. The field work was carried out under the supervision of Mr.D.J.Mott, Head Office Toronto, who visited the party for a few days in July. Mr.R.P.Lockwood visited the project area for one week in July and provided valuable advice during the field trip and at later occasions. Dr.O.A.Erdman and Mr.J.S.Wonfor provided helpful discussions and Dr.A.D.Baillie critically read the manuscript. Officers of the Quebec Department of Mines provided many interesting discussions and grateful acknowlegement is particularly extended to Dr.J.Beland and Dr.W.G.Skidmore of the Department. Drs.I.W.Jones and H.W.McGerrigle gave their advice freely as had been the case in the 1958 field season.

Published previous work, on physiography, glaciology and other aspects of the project area were compiled in the bibliography prepared by the writer in an earlier report (Knipping 1958).

# DEPOSITIONAL HISTORY, STRATIGRAPHIC UNITS AND FACIES

## INTRODUCTORY STATEMENT

The project area, the Gaspe Palaeozoic basin and its southwestern extension, forms a small part near the northeast terminus of the large Appalachian Palaeozoic disturbed belt, the visible end of which is present in Newfoundland. During the Palaeozoic era the sedimentation history of the Gaspe basin was highly variable. Sedimentation was interrupted in the late Ordovician by the Taconic orogeny, sedimentation again commenced in the Silurian and culminated during the Lower Devonian in the formation of separate or at least poorly connected troughs. The Gaspe basin appears to have been separated from the main Appalachian geosyncline by a sill and was actually a separate sedimentation area following the Taconic orogeny, which separated the Ordovician and Silurian deposition.

The basinal sediments of the Gaspe are separated from the Ordovician and Silurian shelf sediments on Mingan and Anticosti Islands by the Logan's Line or Champlain-St.Lawrence fault. This fault is believed to be a south dipping thrust fault with large displacement (Figure 1), which thrust basin sediments over shelf sediments and the Precambrian of the Canadian Shield.

The main trough of the northeast end of the Appalachian sedimentation belt was present south of the Chaleur Bay in New Brunswick, Prince Edward Island and northern Nova Scotia and its depositional history includes the Pennsylvanian and possibly part of the Permian. The marginal character of the Gaspe basin in relation to the main Appalachian belt not only is expressed in its sedimentation pattern but also in its structural features, which will be discussed in the chapter on structural geology.

ORDOVICIAN (INCLUDING PRE-ORDOVICIAN)

The early Palaeozoic sediments deposited before the Taconic orogeny appear to have little value for commercial hydrocarbon accumulations. The bulk of the known sediments is Ordovician, older sediments being exposed only in a few isolated locations in the peninsula. The general sedimentary strike is northeast but the pre-Ordovician may not conform to this direction. Figure 2 depicts the stratigraphy normal to depositional and structural strike. In this figure the original width of the deposition area has been neglected and the reference points at the surface are towns and rivers. It is estimated that as a result of structural foreshortening the present belt is 1/3 to 1/5 of its original width.

The depositional pattern of the questionably Precambrian metamorphosed clastics of the Maquereau group is unknown. The Maquereau apparently was deposited in an ancient trough, the axis of which may or may not have paralleled the Ordovician northeast trend. The Maquereau has undergone at least one major deformation before the Ordovician, which overlies it with angular unconformity, was deposited.

The highly matamorphosed Shickshock group may be Lower Ordovician as recently suggested by Quebec Department of Mines geologists (Dr.J.Beland, Mr.N.Ollerenshaw, personal communication). Other authors assume the Shickshock clastics and volcanics to be Precambrian.

The aerial extent of known Cambrian beds is very small. Lower Cambrian limestones and shales of the Corner of the Beach formation and Upper Cambrian limestone of the Murphy Creek formation are recognized only northeast of Perce in eastern Gaspe. Some Cambrian may be exposed in the

Lower Ordovician belt of northern Gaspe but the known distribution is insufficient to interpret the depositional pattern.

Many more stratigraphic facts are known of the Ordovician system in southeastern Quebec and northern New Brunswick. Lower Ordovician clastics consisting of dark grey to red shales, silty slates, quartzites, conglomerates, limestone conglomerates and basic volcanics are recognized only in the northern belt of Gaspe. If the Shickshock series is included in the Lower Ordovician a strong concentration of basic volcanics in a relatively small area would be present. The known Lower Ordovician sediments are limited to the belt south and adjacent to the St.Lawrence River, however, correlative deposits could be present in the broad metamorphosed belt that stretches through New Brunswick from Bathurst on the Chaleur Bay to the southwest. In Figure 2 the trough axis for the Lower Ordovician deposition cannot be established. It may be situated a short distance south of Matane or it may coincide with the trough axis of the Middle Ordovician in the general vicinity of Campbellton. In the latter case the entire project area and northern New Brunswick would be underlain by Lower Ordovician sediments, completely covered by very thick and diverse younger rocks.

It can be safely stated that the Middle Ordovician clastics are present in the subsurface of most of the project area and northern New Brunswick since this age group has been recognized in all areas of Ordovician outcrops. The trough axis has been assumed in the Campbellton area, however, a subdivision into separate basins and intervening areas of limited deposition is possible. The Tetagouche series of northern New Brunswick could have been deposited in a separate basin as the Mictaw series of southern Gaspe. The Ordovician clastics of the broad belt southeast of the Upper Restigouche River in New Brunswick (Figure 1) are tentatively correlated with the known Middle Ordovician, Mictaw and Tetagouche series and similar beds north of Carleton.

The known Upper Ordovician deposition is limited to southern Gaspe and its southwest extension to the St.Leonard and Grand Falls area in northwestern New Brunswick. In Figure 2 the trough axis for Upper Ordovician deposition lies in the general Restigouche River area. The Upper Ordovician Matapedia group, Pabos and Whitehead formations appear to be thick and contain fine clastic units with a high content of limestone. The deposition area of the Upper Ordovician appears to be a narrow basin in comparison to Middle Ordovician sedimentation. This fact may herald the approach of the main phase of the Taconic orogeny, which folded and faulted the described assemblage at the end of the Ordovician.

The Ordovician certainly provided sedimentary environments for the generation of hydrocarbons,as indicated by the numerous low grade oil-shale or oil-slate occurrences within the Ordovician belt of southern Gaspe. In some cases the tear fractures in the limy shale of the Upper Ordovician Whitehead formation in Joncas and Fortin townships are filled with black, viscous petroleum derivates, probably viscous asphalt. Possible reservoir beds appear to be rare in the Ordovician succession as exposed in the Gaspe. In the northern belt of the Gaspe the Lower Ordovician contains clear, white quartzites of several hundred feet thickness and the Middle Ordovician in the same belt contains numerous dirty and tight sandstone beds. It is possible that Ordovician hydrocarbon accumulations existed but were destroyed as a result of the severe Taconic deformation or eroded in the interval before Silurian transgression and deposition.

Ordovician shelf type deposits are exposed only on Anticosti and Mingan Islands northeast of Gaspe. The Lower and Upper Ordovician include mainly limestone and limy shale, all units being comparatively thin. Uniform dip is to the south. About 3300 to 3500 feet of Ordovician deposits are present on the shelf.

SILURIAN

The entire report area was elevated above sea level at the end of the Ordovician during the main phase of the Taconic orogeny. During most of the Lower Silurian the intricately folded and faulted pre-Silurian sediments were eroded and transported to deposition areas that are not yet known and may be concealed by the Permo-Carboniferous blanket of New Brunswick, Prince Edward Island and adjacent parts of the St. Lawrence Gulf.

It is very difficult to determine the degree of peneplanation of the pre-Silurian terrain, since the Taconic unconformity was found exposed only in two locations in northeastern Gaspe, along Griffon Cove River and along the north shore of Forillon Peninsula. Structural attitudes on both sides of the angular unconformity are strongly divergent, but only a few feet of the unconformity is exposed and relief cannot be determined.

However, from various types of evidence present it is believed that the Middle Silurian sea transgressed over a fairly mature peneplain.

The complete Silurian section can be studied only along the northern outcrop belt from Lake Temiscouata to the Forillon Peninsula, on the flanks of the St. John River Anticline and in the Chaleur Bay region. In the intervening areas the higher Silurian beds are exposed in the core of several structurally complex anticlines, but nothing is known about the basal Middle Silurian

(Upper Llandovery-Upper Valentian) transgressive deposits.

Many excellent potential reservoir beds are exposed in the Silurian outcrops therefore the correct interpretation of the sedimentation pattern is of utmost economic importance. Surface geologic data are too few to determine the exact nature of this pattern, therefore several possible interpretations are given, all of which fit the observed surface data.

The outcrop pattern of the Silurian is mapped in green on map 1000 of the Quebec Depattment of Mines and also in green, with the exception of the area west of Matapedia Lake, in Figure 1, a geological map compiled from surface mapping in 1958 and 1959 and additional surveys by other workers.

All previous workers postulate the formation of one trough in southeastern Quebec and northern New Brunswick, the Gaspe or St. Lawrence geosyncline, trending northeast with the trough axis in the Chaleur Bay region. The Gaspe trough was separated from the Acadian geosyncline in Nova Scotia by the postulated New Brunswick geanticline. No data are known that support the presence of the New Brunswick geanticline.

The configuration of the Gaspe trough in the report area, filled with Silurian sediments, is shown in Figure 6. The trough axis bifurcates in the northeast part, and the area between the two trough axes is occupied by the St. John River high. The maximum thickness of 20,000+ feet in the Campbellton area was estimated by C.F. Burk (1959) and includes the Lower Devonian volcanic assemblage (No.9 - blue unit on map 1000 and the blue-green striped unit on Figure 1) on the Chaleur Bay. Lower Devonian fossils are present in this unit north of St. Omer (W.B. Skidmore, personal communication) and the Silurian-Lower Devonian boundary is present within this unit. It is evident from structural cross-sections

1 and 2 that the Silurian thickness in the Campbellton-Carleton area is in the neighborhood of 5,000 to 8,000 feet, depending on the location of the Silurian-Lower Devonian boundary.

Figures 3, 4, 5, 7 and 8 show the variability of possible Silurian sedimentation patterns. It is here postulated that the Silurian sedimentation in the report area did not take place in one large trough, the St.Lawrence geosyncline, but in two basins more or less interconnected. There is very little surface evidence in support of this conclusion because in critical areas the Silurian cannot be examined. However, Silurian thickness variations and some lithologic aspects can be cited indicating the presence of two troughs. The Silurian, a few miles north of Campbellton and Dalhouseie, contains possible shoreline sediments and is 2,800 to 3,500 feet thick increasing southeastward to 12,000 feet, whereas more than 5,000 feet of Silurian is present at Causapscal. It is known that the Devonian sedimentation occurred in two or possibly three troughs and it may be that the Silurian depositional pattern was similar.

Figures 7 and 8 show the possible shape of the two Silurian troughs, with the intervening high or shoal areas in brown. The maps include structural foreshortening of the Acadian orogeny and the original north - south width was approximately three to five times greater than shown in Figures 7 and 8. The northern zero edge is structural and erosional and thus stripped back (southward) from its original position, which may have been a shore line.

Most of the high areas in the Silurian sea (brown on Figures 7 and 8) may have been covered by thin Silurian sediments, which have been removed by erosion. Strong indication of Silurian shore lines is present west of Campbellton and north of Carleton, where the lower part of the Silurian contains many dirty feldspathic sandstone beds. The Silurian fence diagram, Figure 3, contains most of the formation names originated by previous workers. Rock units are strongly diverse, reflecting the mobility of the sedimentation area and the changing environmental conditions. Detailed time correlations between the rock units have been attempted by palaeontologists but are limited to small areas.

Figure 4 is a diagram of possible Silurian sedimentation between Campbellton and Matapedia Lake. In this diagram, the complete Silurian succession is known only in the area a few miles west and northwest of Campbellton and west of Matapedia Lake in the Sayabec - Val Brillant - La Redemption area. Three possibilities of Silurian sedimentation are shown in Figure 4 and designated A, B, and C. At Matapedia Lake the lowest Silurian formation is the St.Pierre (field term of Quebec Department of Mines geologists, Madeleine River formation of Burk), which consists of from 100 to 200 feet of strongly limy shale with prolific Atrypa sp. The St.Pierre (brown in figures 3 and 4) is present along the entire northern basin margin between La Redemption and Madeleine River southeast of the Tabletop granite. The St.Pierre is conformably overlain by the Val Brillant which is present along the northern basin margin between Lac Temiscouata (Mount Wissick) and Isabelle brook, north of Mount Hogsback, and probably farther east (Figure 9). At Isabelle brook the Val Brillant is strongly quartzitic and limonitic, and some reddish brown beds are also present at Lake Matapedia. The overlying Sayabec formation (blue in Figures 3 and 4) is between 300 and 500 feet thick and contains a large variety of lithologies. The Sayabec consists of bioclastic limestone of all sizes from calcarenite to calcirudite, and small stromatopora bioherms are developed west of Matapedia Lake.

Crinoidal fragmental limestone and coarse-grained oolites are common in the same area. Argillaceous limestones of the Sayabec have been described from the Temiscouata Lake area. The distribution of the Sayabec along the northern basin margin is similar to that of the Val Brillant; however, east of Isabelle brook (North of Mount Hogsback), the Sayabec loses its continuity. Only thin lenses of bioclastic limestone are present near the base of the Silurian north of Murdochville in Lefrancois township and farther east, and are probably not connected laterally. TheSt.Leon formation (green in Figures 3 and 4) overlies the Sayabec and increases in thickness from north to south from a few hundred feet in the Sayabec area to more than 5000 feet in the Causapscal area. TheSt.Leon contains greenish grey limy silstone, silty shale, occasional fine grained sandstone, and rare intraformational conglomerates.

The Val Brillant sandstone and the Sayabec bioclastic limestone are excellent possible reservoir beds and contain hydrocarbons in several outcrops west of Matapedia Lake. Both formations indicate a shallow water environment with a low rate of subsidence. The Val Brillant sandstone is fairly clean and uniform and resembles those of a shelf environment. The same can be said about the Sayabec. Reef growth was present and a large amount of the bioclastic limestone is derived from bioherms within the Sayabec.

Shelf conditions obviously were present during the Silurian Val Brillant and Sayabec interval over a southwest-northeast extension of more than 150 miles along the northern basin margin. At the end of the Sayabec the temporary shelf subsided rapidly, being covered successively by St.Leon clastics. How far south these shelving conditions continued is as yet unknown. Figure 9 shows the lateral extension of Val Brillant and Sayabec formations. The initial

Silurian shelf could have extended very far southward through the entire basin, and only later geosynclinal conditions developed. In Figure 4 some of these possibilities are shown.

The Val Brillant is fairly uniform over its outcrop area but the Sayabec appears to have its best reefal and bioclastic development in the area west of Matapedia Lake and La Redemption. The possibilities for porosity development in the Sayabec are very high. Near La Redemption large caves have been formed in this formation, and one river flows underground for the distance it remains in the Sayabec. Fresh surfaces of the Sayabec have a strong petroliferous odour in the La Redemption area, and similar hydrocarbon content has been reported from the Val Brillant in the general area. It is also possible that farther to the south, e.g. south of La Redemption, the subsidence of the sea bottom was in equilibrium with bioherm growth in the Sayabec for a longer time and a large northeast-southwest trending bioherm could grow. However, the growth was terminated by an influx of shale and siltstone of the St.Leon formation, caused by acceleration of the rate of subsidence. The Silurian at the south end of the diagram in the Campbellton area (Figure 4) is well known. The general thickness of the sediments between the Ordovician and the overlying volcanics complex is 3000 to 5000 feet. The position of the Silurian-Lower Devonian boundary is still subject to discussion and is present within the thick complex of basic and acid volcanics with its agglomerates and tuffs and intercalated sediments. The opinions about this time line vary strongly. Whereas F.J.Alcock (1935) assumes that the entire volcanics and sediments assemblage above the Silurian sediments are Lower Devonian and separated by tectonism, in this case partial uplift and erosion of the underlying Silurian, C.F.Burk (1959) postulates that the volcanic unit (No. 9 - blue on Chaleur Bay in map 1000 and green-blue striped unit in Figure 1) is for the most part Silurian. The sedimentary Silurian consists of greenish-grey limy and silty shale, siltstone and fine grained feldspathic sandstone. One intraformational conglomerate below the volcanics in some areas has been designated a Lower Devonian basal conglomerate by F.J. Alcock (1935). A few thin calcarenite (clastic limestone) bands are present below the volcanics. Six miles northwest of Campbellton, a bioclastic limestone lens, with stromatopora colonies similar to the Sayabec lithology described above, is present about 2000' above the base of the Silurian and is indicated in blue in Figure 4.

Between the Campbellton and Matapedia Lake areas, only greenish grey silty shale, siltstone, and rare red limy shale of the upper part of the Silurian are exposed.

Figure 4A shows one of four possible interpretations of the Silurian sedimentation pattern. One high with a trough axis near Causapscal separates a northern basin from the Chaleur Bay basin. Carbonate development of the Sayabec type is possible on the north flank of this high, but surface evidence is lacking completely in this respect. Figure 4B shows the concept of one undifferentiated basin as postulated by previous workers (see also Figure 6) and Figure 4C contains two basins separated by a submarine sill which received some thin Silurian sediments. There are all types of gradations possible between the three possibilities shown, but most of these concepts are attractive from the economic point of view. The presence of bioclastic limestone with reef formation of Sayabec lithology type on the flanks of possible sills, or highs, in the Silurian sea, in view of the presence of petroliferous bioclastic and reefal limestone in the northern outcrop area, can only be assumed and suggested. Surface geological methods cannot localize these possible reservoir beds.

A west-east sedimentary section of the Chaleur Bay basin or trough is contained in Figure 3, the Silurian sedimentation fence diagram. This section, from Campbellton via Black Cape to Port Daniel, approximately parallels the trough axis, which, though not located, is believed to be present south of the indicated section.

The thickest Silurian basin sediments are present in the Black Cape-Port Daniel area. Crustal downwarp caused Middle Silurian transgression and deposition of the conglomerate, sandstone and shale of the Clemville formation. The muddy nodular limestone and upper reefoid beds of the La Vielle formation, which overlies the Clemville, indicate a slow subsidence maintaining shallow water conditions combined with a minor influx of clastic material from the source areas. The rates of subsidence and influx of sedimentary material were at equilibrium, maintaining shallow water conditions of the Gascons and Bouleaux formations, with green and reddish limy silstone, shale, fine grained sandstone with worm burrows, mud cracks and raindrop imprints, indicating very slight emergence at times. The Bouleaux contains rare thin beds of bioclastic limestone, but a boundary between the Gascons and Bouleaux is very difficult to establish, the Bouleaux being a transition zone between the clastic Gascons and the bioclastic and reefal West Point. The lithology of the West Point formation is very similar to the above described Sayabec beds. Coarse bioclastic limestone, algae and stromatopora bioherms make up the lithology, and clastic material from source areas outside the basin was introduced sparingly in the form of thin shale beds.

The Indian Point is the topmost Silurian formation of the Chaleur Bay Basin and contains muddy, fine grained, greenish grey sandstone and local lenses of brownish grey limestone. The Indian Point is present only in the Port Daniel area and appears to represent a deposit of a constricted basin.

At the end of the Bouleaux, basic volcanics were emplaced northeast, north, west of and in the Black Cape area. At Black Cape, West Point lithology is present for three feet below the lowest basalt flow and between the first and second basalt blanket. The La Vielle formation wedges out completely westward and is not present in the Carleton area. All other formations, Clemville, Gascons and Bouleaux, converge imperceptibly westward and decrease in thickness, probably as the western limit of the Chaleur Bay basin is approached.

Other workers, particularly F.J. Alcock (1935), assume that the entire Middle Silurian Chaleur Bay series, as present in the Black Cape-Port Daniel area, was deposited in the Campbellton area but later eroded in accordance with tectonic movements at the end of the Silurian, leaving only the Clemville formation in the Campbellton area uneroded.

A Silurian sedimentary diagram from Black Cape north-northeastward to Isabelle brook, north of Mount Hogsback, in the northern Silurian outcrop belt, is indicated on Figure 3. Possible sedimentation patterns of the Silurian are similar to those shown in Figure 4 and described above. The top of the Silurian is exposed along Skimenac River (Riviere Angers) and around the confluence of Josue and Cascapedia Rivers in Clapperton township. Silurian basic volcanics are present at the top of the Silurian in all locations and have been named Baldwin volcanics, C.F. Burk (1959), in Clapperton and Baldwin townships. However, the volcanics are only a few hundred feet thick and may indicate the presence of a northern and northwestern edge of a large volcanic blanket or of separate extrusions. Below the volcanics are greenish grey and rare reddish limy siltstone and silty shale of Bouleaux-Gascons or St. Leon lithology. A thin sandstone band is exposed also along Cascapedia River, but no information about the lower two-thirds or half of the Silurian section can be obtained.

Along Grand North River, north of its confluence with the Skimenac River (Riviere Angers) in Angers township, a thin bed of bioclastic limestone is associated with basic volcanics. From the amount of talus present, one could assume that perhaps 50 feet of bioclastic limestone, in this case calcarenite with few stromatopora, is present but concealed by talus and dense vegetation. The bioclastic limestone may be directly related to the north flank of a high, or sill, in the Silurian sea separating the Chaleur Bay basin from a northern trough, as shown in Figure 4A, and C, and 7 and 8. However, no hydrocarbon content was noted in the calcarenite of Angers township. Farther west, the calcarenite of the silurian is not exposed but may be present below a thrust fault, which thrusts Ordovician over Silurian and Lower Devonian beds.

A sedimentation diagram from Black Cape to the northeast through eastern Gaspe shows a markedly different arrangement of Silurian units, as heretofore described. The points of Figure 3, the Silurian fence diagram, are represented by Black Cape, Mount Alexander, Owl Capes on St. John River and Griffon Cove River, seven miles northeast of Gaspe town. Figure 5 shows three interpretations of the same section. In Figure 5A, two Silurian basins are assumed separated by the St. John River sill. This interpretation would necessitate the complete erosion of Silurian beds between the Mount Alexander Silurian belt and the Chaleur Bay series over the area around Pabos, Bonaventure and Reboul Rivers. Further, the subsidence, which had ceased in the Chaleur Bay region with the deposition of the Indian Point and the extrusions of the volcanics at Black Cape, continued in the Mount Alexander area, forming a separate and constricted basin.

The structural foreshortening between the Mount Alexander area and the St. John River Silurian is greater, to an unknown amount, than the estimated regional foreshortening of 30 to 50 per cent. Large strike-slip and thrust faults are believed to have been combined in moving the Mount Alexander Silurian belt northward for a large, but undetermined amount.

The St. John River anticline contains relatively thin Silurian of diverse lithologies, mostly coarse clastics. The south flank of the anticline contains 200 feet of basic volcanic flows with agglomerates and interflow sediments. Farther on the south flank 500 feet of greenish grey and dark grey Monograptus bearing shale, of the Burnt Jam brook formation, is present. The 1000 foot Owl Capes conglomerate, composed of pebbles and boulders of bioclastic and reefal limestone and volcanic detritus, is present only on the east end of the anticline. To the west, the Sirois formation, named by W.B. Skidmore in an unpublished Ph.D thesis of Princeton (1959), takes the place of the Owl Capes formation. The Sirois contains many very coarse pebbly sandstone beds described as grits by H.W. McGerrigle (1950). Since very few grains and pebbles of the underlying Ordovician Whitehead formation are present in the Silurian clastics of the St. John River anticline, not much Ordovician could have been eroded from that anticline during Silurian deposition. The presence of much bioclastic and coralline limestone detritus in the Silurian clastics, however, indicates that bioclastic limestone was formed and reefs grew on and at the flanks of a sill. Later, the sill partly emerged and erosion took place, providing the material for the Sirois and Owl Capes formations. Other reefs grew along the east and probably the west plunge of this sill. The Ascah brook reef on the east plunge of the St. John River anticline, consisting of oil-stained stromatopora reef, is an example. The volcanics of the southern basin (Mount Alexander area) extended to the depositional sill and later emerged and were eroded, providing the igneous boulders, pebbles and grains of the Silurian clastics.

It is difficult to visualize the behaviour and form of the St. John River sill during Silurian sedimentation. Slow subsidence of this narrow platform caused reef growth and formation of bioclastic limestone.

North of the St. John River high was the northeast extension of the postulated northern Silurian basin (Figures 7 and 8). On the north flank of this basin, the St. Alban formation, with general Sayabec lithology, is developed and consists of nodular bedded silty and argillaceous limestone, bioclastic lenses and reefoid developments in the form of stromatopora growth. The sandstone, conglomerate , shale and limestone of the Griffon Cove River formation are a very local development only. L.M. Cumming (1959) correlates the Griffon Cove River beds with the Owl Capes Figure (5B) and assumes a general south slope of the trough without the St. John River barrier or sill. The northern basin obviously is non-existent, and the limited Silurian thickness over the St. John River arch, or sill, does not appear in his cross-section (Figure 5B). The presence of thick greenish grey limy siltstone and shale north of Owl Capes, however, can be safely postulated since they are present in the Bald Mountain area and in Imperial Mississippi No. 1 well, 13 miles northwest of Owl Capes. A third solution for the Silurian sedimentation pattern has been attempted in Figure 5C. The Mount Alexander basin is separated from the Chaleur Bay basin by a partial high existing up to the time of volcanic eruption. There are many variations possible, but available information is insufficient to discuss in detail the sedimentation pattern of the Silurian south of Mount Alexander.

The Silurian described in this chapter belongs entirely to the

Middle Silurian epoch. At Temiscouata Lake, at the western limit of the report area, a coarse clastic unit underlies the Middle Silurian and is named the Cabano group. According to Dr. Jacques Beland of the Quebec Department of Mines, (personal communication) the Cabano is the oldest formation in the area, and similar strata are present also in Newfoundland. The entire Gaspe basin obviously widens southwestward and merges with the main Appalachian basin. There is also slight indication that the lower Devonian Fortin group may contain Silurian strata in northern New Brunswick and Maine.

The southwest half of Anticosti Island, northeast of Gaspe, contains relatively thin Lower and Middle Silurian sediments. These beds belong to the unfolded rocks of the St. Lawrence Lowlands. They are interpreted as shelf sediments to the north and northwest of the Appalachian mobile belt.

Tectonic activity occurred at the end of the Silurian in the Newfoundland sector of the Appalachian mobile belt. These movements are considered to represent phases of the Caledonian orogeny.

Evidence of Caledonian movements in southeast Quebec would be very difficult to detect. F.J. Alcock (1935) has postulated uplift and successive erosion at the end of the Silurian; however, the evidence for this postulate is questionable and still under discussion (C.F.Burk,1959). Most evidence, particularly the contact of St. Leon-Causapscal formations or St. Leon-Cape Bon Ami formations, point to a conformable succession, though through a small gradation interval, from the Silurian to the Lower Devonian.

## LOWER AND MIDDLE DEVONIAN

The exposed rocks in the project area are largely Lower Devonian slate, limestone and sandstone. Many different rock types are involved in the Lower Devonian sedimentation reflecting continued mobility of the crust with changing conditions of environment, influx of detritus from the source areas and differentation of the basin. The Devonian formations have been treated in some detail in the 1959 report on east central Gaspe. Abundant oil shows occur in numerous wells drilled into the Lower Devonian in eastern Gaspe. However, production never reached economic proportions because of poor porosity and permeability.

Palaeontological evidence for the age of the Devonian formations is conflicting however. The significant contributions to this problem by Boucot and Cumming (Beginning of Acadian Orogeny in the Northern Appalachians, G.S.A. An. Meeting 1958, Abstracts p.33), have supported a Lower Devonian age for most of the Devonian formations and only the highest beds of the Gaspe sandstones may be Middle Devonian in age. However, in the western Chaleur Bay region Upper Devonian formations are well established in a limited area and these formations will be treated under a separate heading.

The Devonian formations appear to have been deposited in two basins in the report area, a northern or central Gaspesian basin and a southern or Chaleur Bay basin. Both basins were deformed and foreshortened and their present boundaries on map 1000 and Figure 1 are structural. The central Gaspesian basin with a width of 25 to 35 miles occupies the centre of the entire Gaspe Peninsula and widens in a southwest direction into Quebec and northwest New Brunswick and Maine. At Edmundston near the western limit of the report area the basin has a width of 55 miles. The southeast and south boundary is presently the southern limit of the Fortin group and its north boundary is formed by the outcrop edge of the Cape Bon Ami east of, and the Causapscal formation west of, Matapedia Lake.

The Devonian sediments in the central Gaspesian basin were subjected to a marked facies change in a general north-south direction and a minor one in an east-west direction. The cause of the facies change from north to south is open to various interpretations, which are discussed below. In the northern half of the central Gaspesian basin sedimentation continued conformably and gradational from the Silurian to the Lower Devonian. The medium to dark grey silty and argillaceous dense limestone beds of the Cape Bon Ami formation contain Silurian graptolites near its base but a Lower Devonian fauna in higher beds (L.M.Cumming,1959). As has been pointed out in the 1959 report on east central Gaspe the Cape Bon Ami increases in thickness rapidly from the northern outcrop edge southward. In the area south, adjacent to the Shickshock Mountains, the silty and argillaceous limestone and limy shale of the Cape Bon Ami is almost black and has a strong petroleum odour on fresh cuts. In this area and farther west the Cape Bon Ami cannot be separated from the overlying Grande Greve formation and these two formations together are designated as the Causapscal formation.

The Lower Devonian Grande Greve formation overlies the Cape Bon Ami conformably and gradationally. The Grande Greve comprises thin bedded medium grey siliceous limestone and calcareous siltstone and detailed descriptions are given in the 1959 report on east central Gaspe. The thickness pattern is similar to that of the Cape Bon Ami, a strong increase from the northern outcrop edge southward. Westward toward the Matapedia Valley the Grande Greve formation loses its lithologic characteristics and merges imperceptibly with the Cape Bon Ami to form the Causapscal formation. The top of the Grande Greve in eastern Gaspe is marked by a sharp break where the feldspathic sandstone of the Lower Devonian York River formation overlies it. However in central Gaspe in the York Lake area and farther west the Grande Greve-York River contact is gradational. The siliceous limestone beds of the Grande Greve and the feldspathic sandstone beds of the York River intercalate forming a transition zone, named the York Lake facies by McGerrigle (1950).

The Lower Devonian York River formation is the basal formation of the Gaspe sandstone group. York River greenish grey argillaceous feldspathic sandstone, sandy shale and siltstone of strongly varying thickness form a wedge edge in the north and increase in thickness to 7,000 to 8,000 feet in the south in eastern Gaspe and in west central Gaspe. The York River contains a marine Lower Devonian brachiopod fauna. In western Gaspe and farther west to the Rimouski River, the Heppel formation of almost identical lithology is correlated with the York River formation. The York River formation southwest of the Tabletop granite contains thick flows of basic volcanics (Map 1000). The area of extrusion during the York River interval probably does not exceed 400 square miles.

The York River and its equivalent, the Heppel formation, in the Matapedia valley and west of it are the youngest beds present in most of the central Gaspesian trough. However at the east coast of Gaspe and inwest central Gaspe younger formations of the Gaspe sandstone group are present. At the east coast of Gaspe, feldspathic sandstone, conglomerate and a few shale beds of the Battery Point formation overly the York River and are in turn overlain by the Malbaie formation in a very limited area at the north and northwest coast of the Bay of Malbaie. The Battery Point contains a pink feldspar and much coarser clastics than the York River. The feldspar heretofore described as orthoclase is a pink plagioclase (Carbonneau, C., 1953). Iron-oxide content is high in the Battery Point and Malbaie and the latter formation contains conglomerates composed of the Ordovician Whitehead formation indicating that the Acadian earth movements commenced after the deposition of the York River. This evidence is also in accordance with palaeontological evidence supplied by A.J. Boucot (1958). The Battery Point and Malbaie formations appear to be delta deposits and are probably early Middle Devonian. Battery Point and Malbaie formations may be facies equivalents as pointed out in the 1959 report on east central Gaspe.

Post-York River deposits are also present in west central Gaspe, where delta deposits of the Lake Branch formation (Map 1000) of limited areal extent occur. The Lake Branch, up to 5,000 or 6,000 feet thick, contains brick-red coloured argillaceous feldspathic sandstone and sandy shale beds with rare grass green parts. This formation has been treated in some detail by C. Carbonneau (1953), who interprets the Lake Branch as a delta deposit, the source of which was from the Precambrian terrain north of the St. Lawrence uplifted to a high relief at the beginning of the Acadian orogeny. Carbonneau (1953) made a detail lithologic study of the Lake Branch and concludes that the gross lithology fits exactly a detritus expected from the Precambrian terrain north of the St. Lawrence. The Lake Branch is overlain by and interfingers with the Battery Point formation in the area of Square Forks brook, or west tributary of the Cascapedia River. The Battery Point is similar to the Battery Point in the type area of eastern Gaspe with which it could originally have been connected. York River beds and Grande Greve beds have been mapped by Dr. W.B. Skidmore of the Quebec Department of Mines, eight miles southwest of Mount Alexander. This area can be worked only from a camp and was not investigated during 1958 and 1959.

Approximately the southern one-third of the northern or central Devonian Gaspesian basin, east of the Matapedia Valley, is underlain by Fortin group. (Figure 1 and Map 1000). Few fossils have been found in the monotonous succession of the Fortin, but the diagnostic forms establish the Fortin as Lower Devonian. The Fortin thus is the southern equivalent of the above described Cape Bon Ami, Grande Greve and all or parts of the York River formation. Despite detailed traverses through the entire Fortin outcrop belt it was not possible to determine the thickness of this group. The structural cross-sections A and B (scale 1" : 1 mile) contain much detail at the surface but the extremely complicated surface structure of the Fortin combined with sedimentary slump structures in many parts do not permit projection of the structure to depth. There is, however, some faint indication, that the maximum thickness of the Fortin does not exceed 5,000 feet east of Matapedia Valley, but farther west the Fortin thickness increases rapidly.

The bulk of the Fortin sediments consists of medium to brownish grey slate with silt laminae. The transverse cleavage present in the Fortin of the entire report area intersects the bedding, which is only observed when silt laminae are present. Originally it was a limy shale deposit with prolific silt bands and laminae that give much of the Fortin the appearance of a rhythmically deposited sediment. In some parts thin bands are strongly limy and the Fortin resembles the Cape Bon Ami formation. In other parts silty limestone in thin strata, similar to the Grande Greve lithology prevails. In the northern part of the Fortin belt typical greenish grey feldspathic sandstone beds of the York River formation to the north apparently interfinger with Fortin beds. These basal and intraformational conglomerate beds occur in the Fortin east of longitude 65° 30' W. but farther west very few intraformational conglomerates are intercalated. The fauna is marine and consists of brachiopods (McGerrigle 1950). Along Little Cascapedia River near the centre of the Fortin belt an assemblage of Spirifer (Acrospirifer) of Murchisoni, a well known Lower Devonian (Oriskany) form of the entire northern Appalachians, was collected in the 1959 field season.

A characteristic sedimentary feature of the Fortin observable from the border at Maine to eastern Gaspe is the submarine slumping of shale with laminated siltstone which in many cases makes it impossible to determine even the general attitude of the bedding. Similar slump structures are also present in the Cape Bon Ami formation in northeast Gaspe. The impulse for these slumps could have been generated by earthquakes accompanying the Lower Devonian extrusions of basic lavas in the western Chaleur Bay region. Volcanic strata are rare within the Fortin and have been mapped at Ste. Marguerite southeast of Causapscal and in northern Angers township north of Carleton.

Two interpretations of the Devonian sedimentary pattern have been offered to explain the deposition of the Fortin in the east central Gaspe.

The east central Gaspesian basin is subdivided into two troughs with an intervening barrier which separated the Fortin deposition from the Cape Bon Ami, Grande Greve and York River deposition, but allowed interfingering of the sediments. In eastern Gaspe this barrier is exposed partly and is presently known as the St. John River anticline. Another interpretation is noted in which the central Gaspesian basin is a simple feature without intervening barriers and uncomplicated facies changes occurring in a north-south direction through the basin. This last intepretation is shown by L.M. Cumming (1959). The barrier interpretation however, appears more probable to the writer and McGerrigle (1950) also favours the concept of a separate basin for the Fortin sediments. A.J. Boucot (personal communication through Dr. A.D.Baillie, 1959) postulates, that the Fortin sediments came from the south, which conforms with the general regional aspect of the Fortin unit on Map Figure 1. The Ordovician to the south of the Fortin belt is very similar to the Fortin and probably provided the sediments for this monotonous Lower Devonian unit. If this is true, one could designate the Fortin sediments as second cycle sediments derived from the Middle and Upper Ordovician.

At the south boundary of the Fortin belt the Fortin sediments may onlap the Silurian beds in which case a disconformity would be present. This disconformity is not visible because it is faulted out. Farther west of the Matapedia Valley Silurian sediments probably merge with the Fortin group and in the Edmundston-St. Leonard area at the Maine border the Fortin group may contain the entire Silurian and Lower Devonian equivalents.

The Chaleur Bay basin of the Lower Devonian contains an entirely different succession as described for the central Gaspesian basin, which suggests that the two basins were separate or only very slightly connected. Sediments of the Chaleur Bay basin contain a thick succession of Lower Devonian basic volcanics with few intermediary and acid flows. Greenish grey silty shale and argillaceous sandstone beds are present between the flows. In some areas the volcanic material and in others the Lower Devonian. Since the Lower Devonian-Silurian boundary is poorly defined the unit has been mapped as undivided Silurian and Lower Devonian on Figure 1 (blue and green stripes). C.F. Burk (1959) assigns almost the entire volcanic sediment unit to the Silurian and arrives thus at great Silurian thicknesses in the western Chaleur Bay region, however palaeontological evidence indicates a Lower Devonian age (personal communication W.B. Skidmore, Quebec Dept. of Mines). Gaspe sandstones of the York River type overlie the volcanics and sediments described in the western Chaleur Bay region and may be classified as Lower and Middle Devonian, since certain Upper Devonian follows conformably upward. The Gaspe sandstones apparently were deposited in a constricted basin, since this unit has only very limited distribution. At Grand Cascapedia in New Richmond township the Gaspe sandstones lie uncomformably on Ordovician. A continuity of the Gaspe sandstones between Grand Cascapedia and Pointe a la Garde area is expected below the Bay of Chaleur. The maximum thickness of the Gaspe sandstones in the Chaleur Bay trough is in the neighbourhood of 5,000 feet. Detailed descriptions of the sandstone, conglomerate and shale beds of the Gaspe sandstones in the Chaleur Bay basin with faunal content has been made by F.J. Alcock (1935).

## UPPER DEVONIAN

South of Nouvelle a small area is underlain by Upper Devonian rocks. The Acadian orogeny had commenced during the deposition of the Gaspe sandstone group and the depositional basin was gradually constricted. The central Gaspesian trough farther north was already elevated above sea level and did not receive any more sediments. The constricted Chaleur Bay basin received approximately 2,500 feet of Upper Devonian clastics. F.J. Alcock (1935) divided the Upper Devonian in ascending order into the Pirate Cove, Fleurant and Escuminac formations. Soft reddish shale and conglomerate with pebbles of the Upper Ordovician and Silurian make up the Pirate Cove formation indicating that the Acadian orogeny was in process. These deposits can be designated as synorogenic sediments. The overlying Fleurant formation is a conglomerate composed of pebbles of Ordovician and Silurian formations and Lower Devonian volcanics. The highest Upper Devonian Escuminac formation comprises sandstone, shaly sandstone and sandy shale with ripple marks and an Upper Devonian fish fauna. The Acadian orogeny, which had commenced near the boundary of Lower and Middle Devonian, progressed further and folded and faulted all beds in the entire report area.

## CARBONIFEROUS

During the Mississippian epoch the Acadian folded belt was eroded and the detritus moved to the large basin that had developed in eastern New Brunswick and Prince Edward Island and adjacent parts of the St. Lawrence

Gulf. Pennsylvanian sediments of the Clifton and Bathurst formation were deposited in northeastern New Brunswick and the red conglomerate of the Pennsylvanian Bonaventure formation lapped on to the south coast of Gaspe. The Bonaventure conglomerate is horizontally bedded and overlies with angular unconformity the assemblage which was folded during the Acadian orogeny. The Appalachian orogeny, the terminal orogeny of the main Appalachian basin farther south, affected the project area only in a minor way. Normal faults and tilting of Bonaventure strata and basic dyke intrusions are attributed to the Appalachian movements.

## STRUCTURAL GEOLOGY

### INTRODUCTORY STATEMENT

Structural surface data have been collected mostly in river and lumber road traverses. Sheets 1, 2, 3 and 4 of the 1:50,000 base map contain most of the structural detail as measured in field locations. Many difficulties were encountered in obtaining the structural detail of particularly the noncompetent units, e.g. the Fortin group. Sedimentary slump structures and a very contorted appearance of the bedding obscured in many cases the general bed attitude in the Fortin unit. Photogeological methods have not proved of great value in elucidating the complex structure. The structural attitude of cleavaged beds, e.g. the Fortin slate or slated equivalents of Silurian and Cape Bon Ami formations, cannot be seen on aerial photos. However, aerial photos have been used in outlining and mapping some of the major faults.

The structural detail of the 1:50,000 base map has been plotted in four cross-sections with a scale of 5" to 1 mile. These large cross-sections, Matapedia Valley, Escuminac-Upper Nouvelle Rivers, Mann River-Hale brook north of Nouvelle, and Cascapedia River contain only the observed structural detail at the surface. In some of these large cross-sections, an attempt has been made to connect the observed localities in order to show structural continuity, but many interpretations are possible which would fit the surface evidence.

In order to show structure at depth, seven structural cross-sections with a scale of 1" to 1 mile and 1" to 5 miles have been constructed. The projection of structure at depth is not only dependent on structural surface detail but also on the solution of the sedimentation pattern of the involved systems. The latter is open to various interpretations according to the preceding chapter on depositional history, stratigraphy and facies.

## STRUCTURAL HISTORY

In the northwestern part of the northern Appalachians, the Ordovician and older beds were severely deformed near the end of the Ordovician during the Taconic orogeny. Large low angle, southeast and south dipping imbricate thrusts developed, on which the early Palaeozoic synclinal sediments were thrust over the foreland to the northwest and north onto thin shelf deposits and the Precambrian rocks of the Canadian Shield.

The precise dating of the main deformation phase of the Taconic orogeny has been accomplished in the Appalachian basin in central Pennsylvania. Here the unconformity occurs between the lower part of the Upper Ordovician and the upper part of the Upper Ordovician.

The hiatus in southeast Quebec is much larger and comprises the interval between Upper Ordovician and Middle Silurian at the narrowest point. Since the Taconic unconformity is angular, all pre-Upper Ordovician rocks can be found in unconformable contact with the Silurian at one place or another. Despite the surveys of many workers for several decades, the angular unconformity has been observed in outcrop only along Forillon Peninsula and Griffon Cove River in northeastern Gaspe Peninsula.

Since the main phase of the Taconic deformation occurred within the Upper Ordovician, one could assume a similar position of the unconformity in Gaspe. This has been suggested by geologists of the Quebec Department of Mines (personal communication W.B. Skidmore), who favour separating the Upper Ordovician Matapedia limestone from the Middle Ordovician clastic series (Mictaw and Tetagouche) by an unconformity. These relations, however, are not yet clear and require more detailed field work. The economic implications would be important if the main phase of the Taconic orogeny could be established at the base of the Upper Ordovician. The Matapedia limestone could contain bioclastic limestone above the unconformity and thus would provide possible reservoir beds.

In the opinion of all previous workers in southeast Quebec, the main phase of the Taconic earth movements occurred at the end of the

Ordovician and the first post-orogenic sediments belong to the Silurian system.

Low angle thrust faults and imbricate thrust sheets observed along the northern margin of the project area and the large inferred Logan's thrust shown in the St. Lawrence River are attributed to the Taconic orogeny. However, many of these faults may have been rejuvenated or even formed during the later Acadian orogeny. The complicated mountain system of the Taconic orogeny was truncated by erosion and then submerged, receiving a new cycle of eugeosynclinal sediments. There is only faint evidence of Caledonian earth movements in southeast Quebec at the end of the Silurian. Some very slight disconformities may exist between Silurian and Lower Devonian but these cannot be mapped on account of the very poor outcrop conditions in Newfoundland. The Caledonian earth movements in Newfoundland were of orogenetic character with accompanying granite intrusions, however, Taconic movements were practically absent.

Near the end of the Lower Devonian (end of York River sandstone deposition) the marine environment in the central Gaspesian basin changed to a non-marine environment indicating the advent of the Acadian orogeny.

Whereas the Taconic orogeny had only deformed the pre-Silurian sediments in the northwest part of the Appalachians the Acadian orogeny was much more extensive and probably deformed large parts of the northern Appalachians. The Acadian deformation was mainly accomplished during the Middle and Late Devonian and the features of this deformation were produced during several structural stages. The terminal Acadian deformation occurred near the end of the Upper Devonian.

The Appalachian earth movements near the end of the Palaeozoic (end of Permian) caused only normal faulting, tilting of late Palaeozoic sediments and intrusions of basic dykes.

## STRUCTURAL FEATURES

The majority of the visible structural features in the report area are the result of Acadian deformation caused by compressive stress acting in a northwest-southeast and north-south directions. The Ordovician and older strata, already strongly deformed during the Taconic orogeny, were again subjected to the Acadian orogeny. Strong transverse cleavage within almost the entire Ordovician and older rock units was noted. In a few locations two distinct sets of cleavage were observed. It is possible that these two sets of cleavage indicate the two separate orogenies however resolving of the problem would require considerable detailed study.

The Acadian orogen, as delineated by the outcrop pattern in general, parallels the inferred Logan's thrust and also the arcuate trend of the northern Gaspe coast. In the report area, limited by the map boundaries of Figure 1, (geological map 1" : 8 miles), the general trend based on present distribution of sediments and structural trends is arcuate convex to the north, in the area between longitude 64° 10' and 69° 0' West. This general arcuate trend can be subdivided into three segments each of which is also arcuate. On Figure 1 the three segments can be recognized by the northern outcrop edge of the Silurian rock units which is convex to the north or northwest. The easternmost segment extends from the Tabletop granite massive at 66° W longitude to the eastern tip of Gaspe Peninsula at 64° 10' W longitude. This eastern segment contains fairly distinct structural features, which will be discussed later.

The central segment of the Acadian orogen is not too distinct and it extends between the Tabletop granite massive at $66^{\circ}$ W longitude to the area approximately 8 miles east of Matapedia Lake at $67^{\circ}$ 20' W longitude. The convexity at the northern outcrop edge of the Silurian is faint. The north front of the Shickshock series, however, is distinctly arcuate.

The western segment is readily recognizable at the north and northwest outcrop edge of the Silurian rock unit. It extends between W longitude $67^{\circ}$ 20' east of Matapedia Lake to Lac Temiscouata at $68^{\circ}$ 50' W longitude. The definition of the boundary, however, is not well delineated as the structural features west of W Meridian $69^{\circ}$ are as yet unknown.

The length of the segments along their north and northwest front, i.e. the northern outcrop edge of the Silurian rock units, is fairly constant.

In this report it is postulated that the three outlined Acadian arcuate segments are the result of large thrust sheets, over-thrust to the north on low angle south dipping thrust planes. The segments are separated from each other by large strike-slip faults. The strike-slip faults on the east boundary are dextral and on the west boundary of each arch they are sinistral.

To the south the three segments merge structurally and the fairly clear structural features at the north margin become complex and indistinct southward.

The eastern segment between the Tabletop granite massive and Cape Gaspe is limited on its sides by large strike-slip faults and its front is formed by an inferred large low angle thrust fault. Thrust faults and strike-slip faults are intimately related, since they originate from the same compressive stress system (De Sitter, Structural Geology, 1956).

Thus the large dextral strike-slip fault, the Northwest Arm Fault, northwest of Gaspe town, becomes a low angle thrust fault within the northern Ordovician belt as shown with a dotted red line. Some of the elements of this large thrust are known but further detailed mapping is required in that area. Since the Ordovician is lithologically fairly monotonous, photogeological methods are not applicable in mapping this low-angle thrust fault. To the west this thrust fault probably joins the Tabletop granite massive. Many elements of the sinistral strike-slip fault, which bounds the eastern segment to the west, have been mapped on Figure 1. The connection between the established elements of the wrench fault has been dotted in, since surface and photo evidence is lacking. The sinistral strike-slip fault, thus defined, is mapped between the south end of the Tabletop granite massive and a point three miles north of Campbellton, N.B. The presence of this large sinistral strike-slip fault was suggested by Mr. R.P. Lockwood during his field visit in July 1959 and subsequent detailed field work outlined four sinistral strike-slip fault elements of this large feature.

Many large dextral strike-slip faults are present in the centre and east part of the eastern segment and have been described in detail in the 1959 report on east central Gaspe. The photogeological evidence of these large dextral strike-slip faults is excellent.

Within the block of the eastern segment a multitude of south dipping thrust faults occur. Since photogeologic evidence is very poor to outline the thrust faults and probable imbricate structures, much interpretation is necessary. Observation of thrust planes in the field is practically impossible on account of the dense vegetation and generally poor outcrop conditions. However, several attitudes of associated thrust planes were measured and the construction of cross-sections C1 and C2 is based on these measurements. Cross-sections C1 and C2 are two structural interpretations in the horizontal and vertical scale of 1" to 5 miles between New Carlisle in the south on Chaleur Bay and Petite Vallee in the north on the St. Lawrence River.

The frontal thrust fault in the north of the eastern segment, which is connected laterally to dextral and sinistral strike-slip faults is observed outcropping at mile 78 of sections C1 and C2. Surface evidence of this low angle thrust was observed north of Murdochville, where the fault plane dips $40^{\circ}$ to $45^{\circ}$ southward. Southward this large thrust fault may underlie the entire central Gaspesian basin in the form of a sole fault and many of the thrusts shown outcropping farther south may be connected with that sole fault, as is shown in Section C2 and indicated in C1.

The anticlines within the eastern segment have been described in the 1959 report and are well established. Besides the interpretations shown in sections C1 and C2 there are many more possible ones. Some are published by W.A. Roliff (1952). The low angle thrust between the Mount Alexander Silurian belt and the Fortin may be much less inclined to the south and the Fortin sediments may extend very much more south under the thrust as indicated on C1 and C2 sections.

The central segment, as mentioned earlier, is a faint feature and is poorly delineated in comparison to the eastern segment. There is some indication of a frontal thrust west of the north part of the Tabletop granite massive and crossing Candego Mines (Map 1000). Another possibility of a frontal thrust is the thrust that separates the shickshock series from the Ordovician to the north. The lateral limits to the east and west of the central segment have not been mapped. The central segment possibly merges with the eastern segment south of the Tabletop granite massive. The large dextral strike-slip fault north of Mount Alexander could be defined as the eastern limit of the central segment. In the area, where the sinistral strike-slip fault south and south-southwest crosses the inferred extension of the dextral strike-slip fault north of Mount Alexander, a concentration of Acadian granite intrusions is present. Since strike-slip faults have mostly vertical fault planes and are assumed to reach very deep, the granite magma could conceivably have travelled upward along the strike-slip fault zones. Cross-section B with scale 1" to 1 mile and section B1 with scale 1" to 5 miles are structural interpretations of a section between Fleurant on the Chaleur Bay and Ste. Anne-des-Monts on the St. Lawrence River.

The interpretations of this section are also heavily dependent on the stratigraphic relations in the Silurian and in the Lower Devonian, which are still open to much discussion. Section B1 is quite different from C1 and C2 farther east. The sinistral strike-slip fault bends around to the east of the large syncline with Gaspe sandstones along Square Forks Brook, an indication that this large competent sandstone block acted as a buttress and was not strongly deformed. The sections B, and B1 bear this out and a generally gentle synclinal structure dominates the centre of these cross-sections.

In the north, low angle thrust faults have been postulated, which may extend southward as sole faults. Normal faults are present south of the Shickshock series and may be related to the large inferred thrust fault to the north. The problem of the Shickshock series still is not resolved. It has been suggested that the Shickshock series is Precambrian and overthrust to the north over Lower Ordovician strata. Geologists of the Quebec Department of Mines (Dr. J. Beland and Mr. N. Ollerenshaw) suggested during the 1959 field season, that the Shickshock series may be as young as Lower Ordovician. This latest suggestion however, is not in accordance with the high degree of metamorphism in these rocks. To the south the Ordovician is thrust over the Fortin series at mile 10.5 of section B and B1. The outcrop of this fault plane is very steep and partly invaded by diabase. On aerial photos some parts of the fault plane are vertical and it has been suggested, that a normal fault separates the Fortin and Ordovician. In view of the strong compression of the Fortin beds with imparted transverse cleavage and the multitude of measurements on associated small thrust faults, a large thrust fault is here postulated and constructed in sections B, and B1.

This thrust fault, though steep at the outcrop, may become a low angle south dipping thrust at depth and could have caused the upwarping of the Silurian at mile 12 of section B, and B1. The structural detail of the Silurian below the Fortin is obscured. The Fortin slate is squeezed and contorted strongly and a projection of surface structure of the Fortin downward is not possible.

Farther south the sediments of the Chaleur Bay trough occur in the form of a syncline, which has been simplified on sections B, and B1. Cross-sections A, A1 and A2 from Christopher, N.B. near Highway 17 (N.B.) southwest of Campbellton to Matane, P.Q., on the St. Lawrence River contains similar interpretations in the southern half as in sections B, and B1. The northern half, however, is considerably different, since the large syncline of section B is replaced by anticlines and synclines. On Figure 1, three anticlines with the Silurian St. Leon formation exposed in their core are mapped. Several more anticlines are expected west of Meridian 67° 40' W and north of the outcrop edge of the Lower Devonian Heppel formation, the equivalent of the York River formation farther east.

Many faults shown in section A, A1 and A2 have very faint surface evidence and are inferred. A thrust at the northern outcrop margin of the Heppel formation (sketch A3 on section A2) is only inferred but would explain convergence of the anticlinal axes of the anticlines northwest of Causapscal with the Heppel-Causapscal formation contact (Figure 1).

The western segment south of Mont Joli and Rimouski has been traversed only in reconnaissance fashion. Detail work was carried out by Quebec Department of Mines geologists during 1959 in that area. The structures west of Lake Matapedia appear to be fairly complicated. The presence of anticlines and numerous faults can be predicted southeast of the arcuate outcrop edge of the Silurian rock units south of Mont Joli but surface information of the 1959 field season does not permit detail discussion of this area.

It appears that the frontal thrust of the western segment is located at the northern Silurian outcrop edge a short distance south of Mont Joli. A sinistral strike-slip fault is present southwest of Mont Joli (Figure 1) and a dextral strike-slip fault may be present southeast of Mont Joli. It is evident from Figure 1 that the anticlines of the Matapedia Valley area with Silurian St. Leon formation in its core present a structural pattern, that certainly continues to the west.

Large low angle south dipping thrusts approximately paralleling the Heppel-Causapscal formation contact can be expected. These thrusts caused the Strata to the north of them to be folded, indicating that the area southwest of Matapedia Lake probably contains several structures, combined with thrust faults and strike-slip faults.