GM 28427

MEMORANDUM REPORT ON THE AREAL GEOLOGY AND STRUCTURAL INTERPRETATION OF THE GASPE PENINSULA

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on the

AREAL GEOLOGY and STRUCTURAL INTERPRETATION

of the

GASPE PENINSULA, EASTERN CANADA

Prepared For

LA SOCIETE ACADIENNE

DE RECHERCHIS PETROLIERES

By

V. ZAY SMITH ASSOCIATES LTD.

Calgary, Alberta

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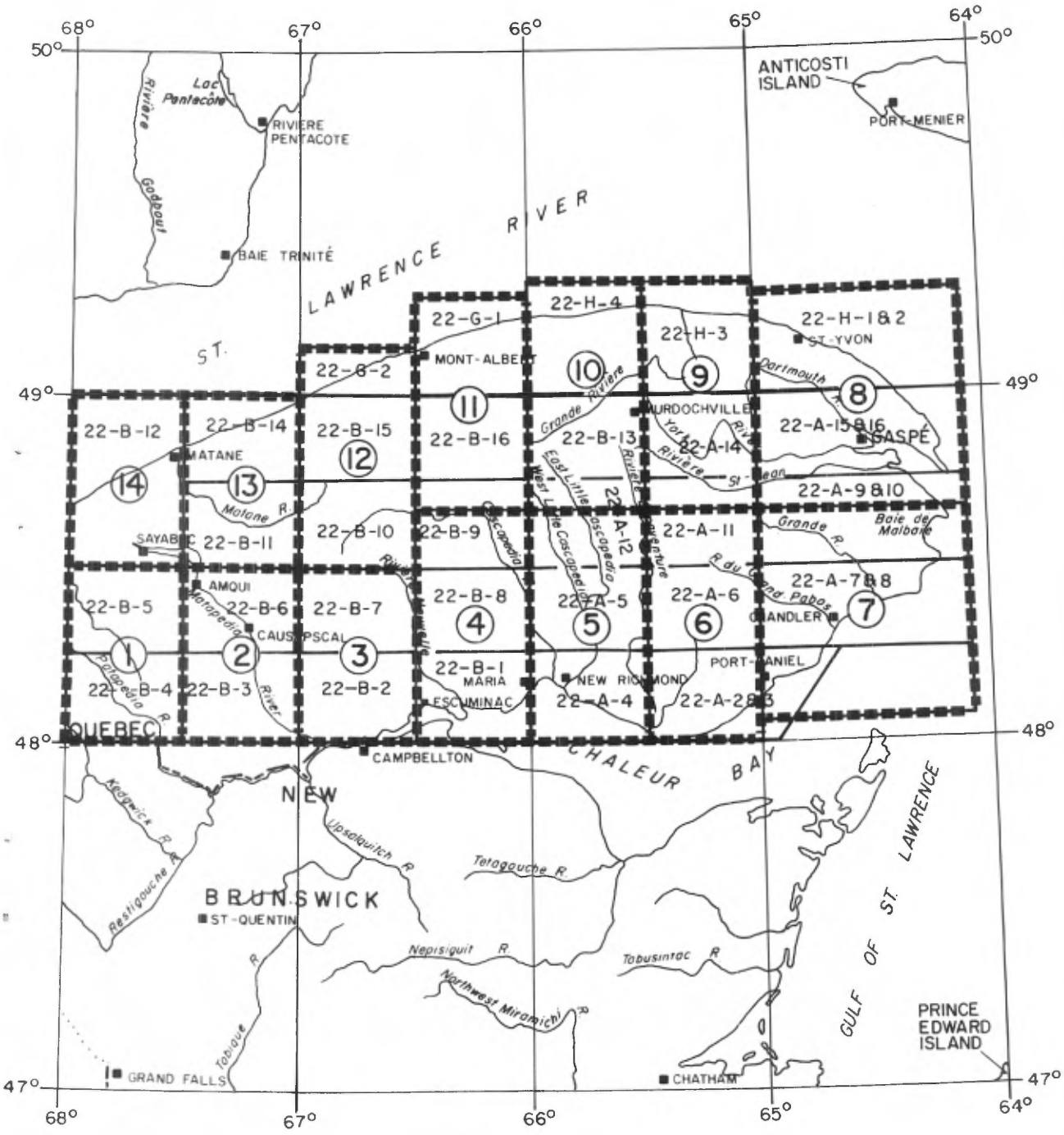

LOCATION MAP

22-B-3 — Photomosaic coverage

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V ZAY SMITH ASSOCIATES LTD.

MEMORANDUM REPORT

on the

PHOTOGEOLOGIC MAPPING PROGRAM

of the

GASPE PENINSULA

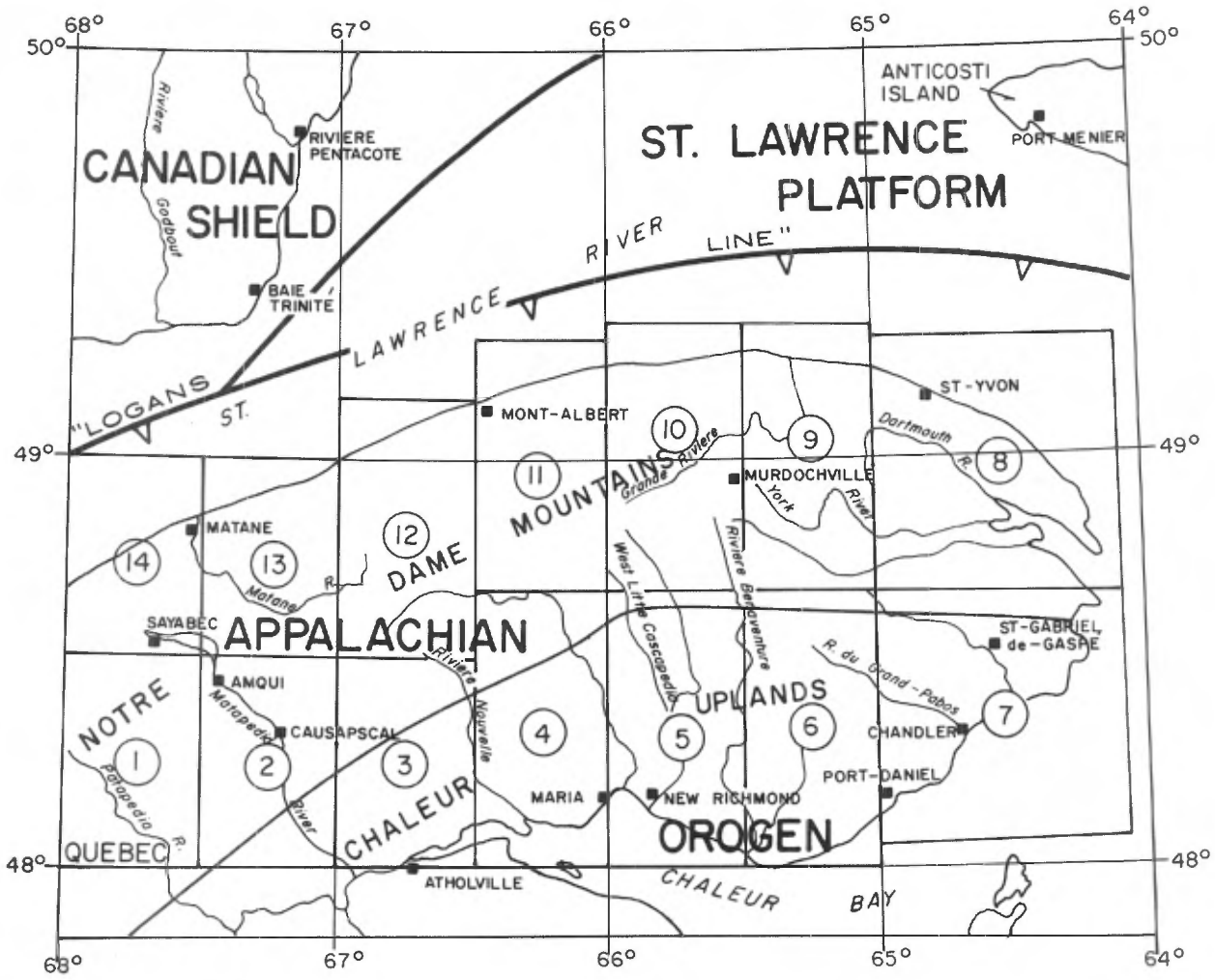
INTRODUCTION

In November, 1969, V. Zay Smith Associates Ltd. and Veezay Geodata Ltd. of Calgary, Alberta initiated a photogeologic mapping program of the Gaspé Peninsula on behalf of La Societe Acadienne De Recherchis Petrolieres. The project area includes all of the Gaspe Peninsula lying north of lat. 48° N. and east of long. 68° W., a total of approximately 11,800 square miles (see Location Map Fig. 1).

AIMS of PROGRAM

The purpose of the mapping program was to provide a set of photogeologic maps incorporating a comprehensive compilation of available published and open file data. The maps and photomosaics were designed for use as a guide for field work to be conducted by SAREP during the summer of 1970.

FIGURE 2



MAJOR TECTONIC AND PHYSIOGRAPHIC ELEMENTS OF THE GASPÉ REGION

(3) Map sheet number

PROCEDURES

Vertical air photographs covering the entire project area were obtained from the Quebec Provincial government at an approximate scale of 1:30,000.

The airphotos were indexed and appropriately stamped according to the National Topographic System for ease of identification and handling. They were then used for construction of photomosaics at a scale of 1 inch to 1 mile. A total of 31 mosaics, photographically adjusted to the proper scale, were required to cover the entire area. The layout and identification of mosaics are indicated on the Location Map.

A complete set of photomosaics were split-mounted and folded to a convenient size to be used during the field program.

Half-tone cronar prints of 1:50,000 scale topographic maps acquired from the Dominion Government were obtained at the scale 1 inch to 1 mile to be used as base maps for drafting of geologic detail. The resulting map provides bold geologic detail on a subdued background of detailed planimetry and topography. The boundaries of the resulting 14 map sheets are also shown on the Location Map.

After completion of the base map construction all wells within the project area were plotted on the base cronars.

The aerial photographs used in construction of the photomosaics were later utilized for the photogeologic mapping. The airphotos were viewed stereoscopically to allow a semiquantitative evaluation of the rate of dip of visible bedding surfaces and to provide the three dimensional picture necessary for effective photogeologic mapping. During this step, visible geologic detail is annotated directly on the airphotos. Such detail includes formational contacts, key beds, stratigraphic breaks, faults, anticlinal and synclinal axes, strike and dip of bedding, distinctive alignments, and other pertinent geologic observations. During this phase of the program published and open file maps provided valuable information and were used as a guide in mapping, particularly in areas of poor bedrock expression due to widespread mantle or heavy forest cover. A representative selection of field measured dips from these maps were incorporated to aid in structural definition.

The resulting geologic data were then posted to ozalid prints of the base maps and later drafted to the cronar originals. The maps were edited and a set of prints pulled for use in the field studies.

Data resulting from SAREP field studies during the summer of 1970 were later added to the maps. Although the resulting information necessitated local revisions, the field mapping proved generally quite compatible with the photogeologic interpretation and added valuable structural and stratigraphic detail.

The bibliography included within this report lists the papers, maps, and other published and open file information utilized in the mapping.

The enclosed legend outlines the formation symbols used on the maps as well as the formation names and a brief description of lithologies. The legend is arranged in several columns to accommodate variations in nomenclature and lithologies in different areas within the project. The general outlines of the areas indicated in the legend are shown on the accompanying index map.

REGIONAL GEOLOGIC SETTING

The Gaspe Peninsula lies in the northern part of the Appalachian Orogen (Figure 2) and is separated from the Canadian Shield and the St. Lawrence platform to the north by "Logan's Line" of faulting believed to lie beneath the waters of St. Lawrence River. The overall configuration of the peninsula reflects the general structural fabric of the region with dominant northeasterly trends in the western project area swinging through easterly and southeasterly in the east.

Regionally, the Gaspe Peninsula forms a broad synclinorium of Silurian-Devonian strata exhibiting folding of mild to moderate intensity flanked on the north by more highly deformed Cambrian-Ordovician beds of the Shickshock-Quebec Groups and on the south by Ordovician-Silurian beds of the Matapedia and Honorat Groups. In the southern project area, adjacent to Chaleurs Bay, a contrasting sequence of clastics and carbonates of Silurian to Carboniferous age rests on Cambro-Ordovician rocks of the Mictaw and Maquereau Groups.

Two major periods of folding have affected the region. Beginning in Ordovician time, the Taconian Orogeny folded, faulted, and in places uplifted and slightly metamorphosed, sediments and volcanics of Cambrian through Lower Silurian age. The attendant uplift and erosion was followed by subsidence and accumulation of a thick, mainly clastic, succession in Silurian and Devonian time. Folding and faulting associated with the Acadian Orogeny in Middle and early Upper Devonian time produced broad, open folds in these strata along trends which closely parallel the pre-existing structural fabric imparted by the Taconian Orogeny. Northward thrusting of the Gaspe plate occurred along "Logan's Line" of faulting at this time.

Minor accumulations of Upper Devonian clastics were deposited on the Acadian erosion surface in the Escuminac area. Tilting, uplift, and erosion of these beds occurred during the Maritime Disturbance in early Carboniferous time. Conglomerates of the Bonaventure and Cannes de Roche Formations were then deposited on older beds with angular unconformity. Continued tectonic activity associated with the Maritime Disturbance, or possibly with the Palisades Disturbance (Upper Triassic), later imparted dips to the Carboniferous conglomerates which locally range up to 90°. In most places, however, Carboniferous beds are little disturbed.

Volcanic and intrusive activity which occurred intermittently during Paleozoic time was responsible for the emplacement of both basic and acidic intrusive rocks and the accumulation of a variety of volcanic sediments in some areas.

Of primary interest in the search for petroleum are the post-Taconian clastics and carbonates of the central Gaspe region.

The general topographic character of the Gaspe Peninsula is in many cases a direct expression of the underlying geologic structure. The Chaleur Uplands of the southern project area (Figure 2) present uniform concordant summits with elevations ranging mainly between 1,000 and 2,000 feet above sea level in the northern part falling to sea level in the south. The Notre Dame Mountains of northern Gaspe attain elevations ranging most commonly from 2,000 to 3,000 feet and occasionally rising to around 4,000 feet in the Shickshock Mountains and the area of granitic terrane immediately to the east known as the McGerrigle Mountains. Widespread, dense forest cover exists over most of the area masking much of the surface structural detail.

Approximately 60% of the Gaspe Peninsula is drained by southeasterly flowing rivers and streams which empty into Chaleurs Bay. The major drainages are the Bonaventure, Cascapedia and Matapedia Rivers. The northern region is drained by a series of mainly minor northwesterly flowing streams. The Matane, Cap Chat, and the St. Anne Rivers are among the larger streams of this region. The easterly flowing York River which flows into Gaspe Bay provides drainage for a large part of northeastern Gaspe.

STRATIGRAPHY

Complex stratigraphic and structural relationships within the Paleozoic sequence in the Gaspe Peninsula have in some cases led to considerable confusion in the definition and boundaries of the stratigraphic units of the region. Gradational contacts and facies changes diagrammatically portrayed on the accompanying stratigraphic correlation chart (Figure 3), and the lack of persistent continuous exposures of bedrock are largely responsible for the difficulty in establishing definite, well documented lateral relationships. As illustrated on Figure 3, sediments ranging in age from Cambrian through Carboniferous form surface bedrock in the Gaspe Peninsula. The columns of the correlation chart are designed to closely parallel the map areas outlined on the index map of the legend accompanying the areal geology maps.

The following discussion briefly describes the general relationships and lithologies of the various formations. For more detailed information the reader is referred to the references in the Selected Bibliography.

CAMBRIAN, ORDOVICIAN and LOWER SILURIAN

Rocks of pre-Taconian age include a sequence of considerable but unknown thickness in the Gaspe including meta-volcanics, metasediments coarse-to fine-grained clastics and limestones. In some places, notably the northern part of the map area the Shickshock-Quebec Group lithologies display variable degrees of metamorphism and consist mainly of slates, sandstone, conglomerate, limestone and chert. The Shickshock Group

includes several thousand feet of mafic lava, tuff, sandstone, and schist. Stratigraphic relationships between the Shickshock and Quebec Groups are uncertain. They are overlain, often with angular unconformity, by less disturbed basal formations of the post-Taconian sequence.

In Map Area 5 (see index map) of southern Gaspe a broad, northeasterly trending band of pre-Taconian rocks includes argillites, siltstones and conglomerates of the Honorat Group and the overlying limestones and shaly limestones of the Matapedia Group. The Matapedia Group is also present in the core of St. John River anticline. Although beds of the Matapedia often appear more highly deformed than those of the overlying Silurian-Devonian sequence, no definite evidence of unconformity has been documented on the St. John River anticline. Contact relationships are also obscure along the southern edge of the central synclinorium and available evidence indicates a mildly unconformable or perhaps conformable relationship between the Matapedia Group and overlying beds.

Thus, the effects of Taconian uplift, erosion, folding and faulting appear to be quite variable in the Gaspe region and the Taconian unconformity may in some places be absent in the subsurface of the central synclinorium. Although rocks of pre-Taconian age are often considered effective basement for the purpose of petroleum exploration, it is possible that an unbroken depositional sequence may exist in the subsurface of the central Gaspe Peninsula.

The oldest surface rocks of the region are located in the Port Daniel area. These are comprised of the Maquereau and Mictaw Groups of Cambrian-Ordovician age including mainly quartzose , greywacke, quartzite, volcanics, conglomerate, sandstone, shale slate, and schist. These rocks are in some places intensely deformed with moderately heavy faulting and tight, often overturned, folds.

SILURIAN

In the Matapedia region of the western project area and beyond, the Awantjish Formation is the oldest of four conformable formations comprising the Silurian Series. The Awantjish ranges from 20 to 300 feet in thickness within the map area and up to 1,000 feet in other parts of the Matapedia region. It is comprised of green, grey and occasional red, calcareous shale and siltstone of upper Llandoverian age. Rare limestone beds are also reported (Beland, 1970). Occurrences of the Awantjish Formation are scattered and of local extent on the accompanying geologic maps. They are mapped only in the Cap Chat and Matane Rivers area.

On Cap Chat River Beland reports 180 feet of thin-bedded lithographic limestone and limy mudstone which he considers to be the westernmost known occurrence of the Sources Formation which overlies the Awantjish shales and underlies the Val Brillant quartzite. The Sources is also present in the Beland River area to the northeast where it is included with the overlying Val Brillant Formation map unit (Svb).

The Awantjish Formation is conformably overlain by 50 to 500 feet of fine-grained white to pink quartzite of the Val Brillant Formation which often forms a persistent marker horizon along the northern fringe of the Siluro-Devonian synclinorium. The Val Brillant Formation overlaps the Awantjish northward to rest unconformably in some areas on the folded Cambrian-Ordovician strata.

The Val Brillant quartzite grades upward to sandstone, calcareous sandstone, and limestone of the Sayabec Formation of Wenlockian to lower Ludlovian age. In places the Sayabec limestone becomes dolomitic and occasionally contains vuggy crystalline dolomite or bioclastic limestone. The maximum thickness of the Sayabec Formation within the map area is on the order of 500 feet.

In the area north and west of Gaspe Bay the Griffon Cove River Formation separates the Sayabec Formation from underlying Cambro-Ordovician strata and is included with the Sayabec Formation (map unit Ss). The formation includes up to 700 feet of shale, siltstone, and mudstone with minor conglomerate and limestone occupying the stratigraphic position of the Val Brillant and Sources Formations to the west.

In the east-central map area on the flanks of the St. John River anticline the Burnt Jam Brook Formation overlies, with apparent conformity, the White Head Formation of the Matapedia Group. It consists of dark claystones, mudstone, and shale up to 800 feet in thickness.

The LaForce Formation includes sandy calcarenite, minor calcareous sandstone, and conglomerate which rests conformably upon the Burnt Jam Brook Formation. The sequence, of mainly Wenlockian age, ranges from 415 feet to 860 feet thinning to 50 feet west of Malbaie Bay.

A thick succession of siltstones and mudstones with some sandstones and minor limestone comprises the St. Leon Formation. It rests conformably on Sayabec limestones in the north and on the Laforce Formation to the south. Maximum thicknesses range from around 7,000 in the western map area to approximately 2,500 feet in eastern Gaspe Peninsula. The formation is strongly diachronous in northeastern Gaspe. To the west the St. Leon Formation ranges in age from Upper Silurian to Lower Devonian. In the northeastern map area Lesperance and Bourque (1970) demonstrated the St. Leon to be entirely of Lower Devonian age and to undergo a rapid time transgression in surface exposures of the Dartmouth River area. The St. Leon Formation is present throughout the central band of Siluro-Devonian sediments.

In northeastern Gaspe, limestone beds within the St.Leon Formation are designated the Lefrancoise Member by Lesperance & Bourque (1970). Reefal buildups occur within the Lefrancoise Member which varies in thickness from around 90 feet to 1,090 feet. Outcrop characteristics indicate that the Lefrancoise Member occurrences are probably erratic and spotty in the subsurface providing an elusive but favorable potential reservoir. Occurrences of Lefrancoise Member are mapped in the Madeleine River area of map sheets 9 and 10 and in isolated exposures on the eastern end of St. John River anticline on the basis of field observations by Bourque (1971).

In the Port Daniel area (Map Area 3 of Index Map) a contrasting sequence of Silurian strata accumulated in a somewhat different depositional environment than that which prevailed to the north, resulting in a substantially different stratigraphic column.

The oldest of the post-Taconian formations is the Llandoverian Weir Formation including 600 feet to 2,000 feet of greyish-green siltstone with interbedded conglomerate, sandstone and silty limestone. The Weir Formation rests on the sandstone, greywacke, siltstone, slate and conglomerate of the Ordovician Mictaw Group with probable unconformity. The contact however, has not been observed.

Quartzose sandstone, calcareous sandstone, siltstone and minor quartz pebble conglomerate of the Clemville Formation conformably overlie the Weir Formation where the latter is present but is elsewhere unconformable on the Mictaw and Maquereau. The thickness ranges from 90 feet to 2,000 feet.

Considerable confusion exists over the validity of the Anse Gascon formational status. The term was originally designed to include the sandstones and shales in the lower part of the overlying La Vieille Formation. The Anse Gascon includes limestone, shale, siltstone, sandstone and conglomerate ranging in thickness from around 500 feet to 900 feet. Any beds of the Anse Gascon Formation and underlying Weir Formation within the map area are included in map unit Sc (Clemville Formation).

Dark grey, nodular and reefal limestone, argillaceous limestone and calcareous shales of the La Vieille Formation rest unconformably on the Anse Gascon Formation. A thickness of around 1,355 feet is reported by Bourque (1964).

The Gascons Formation lies conformably on the La Vieille Formation. It is comprised of 1,450 to more than 3,800 feet of green to grey, calcareous and non-calcareous silstone, sandstone, and minor limestone and red siltstone. The contact with the underlying La Vieille Formation is gradational.

Maroon and green calcareous siltstone with lenticular interbeds of biostromal limestone ranging in thickness from around 700 to 2,700 feet constitute the Bouleaux Formation which rests conformably on the Gascons Formation.

More abundant faunas occur in the crinoidal and partly reefal limestones of the conformably overlying West Point Formation. A gradational contact separates the West Point from the Bouleaux Formation and the total thickness is most commonly around 1,450 to 1,700 feet, although Skidmore (1958) reports a thickness of 3,000 feet.

The Indian Point Formation comprises the youngest Silurian strata of the Port Daniel area. It overlies the West Point Formation with gradational contact and consists of maroon and green siltstone with interbeds of fossiliferous limestones similar to the Bouleaux Formation.

Up to 2,100 feet of volcanics including basic lavas, breccia, and conglomerate with interbedded maroon siltstone and grey limestone are reported in the Black Cape area at the western edge of Area 3. The sequence has been designated the Black Cape Formation and is believed to be at least in part correlative to the West Point Formation. It rests with sharp conformable contact on the Bouleaux Formation.

The Silurian sequence in the Escuminac area and western Port Daniel map area is mapped as the Chaleurs Bay Group (Scb) due to the lack of distinctive expression on the aerial photographs and the scarcity of field observations from published sources.

A thick succession of Silurian volcanic and sedimentary rocks is mapped along the southern edge of the Siluro-Devonian synclinorium of Map Area 1. The sequence is thought to range in age from Llandoverian to early Ludlovian and is divided into three unnamed divisions by Skidmore (1965) with a total thickness of between 8,000 to 16,000 feet. The lower unit includes about 2,400 feet of silty limestone overlain by 2,000 feet of interbedded silty limestones and amygdaloidal andesites. The middle volcanic unit includes massive lavas and tuffs and the uppermost unit is comprised of 2,000 feet of brown to grey, finely crystalline limestone.

The threefold sequence apparently thins rapidly northward where it assumes a greater proportion of clastics and fewer carbonates and volcanics.

For the purpose of mapping, the upper and lower limestone units of the Mount Alexander Group are designated Smal and the middle volcanic unit is denoted by the symbol Smav. The undivided Mount Alexander group is designated Sma.

Mount Alexander beds rest with uncertain contact relationships on those of the Matapedia Group in the southern part of Map Area 1 and are overlain conformably by the Devonian Cap Bon Ami Formation and the Fortin Group. The Mount Alexander Group apparently thins rapidly eastward near Malbaie Bay where McGerrigle (1950) reports the absence or near absence of the Cap Bon Ami Formation and maps the Grand Greve Formation in contact with the Mount Alexander Group. Regional mapping southwest of the Mount Alexander area suggests rapid thinning in that direction and perhaps complete absence of the Mount Alexander Group in some places.

In the western part of Joshua anticline the Baldwin Volcanic Member (Burk, 1964) of the St. Leon Formation includes up to 3,000 feet of porphyritic andesites, bedded volcanic conglomerates and tuff with minor rhyolite and basalt which grades eastward into the St. Leon Formation.

The Owl Capes Conglomerate Member of the St. Leon Formation occurs in the eastern part of the St. John River anticline and includes pebble and cobble conglomerates comprised of limestone, quartz, and basic lava clasts with minor interbedded siltstone, volcanic sandstone and stromatoporoidal limestone. According to Burk (1964) the Owl Capes Member attains a thickness of 1,000 feet and interfingers to the east with massive green mudstone and grades southwestward to the Cedar Barn Volcanic Member which comprises 1,800 feet of interbedded basic lavas and volcanic conglomerate. Elsewhere it is overlain and underlain by St. Leon Formation mudstones.

DEVONIAN

Deposition of the St. Leon Formation continued into early Lower Devonian time in a sea which was apparently transgressive to the northeast. As a result, St. Leon Formation deposition in northeastern Gaspe is entirely of Lower Devonian age. The underlying Sayabec Formation, mainly of Middle and Upper Silurian age in central and western Gaspe, is of late Upper Silurian and early Lower Devonian age in the Forillon Peninsula area.

In Lower and Middle Devonian time a thick succession of marine sediments, and later mainly nonmarine clastics, were deposited in a mainly conformable sequence in central Gaspe. Both vertical and lateral transitional lithological changes and variable degrees of diachronism have led to considerable difficulty in establishing valid correlations in various parts of the region. In the northern part of the central synclinorium the various formations provide reasonably well expressed map units for the purpose of both field work and photogeologic mapping. Along the southern edge of map area #1 south of St. John River anticline the diagnostic features of the Cap Bon Ami, Grand Greve, York Lake and York River Formations become indistinct precluding effective division of map units. The resulting undivided sequence of clastics is referred to as the Fortin Group.

In central Gaspe rocks of Devonian age are widely distributed and form surface bedrock over 85% to 90% of the area.

The Cap Bon Ami Formation rests with conformable and transitional contact on the St. Leon Formation. It includes mainly calcareous mudstone and siltstone, and silty and sandy limestone and shale. McGerrigle (1950) estimates a thickness range of from 1,000 to 6,000 feet in eastern Gaspe. Mattinson (1964) estimates 2,500 feet in the Cap Chat River area and Beland (1970) reports a thickness of 2,000 feet on the Causapscal anticline.

The Grand Greve Formation rests conformably on the Cap Bon Ami and in eastern Gaspe consists mainly of hard, cherty limestones and calcareous siltstones. Farther west in the Matapedia River region the chert content decreases and the formation is comprised mainly of grey and greenish-grey, mainly non-calcareous, claystones and mudstones in the lower part and hard calcareous siltstones in the upper part. On the Causapscal anticline, Beland (1970) reports around 2,400 feet of Grand Greve. A wide range of reported thicknesses for the Grand Greve Formation is due largely to variations in the way the formation is defined by various workers in the region.

Sandstones, shales, and limestones comprising the York Lake Formation rest conformably on the Grand Greve Formation in western Gaspe where it constitutes a transitional zone between marine beds of the Grand Greve Formation and the overlying, mainly nonmarine clastics of the York River Formation. In the absence of distinctive formational boundaries Beland (1970) applied York Lake terminology to a 1,200 to 2,400-foot-thickness of interbedded Grand Greve and York River lithologies consisting of calcareous siltstones and claystones and feldspathic and arkosic sandstones in the Causapscal - Lake Casault area.

The York Lake Formation grades upward to greenish or grey, fine to coarse grained arkosic and feldspathic sandstones and shale of the overlying York River Formation. As in the case of other Devonian formations, reported thicknesses of the York River Formation vary widely due mainly to subtle changes in lithology and variations in definitive terms applied by different workers. Thickness estimates ranging from 1,300 feet in the northeast to 14,000 feet in western Gaspe have been reported. In contrast, Beland (1970) estimates a combined thickness of 7,000 feet for the York River Formation and the overlying Lake Branch Formation south of Causapscal anticline.

In the Richard-Gravier area of central Gaspe and in the Causapscal area to the southwest, a change from the mainly greenish colour of York River lithologies to reddish colored sandstones and shales provides the basis for a mappable unit known as the Lake Branch Formation. Except for the contrasting colour, lithologies of the Lake Branch Formation are very similar

to those of the York River Formation. The upward change in colour is variously reported due to either an increase in hematite-limonite pigment or in the content of red feldspathic sandstones and shales. Stearn (1965) reports a thickness on the order of 4,000 feet for the Lake Branch Formation in the Causapscal area.

The Battery Point Formation includes medium to coarse grained greenish grey, feldspathic sandstone in the lower part and red to brown feldspathic sandstone, shale and conglomerate in the upper part. McGerrigle (1950) reports a thickness of 5,000 to 7,000 feet in eastern Gaspe while Carbonneau (1959) estimates 8,000 to 10,000 feet of Battery Point Formation in the Richard-Gravier Area. Although the Battery Point Formation is usually considered to rest conformably on the York River or Lake Branch Formations, Carbonneau describes at some length the divergence of regional structural trends existing between Lake Branch and Battery Point beds. Photogeological characteristics observed during mapping strongly suggest the presence of an unconformity in the vicinity of Square Forks River at longitude 66° 30' W. In this area beds of the underlying York River Formation appear to be steeply dipping and discordantly overlain by more gently dipping beds of the Battery Point Formation. A period of uplift and erosion prior to Battery Point deposition may also explain the absence of Lake Branch Formation on the southern flank of the regional syncline in southern Richard-Gravier area as mapped by Carbonneau (1959).

In eastern Gaspe along the shores of Gaspe Bay and Malbaie Bay the Battery Point Formation rests with reported conformity on the York River Formation although McGerrigle mentions "local exceptions pointing to emergence and submergence".

The Malbaie Formation occurs in the eastern map area where it consists of around 2,000 feet of grey to reddish brown pebble conglomerate, sandstone, minor green and red shale, and very minor limestone. McGerrigle (1950) reports the Battery Point - Malbaie contact to be strictly conformable and even gradational where observed in outcrop but notes that sandstone boulders similar to Battery Point lithologies are present within the Malbaie Formation indicating the possibility of locally unconformable relationships.

In the Escuminac area (Area 2 of the legend) the formations of the Chaleurs Bay Group are less distinctive than in the Port Daniel area to the east and they are mapped as a combined unit designated Scb. Included in the Chaleurs Bay Group of this area, are a sequence of interbedded calcareous and sandy shale, siltstone, shaly limestone, and boulder conglomerate. These sediments are interbedded with basalt and andesite flows, breccias and tuffs.

Up to several thousand feet of sandstone, conglomerate and mudstone with minor coal seams rest with probable disconformity on the Chaleurs Bay Group. These beds are mapped as the La Garde Formation in accordance with Skidmore (1967).

Over 600 feet of red and green conglomerate and sandy shales comprise the conformably overlying Pirate Cove Formation which is equated in age with the late Lower Devonian and younger Battery Point Formation.

The Fleurant Formation rests with disconformity or unconformity on the Pirate Cove Formation. It is comprised of around 45 feet of pebble and boulder conglomerate containing occasional sandstone lenses. The boulders attain considerable size (one to four feet) and are composed of volcanic materials and older sedimentary rocks derived from a source area to the northwest. On the accompanying maps, the Dfc map unit designating the Fleurant conglomerate also includes the Escuminac Formation which consists of 370 feet of nonmarine shale and sandstone resting conformably on the Fleurant Formation.

CARBONIFEROUS

Folding, uplift, and erosion associated with the Acadian Orogeny was followed by deposition of a conglomerate and sandstone sequence with gross angular unconformity on pre-Acadian rocks along the northern edge of Chaleurs Bay and in the area west and southwest of Malbaie Bay. Accumulation of the conglomerates may have occurred in two separate basins, one in the Malbaie Bay area where the formation has been named Cannes de Roche, and the larger area bordering the north edge of Chaleurs Bay where it is mapped as the Bonaventure Formation.

Both formations are very similar in lithology consisting of reddish coloured conglomerates and sandstones with red and green shales. The thickness of the Bonaventure Formation is usually around 250 feet while the Cannes de Roche is up to 800 feet thick. They are thought to be of the same or similar age, probably Upper Mississippian and/or Lower Pennsylvanian.

Pronounced angular unconformity at the base of the Bonaventure and Cannes de Roche Formations may be observed in numerous places on the air photographs where they are clearly less disturbed than the underlying formations. Although bedding attitudes are gentle in most places, locally steep dips and occasional faulting in Bonaventure beds indicates that they have been affected by a later period of tectonic activity.

QUATERNARY

Unconsolidated material consisting mainly of alluvial deposits in major stream valleys and minor accumulations of glacial drift and glacial erratics comprise the Quaternary sediments of the map area.

IGNEOUS ROCKS

Volcanic and intrusive activity have occurred periodically in the Gaspe region beginning at least as early as Ordovician time and perhaps before. In early and Middle Ordovician time great thicknesses of volcanics including mafic lavas and tuffs, were interbedded with clastic sediments and metamorphics. Mafic volcanics were also introduced into the thick sedimentary sequence comprising the Maquereau Group in southern Gaspe.

Several large masses of serpentinized periodite mapped in the Mount Albert area probably originated as high temperature intrusive bodies. The rock contains a large percentage of olivine, often completely altered to serpentine, and appreciable amounts of chromite. Emplacement of the original intrusives probably occurred in Ordovician time.

Another serpentine mass is located in Silurian strata of Weir Township northwest of Port Daniel. The history of emplacement is somewhat obscure. Ayrton (1967) suggests that the body was originally intruded into Maquereau and Mictaw strata during late Ordovician time and, after later deposition of overlying Silurian strata, was forced upward as a "cold intrusion" lubricated by serpentine and accompanied by heavy shearing and later intruded by granite. Although the body is designated Os on the geologic map, an accompanying note suggests a possible Silurian or later age in view of the adjacent Silurian strata.

Basic volcanics and serpentinite of Cambrian and/or Ordovician age are also reported in the Quebec Group of the Matapedia Lake area.

Extrusion of mainly basic volcanics in Middle and Upper Silurian time occurred in southern Gaspe adjacent to Chaleurs Bay. In the Black Cape area volcanics, probably occupying the stratigraphic position of the West Point Formation to the east, comprise the Black Cape Formation proposed by Burk (1964).

Farther west, in the Escuminac region, Silurian volcanic rocks interbedded with sediments include rhyolite, andesite and local volcanic conglomerate.

Interbedded basic lava flows and volcanic conglomerates totalling around 1,800 feet in thickness comprise the Cedar Barn Volcanic Member of the St. Leon Formation as described by Burk (1964). The sequence may grade eastward into the Owl Cape Conglomerate Member.

The Cedar Barn Member apparently originated with the same period of volcanism responsible for the interbedded lava flows and volcanic conglomerates of the Baldwin Volcanic Member of the St. Leon Formation in the southwestern part of Joshua anticline.

Several thousand feet of andesite, basalt, agglomerate, and tuffs in the Mount Alexander area comprise the middle part of the Mount Alexander Group. Numerous associated diabase sills and dikes are also of Silurian age.

A sequence of predominantly basic lavas up to 2,000 feet or more in thickness forms a continuous, resistant ridge within a sequence of Lower Devonian sediments on the northern flank of the broad syncline in the Richard Gravier area of central Gaspe. Diabase is the most common rock type and also included are acidic to basic tuffs, especially in the lower part.

Beland (1970) reports conformable masses of vesicular andesites accompanied by small basic intrusive bodies and including coarse to fine grained tuffs within the Cap Bon Ami and Grande Greve Formations on northeastern Causapscal anticline. On the flanks of southwestern Causapscal anticline and the northeast end of the adjacent Albertville anticline a persistent band of volcanic tuffs, 15 feet thick, at the top of the Cap Bon Ami Formation provided a useful marker bed during field mapping.

Numerous bodies of Middle Devonian granites occur in and around the McGerrigle Mountains of north central Gaspe. They are composed mainly of pink granite associated with smaller masses, sills, and dikes of rhyolite and syenite. These intrusives are believed to be directly associated with the copper-lead-zinc mineralization in the region.

Recent isotopic dating of diabase dikes in the Forillon Peninsula indicates a Pennsylvanian age suggesting the possibility of a similar age for diabase and related rock mapped as Dd in other parts of the area.

Ayrton (1967) tentatively assigns glassy-welded tuffs, agglomerates, and volcanic breccias encountered in the Chandler-Port Daniel area to the Tertiary Period.

STRUCTURE

The maps accompanying this report portray the areal geology of the Gaspe region at the scale of 1 inch to 1 mile. The interpretation is based mainly on photogeologic interpretation and includes information from published and open file sources some of which have proved extremely helpful in areas of poor surface bedrock expression. Appropriate symbols are used to

portray the strike and rate of dip of bedding, formational boundaries, faults, anticlinal and synclinal axes, and other pertinent features.

In general, a distinct difference is noted in the geologic structure of rocks of pre-Taconian age and those of later origin.

A 10 to 20 mile wide band along the northern coast of Gaspe is underlain by Cambrian-Ordovician rocks of the Quebec and Shickshock Groups. In most places the beds are tightly folded, heavily faulted, and metamorphosed. Structural trends in this region display a pronounced parallelism to the overall arcuate configuration of the northern Gaspe Peninsula. Dips defining the flanks of the folds most commonly range from 45° to vertical. Heavy forest cover exists in most places and outcrops are confined mainly to the deeper stream cuts. As a result, structural continuity is often obscure. Numerous faults, most of indeterminate throw, and distinctive alignments are visible on the airphotos. A regional normal fault known as the Shickshock fault, separates the volcanic and metamorphics of the Shickshock Group from the adjacent Silurian sediments for a distance of 40 miles or more northeast of Matane River. Southwest of the river, the fault separates mainly Quebec Group lithologies from Silurian and Devonian sediments. Beland (1970) describes the Shickshock fault as essentially a tear fault of mainly right lateral movement.

Faults of regional magnitude also occur in southern Gaspe. The largest of these is the Grand Pabos fault which separates beds of the Matapedia Group from those of Honorat Group between the Chandler area in the east to beyond the Cascapedia River in the west, a distance of more than 75 miles. The fault plane is essentially vertical with the downthrown side to the south in the Chandler area where it separates formations of the Silurian Chaleurs Bay Group on the south from the Matapedia Group on the north. Farther west, age relationships of lithologies on opposite sides of the fault indicate a net vertical movement of downward displacement to the north.

The Raudin fault converges with the Grand Pabos fault north of Chandler. It trends west-southwesterly for a distance of about 40 miles and in the eastern part forms the northern boundary of the Maquereau Group. The area of Maquereau exposures is bounded on the west and south by the Port Daniel River fault which is strongly arcuate and which displays a complicated history of development. The fault dips vertically in most places and due to rejuvenated movement shows changes in the direction of relative displacement along its length.

Faults of moderate to major magnitude are also apparent in the central Gaspe trough where their trend mainly conforms to the regional structural fabric. Several important fault zones in eastern Gaspe are traceable over distances of 25 to 35 miles. In most cases they trend northwesterly cutting obliquely across the east-west folds of the region and elsewhere they become parallel to the folds.

Westerly trending faults, mainly upthrown to the north, cut the southern flank of the St. John River anticline. In the eastern part of the anticline northwesterly trending faults intersect and displace the anticlinal axis and join the longitudinal fault on the south flank. Major lateral offset is also apparent near the west end of St. John River anticline where a northwesterly trending normal fault, upthrown to the southwest, and a related longitudinal fault on the south flank displace the anticlinal axis 2 miles to the northwest. A similar interruption in the axial trend of the Joshua anticline probably represents a westerly extension of this fault through the Bonaventure River area.

A persistent northeasterly trending fault extending 70 miles into the southwest map area separates beds of the Devonian York Lake, York River and Lake Branch Formations on the north from lithologies mapped as Fortin Group on the south indicating upward movement on the south side.

In general, geologic structure in the Siluro-Ordovician rocks of the St. John River anticline and southern Gaspe display greater structural complexity than is seen in the younger Silurian-Devonian sequence. In spite of this, evidence supporting the existence of a Taconic unconformity in the region is poorly defined and in some places continuous deposition may have occurred.

In the areas of Silurian-Devonian formations of the central and extreme southern Gaspe Peninsula, folding is the dominant structural mechanism while faulting plays an important but subordinate role. Folds are generally broad and elongate and often doubly plunging. Large areas of independent surface closure are present on several anticlines of the western map area. The Causapscal anticline displays an area of closure over 26 miles of length and 4 miles of width. Dips defining the northwest flank range most commonly from around 15° to 45° and those on the south flank are typically from 45° to 70° or steeper, imparting an asymmetric configuration to the anticline.

The northeasterly trending Albertville anticline lies 3 miles northwest of the southwestern end of Causapscal anticline in an en echelon relationship. The axis can be traced for a distance of about 25 miles. The area of the apparent independent surface closure is some 12 miles in length and three miles in width. The closure has been tested by Associated Development Causapscal No. 1 spudded in the valley of Matapedia River near the apex of the fold. The hole was reported dry and abandoned in 1958 after penetrating to a depth of 4,715 where it bottomed in the St. Leon Formation.

A pair of parallelling, northeasterly trending anticlines located west of Albertville anticline are referred to as the Humqui and Amqui anticlines. Both are broad, elongate folds exhibiting good northeasterly plunge in the vicinity of Lac au Saumon in the valley of Matapedia River. Good definition of surface closure is lacking due to poorly defined southwesterly plunge at the western edge of the project area. The regional configuration of formational contacts on the flanks of Amqui anticline suggest an area of possible closure on the axis three miles west of St. Leon Le Grande. A poorly defined apex may also be present in the area south of Lac Humqui on Humqui anticline. The axes of the two anticlines are separated by a distance of 4 to 5 miles and have lengths of 35 to 40 miles within the map area. A series of northeasterly plunging, relatively minor folds separate the two main anticlines northwest of Lac au Saumon. Although surface expression of bedrock is poor in many places, sparse field observations from published sources suggest the southeasterly flanks on both features are steeper than opposing flanks resulting in asymmetry to the southeast.

The largest anticlines in eastern Gaspe are the Joshua and St. John River anticlines. The Joshua anticline can be traced northeastward from the headwaters of Ruisseau Grand Nord to a point beyond St. John River, a distance of 55 miles. The anticline is narrow in relation to its length, elongate, and in some places broken by transverse faults and associated with minor folds. Poor surface expression of bedrock necessitates some generalization of the structure in the central and northeastern parts. In the Cascapedia River area of the southwestern Joshua anticline, surface expression is considerably better and the mapping is supplemented by field observations of Lajoie and Lesperance (1969). Reversals of axial plunge along the crest of the anticline are poorly defined, if at all present, and positioning of structural high points on the axis is difficult. An area of closure may exist near the northeastern end of the axis where opposing axial plunge is apparent over a 20 mile segment. Structural complications are apparent on the north flank where minor folds and at least one fault of considerable magnitude are mapped in an area of poor bedrock definition. The oldest rocks exposed in the core of the anticline are those of the St. Leon Formation.

The St. John River anticline roughly parallels the Joshua anticline some 5 to 6 miles to the south. This structure has a length of approximately 50 miles and is broken in several places by northwesterly trending faults which offset the surface trace of the axis as much as 2 miles. The horizontal component of the larger transverse faults is right lateral producing southeastward displacement of the axis as one moves from the western to the eastern end of the St. John River anticline. Limestones of the Matapedia Group are widely distributed in the core.

Good surface definition of other closed anticlines in eastern Gaspe is generally lacking. Moderately good expression of surface closure is apparent on Bald Mountain anticline over a length of 20 miles and a maximum width of around 4 miles. A westerly trending anticlinal axis emerges from a bifurcation on the northwest flank of the Bald Mountain anticline to form the Holland anticline. Two test holes on the crestal area of Bald Mountain anticline and three holes drilled in the vicinity of the Holland anticline to the west were all dry and abandoned although shows of oil and/or gas were encountered. Considerable drilling has been done in the area south and east of Bald Mountain

anticline. Most of the numerous wells in this area are shallow and have been located with little or no attention to surface structure.

An easterly extension of Bald Mountain anticline displays opposing plunge over a length of about 8 miles. The feature has been tested by 3 wells on the south flank all of which were less than 2,500 feet in depth and all of which encountered substantial shows of oil and/or gas.

Structural closure may also exist on the anticline 4 miles south of Bald Mountain anticline. Mississippi No. 1 drilled to a total depth of 5,995' and bottomed in beds of probable Silurian age. The hole was dry and abandoned.

The deepest hole in the area is Gulf Sunnybank 1 drilled in 1970. It reached a total depth of 11,800 feet and bottomed in the St. Leon Formation. The hole was continuously cored and was suspended in February, 1970. It is located near the axis of an easterly trending anticline 2 miles north of York River.

Numerous smaller positive features are mapped in the project area. Some of these are simple anticlinal noses with no reversal of axial plunge, and others display independent surface closure, occasionally associated with faulting.

In the Port Daniel area Silurian formations of the Chaleur Bay Group have been moderately to intensely folded forming a series of northeasterly trending anticlines and synclines. An area of closure mapped on an anticline southwest of Port Daniel in the southeast corner of map sheet no. 6, is about 5 miles long and 1-1/2 miles wide. Another anticline located 20 miles to the west-northwest exhibits closure over a length of about 12 miles and a width of over 1-3/4 miles. It is bounded on both flanks by longitudinal faults upthrown on the outer flanks.

CONCLUSIONS

Although emphasis in the brief foregoing discussion has been centered on areas of anticlinal surface closure, other structural environments may be equally effective in the entrapment of hydrocarbons in the Gaspe region. Numerous facies changes of both regional and local extent are known to exist in the Silurian and Devonian formations of the region. These include a variety of porous and permeable lithologies including reefal limestones and porous sandstones and conglomerates. Up-dip pinchouts of such porous and permeable beds may form effective traps in any area of appreciable structural relief.

Buildups of conglomerates or other porous clastics may be associated with irregularities on the surface of the Taconian unconformity. Such irregularities may result from an uneven erosional surface and from the effects of earlier folding and faulting.

Unconformities may also occur within the post-Taconian sediments although little direct evidence of this is seen to date. An heretofore unsuspected angular unconformity apparently exists at the base of the Battery Point Formation in central Gaspe. In view of the common occurrence of oil seeps in York River and Battery Point beds, such a structural relationship may be important in limited areas of central and eastern Gaspe and emphasizes the possibility of similar relationships in other parts of the sedimentary section.

Entrapment could be enhanced in many cases by faulting in association with structural highs.

Surface evidence of petroleum in the form of oil seeps and petroliferous limestones has been reported in numerous places in the Gaspe region.

Approximately 85 wells have been drilled in the Gaspe Peninsula, the great majority of these were drilled over 50 years ago and were located mainly on the basis of oil seeps and other visible signs of petroleum at the surface. In most cases they were located with little or no regard for geologic structure and were drilled only to shallow depths; thus they did not adequately test the potential of the area. In spite of this, most of the wells drilled encountered oil and/or gas

in noncommercial quantities mainly from Devonian formations.

Respectfully submitted,

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