Salt Basins in Nova Scotia

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ABSTRACT

Commencing in 1966, an assessment of areas in Nova Scotia considered to contain significant deposits of salt was carried out by government agencies and industry. This work covers all areas of the Province underlain by the Windsor marine sedimentary series of the Lower Carboniferous. This major geologic system contains practically all of the various industrial minerals produced in Nova Scotia.

Based on data accumulated through geological and geophysical work, drilling in a number of Windsor marine basins was carried out as a preliminary or pilot program to more detailed surveys. In all areas studied and drilled salt has been discovered.

Evidence to date suggests that all known salt deposits occur in the form of steeply dipping tabular on brecciated bodies of rock salt, having unknown thickness, extent and grade. Faults of a variety of magnitudes are present. The effects of these faults on the deposits are yet generally unknown.

INTRODUCTION

Within the past five years, more significant and meaningful exploratory work in the assessment of salt deposits of Nova Scotia has been carried out than at any one given period previously. This assessment has involved most areas of northern mainland Nova Scotia and Cape Breton Island.

Many preliminary geophysical and drilling programs have been conducted by government agencies and industry since 1965. Such government agencies include the Nova Scotia Research Foundation, Atlantic Development Board (Federal) and the Nova Scotia Department of Mines. In some instances this work was carried out as joint projects.

All this work was performed in areas of Nova Scotia underlain by the Windsor marine sedimentary series of Early Carboniferous (Mississippian) age. This geologic system provides practically all of the non-metallic mineral production in the Province.

During 1969, programs were conducted to arrive at a more comprehensive interpretation of the stratigraphy and structures of the basin areas in the north mainland and Cape Breton Island. This assessment, now in the preliminary stages, is expected to advance considerably during 1969 and 1970. These surveys, in conjunction with specific programs and studies by industry, should and will provide a sound basis for updating all interpretations with respect to salt basins in the Province.

Subject matter presented herein will also cover the prevailing geological thought concerning the Lower Carboniferous (Mississippian) insofar as it applies to the individual basins of Nova Scotia, with a view to providing insight into what has been done and what is proposed and designed to assist in the economic evaluation of salt deposits.

HISTORY

The earliest recorded attempt to produce salt in Nova Scotia was made in 1813 wherein a 200 foot shaft was sunk in the vicinity of a brine spring at Salt Springs, Pictou County. This venture is reported as unsuccessful but later reports indicate that some years later, brine from this area was used in the manufacture of salt. In the vicinity of Salt

Springs, Cumberland County, an attempt also was made to produce salt from a brine spring. This effort likewise met with little success.

During 1866 a company known as the Nova Scotia Salt Works and Exploration Company drilled a hole near Town Point, Antigonish County. No salt was encountered. A second hole was drilled near the present railway station in Antigonish. This hole produced a considerable amount of brine; however the strength of the brine decreased and the operation was abandoned.

In 1912 a well drilled for water, approximately 7 miles northeast of Malagash Station, Cumberland County, produced a strong brine solution. This discovery was followed a few years later by exploratory drilling, then by the sinking of a shaft. Salt was encountered at a reported depth of 85 feet from surface. The first production of salt from this area was realized in 1919.

Considerable thicknesses of salt were recorded in borehole put down by Imperial Oil near Nappan in 1931. Salt was first encountered at 920 feet; a total of 1640 feet of salt was penetrated in this hole.

Between 1942 and 1944 the Department of Mines carried out an investigation for salt in the Nappan area, intersecting a salt zone at 772 and 880 feet. These holes bottomed in salt.

Sun Oil Company drilled at Nappan in 1945, entered a salt zone at 1360 feet and continued in this deposit to a depth of 6,172 feet. During 1946 Maritimes Industries drilled two holes at Nappan and encountered salt at 812 feet. As a result a new industry was established in Nova Scotia.

During 1951 a program was carried out to assess the economic potential of salt and limestone in the Antigonish basin. This was done by the Nova Scotia Department of Trade and Industry. In this area three holes intersected salt but the economics of the day did not warrant the development of such a deposit.

Following the significant discovery of the salt deposit at Pugwash in 1953 little or no assessment of such deposits through drilling was carried out until 1965 and 1966. However, throughout this period numerous gravimetric surveys were conducted in many of the basin areas of the province by the Nova Scotia Research Foundation.

During 1965 the Nova Scotia Department of Mines, in association with the Atlantic Development Board and the Nova Scotia Research Foundation through a jointly financed program, undertook to assess an area in the vicinity of Malagash, Cumberland County, for salt and potash. This area involved 72 square miles.

During 1966 Dow Chemical of Canada and Canadian Industries, as a result of preliminary geological work and gravimetric surveys, carried out drilling programs for salt in the Port Richmond area of Richmond County on Cape Breton Island. During 1968 Domtar continued this assessment on Cape Breton Island by carrying out deep drilling programs near St. Peters and Kingsville in Richmond and Inverness counties respectively.

Again during 1968, Peel-Elder and New Senator Rouyn on a jointly financed program drilled two holes in the Colchester basin near Beaver Brook in Colchester County. Both holes encountered salt.

During 1969 Antigonish County was assessed for salt in the Pomquet area. This work was done by a private concern which encountered salt at 768 feet and bottomed in salt at 1200 feet.

GENERAL GEOLOGY

Salt in Nova Scotia occurs in the Windsor Group of marine sediments of Early Carboniferous (Mississippian) age. These Windsor sediments are part of a large Carboniferous basin which underlies eastern and southeastern New Brunswick, Northern Nova Scotia and Cape Breton Island. Sediments of this basin also occur seaward from these provinces, (Map 1).

The Windsor Group of sediments is more or less a conformable sequence which rests conformably to disconformably on the Horton Group of continental sediments or overlaps onto pre-Carboniferous rocks.

Bell (1929) divided the Windsor Group at the type areas near Windsor, Nova Scotia, into five subzones on the basis of fossil evidence, in ascending order subzones A, B, C, D and E. These subzones may be recognized in all Windsor areas in Nova Scotia and were further substantiated by Stacy (1953) and Sage (1954). This group has not been subdivided into rock stratigraphic units partly because of scarcity of outcrop.

A maximum thickness within the range of 3,000 feet is probably not unreasonable for a relatively undisturbed section of the Windsor sediments. However, in some areas the more plastic salt and sulphate members of the group have flowed and developed piercement structures during faulting and folding, this resulting in considerable thickening of the evaporite members. Holes drilled throughout the province have encountered more than 2,000 feet of evaporites, in most cases, mainly salt. In many instances holes bottomed in the evaporites.

MAP I

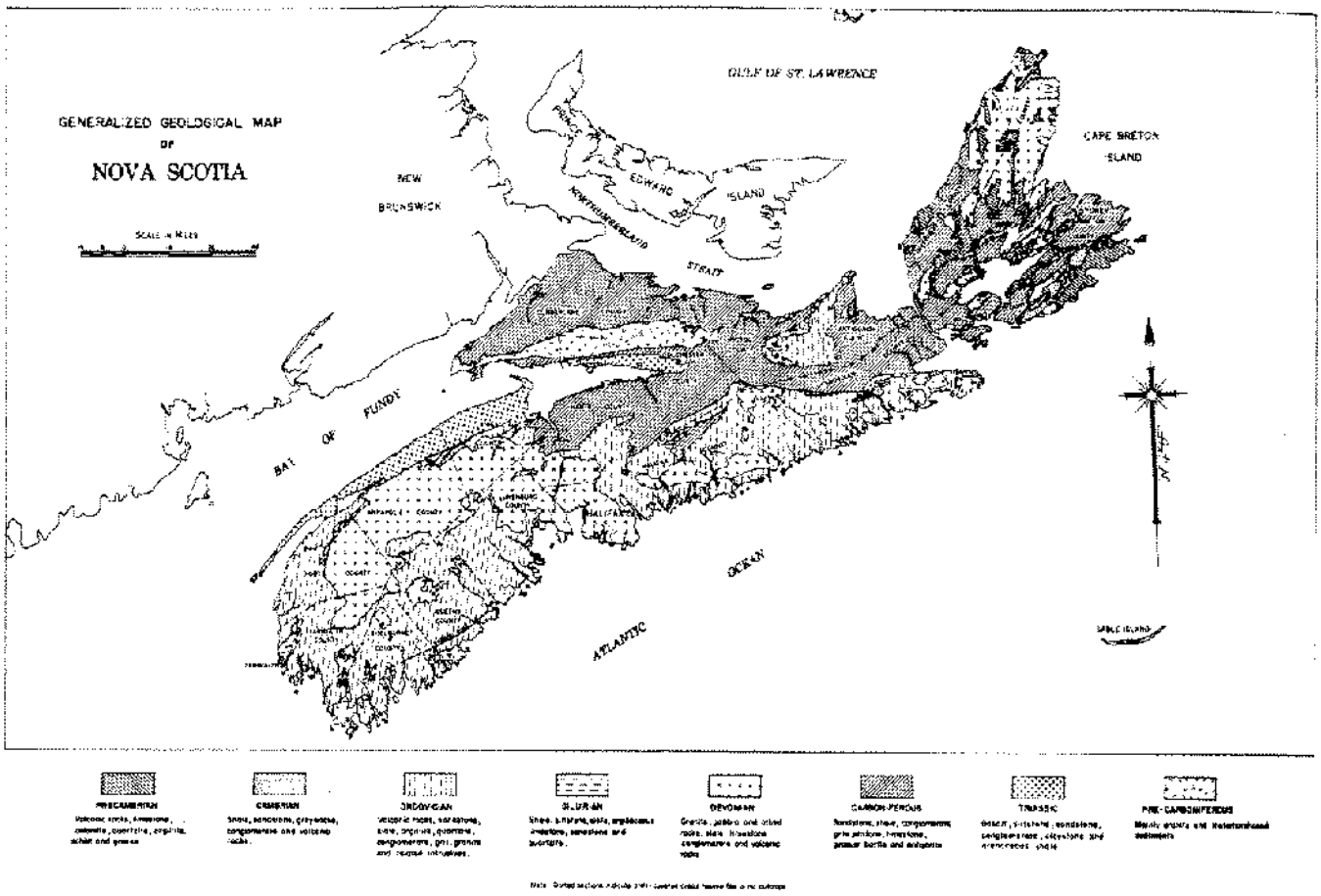

Figure 1.

Gypsum and anhydrite are present in practically all areas of Nova Scotia underlain by the Windsor Group. Their thicknesses range upward to many hundreds of feet. Various types of faults and folds and related structural features are quite common in Windsor basin areas, but in many areas cannot be interpreted due to lack of both surface exposures and comprehensive subsurface assessments. A comprehensive program of drilling is further needed before the prevailing conditions become more clear.

WINDSOR BASINS

General.

As mapped, areas in Nova Scotia underlain by the Windsor Group of marine sediments consist of approximately 1500 square miles. The greater percentage of this area occurs on the mainland in the north and north-central part of the Province.

As previously mentioned, the Windsor basins form part of a large Carboniferous basin which underlies portions of New Brunswick and Nova Scotia and extends seaward. This large basin is divided into four subbasins in Nova Scotia and are designated Cumberland, Minas, Antigonish-Mabou and Sydney subbasins.

The Cumberland subbasin underlies primarily Cumberland County and extends into Pictou County. The Minas subbasin underlies Hants, Colchester and Pictou counties. The Antigonish-Mabou subbasin underlies the counties of Antigonish, Inverness and Richmond. The Sydney subbasin underlies Cape Breton and Victoria counties.

In most cases the Windsor Group of marine sediments in the Cumberland basin are overlain by continental sediments of the Upper Carboniferous and are only exposed in isolated sections near Nappan,

Oxford, Pugwash and Malagash. The Minas subbasin exhibits the largest area of exposures of the Windsor Group on the mainland and contains limestone, dolomite, gypsum and anhydrite deposits from which production is now being realized. The Antigonish-Mabou (Ainslie) subbasin has many exposed or near surface deposits of Windsor sediments which consist of evaporites, some of which are now being exploited. The Sydney subbasin, the smallest, has received to date little or no assessment insofar as evaporite deposits are concerned, particularly salt deposits in the central part of this subbasin southwest of the city of Sydney.

For the purpose of this paper it has been decided to resubdivide the Carboniferous basin with respect to the counties which portions underlie. This will, it is hoped, simplify the interpretation of these basins with regard to what has been done through recent assessment and that which is proposed for future programs. These subbasins will now be referred to individually as the Cumberland, Hants, Colchester, Antigonish, Inverness, Richmond and Sydney subbasins.

CUMBERLAND SUBBASIN

Geology.

The Cumberland subbasin consists of a series of extensive Carboniferous sediments which lie north of an exposed ridge of older rocks that form the Cobequid Highlands Complex.

Thicknesses of these various sedimentary series are variable over the basin, but the total determined for the Pennsylvanian strata alone is in the range of several thousand feet. The Windsor Group is of marine origin with zoning determined primarily by fossil assemblages in limestone members. The thickness of the Windsor sedimentary rocks range upward to many thousands of feet or more depending in part, on structural influence.

Structure.

In the Cumberland basin, the Mississippian rocks are brought to surface along two major fold structures, the Minudie and the Claremont salt anticlines. The former passes through the Nappan area with a general northeast trend and has been mapped and interpreted in the vicinity of Oxford in Cumberland County. The Claremont anticline which trends N.70° E. to neareast extends from Springhill to Malagash Point, a distance of about 42 miles. Along this structure Mississippian rocks are exposed at or near surface over a width of 0.5 mile. Faulting, both parallel to and at right angles to this fold trend is prevalent, and has brought other blocks of Mississippian strata to surface or near-surface position. This is the case as found at Roslin in Cumberland County. The fold structure at Malagash is further complicated by local cross folding.

Recent Developments.

Although salt in the Cumberland basin has been known for many years and potash in association with some of the known deposits (Malagash and Pugwash) has been assessed, this basin required renewed studies in an effort to determine, as well as possible, the economic potential of the deposit.

Since 1954 the Nova Scotia Research Foundation has conducted geophysical, geological and geochemical studies of deposits in Cumberland County. During 1964 and 1965 the Nova Scotia Department of Mines joined in this program and conducted geological, magnetic and diamond drilling surveys on selected areas of this basin in the vicinity of Roslin and Wallace in Cumberland County.

As an outgrowth of gravity, magnetometer and geological surveys, the Department of Mines began a preliminary drilling program in the winter of 1965 at Malagash and Roslin in Cumberland County. Hole No. 1 at Malagash was drilled to a depth of 1000 feet. Salt was encountered at 800 feet, filling cavities in brecciated siltstones and shales; more massive salt was encountered at 900 feet and below. A second vertical hole at Roslin encountered small amounts of salt in brecciated siltstone at 400 feet with the salt content increasing in depth to 50 per cent in a grey brecciated siltstone. Unfortunately, and primarily due to the type of drilling rig, these two holes did not penetrate further into these structures. However, the results substantiate the gravity and magnetic interpretations.

Based on these preliminary holes, two additional deep bore holes were drilled in the Wallace area to a depth of 4,011 feet and 2,619 feet respectively. The first hole (Wallace No. 1) encountered salt at 2,740 feet and the second hole (Wallace No. 2) at 1,208 feet.

Wallace No. 1 intersected conglomerates, sandstones, shales, light coloured limestones, and calcareous sandstones of the Boss Point Formation. The top of the Windsor Group of marine sediments was encountered at 2,700 feet with first indications of salt at 2,746 feet. From here to bottom of hole, beds of grey, pinkish, and white banded halite alternating with beds of fractured and often

brecciated grey mudstone were penetrated. Throughout this hole a number of sections contain relatively thick beds or bands of grey to yellowish halite alternated with beds of mudstone breccia containing variable amounts of potassic salt, carnallite, and sylvite. Detailed logs of this hole are on file with the Nova Scotia Department of Mines.

Results of Hole Wallace No. 2 also showed interesting sections of potash, thus adding significantly to the data obtained from Hole No. 1. In short, a perfect batting average for a preliminary program; however, much exploratory work remains to be done before a comprehensive appraisal of the size and grade of the salt deposits and potash mineralization are known in this area.

MINAS SUBBASIN

General.

The Minas subbasin of the Carboniferous is that part of a basin of deposition south of the Cobequid Uplands and north of an upland in central Nova Scotia, extending from the Minas Channel to the Stellarton structural gap and as thus defined includes part of Hants, Colchester and Pictou counties. This subbasin merges with the Cumberland subbasin in Pictou County.

Carboniferous strata in this subbasin range in age from Early Mississippian (Horton) to Late Westphalian (Cumberland Group) and are overlain by nonmarine sediments of Triassic age.

In this environment the nonmarine sediments west of Pictou County contain many structural features. East-west longitudinal faults parallel with the axis of the Cobequid Uplands are dominant. Transverse faults are of secondary importance, some being younger in age than the longitudinal faults and offsetting them. Some of these longitudinal faults that affect the Pennsylvanian sediments are normal. As a result of many studies it has been concluded that the longitudinal faults that cut the Pennsylvanian rocks in this subbasin were all of post-Triassic age and thus have affected all formations in the Minas subbasin.

Hants County.

Hants County is underlain by sediments of this subbasin and range in age from Early Mississippian (Horton) to Triassic. The area generally extends from the Avon River to the Shubenacadie River and is transversed by such major structural features as the Walton anticline, Windsor syncline and Shubenacadie syncline. Superimposed upon these anticlinal and synclinal structures are a number of small anticlinal folds which have been delineated through mapping and preliminary test drilling. It is within these areas of this subbasin that salt deposits occur.

Wells drilled in the Falmouth and Kennetcook areas of this county recorded salt at depths of 543 feet and 1,200 feet and always associated with beds of anhydrite and limestone. In most instances these holes did not pass through the salt, usually bottoming in evaporites. It must be pointed out that all holes that have been drilled in Hants County were primarily put down to investigate petroleum and base metal potential. It was as a result of these surveys that significant salt deposits was first observed.

Recently a number of holes, drilled specifically to determine structure and to determine the potential for base metal and sulphur production have encountered salt structures at a depth of 1,700 feet. Unfortunately, because the primary purpose of these holes was not to evaluate salt and potash, further exploratory assessment ceased. Presently, the Nova Scotia Department of Mines and the Nova Scotia Research Foundation are reassessing this data with a view to carrying out further exploratory work.

Colchester County.

Carboniferous strata occur in Colchester County and are an extension of those in Hants County as part of the Minas subbasin. This would include formations of Early Carboniferous (Mississippian) to Triassic age. The more significant structures as found in Hants County can be traced into Colchester County, with names changed to fit the locality.

The Lower Mississippian (Horton Group) in this county may be estimated to have thicknesses up to 3,000 feet and consists of siltstones, fine to coarse grained sandstones, grits, and conglomerates.

The Horton Group as in Hants County is overlain by marine sediments of the Windsor Group and separated across contacts which may be either unconformable or disconformable. These soft marine sediments occur exposed or near-surface over approximately one-third of the county. It is generally accepted that these sediments also occur below the Triassic and Pennsylvanian sediments in the same area.

The Windsor marine sediments are basically divided into limestones, limestone conglomerates and evaporite units. They are classed as the Macumber Limestone, Pembroke Limestone Conglomerates, and undivided Windsor sediments. The undivided sediments consist of grey to black limestones, red-green shales, siltstones, sandstones, gypsum, anhydrite, and salt. All these Windsor sedimentary rocks

are present in Colchester County. With the probability of error, the maximum thickness of the undivided Windsor would be well in excess of 2,000 feet and certainly not less than 1,500 feet.

Throughout Colchester County, the rocks of the Carboniferous strata are, in general, more openly folded and unmetamorphosed. The Triassic rocks are relatively flat-lying and undisturbed.

In contrast to the older basement rocks, the Carboniferous of this county is little disturbed. Where dips of beds are steep and attitudes erratic, the cause may be generally due to local faulting and/or the flowage and expansion of the evaporite deposits. Regional dips are gentle. Folding throughout this area occurs below the Mississippian and Triassic. Pennsylvanian rocks have gentle regional dips except where disturbed by faults.

Sediments throughout this area have been extensively faulted. In most instances the structures of these Carboniferous lowlands are particularly difficult to define and only by the absence or repetition of units may faulting be assessed.

As briefly described, this is the geologic setting in which the assessment of rock salt deposits may take place. As in Hants County, rock salt is not seen in outcrop and not until late 1968 and early 1969 was any significant work (drilling) carried out to determine the presence of salt deposits. Throughout the county numerous brine springs are recorded, and some have been tested. The existence of these brine springs has led to a controversy regarding the presence of salt deposits of economic value. Most of the salt springs issue from rocks of Pennsylvanian and Triassic age which normally overlie the Windsor marine sediments from which is derived the salt content of the springs. As proven in other Windsor basins, most of the springs originate in the lower measures of the Windsor Group. Wright (1930) and others are of the opinion that moderately extensive salt beds and/or structures at depth exist throughout the county underlain by lower Windsor sediments but are sealed by overlying Windsor beds and Pennsylvanian strata.

Although considerable drilling has been done in Colchester County in the search for limestone, dolomite, gypsum, anhydrite, barite, and base metals, little or no drilling has been done specifically for salt or to obtain data for the interpretation of salt structures. As in most areas of Nova Scotia underlain by Carboniferous sediments any deep drilling carried out was in an attempt to assess petroleum possibilities at depth.

Recent developments.

As a result of gravity surveys in the Truro-Hilden-Beaver Brook area of Colchester County and the discovery of elemental sulphur in anhydrite during 1966, an exploration company selected two large gravity anomalies between Hilden and Beaver Brook to test.

Two vertical drill holes were spotted and collared over a large gravity low in the vicinity of Beaver Brook, Colchester County. This location coincides with an anticlinal structure which has a trend north-south and affects the Horton-Windsor and Triassic sediments in the area. It is questionable however, that the axis occurs as shown on surface maps due to the lack of interpretable outcrops.

The first hole was drilled to a depth of 1,404 feet and passed through a series of mudstones, siltstones, isolated bands of limestone, gypsum, and anhydrite to a depth of 1,317 feet. At this point salt in brecciated mudstones and siltstone was encountered and drilled for 86 feet to a depth of 1,404 feet. At 1,404 feet the hole was stopped due to difficulties in drilling. The hole bottomed in evaporites (salt). Visual estimates of salt in this hole as intersected range from 50 per cent to 95 per cent. Analyses of selected samples showed 96.1 per cent to 98.7 per cent NaCl.

Because of the data obtained from this hole, it was decided to drill a second vertical hole to a depth of 2,400 feet. The second hole was collared 100 feet southwest of the first and drilling began during the autumn of 1968. This hole encountered salt (the upper salt zone) at 1,286 feet and passed through salt for 65 feet. From 1,286 feet downward the hole intersected steeply dipping mudstones and salt, the salt ranging from 1 per cent to 80 per cent in some sections. Considerable brecciation and minor faulting was observed in this hole. Passing through 1,117 feet of mudstone and salt, this hole then encountered what is considered the main salt mass and remained in such to 2,400 feet. This hole also bottomed in salt. The salt (NaCl) here may be white, grey, or orange in color and may comprise from 50 per cent to 98 per cent of the section. Sporadic anhydrite and limestone were also recorded. It is interesting to note that at 2,240 feet a very strong odor of H_2S was observed in the hole, although no sulphur was visible in the core at this point. Dips in this hole ranged from 40 to 80 degrees throughout with pseudo-banding in the salt.

These two holes to date provide the only subsurface information in this basin; both holes intersect identical zones of undivided Windsor sediments and salt. Consideration is being given to deeper drilling and covering a similar anomaly in the same area.

North of Truro, in the Debert-Belmont area of Colchester County significant gravity lows have been delineated by the Nova Scotia Research Foundation. These gravity lows are considered to be related salt structures at depth in this area. To date, no subsurface assessment save gravity work has been attempted in this area. It is probable, following further gravity surveys, that preliminary assessment programs will be carried out in this area by drilling to determine bedrock structure and the existence of salt deposits as suspected in this part of Colchester County.

ANTIGONISH-MABOU (AINSLIE) SUBBASIN

This subbasin in part includes the Carboniferous strata that lies east of the uplands at the boundary of Pictou and Antigonish counties. The subbasin of deposition connects westward and south of the Pictou-Antigonish uplands with the Minas subbasin, and eastward beyond the Strait of Canso with the Carboniferous subbasin of western Cape Breton Island.

From the point of view of Carboniferous deposition the Ainslie area is an integral part of the Antigonish subbasin. This subbasin had direct connections with, or extended into areas of Carboniferous deposition in south-central Cape Breton that lay south of the Northern Tableland and west of the uplands of Kelly Mountain, Boisdale Hills, East Bay Hills and the southern upland of the island. Sufficient detailed geological work has not been done in the heterogeneous eastern end of the Antigonish-Ainslie subbasin to determine whether all of presently disconnected uplands were in the nature of "monadnocks" in the subbasin; or whether one or more were tectonically positive, having as it were a history of intermittent uplift by warping and faulting during early Carboniferous times (Bell, 1958). In most cases geologists feel that they were not positive areas complimentary to adjacent subbasins, but were more or less tectonically stable elements in the Antigonish-Ainslie subbasin and in the Bras d'Or subbasin which is generally considered as an arm of the former. It is within these subbasins of this part of Nova Scotia that salt has been found and thus these areas will receive further study.

Antigonish County.

Although salt in Antigonish County has been known for many years, no concentrated effort has been made by drilling to properly assess and interpret these salt structures. The Nova Scotia Research Foundation has carried out many gravimetric surveys and compiled significant data over the basin, outlining a number of gravity lows which are considered significant with respect to salt occurrences. Since 1951 and 1952 no appreciable drilling had been done until 1967 when an exploration company drilled some holes in the search for potash. Salt was encountered but no potash was found. During 1969 a private concern completed a hole in the Pomquet area of Antigonish County to a depth of 1,200 feet. This hole intersected shales, siltstones, and gypsum to 768 feet where it entered salt. The hole continued and bottomed in salt in 1,200 feet. The data from this hole are presently being evaluated.

Inverness County.

The Windsor Group of marine sediments is well developed in the lowlands of Inverness County and along the west coast and inland to Lake Ainslie and the Margaree Valley complex. This group is more easily denuded than the older or younger Carboniferous rocks and tends to underlie large and small valleys and overlap onto pre-Carboniferous basement rocks. These rocks underlie the major depressions marked by Lake Ainslie, Mabou Inlet and the various river valleys in this county. The Windsor rocks here are exposed intermittently along these valleys, but the most continuous exposures occur in the coastal areas.

The Carboniferous in this part of Nova Scotia forms a well defined lowland belt that extends in a northeasterly direction across the western part of Cape Breton Island. The most prominent structural features in this basin are plunging anticlines and synclines outlined by folded Carboniferous rocks and upwarped and upfaulted masses of pre-Carboniferous rocks. The Carboniferous folds are in part broken by faults and distorted by cross-folding. The development of the fold structures progressed by periodic movements during Carboniferous time. Minor uplifts occurred at the close of the Mississippian period and are indicated by the disconformable and locally unconformable relations of the Windsor Group to the nonmarine Horton Group. The comparatively restrictive size of the Carboniferous basins, the thickness of the strata that they contain, and their relation to the uplifted masses of pre-Carboniferous rocks have

suggested that slow progressive uplift of these masses accompanied Carboniferous sedimentation in the basins. Periodically the uplifts became sufficiently accentuated to deform the Carboniferous strata.

The general regional trend of folding in this part of Cape Breton Island is northeasterly to north-northeasterly and is evidenced by the major syncline that follows the valleys of the Mull, Mabou, Hay and Southeast Margaree rivers. The relationship of the minor northerly to northwesterly striking structures to the major folds of the area implies that cross folding and faulting were impressed on the regional trend after the main lines of deformation had been established.

The development of structures with an angular relationship to the regional trend of folding is exhibited elsewhere in Nova Scotia as in the Cumberland and Minas subbasin. The Windsor rocks there and in the Ainslie subbasin were brought up along the axis of a series of anticlinal folds striking in an easterly direction, and it is reported that along the folds they swell out in domelike masses (Norman, 1935).

Faulting is important throughout the Ainslie subbasins, striking either the faults parallel to the regional trend or cutting across this trend. Faults that strike northeasterly apparently developed as thrusts toward the axis of the Carboniferous basins. The large northwesterly striking faults are thrust toward the west and are downthrown on the west.

The estimated thickness of the Windsor Group in Western Cape Breton is between 2,200 and 2,700 feet and not less than 1,500 feet. In relatively undisturbed sections 2,700 feet of Windsor strata is not an unreasonable thickness. However, this thickness may be greater than the original thickness because the more plastic salt and gypsum members of the group were concentrated by expansion and flowage during folding and faulting. Evidence of such conditions is to be found in the abnormal thicknesses of gypsum and salt encountered during drilling of anticlinal structures.

Gypsum and anhydrite are common in the Windsor Group with the thickest units being in the lower Windsor. Salt is not known to outcrop but has been encountered in the Lake Ainslie and Mabou area of Inverness County. Many salt springs have been found throughout the Ainslie subbasin issuing from Windsor strata or overlying Pennsylvanian sediments.

As was normally the case in deep drilling in the Windsor (salt) basins, most programs were carried out to assess the petroleum possibilities in this area. This was the case in the Ainslie subbasin. Two deep holes were collared by the Lion Oil Company in the Mabou area and drilled to a depth of 5,579 feet and 6,689 feet respectively. Mac No. 1 encountered salt bearing strata at 1,400 feet and remained in the same to 5,579 feet for a total distance of 4,000 feet. The salt was found in brecciated zones of gypsum, limestone, shale, and siltstone. Mary No. 1 encountered salt at 4,480 feet and continued in it to 6,689 feet. The drilling sites, based upon interpretation of structure following seismic and gravity surveys, were along asymetrical folds with northwestward dipping axial planes.

During 1959 and 1960 Imperial Oil Company also drilled in the Port Hood-Mabou areas. Mabou No. 1 was drilled to a depth of 5,145 feet and Port Hood No. 1 to a depth of 9,840 feet. Port Hood No. 1 encountered over 3,000 feet of salt above the subzone "A" of the lower Windsor. This structure is assessed as a massive tabular body of salt. Selected analyses of this hole through the salt section gave up to 99.1 per cent NaCl. Analyses of these samples also gave up to 0.57 per cent KCl. These holes were drilled based on interpreted gravity surveys throughout this area. As a result of this drilling the diapiric nature of the salt mass has been established with sulphate and salt piled up on the axial region of triangular fault blocks.

Numerous salt springs are reported and found throughout this subbasin suggesting the presence of salt in the Windsor strata in many areas. Salt springs are known in the Whycocomagh, Bucklaw, Baddeck Bay and many other localities.

The Bras d'Or subbasin is considered an arm of the Ainslie subbasin and more or less contains structures similar to those found to the north with local variations. It is held that this subbasin had direct connection with the Antigonish-Ainslie subbasin. A southeastern boundary cannot be postulated for this subbasin until more knowledge of Carboniferous tectonic history of this area is forthcoming. It is considered, however, that the Bras d'Or subbasin was a heterogenous unit of deposition, marked by differential subsidence and it is presently advisable to consider this entire area a separate unit. A large part of this area is underlain by synclinal and anticlinal structures of Windsor strata, these also in turn cut by northeast and northwest trending faults.

It is within this area that considerable interest has been shown as a result of geophysical and drilling surveys in the assessment and study of salt and

salt structures. The areas around Kingsville in Inverness County were assessed during 1968 for this purpose by Domtar. These surveys were based on geological interpretation, followed by gravity surveys. The southern part of the Bras d'Or subbasin which contains a major syncline the axial region of which is occupied by Pennsylvanian strata has been named the Richmond subbasin by geologists and is entirely within Richmond County on Cape Breton Island. The Windsor Group in this area has been assessed as being 1,200 feet to 1,400 feet in thickness; however, structural changes and the expansion and flowage of evaporite deposits undoubtedly cause these thicknesses to be exaggerated.

Basically, this basin is a geosynclinal structure, tilted downward toward the east, and is further complicated by large faults and minor flexures. Small but significant anticlinal folds have been found in this area based on surface interpretation.

It is within this area near the shore of Inhabitants Bay that considerable interest has been directed to the assessment and study of significant gravity anomalies suggesting the occurrence of salt deposits. During 1967 and 1968, Canadian Industries and Dow Chemical have carried out drilling programs to assess the salt in this area. At the present time the policy of these companies does not permit the divulging of this data so obtained from these surveys. It may be said, however, that significant salt deposits were encountered at depths downward from 800 feet from surface.

SYDNEY SUBBASIN

General.

The Sydney subbasin exists along and inland from the northeast coast of Cape Breton Island. It lies east of a large pre-Carboniferous upland represented as the Northern Tableland, and pre-Carboniferous rocks of southeastern Cape Breton. This subbasin is found almost entirely within the County of Cape Breton and consists of considerable exposures of Pennsylvanian sediments. Marine sediments of the Windsor Group are exposed in this area southwest of Sydney. The general sequence of this group includes siltstone to conglomerate, limestone, dolomite, and gypsum on anhydrite. The thickness of this group ranges from 2,500 to 3,500 feet. In many areas the sequence of the marine Windsor strata is inadequately known so that a suitable evaluation and interpretation of events in the Sydney subbasin area cannot be made. Although considerable drilling has been done in this area, most of the holes were drilled to assess the coal deposits, limestone, and dolomite. The deep holes were drilled primarily in the Pennsylvanian sediments while only shallow holes were required to assess near surface limestones and dolomites for quarrying purposes.

It is thus necessary to propose that deep drilling to assess the Windsor strata and possible salt structures be carried out in Leitches Creek area southwest of Sydney. Presently, little or no comprehensive interpretation of events or conditions in this basin with respect to economic possibilities of rock salt can be made. The occurrence of an economic salt deposit here would be considered highly favorable due to its proximity to an industrial area and nearness to coastal and deep sea shipping.

AREAS OF INTEREST

Throughout Nova Scotia, particularly those parts underlain by the Windsor marine sediments, areas of interest with respect to salt deposits have been delineated. (Map 2). The areas shown have been identified on the basis of detailed or reconnaissance gravity surveys which have revealed large negative anomalies, these, in the Carboniferous sediments of this Province, probably being indicative of large salt bodies.

On the mainland in Hants, Colchester, Pictou, Antigonish, and Cumberland counties, in approximately 45 areas underlain by Windsor or younger marine sediments, significant negative gravity anomalies have been recorded. As shown on this map some such areas have been drilled and salt bodies intersected by one or more holes. Some of the salt bodies are now being exploited (see Cumberland County).

On Cape Breton Island, primarily in Inverness and Richmond counties, in areas underlain by Windsor marine sediments significant negative anomalies have been recorded. Some of these areas have been drilled and salt structures were encountered, particularly at Port Richmond in Richmond County and at Kingsville and the Port Hood-Mabou areas of Inverness County. These areas have been assessed by preliminary drilling programs. In the Port Hood-Mabou area this work was done with a purpose of assessing the petroleum possibilities, while in Port Richmond and Kingsville all drilling was done to assess the salt deposits.

Based on the results of the already established gravity surveys, it is obvious that more meaningful work will be needed to further assess and interpret the many areas that have the potential for salt

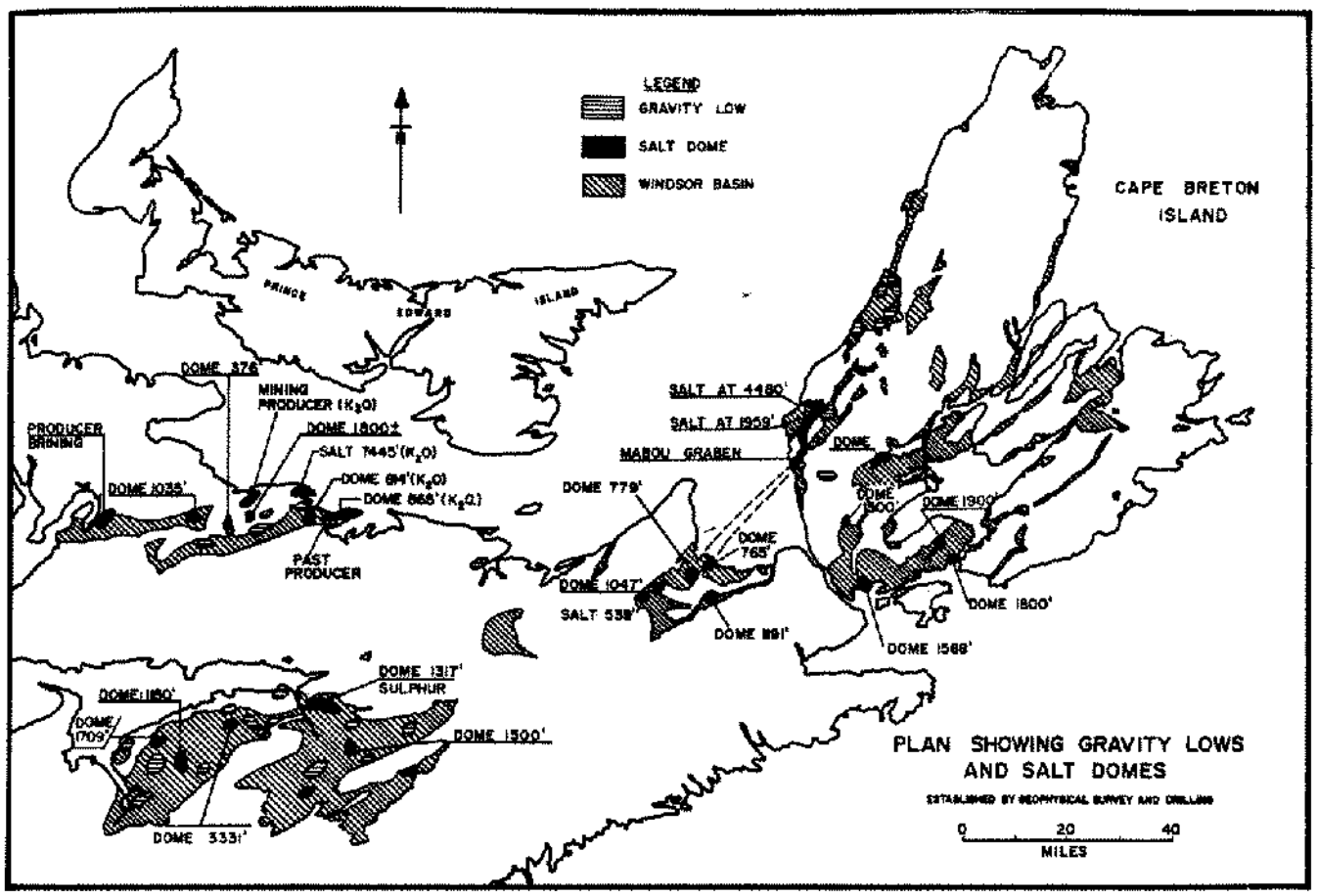

Figure 2.

production. Many of these areas will need further geophysical work followed by comprehensive drilling programs. Presently, plans are being formulated to begin this study which will involve the areas of Nova Scotia which lend themselves to favorable economic factors deemed necessary for the development and production of salt and related products, probably associated with the petrochemical industry.

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