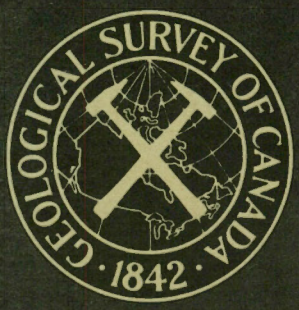

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 65-9

SALINA SALT BEDS SOUTHWESTERN ONTARIO

B. V. Sanford

Price, 75 cents

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INTRODUCTION

The discovery of salt in Ontario resulted from the early search for oil in the southwestern part of the province. In 1866, only a few years following the discovery of Oil Springs and Petrolia, a company was formed at Goderich with the object of drilling for oil on the outskirts of the town. Instead of finding oil, the drill encountered a 60-foot layer of salt at a depth of 944 feet, and thus a new industry was initiated almost overnight. Recovery was by the "Artificial Brine Method", a process which spread to additional centres in Ontario such as Kincardine, Wingham, Clinton, Exeter, Parkhill, Warwick, Sarnia, Corunna, Windsor and Amherstburg. As of 1964, brine was being recovered at only four of these localities, namely at Goderich, Sarnia, Windsor and Amherstburg. In recent years two salt mines have come into production, one located a short distance south of Windsor at Ojibway, which began operations in 1955, the other at Goderich which came into production in 1959.

Although salt has been produced continuously since its discovery in 1866, production figures are only reliable for the years 1895 to 1964 inclusive. During that interval however 41,129,108 tons valued at $213,961,438.00 have been recovered. Production during 1964 amounted to an estimated 3,265,905 tons (D.B.S. personal communication) which constituted 82 per cent of the Canadian total salt production.

Since the accidental discovery of salt nearly a century ago, several thousand wells have been drilled throughout southwestern Ontario, so that it is now possible to map the distribution of the individual salt units with some accuracy. The sample cuttings for a large number of these wells are on file at the Geological Survey of Canada and are the source of information for the maps issued in this report.

GENERAL GEOLOGY

Salt occurrences in Ontario are confined almost exclusively to strata of Upper Silurian age, and more specifically to the Salina Formation (see Fig. 1). The Salina outcrop belt extends from the foot of Bruce Peninsula on Lake Huron southeastward to Niagara River (Sanford, 1958). The formation is everywhere present in subsurface to the south and westward where it ultimately reaches a maximum thickness of 1,340 feet in a well located in a southern suburb of Sarnia.

A regional study of the Salina in the Michigan Basin by Landes (1945) resulted in a sevenfold subdivision by units designated from A to G in

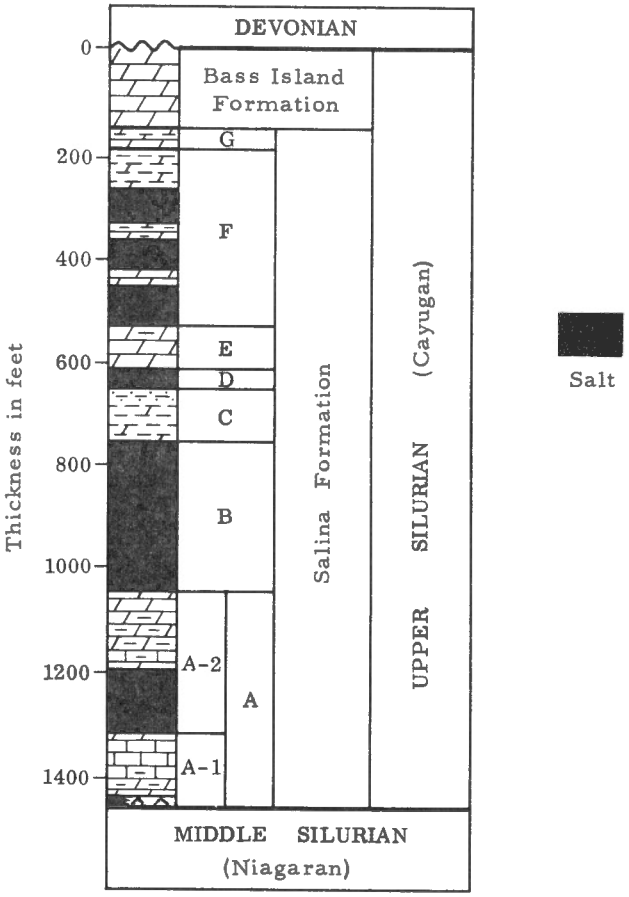

Figure 1. Generalized columnar section of the Upper Silurian rocks of southwestern Ontario.

ascending order. Subsurface studies by Roliff (1948) and Evans (1950) indicate that the units established by Landes are applicable in Ontario. A major contribution by Evans (1950) was the further subdivision of the A unit into A-1 and A-2 subunits.

Salt beds are contained within units A, B, D, and F. Where the total salts are present, the Salina reaches its maximum development. In Ontario this occurs along the shores of Lake Huron in the counties of Huron, Middlesex and Lambton, and in the northwest part of Essex county. Total salts reach a maximum thickness in excess of 700 feet in the Sarnia region (Fig. 2) and thicken westward into Michigan. Not all of the salt units are present throughout the area designated as total salts in Figure 2; the zero isopach line however in this figure coincides roughly with the areal distribution of the B unit salt which has by far the widest distribution of any of the saline units.

A Unit salts. The A unit is further subdivided into A-1 and A-2 subunits. The white and grey bedded anhydrite which normally occurs at the base of the A-1 carbonate throughout a wide area in southwestern Ontario adjacent to the Michigan Basin, gives way to salt in the lower structural part of the Basin. A-1 salt is known to occur at only two localities in Ontario, that is beneath the townsite of Goderich, and in lot 7, concession 6 East, Ashfield township, Huron county, where 13 and 5 feet are present respectively. To the writer's knowledge A-1 salt beds have not been encountered in any of the wells drilled south of Goderich, although they may be present beneath a large part of southern Lake Huron.

The A-2 salt (Fig. 3) is present in a wide region bordering and underlying Lake Huron. From its zero edge it thickens gradually westward to a maximum of 150 feet. At its depositional edge, the A-2 salt gives way to a thin zone of white and grey bedded anhydrite that can be traced over a wide area bordering the Michigan Basin. The somewhat crowded effect of the isopachous lines of the A-2 salt particularly along its southern boundary in Lambton county indicates that the zero isopach line in this region constitutes its solution edge.

During deposition of the A-2 salt, underlying Niagaran pinnacle reefs were of considerable structural relief and in some cases may have even projected above the depositional interface. Some 40 such reefs have been discovered to date in Ontario and invariably the A-2 salt grades to anhydrite above the highest part of the structure. Whereas up to 50 feet of anhydrite was deposited in the place of salt above some of the reefs, those along the eastern margin of the basin have merely a veneer of anhydrite.

B Unit salt. This unit is mainly salt, but may also contain numerous interbeds of dolomite and anhydrite. Whereas its present zero edge only slightly overlaps that of the A-2 salt in Huron county, it extends much farther to the east and southward to underlie parts of Kent, Essex, Elgin

and the southwestern part of Middlesex county (see Fig. 4). The B salt varies in thickness from zero at its solution edge to a maximum of about 300 feet at Sarnia. It reaches a thickness of 250 feet at Windsor, and an average of 150 feet where preserved in the "Chatham Sag" beneath the central part of Kent county.

Of the 40 bioherm pinnacle reefs discovered to date in Ontario, B unit salt is absent above 15. Unlike the A-2 salt however which grades to anhydrite above the reef, the B unit salt was present at one time above its crest and was subsequently leached. At the reconstructed depositional edge of the B unit salt, equivalent strata consist of dark brown anhydrite.

D Unit salt. The D unit salt forms a consistent blanket deposit over a wide region bordering Lake Huron, and is present in the extreme northwest corner of Essex county. Throughout the area of its distribution it has an average thickness of 35 to 40 feet, reaching a maximum of 50 feet (see Fig. 5). A characteristic feature of this unit is the presence of a thin dolomite bed at a consistent horizon in the approximate middle of the unit which can be traced over a wide area in subsurface. The presence of outliers of D salt in Moore and Enniskillen townships of Lambton county and fairly close spacing of the zero and 25-foot isopachs indicate that its southern boundary at least constitutes a solution edge. It would seem that there was not the same normal gradation from D unit salt to anhydrite such as occurred at the depositional edges of the A-1, A-2, and B unit salts. The D unit instead grades laterally to fine-grained dolomites. The absence of D unit salt above several bioherm reefs in eastern Lambton and throughout Huron county is the result of selective leaching.

F Unit salts. Although the F unit in Ontario may contain as many as four or five salt layers separated by dolomite and shale, they can be zoned into three subunits as shown in Figure 1. The lowermost subunit has somewhat wider distribution than the succeeding subunits which gradually recede one by one in a basinal direction. The combined F unit salts (see Fig. 6) vary in thickness from zero to a maximum of 300 feet at Sarnia. Although the initial distribution of F salts has undoubtedly migrated basinward from that of the preceding A-2, B and D salts, it is evident that this is due in part to removal by solution. Whereas the lowermost zone of the F unit salts grade to dolomite towards the margin of the basin, it would appear that each of the succeeding subunits interfingers laterally with anhydritic shales. As the overlying F unit shales shown in Figure 1 are traced westward into Michigan, they too become gradually displaced by salt.

STRUCTURE

The development of a thick Niagaran barrier reef complex surrounding the Michigan Basin had considerable effect upon the deposition

of Cayugan evaporites ultimately deposited within its boundary. The reconstructed depositional edge of salt as shown in Figures 2 and 4 closely parallels the very abrupt edge of the carbonate bank. During late Niagaran time (Middle Silurian) large bioherm patch reefs developed along the outer rim of the Michigan Basin immediately adjacent to the carbonate bank, while farther into the basin (Lambton, Middlesex, Huron and southern Bruce county) where subsidence was more rapid, small but very high (300 to 450 feet) pinnacle reefs developed. That the B unit Salina salt at one time covered the entire region between its present zero isopach and the reconstructed depositional edge (area shown in cross-hachure) and was subsequently removed by solution can be readily substantiated by detailed subsurface stratigraphy. Moreover, the period when leaching occurred, which varied greatly from one region to another can be accurately determined. Whereas the process of salt leaching occurred at various intervals beginning soon after its initial deposition to post-Upper Devonian time, the most extensive period of leaching particularly in Essex and Kent counties is known to have begun during late Bass Island time (late Cayugan) and continued into the Lower Devonian. Initial leaching began along the inner margin of the carbonate bank, and almost invariably above some structural irregularity such as a bioherm patch reef or a possible Salina A-1 or A-2 stromatolite mound. This resulted in development of a karst-like bottom topography with cavities on the sea-floor 300 to 400 feet in depth that gradually became filled with carbonate of the Bass Island Formation. As the remaining salts were removed on a more regional basis during the Lower Devonian hiatus which followed, thick carbonate mounds were left as monadnocks on the Upper Silurian surface, where they once filled local depressions. There are more than 30 such mounds in subsurface which occur throughout the present saltless areas. One such structure occurs at Walkerton in Bruce county and is exposed at the surface. It was formed by early leaching of Salina salts, followed by collapse. As Salina sedimentation (shales and carbonate) continued to fill the cavity, leaching gradually continued over a more regional area, leaving the thicker Salina beds considerably higher than regional attitude. Although the Salina was no doubt ultimately covered by Bass Island dolomite, the latter has gradually been removed by erosion over the highest part of the structure so that the Salina is now exposed at the surface.

As geological time passed, leaching processes moved basinward. Leaching is known to have taken place almost immediately following salt deposition in Lambton, Middlesex, Huron and Bruce counties but such instances are few and of local extent. In northern Kent county and adjacent region of Lambton, large-scale leaching and collapse took place during post-Upper Devonian time. Salts above 15 of the 40 pinnacle reefs located in Lambton, Middlesex, Huron and the southern part of Bruce county have been removed by solution resulting in major collapse of overlying Devonian strata. In addition there are numerous concentric and elongated collapse structures, some of which occur above small incipient bioherm reefs; others are in no

way related to reefs. Some of the latter, particularly the elongated collapse features have resulted from leaching along major joint or fault planes. Practically all of the significant Devonian oil fields in Ontario are known to occur in dome structures so developed by salt leaching and collapse.

The leaching of salts above prominent structures such as pinnacle reefs has proved an important aspect in their ultimate discovery. It has been pointed out that the A-2 salt changes to anhydrite above the reef, and that in some cases the B and D salts may also be missing. In such cases the density between salts which surround the reef, and the carbonates and shales which have collapsed into the cavity above it, are of sufficient contrast to provide a significant aid in the gravity prospecting for new fields.

In the saltless areas all known significant structures, whether they occur in A unit Salina, Middle Silurian (Niagaran), Middle Ordovician or Upper Cambrian, have anomalous thicknesses of Bass Island strata superimposed above. A detailed isopachous map of the Bass Island Formation for these saltless areas could well be a useful aid to future exploration.

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