Distribution of Salt in Southwestern Ontario and its Connection to the Late Silurian Paleoenvironment

Eric Pettipiece

Integrated Science Program, Class of 2023, McMaster University

SUMMARY

During the late Silurian period modern-day southwestern Ontario was located at tropical latitudes and covered by large epeiric seas. Evidence for these ancient bodies of water comes mostly from the stratigraphy of the regions previously overlain by the water. One such stratigraphic group that helps determine the extent and depth of these ancient seas is the Salina group, composed of carbonates and evaporites. Through an analysis of subsurface lithology data obtained from the Ontario Ministry of Northern Development and Mines a collection of maps has been produced in GIS that highlight the distribution and thickness of the salt layers of the Salina group in southwestern Ontario. These maps visualize the extent of the epeiric sea in the Michigan basin during different times of sea level drawdown and can inform discussions on the paleoenvironment of the late Silurian in this geographic region. Additionally, the Salina group has become an important economic resource in Ontario, and the maps presented here highlight potential areas for future inland mining.

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INTRODUCTION

During the Silurian period (443.8 - 419.2 Ma) continental land masses were not in the same location as they are today. During this period all the land on Earth was separated primarily into the two large continents of Laurentia and Gondwana (Ziegler et al., 1977). Modern day southwestern Ontario was located beneath an epeiric sea on the continent of Laurussia at a latitude of about 25° S, meaning that the climate of the region was tropical compared to the modern temperate climate (Cocks and Torsvik, 2011; Harrison III and Voice, 2018). This inland sea had three main basin's, namely the Michigan Basin, Appalachian Basin, and Illinois Basin, which were all separated by arches along their margins and connected to the Iapetus Ocean to the south and Panthalassan Ocean to the west (Harrison III and Voice, 2018; Oliver et al., 1989; Caruthers et al., 2018). Southwestern Ontario is located along the eastern margin of the Michigan Basin. During the late Silurian period, fluctuating access to the oceans allowed for the deposition evaporites such as halite, sylvite, and anhydrite in what is now known as the Salina group (Harrison III and Voice, 2018). The Salina group is composed of alternating carbonate and evaporite units that have been subdivided into the A-0 carbonate, A-1 evaporite, A-1 carbonate, A-2 evaporite, A-2 carbonate, B unit, C unit, D unit, E unit, F unit, and G unit (Harrison III and Voice, 2018; Sonnenfeld and Al-Aasm, 1991). Only the A-2 evaporite, B unit salt, D unit salt, and F unit were mapped in this project but a summary of the lithologies of the entire unit is provided in Table 1. This paper outlines the distribution of salt in SW Ontario and relates it to the paleoenvironmental conditions of both the Earth and Southwestern Ontario during the late Silurian.

The paleoenvironment of modern-day SW Ontario during the late Silurian period was characterized by conditions that are conducive to evaporite deposition. As previously discussed, the region was on the eastern margin of the Michigan basin, and therefore is thought to have been under a warm, shallow inland sea (Cocks and Torsvik, 2011; Harrison III and Voice, 2018). During the Wenlock epoch, prior to Salina deposition, vast pinnacle and barrier reef complexes formed along the margins of the Michigan basin. This now forms the Guelph formation, and the Salina group overlies it in many places (Caruthers et al., 2018; Sun, 2018). It is important to note that the Salina group was not deposited under one set of environmental conditions. The alternating beds of carbonate rocks and evaporites suggests that the Michigan basin went through several cycles of sea level drawdown or regional uplift that varied the margin conditions from shallow marine to sabkha-like (Sonnenfeld and Al-Aasm, 1991; Vrazo, Brett and Ciurca, 2016). Changes in the depth of the water

Table 1: Summary table of the composition and characteristics of each of the units of the late Silurian Salina group.

Unit	Composition	Characteristics
A-0 Carbonate	Micritic carbonate	Laminated
A-1 Evaporite	Sylvite, halite	Evaporite shows chevron crystal growth forms, suggesting shallow subaqueous deposition
A-1 Carbonate	Carbonate mudstone	Dark grayish brown in colour, fetid odour, some bituminous partings
A-2 Evaporite	Halite, anhydrite	More uniform in thickness
A-2 Carbonate	Dolomite	Large lens of oolites along the northern rim, rich in carbonaceous material in its base
B Salt	Halite	Coarsely recrystallized
B Unit	Interbedded salt, carbonate, and anhydrite	Distinguished from the B salt via gamma-ray logs
C Unit	Calcareous mudstone, intervals of anhydrite and dolomite	Distinctive orange/reddish-brown salt filling secondary fractures, high gamma-ray log values
D Unit	Halite, separating bed of carbonate mudstone	Thinnest unit, separated into upper and lower D salt by a carbonate mudstone, halite is coarsely recrystallized
E Unit	Fine grained dolomitic carbonate, minor shaley carbonate mudstone, significant intervals of anhydrite	Anhydrite is blue-gray, some fractures in the unit filled with reddish-brown halite
F Unit	Halite, interbedded dolomite and anhydrite intervals	F salt is coarsely recrystallized, contains vertically oriented halite crystals, ripple marks, and salt hoppers. Water salinity is thought to have fluctuated during F deposition due to the presence 6 salt units separated by beds of anhydrite and dolomite
G Unit	Dolomitic shale, some anhydrite	Dark gray colour, thins toward basin edges

level restricted ocean access to the basin due as it was bound to the south and east by structural arches (Sonnenfeld and Al-Aasm, 1991; Harrison III and Voice, 2018). As the depth of the water became shallower the brine concentration increased and evaporation occurred, allowing for the precipitation of thick beds of halite (Satterfield et al., 2005). It should be noted that the depositional conditions of the different salt layers in the Salina group were not identical. For example, the A-1 evaporite is thought to have been deposited during an exceptional period of basin restriction and constant high salinity that resulted in a thick halite bed interbedded with sylvite (Sonnenfeld and Al-Aasm, 1991) while the F salt unit was deposited during a period of frequent fluctuation in brine salinity, resulting in interbedded laminae of anhydrite (Harrison III and Voice, 2018). Moreover, halite growth is thought to have occurred in numerous ways, such as bottom growth, air-water interface salt hoppers, or subsurface salt hoppers (Dellwig, 1955; Vrazo, Brett and Ciurca, 2016; Harrison III and Voice, 2018). These differences in deposition highlight the instability of the late Silurian climate in this region.

The Salina group is buried under several hundred metres of younger rock and sediment. It is important to understand this overlying stratigraphy so the contact between the Salina group and younger rock is not confused. Immediately overlying the Salina group through nearly its entire distribution is the Bass Islands formation consisting, from bottom to top, of dolomitic shale grading into thrombolitic dolomudstone that is overlain by thick carbonate-evaporite beds, creamy homogenous dolomudstone or bituminous dolowackestone, and cream to buff homogenous dolomudstone (Armstrong and Carter, 2006; Sun, 2018). The Bass Islands formation is thought to be 75m thick in the area of study for this report and thins to about 15m in the Niagara region (Sun, 2018). The Bois Blanc formation sits above the Bass Islands formation and consists of approximately 50-75m of grey-tan brown or bluish grey finely crystallized limestone with abundant grey-white chert nodules (Sun, 2018). The Detroit River group consists of quartzitic sandstone, tan to grey-brown to dark brown, fine- to coarse-grained, bituminous, commonly cherty, fossiliferous limestones and dolostones (Armstrong and Dodge, 2007). The Detroit River group is thought to achieve a thickness of 106m near Clinton, ON southeast of Goderich (Hewitt, 1972). Above the Detroit River group lies the Dundee formation. The Dundee formation is a 35-42m thick unit of medium-grey to brown, fossiliferous, crinoid-rich limestone with common chert nodules (Sun, 2018). Other fossils found in the Dundee formation include brachiopods, corals, gastropods, and rare trilobites (Sun, 2018). The next-youngest major group in the Paleozoic stratigraphy is the Hamilton group, which is largely a calcareous shale-dominated unit with thin carbonate (limestone) dominated intervals; the thickness of the Hamilton group is between 24m and 90m (Hewitt, 1972; Armstrong and Dodge, 2007). The Kettle Point formation overlies the Hamilton Group and is composed of brown to black, laminated, organic-rich shales and siltstones with minor green bioturbated shales and siltstones and carbonate concretions in the bottom portions of the formation (Armstrong and Dodge, 2007). The thickness of this formation is between 12m and 88m (Hewitt, 1972). The youngest Paleozoic rocks found in SW Ontario are located in western Lambton county and consist of the grey shales, grey sandstones, and black shales of the Port Lambton group, which attain a thickness of approximately 60m (Armstrong and Dodge, 2007; Hewitt, 1972). No evaporites are found in any of the formations overlying the Salina group, suggesting that the late Silurian may have been the last time SW Ontario experienced sabkha-like environments. Mapping the thickness and distribution of the salt units in SW Ontario may help to determine how the extent of the epeiric seas changed during the late Silurian, which can inform paleoenvironmental reconstructions.

METHODS

Due to the ongoing COVID-19 pandemic at the time of this research it was not possible to obtain data from actual core samples found at the Ontario Oil, Gas and Salt Resources Library in London, ON. Nevertheless, mineral deposit data from drill cores in Ontario is logged in the mineral deposit inventory (MDI) database managed by the Ministry of Energy, Northern Development and Mines (MNDM) and this data was used to construct the maps presented here. The database contains over 32 000 entries covering a wide range of materials that can be searched through a downloadable Microsoft Access file.

Search Methodology

The Microsoft Access file used to search the MDI database allows users to filter results by criteria such as geographic region, commodities present, or the MDI index number if it is known. For this project, a simple query was constructed to filter the database for salt occurrences in the region of Southwestern Ontario. This search returned 165 records, which ranged geographically from La Salle in the south to Kincardine in the north. Interestingly, 165 of the total 166 salt occurrences logged in the database occur in Southwestern Ontario.

Data Collection

Each noted salt occurrence found in the MDI database has its own unique MDI number, which was used to access the online drill card through the MNDM search portal (http://www.geologyontario.mndm.gov.on.ca/index.html). The information from each drill card was transferred to a Microsoft Excel spreadsheet where the name of the drill hole, type of occurrence, coordinates, upper and lower salt depths for each unit, thickness of each salt unit, and adjacent rock units were recorded. Additionally, total salt thickness was calculated for each entry. Elevation data for each occurrence was obtained from Google Earth Pro and used to determine the upper and lowermost salt depths referenced to sea level; this ensured that the depth measurement of the salt units was not influenced by topography and provided a more accurate representation of the subsurface distribution of salt.

Data Management

Subsurface lithology data is never complete across all drill cores and therefore requires a consistent process for the treatment of missing or inconsistent data. In this project any Salina salt unit that was missing from a well record was taken to have no thickness in that location and not included in the final map. Noted salt occurrences that did not have any data were excluded from the final maps. Occurrences that were noted to have abnormally thick or thin salt layers compared to other occurrences were also compared to their five geographically closest occurrences. If the thickness was +/- 250% of the average from the surrounding units, the MNDM was contacted to clarify the discrepancy. If the MNDM confirmed that the data was correct it was included in the map as it appeared on the well card but if the entry was confirmed to be erroneous the updated value was used. If no response was received from the MNDM the occurrence was excluded as an outlier.

Mapping

ArcMap 10.7 was used to map all the data in this project. Each map was created by plotting the occurrences as an xy event layer using longitude and latitude as the x and y components, respectively. An additional z component was also added to the layer and represented either elevation, salt thickness, or salt depth, depending on what was being mapped. Following construction of the event layer an inverse distance weighting (IDW) interpolation was completed in order to create a map showing the gradual change in the z component through the mapped area. Each region was extracted from the original IDW plot using a polygon outline of SW Ontario and the extract by mask tool in ArcMap to create a more recognizable shape. The original IDW plot was included where it was thought useful.

RESULTS

Mapping the data from the MDI database created an interpretation of the distribution of salt in SW Ontario. However, these maps represent only a rough estimate of the salt distribution since the data available through the MDI is not complete and most of the entries in the database were lacking information on one or more of the salt units (either A-2, B, D, or F). As such, the maps created here are not fully representative of the actual distribution of salt in SW Ontario. Nonetheless, interesting trends can be seen in the maps and are worth noting. All the occurrences mapped in this project are shown in Figure 1.

The lowermost salt unit noted in the MDI database is the A-2 evaporite; Figure 2 shows the basal depth of the A-2 evaporite unit, referenced to sea level by subtracting the elevation of the drill site from the depth of the A-2 base. There is a definite shallowing trend visible in the A-2 unit moving eastward across SW Ontario. The full IDW plot is shown here because it better shows the trend than the extracted map. The lowest depth of the base of the Salina salts is 622.804 m near Sarnia and the shallowest depth of the base of the salts is 133.105 m to the east of Goderich.

The uppermost salt unit noted in the MDI database if the F salt unit; Figure 3 shows

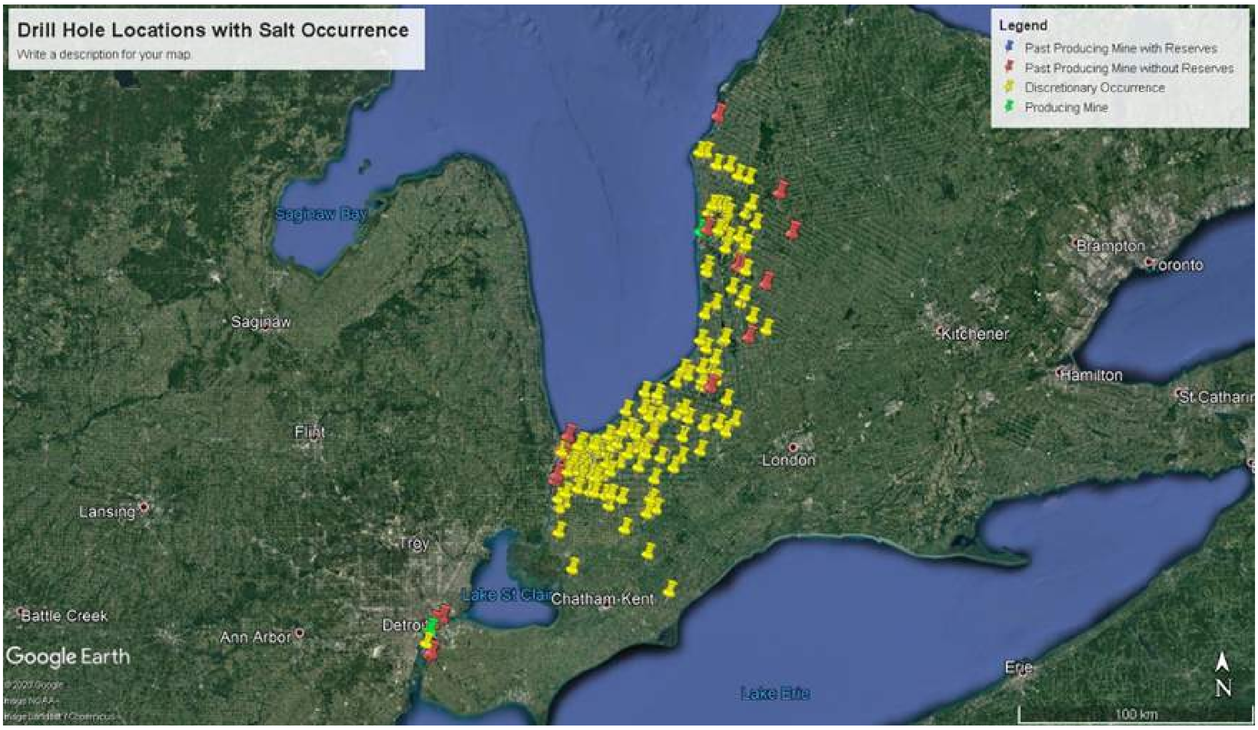

Figure 1: Overview of the study area for this paper and all the noted salt occurrences in the MDI database. Yellow pins represent a discretionary occurrence, red pins are past producing mines without reserves, blue pins are past producing mines with reserves, and green are currently producing mines. Image created in Google Earth Pro.

the upper depth of the F salt unit, referenced to sea level by subtracting the elevation of the drill site from the depth of the top of the F salt. The eastward-shallowing trend noted in the lowermost depth maps is further supported here, with a definite shallowing of the uppermost depth of the F salt unit to the east. The deepest occurrence of the top of the F salt unit was also near Sarnia and was determined to be 304.907 m, the shallowest depth of the F salt was east of Goderich at 42.671 m below ground.

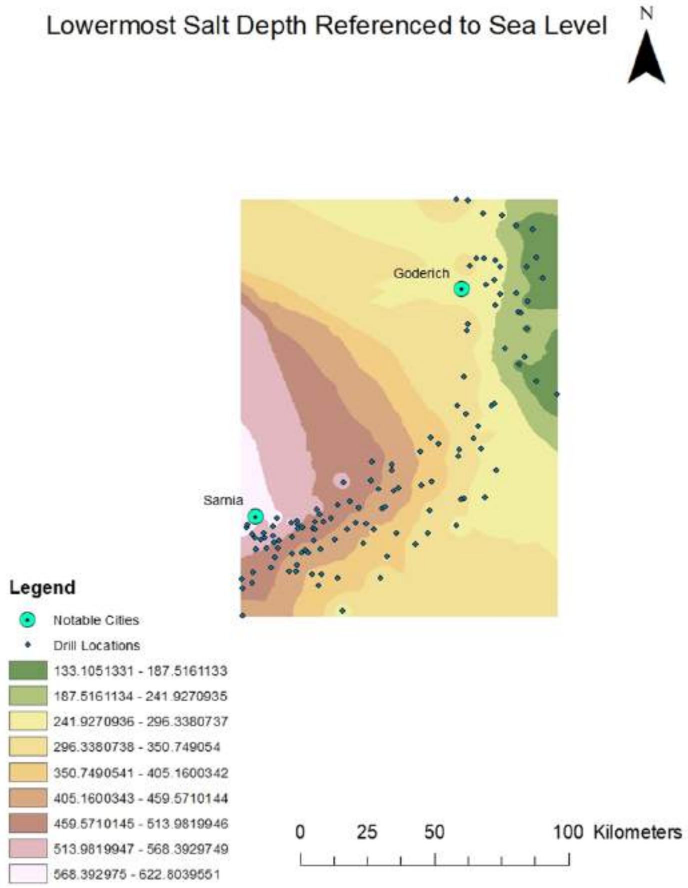

Figure 2: Full IDW plot of the lower salt depth in SW Ontario showing the depth change towards the basin margin. Centre of the basin lies to the east. Depth is in metres (n=124). The cities of Sarnia and Goderich have been added for reference locations; no occurrences of the A-2 evaporite were noted south of Petrolia and so the map does not include this region.

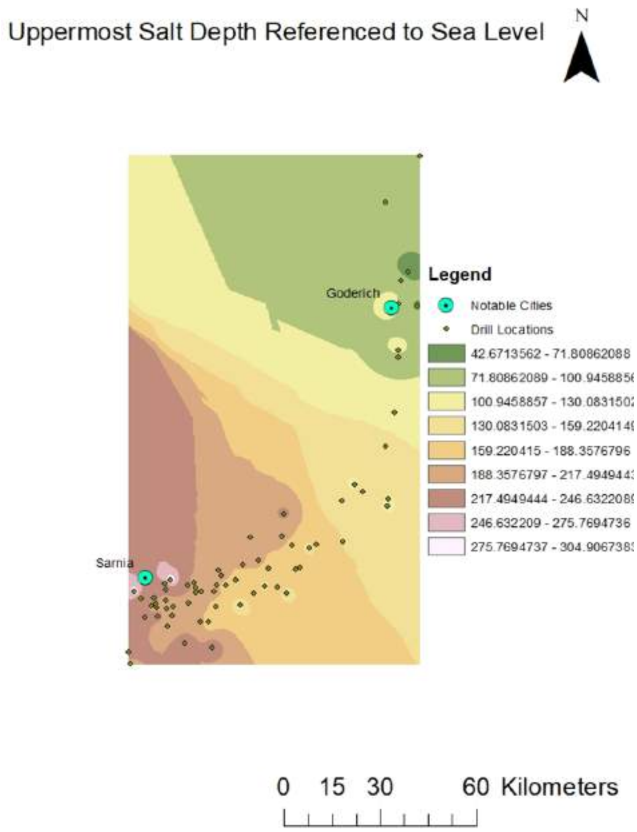

Figure 3: Full IDW plot of the uppermost salt depth in SW Ontario. Note the depth change (in metres) moving west toward the basin margin (n=68). The cities of Sarnia and Goderich have been included for reference. No occurrences of the F unit were noted in the MDI database south of the region mapped here.

The A-2 evaporite unit (Figure 4) is thickest to the southeast of Sarnia, measuring 65.704 m thick, but directly around the city of Sarnia and to the north of Goderich the unit maintains a moderate thickness of about 31 m. The thinnest occurrences of the A-2 evaporite are found about 60 to 80 km east of Sarnia and measure only 3.014 m thick. It is important to mention that there were no noted occurrences of the A-2 evaporite south of Petrolia and that the map shows this by not including the southernmost part of the study area.

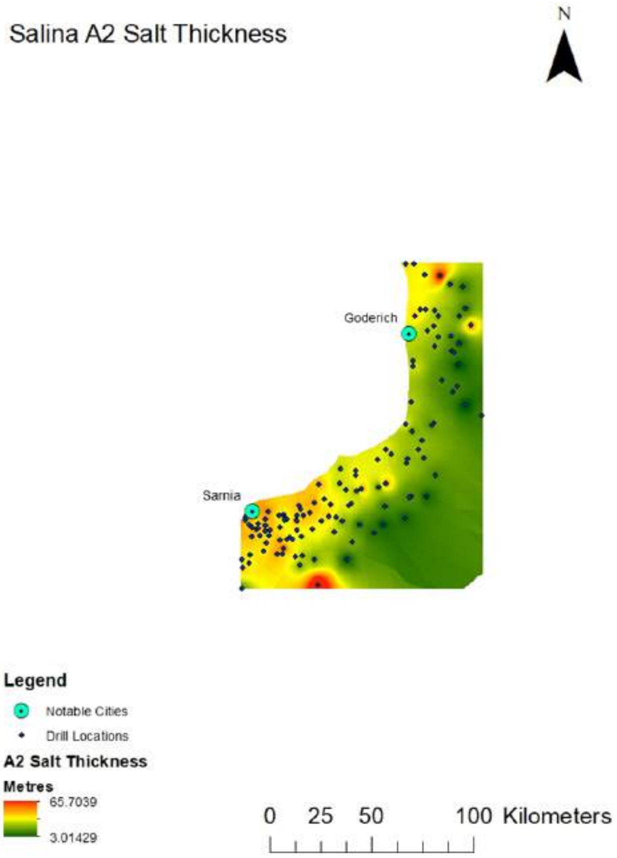

Figure 4: Thickness of the Salina A-2 unit from drill records; thickness is given in metres (n=124). Thickest salt deposits occurred around the city of Sarnia – included on the map for reference. No occurrences of the A-2 evaporite were found in the MDI database south of Petrolia, so this region was not mapped.

The Salina B salt (Figure 5) is thickest around the city of Sarnia reaching a maximum thickness of 115.628 m. The thinnest occurrence is located near Windsor and is 9.800 m thick. Interestingly, nine of the 10 thinnest B salt occurrences were brine fields that fell into the categories of "producing mine" or "past-producing mine without reserves" and five of those nine were located near the city of Windsor. Overall, the B salt unit is by far the thickest of any of the Salina evaporites in SW Ontario and has the most noted occurrences in the MDI.

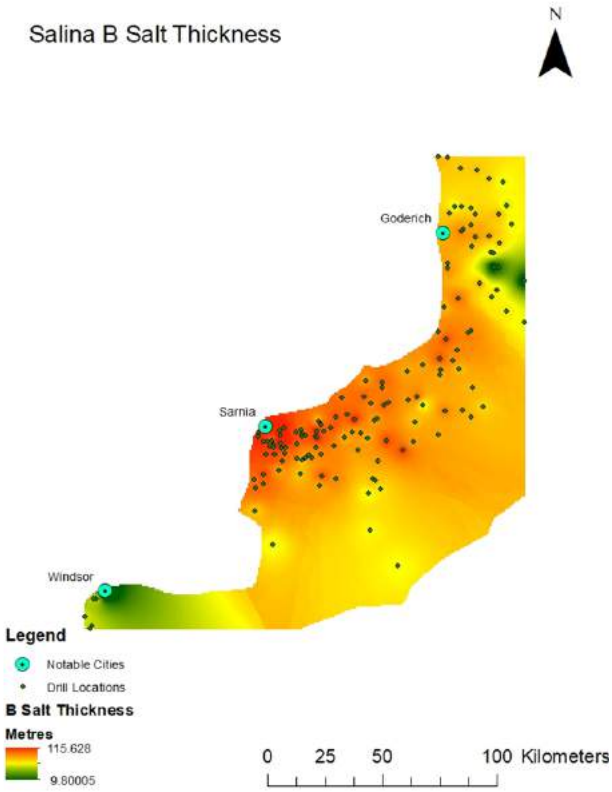

Figure 5: Thickness of the Salina B salt; thickness is given in metres. Note the large range in thicknesses (9.8m - 115.6m) (n=141). The B salt unit is the most documented and thickest unit of the Salina group and is distributed across the entire study area. Thickest occurrences were noted near Sarnia and the thinnest near Windsor. Interestingly, most of the noted occurrences of the B salt unit near Windsor were either producing or past-producing mines.

The D salt unit (Figure 6) is thickest to the east of Sarnia with a maximum thickness of 20.919 m. From the data it appears that the D salt thins to the northeast approaching Goderich, reaching a minimum thickness of 5.000 m just to the northeast of the town. It is difficult to tell how this unit is distributed elsewhere in

SW Ontario due to a lack of data. The D salt is by far the thinnest and least noted (n=47) salt unit in the Salina group. Two occurrences of the D salt, measured at 85.3m thick and 118.8m thick, were considered outliers and discarded from analysis due to them being 4.00x and 5.58x thicker than the next thickest D salt occurrence (21.3m) and over 250% greater than the five geographically closest D salt occurrences. Note that the map of the D salt unit does not extent to the south towards Windsor because there were no noted occurrences in the MDI database for that region.

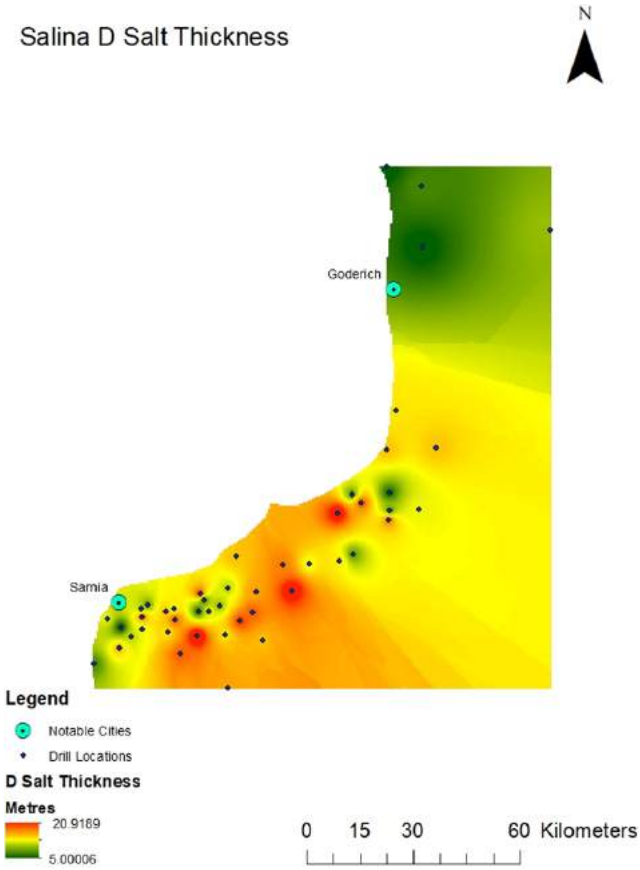

Figure 6: Thickness of the Saline D salt unit; thickness is given in metres. Two noted occurrences of the D salt were excluded from the analysis as they were extreme outliers and likely an error in the MDI database (n=47). The D salt unit is the overall thinnest and least documented salt unit of the Salina group, but still follows similar trends as the other units with the thickest occurrences located near Sarnia. No occurrences of the D salt were located south of Petrolia.

Salina F salt distribution (Figure 7) follows the same trend as all other salt units in being thickest around the city of Sarnia and thinning towards Goderich as well as to the southeast. Maximum thickness is 123.407 m and minimum thickness is 0.404 m; this means that the F salt unit is both the thickest and thinnest of the entire Salina group, depending on location. The F salt was deposited during a period of frequent salinity fluctuation and as such is not a continuous solid bed like the A-2 or B salt (Harrison III and Voice, 2018). F salt thickness in this report therefore is the undifferentiated thickness, determined from the top and bottom noted occurrence of the unit and ignoring interbedded anhydrite or carbonate rocks. This was done to achieve consistency as some drilling companies noted the thickness of each individual F salt bed whereas other companies only noted the undifferentiated thickness.

Total salt thickness (Figure 8) was taken to be the thickness of the separate salt units (A-2, B, D, F) added together. The thickest salt appears to be concentrated around Sarnia with rapid thinning as one moves south and east. However, it is difficult to elucidate a trend from this data because the drill hole data around Sarnia is far more complete than the data from other areas, usually noting all four units in the drill card whereas other occurrences near Windsor and Goderich do not.

Figure 7: Thickness of the undifferentiated F salt unit; thickness is in metres (n=68). This unit is measured as its total undifferentiated thickness of halite, anhydrite, and carbonates because of its laminae-like bedding. Additionally, the undifferentiated thickness is easier to report for consistency among drill cards. The F salt unit is the most variable in its thickness of any of the Salina salt beds, with a range of over 123 m between its thickest and thinnest point. No occurrences of the F salt were noted towards Chatham or Windsor.

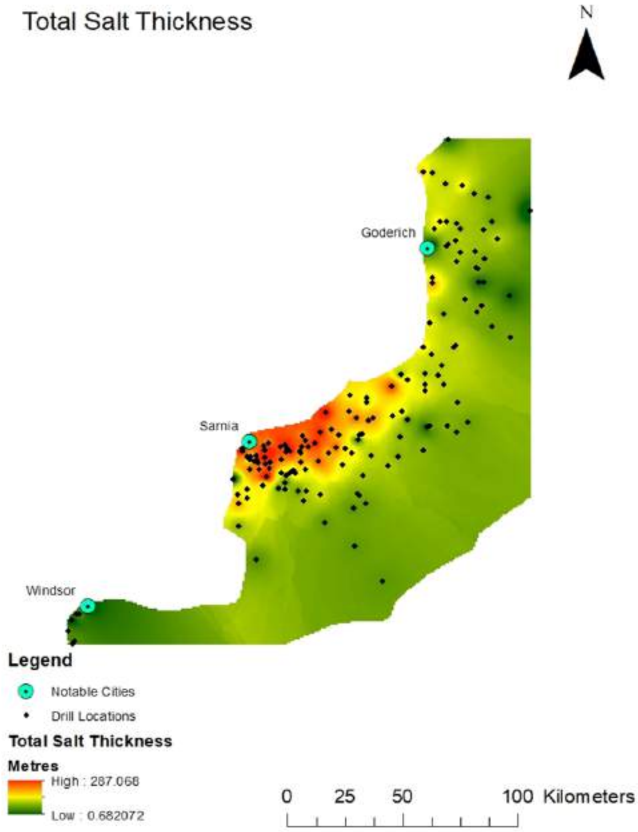

Figure 8: Total salt thickness in SW Ontario obtained by summing the thicknesses of the different salt units. If a unit was not mentioned in the drill data, its thickness was taken to be 0; noted occurrences with no thickness data were excluded (n=155). The thickest occurrences of salt in the study area occurred near Sarnia, and the thinnest near Windsor and to the east of Goderich.

DISCUSSION

Variability in the thickness of the salt units is expected and the eastward shallowing trend seen in the maps is consistent with the positioning of the Michigan basin. This data provides an estimate for the edge of the ancient epeiric seas during different periods of evaporite deposition. For example, the thicker B salt unit across the entire study region suggests that the extent of the sea was greater during this time than during deposition of the D salt unit. Some of the data used to create the maps in this paper may not provide the full picture of the actual thickness of the salt units for several reasons. In all noted salt occurrences, there is no mention of the A-1 evaporite unit, suggesting that no core was drilled deep enough to encounter the halite and sylvite deposited here. This raises the question of if the A-2 evaporite thickness reported in the drill cards is the complete unit or simply the lowest depth to which the core was drilled. Additionally, the highly variable F thickness is not completely explained by the fluctuating salinity during its deposition and likely is due to different methods of reporting between drilling companies. Until a consistent and universal method for reporting the Salina unit groups is developed the thickness of the F unit reported in databases will remain highly variable and inaccurate.

Some of the most powerful tools used in paleoclimatic recreation, such as stable isotope geochemistry, struggle with Paleozoic samples since many rocks of this age have been diagenetically altered and no longer have their original chemical signature (Munnecke et al., 2010). However, combining multiple stable isotope data with sea level analysis, biological proxies, and fluid inclusions can provide a rough picture of the late Silurian climate (Munnecke et al., 2010). According to Munnecke et al. (2010) and Caruthers et al. (2018) the climate of the Earth during the late Silurian period was unstable and characterized by strong swings in eustasy, high biotic turnover, and variable ocean temperatures. Fluid inclusions found in halite are an effective method of determining the brine and air temperature during the time of deposition (Sun et al., 2017). Determination of paleobrine temperature is most often accomplished through an analysis of fluid inclusions in halite where the homogenization temperature of the fluid inclusion is taken to be the temperature of the brine during deposition (Sun et al., 2017). Dellwig (1955) used samples from the Salina A unit and recorded homogenization temperatures ranging from 32.0 - 48.4 ℃; Losey and Benison (2000) recorded homogenization temperatures ranging from 19.8 - 59.0 ℃ (Salina unit not specified); Satterfield et al. (2005) noted homogenization temperatures in the range of 5 - 25℃ (F salt); Davis (2018) identified homogenization temperatures ranging from 13.3 - 35.2 ℃ (A-2 evaporite and B salt). Halite fluid inclusions are also useful for the determination of major ion ratios in ancient seawater. Brennan and Lowenstein, 2002 demonstrated from fluid inclusions in the A-1, A-2, and B evaporites that Silurian seawater had lower concentrations of Mg2+, Na+, and SO42- than modern day seawater and higher concentrations of Ca2+. These results were also found in a study of the F salt unit, which suggests that the major ion composition of Silurian seawater remained largely unchanged during the late Silurian (Satterfield et al., 2005). It has also been suggested that the Paleozoic calcite seas were a result of this major ion composition rather than the partial pressure of CO2 in the atmosphere (Brennan and Lowenstein, 2002). Therefore, the halite deposits of the Salina group are important geological tools that can aid in the reconstruction of the otherwise difficult late Silurian paleoclimate.

In addition to its use in paleoenvironmental reconstruction, the Salina group is an important economic resource in Ontario. The salt itself is intrinsically valuable, especially considering Canadians are the highest per capita consumers of salt in the world (Dumont, 2008) – due mostly to the extensive road de-icing in the winter months. In 2015 Ontario produced 9.8 million tonnes of salt from the mines and brine fields in Windsor and Goderich with an estimated value between $501 million and $536 million (Sangster et al., 2016; Ontario Mining Association, 2015). In 2018 Ontario produced 6.5 million tonnes of salt from mines and brine fields in Windsor and Goderich; the estimated value of this salt was $239 million (Tessier et al., 2019). Additionally, the salt mining industry provides many jobs in Ontario, with over 900 personnel directly employed at the facilities in Windsor and Goderich and many more working at downstream jobs (Tessier et al., 2019). The Salina group is also closely associated with the oil and gas industry in Ontario as its salt beds act as a seal on oil and gas reserves found in carbonate rocks, such as the underlying Guelph formation. A recent OGS report identifies that there has been little interest in developing new oil or gas wells in Silurian carbonates (Tessier et al., 2019). This lack of interest has been attributed to years of natural gas oversupply from the United States, making development of new wells in Ontario economically impractical. However, while new wells may not be in the best financial interests of companies such as Enbridge, the Salina group halite beds provide other benefits. For example, Enbridge operates the Dawn storage facility south of Sarnia that stores natural gas in the depleted Guelph formation and uses the Salina unit as a cap seal (Union Gas, 2020). This facility has a total storage capacity of 272.4 billion cubic feet and is one of the most important storage facilities in North America (Enbridge, 2020). In Michigan the Salina A-2 evaporite and B salt units are used to directly store natural gas and other petroleum liquids, offering over 600 billion cubic feet of storage capacity (Harrison III and Voice, 2018; ICF Consulting and PEG and Exel Consulting, 2004). This is accomplished via solution mining of the salt units until a large cavern is created, at which point natural gas or other petroleum liquids are pumped in.

Sources of Error

It is important to reiterate that the maps produced here are estimates of the distribution of salt in SW Ontario and are limited by the quality of the data found on the MDI database and the software used to generate the interpolations. In the face of poor data quality this project focused on consistent treatment of the data as described in the methods to provide the most accurate maps possible.

Next Steps

Further analysis of salt occurrence data in SW Ontario, either from the MDI or another source, should be completed to ensure that the most-complete image of salt distribution is achieved. This could be supplemented via analysis of drill core logs found at the Ontario Oil, Gas & Salt Resources library in London, ON. Once a more comprehensive 2D view of salt distribution has been achieved, 3D modelling is the next logical step in gaining a better understanding of the true distribution of salt in SW Ontario and would allow for better understand the extent of the epeiric seas throughout the late Silurian.

CONCLUSION

The late Silurian arid tropical paleoclimate of modern-day southwestern Ontario and the presence of an ocean-fed epeiric sea on the continent of Laurussia made an ideal scenario for the deposition of thick beds of halite. The Salina group, located in the Michigan basin, is one such example of this halite deposition and can be found in SW Ontario. The Salina group is composed of alternating beds of carbonate rocks and evaporite minerals, and has been separated into seven units denoted A to G. The A-1 evaporite, A-2 evaporite, B salt, D salt, and F salt are known to have reached halite concentrations and the latter four have been mapped in this report using data from the Ministry of Energy, Northern Development, and Mines mineral deposit inventory database. Notable trends extracted from an inverse distance weighting analysis in ArcMap 10.7 include the eastward-shallowing of the Michigan basin and the seemingly high concentration of salt in the Sarnia-Lambton region. The Salina group is capped by the Bass Islands dolostone for nearly its entire distribution (Armstrong and Carter, 2006). The economic importance of the Salina group cannot be understated, representing nearly two thirds of total salt production in Canada (Sangster et al., 2016), adding hundreds of millions of dollars to the provincial GDP, and supplying Ontarians with hundreds of jobs. The salts of the Salina group provide a unique look into the geologic history of SW Ontario, and further analysis of their distribution would likely yield interesting results.

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