Sedimentology and Stratigraphy of the Salina Group (Upper Silurian) in East-central New York

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Abstract

The available evidence from outcrops suggests that the Salina Group of east-central New York was deposited in peritidal environments of a transgressing epeiric sea. Sedimentologic criteria suggest that the depositional environments were hypersaline with evaporites including halite deposited. The lithofacies of the Salina Group and the restricted fauna are characteristic of hypersaline conditions. The units underlying and overlying the Salina Group are "normal" marine carbonates.

Evidence from outcrops and subsurface studies indicates that the evaporites were deposited in environments which may have ranged from shallow water to supratidal. Thick accumulations of Salina Group rocks resulted from structural activity within the depositional area rather than from infilling of a deep topographic basin.

Introduction

The Salina Group of New York State is one of the major salt producing units in the United States. The production of salt from mines or brine wells has been quite important in the history and industrial development of central New York State. The salt was a major factor in the building of the Erie Canal and in the history of the city of Syracuse. During the War of 1812, salt production began at Syracuse as the result of the high prices for imported salt. During the Civil War, Syracuse salt production freed the North of salt worries while a lack of salt in the South influenced the duration of the war. Production from the Salina Group at Retsof, New York, began nearly one hundred years ago, and today the Retsof mine is reported to be the largest producer of rock salt in the world (King, 1966).

In spite of the economic and historic importance of the Salina Group relatively little is known about the depositional history of this unit. Several important studies have been made of the Salina Group (Clarke, 1903; Leutze, 1956; 1959; Rickard, 1969), but most of these have emphasized stratigraphy rather than its sedimentologic history. Alling (1928) discussed, in detail, the sedimentology of the Salina Group, but his study is now dated even though it contains much useful information. Alling and Briggs (1961) and Rickard (1969) have summarized regional relationships of the Salina Group in the Appalachian and Michigan Basins, but do not treat the sedimentology in a detailed manner.

Recent controversies over the origin of sedimentary evaporites have spurred interest in carbonate-evaporite sequences throughout the world (Shearman, 1966; Buzzalini et al, 1969; Kudryavtsev, 1971; Friedman, 1972). Therefor, a study of the sedimentology of the Salina Group takes on additional interest. In studying the sedimentology of the outcropping Salina Group, limits can be placed upon the environments of evaporite deposition by interpreting the environments of deposition of the interbedded non-evaporite sedimentary rocks.

The purposes of this field trip are 1) to observe the stratigraphy of the Salina Group especially as it relates to sedimentology, 2) to interpret depositional environments, and 3) to gain some insight into the conditions which might have contributed to evaporite formation.

This paper first presents the stratigraphy of the Salina Group. Stratigraphy is essential in ascertaining the lateral relationships of the units and their bearing on the sedimentology. Following the stratigraphy is a section dealing with environmental reconstruction. These environmental interpretations are based on the sedimentologic and stratigraphic relationships of the various units of the Salina Group. Localities at which the Salina Group will be examined are shown in Figure 1.

Stratigraphy

The Salina Group of New York State was deposited during the Late Silurian (Cayugan Epoch) in the northern portion of the

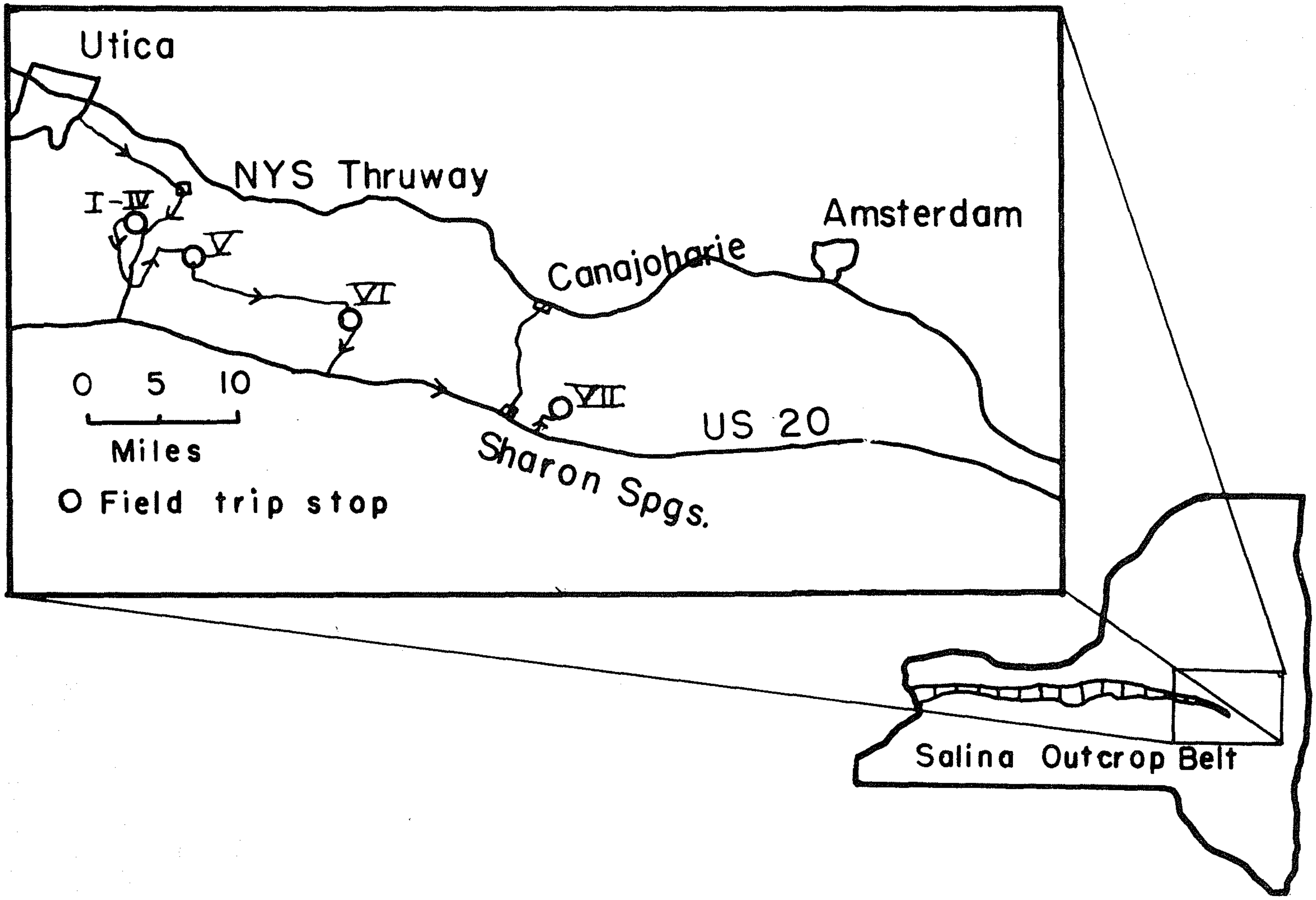

Fig. 1. Sketch map of field trip area showing location of stops and of the Salina Group outcrop belt.

Appalachian Basin. It is underlain in most of the outcrop belt by the Lockport Group (Niagaran Series- Middle Silurian); toward the east the group lies on progressively older rocks (fig. 2). The outcrop belt of the Salina in New York is an east-west trending belt up to ten miles wide (fig. 1). This outcrop belt lies along the boundary of the plateau front to the south and the lake plain to the north. The eastern limit of the outcrop belt is in the vicinity of Schoharie. To the west, exposures extend through the Buffalo region into Ontario; outcrops west of Auburn, however, are quite poor and widely scattered. The best area for outcrop study is an area bounded on the north by the New York State Thruway, on the south by highway U.S. 20, on the west by Auburn, and on the east by Schoharie (fig. 1).

Detailed stratigraphic studies of the Salina Group on outcrop have been made by Leutze (1956, 1959). These studies have solved many problems of outcrop terminology and relationships. Rickard (1969) has clarified subsurface relationships and established correlations with the outcrops. The Salina Group as recognized by Leutze and Rickard consists of four formations - the Vernon, Syracuse, Camillus, and Bertie (fig. 3).

The Vernon Shale, the oldest of the Salina formations, is typically bright red shale with local beds or lenses of green shale, dolomite, sandstone, or gypsum. The Vernon reaches its maximum thickness of 500 to 600 feet in the vicinity of Syracuse. The thickness of the Vernon decreases both east and west. To the west, the formation disappears southwest of Rochester. To the east the Vernon is 120 to 160 feet thick at Ilion gorge

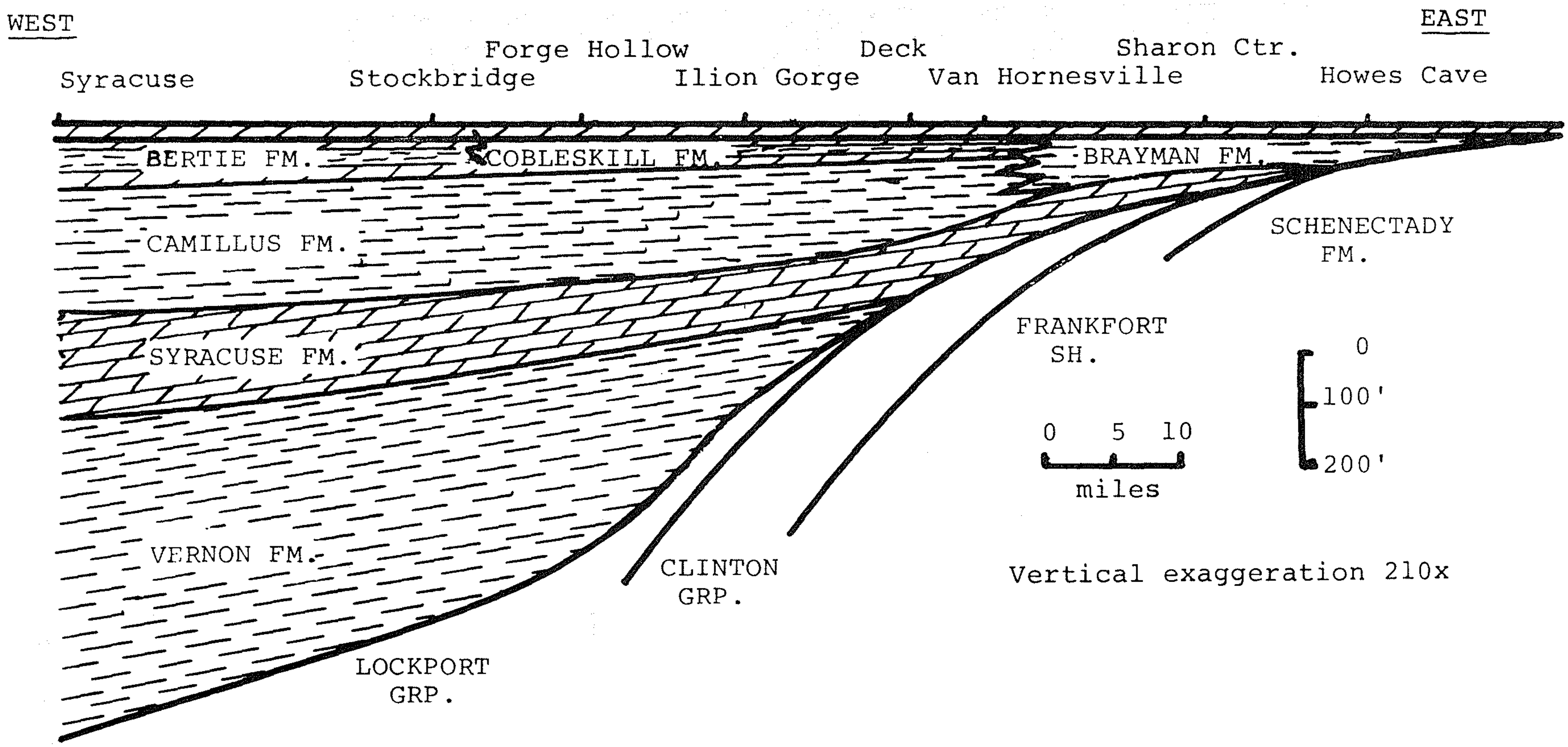

Fig. 2. Schematic east-west section showing transgressive nature of the Salina Group.

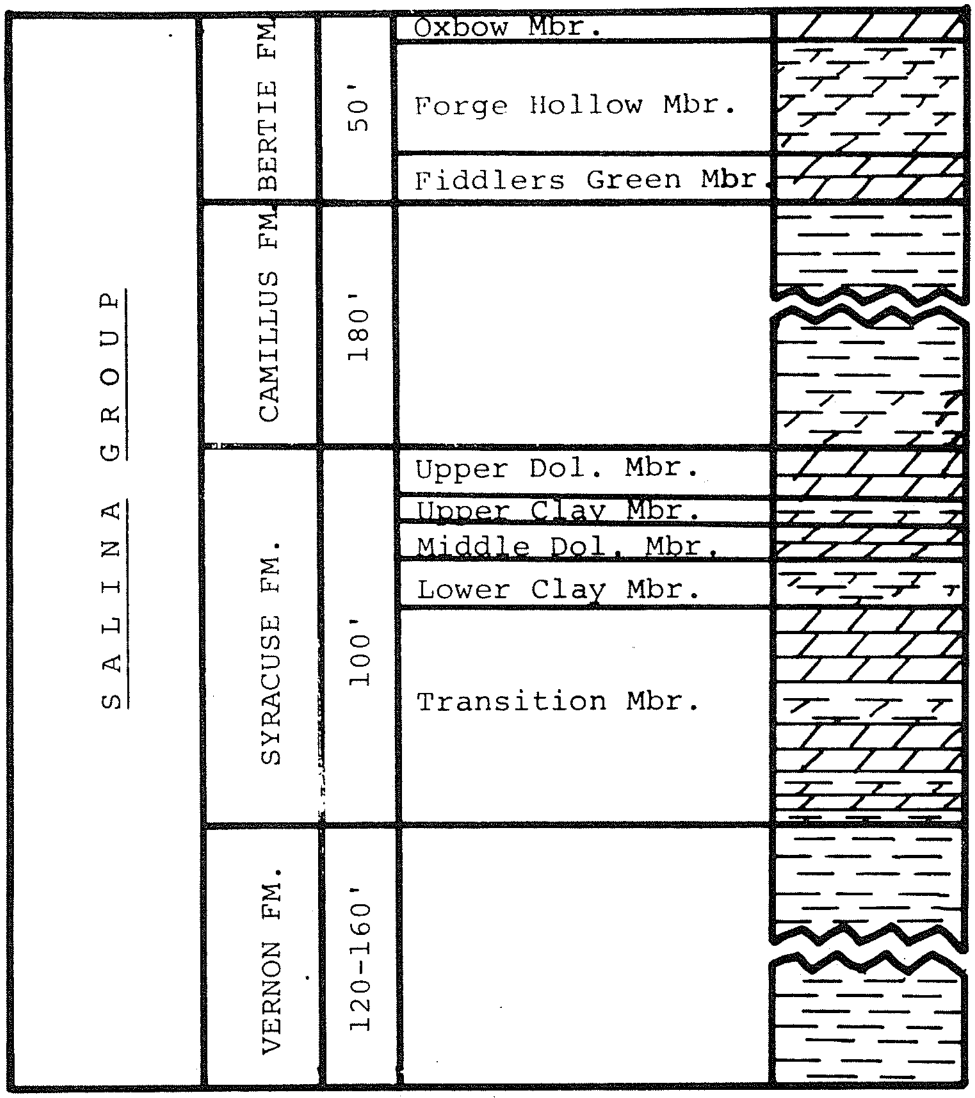

Fig. 3. Stratigraphy of the Salina Group (Cayugan Series - Upper Silurian).

(Stop I) but is not present 11 miles east at Deck where the Syracuse Formation unconformably overlies the Herkimer Sandstone. At Ilion gorge the Vernon consists of at least 95 percent red shale. This red shale decreases in abundance to the west; near Syracuse the red shales make up about 70 percent of the formation . West of the Genesee River red shales make up less than half of the formation (Leutze, 1964).

Overlying the Vernon Shale is the Syracuse Formation. The Syracuse Formation was originally defined as the salt and interbedded sediments known only in the subsurface (Clarke, 1903). At the outcrop, only the overlying Camillus Shale was recognized. Leutze (1956) redefined the Camillus Shale and applied the term "Syracuse Formation" to the dolomites, shales, and evaporites correlative with the subsurface salt sequence. The Syracuse Formation from Ilion gorge west consists of five members. East of Ilion gorge, division of the Syracuse Formation into members is difficult. The members are, in ascending order: the Transition Member, Lower Clay Member, Middle Dolomite Member, Upper Clay Member, and Upper Dolomite Member.

The Transition Member, the lowest member of the Syracuse Formation, consists of thin gray-to-green dolomite beds alternating with green shales. Some gypsum is present in the Transition Member at Ilion gorge (Stop II). Where exposed, the contact with the Vernon Shale is disconformable. The thickness of the Transition Member in Ilion gorge (Stop II) is at least 60 feet. In the central part of the state, the Transition Member reaches 100 feet in thickness. As the name implies, the lithology of this member is transitional between the underlying Vernon and typical Syracuse lithologies.

Overlying the Transition Member of the Syracuse Formation is the Lower Clay Member. Typically, in the Syracuse region, this member consists of structureless, unbedded, gray clay averaging 12 feet in thickness. This member is found at approximately the same horizon as thick subsurface salt beds and is thought to be the insoluble residue of the salt beds (Leutze, 1956, 1959, 1964). This interpretation is supported by the presence, near Syracuse, of blocks of bedded gypsum encased in the clay. In Ilion gorge (Stop II) the Lower Clay Member shows some bedding, but characteristically is a highly weathered clay with some interbedded fine-grained gypsum and dolomite. Relationships of the Lower Clay Member at Ilion gorge to the subsurface Syracuse Formation are unknown. The thickness of this Member is about 11 feet. This member is difficult to distinguish from the Transition Member.

Thick bedded, resistant, ripple marked light gray dolomite characterizes the Middle Dolomite Member. Ostracodes, small pelecypods, and graptolites are present in this member but are poorly preserved. The Middle Dolomite Member is only seven feet thick at Ilion gorge; this compares with a thickness of 37 to 44 feet at Syracuse.

Above the Middle Dolomite Member another clay bed occurs. This has been designated the Upper Clay Member and is about seven feet thick in Ilion gorge. The Upper Clay Member seems to be identical to the Lower Clay Member in all aspects except stratigraphic position.

The uppermost unit of the Syracuse Formation is the Upper Dolomite Member. This member consists of thin-to thick-bedded grey dolomite which internally is finely laminated. Abundant mudcracks and some ripple marks are found throughout the member. Fossils include algal mounds and ostracodes. The contact with the overlying Camillus shale is gradational. Approximately 15 feet of dolomite have been assigned to this member in Ilion gorge.

The Camillus Shale is conformable with the Syracuse Formation. The dominant lithologies of the Camillus Shale are red and olive-green shales; these shales occur as massive beds up to 35 feet thick or as one to three foot interbeds. Some dolomites and brown shales are present in the lower portion of the unit; mudcracks and ripple marks are common in the dolomite sediments. Many of these dolomites are finely interbedded with gypsum. Quartz sand-rich zones are present throughout the Camillus. The sand content seems to decrease westward. No fossils have been found in the Camillus. The thickness of the Camillus at Ilion gorge (Stop III) is about 180 feet.

The youngest unit of the Salina Group is the Bertie Formation. In central New York the Bertie contains three members - the Fiddlers Green Dolomite, Forge Hollow Shale, and Oxbow Dolomite, in ascending order. The Bertie Formation is overlain by the Cobleskill Dolomite.

The Fiddlers Green Member is exposed at the top of the Ilion gorge section (Stop IV) and at Passage Gulf (Stop V). In these sections, the Fiddlers Green Member consists of medium- to thick-bedded, grey to brown, laminated dolomite. Mudcracks and fossils are found at some horizons in this unit. A massive bed at the top of the member contains abundant fragments and a few whole specimens of <u>Eurypterus</u> <u>remipes</u> and, also, abundant mudcracks. Both contacts of this member are sharp but appear to be conformable. The Fiddlers Green Member is about 15 feet thick at Passage Gulf (Stop V).

The Forge Hollow Member is also exposed at Stops IV and V. This member consists of thin-bedded, finely laminated, brown shaly dolomites. Gypsum crystal molds and interbedded gypsum are common. Mudcracks are abundant on some bedding surfaces. Thickness of this member at Stops IV and V is about 30 feet.

The Oxbow Member is not exposed at any of the field trip stops, but at its type section, about 15 miles west of Ilion gorge, it consists of thin-to medium-bedded, light grey dolomite. This unit is about four feet thick at Forge Hollow, the type section, and thins toward the east. Rickard (1962) has identified the Oxbow Member as far east as Deck.

East of Van Hornesville (Stop VI) the Camillus Formation and Bertie Formation are not distinctive units. The equivalent interval, the Brayman Formation, is represented by argillaceous, greenish-grey dolomites with shaly bedding and a high pyrite content. Well-rounded quartz sand and silt particles occur throughout the unit. Due to confusion in the stratigraphic nomenclature of the Salina Group, the relationship of the Brayman Formation with the Syracuse Formation has been unclear. The Brayman was correlated with the "upper Camillus" and Bertie by Fisher and Rickard (1953), but this correlation preceded Leutze's redefinition of the Camillus and addition of the Syracuse Formation to outcrop terminology; therefor, the interval represented by the Brayman is unclear. It is apparent from several exposures east of Deck that the Brayman is equivalent to the Camillus and Bertie Formations but not to any portion of the Syracuse, as defined by Leutze (1956, 1959). This relationship is clear at Sharon Center (Stop VII) where Syracuse Formation dolomites, with characteristic fossils, are overlain by a typical Brayman lithology. The Brayman Formation, therefor, is the eastern equivalent of the Camillus and Bertie Formations, but not of the Syracuse. The Syracuse like the Vernon thins to zero thickness eastward through overlap and does not grade into the Brayman.

Environmental Reconstruction

The depositional environments of the Salina Group can be reconstructed through the use of sedimentology and stratigraphy. Sedimentary structures are particularly important in this reconstruction as, in the absence of fauna, they are the only reliable indicators of environments of deposition. Those sparse and poorly preserved fossil assemblages that are occasionally found in the Salina Group are indicative of restricted, hypersaline marine conditions.

The Vernon Shale has been the subject of extensive debate. Grabau (1913, p. 569) considered the Vernon a windblown loess deposit, and Newland (1928) postulated that it was a residual soil. These hypotheses are discredited by the presence of the marine fauna described by Fisher (1957) at the type section in Vernon township.

Alling (1928) proposed that the Vernon Formation was deposited as "an initial shoreward phase of deltaic sedimentation". Fisher (1957) points out that the fossils of the Vernon are characteristic of a hypersaline environment; he suggests deposition in a large restricted multiple lagoon or a series of small restricted lagoons. The stratigraphic relationships of the Vernon indicate that the Vernon Sea transgressed eastward. This transgression was apparently onto a featureless low land which supplied fine grained sediments through long meandering streams. Apparently the eastward limit of transgression was somewhere between Ilion gorge and Deck.

The sedimentary structures and fossils in the Syracuse Formation collectively suggest deposition in a peritidal (near tidal) hypersaline environment. Very abundant mudcracks are found throughout the Syracuse; these mudcracks and associated flat-pebble conglomerates indicate at least intermittent subaerial exposure. Oscillation ripple marks are found in a few places indicating moderate bidirectional currents. Numerous erosional surfaces are also indicative of water movements. Nodular gypsum is present in the Syracuse Formation. This nodular gypsum is quite similar in appearance to nodular anhydrite which Shearman (1966) reported from sabkhas along the Persian Gulf. Friedman and Sanders (1967) report other occurrences of gypsum and anhydrite associated with sabkha dolomites. In addition, the sediments of the Syracuse Formation are typically finely laminated dolomites, quite similar to the stromatolitic sediments of modern peritidal environments; algal heads are found in few places throughout the unit. None of these sedimentary structures alone is indicative of a peritidal environment, but collectively they present valid evidence for such an interpretation.

The fossils of the Syracuse Formation are typical of a hypersaline, restricted environment. Ostracodes are the most abundant fossils. Brachiopods, pelecypods, gastropods, eurypterid fragments, and graptolites have also been reported from the Syracuse Formation. Some horizontal burrows have been identified in the Upper Dolomite Member.

There seems to be little vertical change in the Syracuse Formation other than fluctuation in the amount of argillaceous material. Laterally, however, changes in depositional environments are apparent. The Sharon Center exposure (Stop VII) contains very abundant mudcracks and displays a nodular fabric throughout. The rocks here are representative of much more frequent subaerial exposure - possibly representing supratidal deposition. West of Sharon Center the sedimentary structures indicate less frequent exposure. The Sharon Center locality probably lies near the eastern depositional edge of the overlapping Syracuse Sea.

Although no halite is apparent in the outcrops, the Syracuse Formation is the major salt producer of New York State. The environment of deposition of this salt has been quite controversial. Dellwig and Evans (1969) suggest that the salt was deposited in a shallow sea marked by turbulent water. Rickard (1969), on the other hand, proposes that "most of the Salina evaporites were deposited in waters 100 to 400 feet deep and possibly as much as 600 feet deep". A study in progress by this writer of a core from the Morton Salt Company mine near Penn Yan shows mudcracks, flat-pebble conglomerates, erosion surfaces, nodular anhydrite, and stromatolites in dolomites interbedded with salt beds of the Syracuse Formation. This writer has also observed mudcracks and flat-pebble conglomerates in the base of a dolomite bed immediately overlying one of the major salt beds of the Syracuse Formation in the Cayuga Rock Salt mine north of Ithaca. The sedimentary structures of dolomites from these two localities suggest similar environments of deposition to the peritidal environments of the dolomites along the outcrop belt. The peritidal origin of the dolomites intercalated with the salt beds, therefor, limits the probable environment of deposition of the salt beds to the shallow water or supratidal environments.

If the environment of deposition of the salt beds is limited to shallow water or supratidal environments, a mechanism must be proposed to explain the thickening of the Salina Group to the south. Traditionally, this southward thickening has been explained by the depositional filling of a deep topographic basin which deepens southward. The presence of peritidal dolomites interbedded with the salt beds in the Syracuse Formation, however, makes this deep topographic basin hypothesis difficult to support. The alternative to a deep topographic basin is a structural basin. In the structural basin hypothesis, the basin subsides at approximately the same rate as the rate at which sediments are deposited. The depositional interface is never in "deep water", and an actual topographic basin need never exist. Instead, a broad tidal flat or peritidal area persists. A faster rate of subsidence near the center of the flat accounts for the increased thickness of sediments to the south. This hypothesis is in agreement with the lithology and sedimentary structures of the rocks and is the one proposed to explain the southward thickening of the Salina Group. This structural subsidence may also explain the apparently contradictory conditions of a restricted hypersaline sea which is transgressive. Subsidence of the basin margins of the Salina Sea might result in transgressions in spite of the restricted condition of the waters.

The depositional environments of the Camillus Formation are more obscure. No fossils have been found in the Camillus; a few mudcracks are the only sedimentary structures present. Lithologically the Camillus is a dolomitic shale with the dolomite content decreasing upward. Well-rounded sand grains are found throughout the Camillus. Nodular gypsum and gypsum interbedded with dolomite are found in the lower portion of the Camillus. The association, both above and below, with marine units and the presence of dolomite and gypsum suggest the Camillus is a marginal marine deposit although conclusive fossil evidence is lacking. The sedimentary structures indicate at least intermittent subaerial exposures. Rounded quartz grains may be eolian in origin. East of Van Hornesville (Stop VI), the Camillus along with the Bertie grade into the Brayman Shale.

The Bertie Formation was probably deposited in an environment similar to that of the Syracuse Formation. Mudcracks, flat-pebble conglomerates, small erosional channels, burrows, possible molds of evaporite crystals, and nodular fabrics have been found in the Fiddlers Green and Oxbow Members of the Bertie. The Forge Hollow Member, found between these dolomites, is a mudcracked, finely laminated, argillaceous dolomite with shaly bedding. Fossils of the Bertie are typical of a restricted, hypersaline environment, and the sedimentary structures are compatible with a peritidal origin.

The Brayman Shale which is the eastern equivalent of the Bertie and Camillus Formations is probably quite similar to the Camillus in origin. The presence of abundant pyrite indicates reducing conditions at some time in the history of the Brayman Shale.

Summary

The Salina Group represents a complete cycle of sedimentation. It is underlain and overlain by relatively "normal" marine carbonates, the Lockport and Cobleskill Formations respectively. This cycle of sedimentation is especially interesting in that it is a transgressive hypersaline sequence. Classicly hypersaline sequences were thought to be regressive in nature. Not enough evidence is yet available to explain this apparently contradictory relationship. One possible explanation is that the transgressions are the result of structural activity within the Salina Basin. The sedimentology, however, clearly shows that the Salina Group rocks of the eastern portion of the outcrop belt represent deposition in a hypersaline, peritidal environment. The rocks are characterized by mudcracks, other peritidal sedimentary structures, and restricted hypersaline fossil assemblages.

References Cited

Alling, H.L., 1928, The geology and origin of the Silurian salt of New York State: New York State Mus. Bull. 275, 139 p.

Alling, H.L., and Briggs, L.I., 1961, Stratigraphy of Upper Silurian Cayugan evaporites: Am. Assoc. Petroleum Geologists Bull., v. 45, p. 515-547.

Buzzalini, A.D., Adler, F.J., and Jodry, R.L., eds., 1969, Evaporites and petroleum: Am. Assoc. Petroleum Geologists Bull., v. 53, p. 775-1011.

Clarke, J.M., 1903, Classification of New York series of geologic formations: New York State Mus. Handb. 19, 28 pp.

Dellwig, L.F., and Evans, Robert, 1969, Depositional processes in Salina salt of Michigan, Ohio, and New York: Am. Assoc. Petroleum Geologists Bull., v. 53, p. 949-956.

Fisher, D.W., 1957, Lithology, paleoecology and paleontology of the Vernon Shale (Late Silurian) in the type area: New York State Mus. and Sci. Service Bull. 364, 31 pp.

Fisher, D.W., and Rickard, L.V., 1953, Age of the Brayman Shale: New York State Mus. and Sci. Service Circ. 36, 11 pp.

Friedman, G.M., 1972, Significance of Red Sea in problem of evaporites and basinal limestones: Am. Assoc. Petroleum Geologists, v. 56, p. 970-984.

Friedman, G.M., and Sanders, J.E., 1967, Origin and occurrence of dolostones, p. 267-348 _in_ Carbonate rocks: developments in sedimentology, v. 9A, New York, Elsevier Publ. Co., 348 pp.

Grabau, A.W., 1913, Principles of Stratigraphy, A.G. Seiler, New York, 1185 pp.

King, J.S., 1966, The economic geologic setting of western New York: New York State Geological Soc. Ann. Mtg. Guidebook, p. 69-74.

Kudryavtsev, N.A., 1971, Evaporites and petroleum: Discussion: Am. Assoc. Petroleum Geologists Bull., v. 55, p. 2033-2038.

Leutze, W.P., 1956, Faunal stratigraphy of Syracuse Formation, Onondaga and Madison Counties, New York: Am. Assoc. Petroleum Geologists Bull., v. 40, p. 1693-1698.

Leutze, W.P., 1959, Stratigraphy and paleontology of the Salina Group in central New York: Unpublished Ph.D. dissertation, Ohio State University, Columbus, Ohio, 463 pp.

Leutze, W.P., 1964, The Salina Group, New York State Geological Soc. Ann. Mtg. Guidebook, p. 57-65.

Newland, D.H., 1928, Recent progress in the study of the Salina Formation:National Research Council Reprint and Disc. Ser., no. 85, p. 36-43.

Rickard, L.V., 1962, Late Cayugan (Upper Silurian) and Helderbergian (Lower Devonian) stratigraphy in New York: New York State Mus. and Sci. Service Bull. 386, 157 pp.

Rickard, L.V., 1969, Stratigraphy of the Upper Silurian Salina Group: New York, Pennsylvania, Ohio, Ontario: New York State Mus. and Sci. Service Map and Chart Series no. 12, 57 pp.

Shearman, D.J., 1966, Origin of marine evaporites by diagenesis: Inst. Mining Metallurgy Trans., v. 75, Sect. B, Bull. 717, p. 208-215.

ROAD LOG

Total	From last Stop	
		Stop I - Vernon Shale
0.0	0.0	Start at Junction N.Y. 51 & Jerusalem Hill Road. The exposures on the south side of Jerusalem Hill along the creek are near the bottom of the Vernon Formation. The Vernon here is a massive red shale. A few green spots can be seen in the red shale. These apparently result from reduction around particles of organic matter; dark carbonaceous debris occasionally can be found in the center of these green spots. Green color is also present along joints indicating color change due to ground water action.

The contact of the Vernon with the underlying Lockport Formation is exposed along the west side of Steele Creek about 1000 feet north of this exposure. The Lockport is a medium-bedded dolomite with mudcracks and current ripples. The contact of the Lockport with the Vernon is sharp but may be conformable. The thickness of the Vernon in Ilion gorge is 120 to 160 feet.

Proceed west on Jerusalem Hill Road.

Total	From last Stop	
		Stop II - Syracuse Formation
0.5	0.5	Pull off just west of Bridge where creek crosses road. Outcrop is 0.1 miles further west.

This stop exposes a nearly complete section of the Syracuse Formation. The lower contact of the Syracuse with the Vernon is not exposed. The contact with the overlying Camillus is gradational. The section is as follows:

- Camillus Fm.
- Syracuse Fm. (94 ft.)
  - Upper Dolomite Mbr. (14 ft.)
  - Upper Clay Mbr. (7 1/2 ft.)
  - Middle Dolomite Mbr. (7 1/2 ft.)
  - Lower Clay Mbr. (11 ft.)
  - Transition Mbr. (54 ft.)

Ripple marks and mudcracks can be found throughout the Syracuse and Camillus Formations at this locality. Ostracodes and other fossils are present in the Middle and Upper Dolomite Members, and algal heads in the Upper Dolomite Member. Note also the finely laminated nature of the dolomites and dolomitic sediments; these laminations are characteristic of peritidal deposits.

Continue west on Jerusalem Hill Road.

Total	From last Stop	

Stop III - Camillus Formation

0.9 0.4 Quarry on left (S) side of road.

The section to be examined is in the quarry on the south side of Jerusalem Hill Road. About 80 feet of Camillus are exposed in this quarry. The total Camillus thickness in this area is about 180 feet. The section in this quarry is typical of the middle and upper Camillus. The lower portion of the Camillus, however, is more dolomitic. With the exception of a few mudcracks, sedimentary structures and fossils are generally absent.

Continue west.

Stop IV - Bertie Formation

1.5 0.6 Junction of Jerusalem Hill Road and Cedarville Road, Town of Litchfield Maintenance Building on left (S) side of road. Outcrop is across Cedarville road from building.

This is a brief stop to examine the Fiddlers Green and Forge Hollow Members of the Bertie Formation. These units will be examined in more detail at the next stop. Mudcracks and eurypterids are common in the massive bed at the top of the Fiddlers Green. Poor outcrops in the field above the roadcut may be in the Cobleskill Formation. About 13 feet of the Fiddlers Green Member and 25 feet of the Forge Hollow Member are exposed here. The composite thickness of the Salina Group along the Jerusalem Hill Road in Ilion gorge is about 450 feet.

Turn left (S) onto Cedarville Road.

4.2 2.7 Junction Cedarville road and N.Y. 51.

Proceed onto N.Y. 51 heading East and pass general store on route (S) and then Fire Hall on left (N).

4.3 0.1 Junction of N.Y. 51 and Elizabethtown Road.
Turn left (N) on Elizabethtown Road.

7.3 3.0 Junction Brewer Road and Elizabethtown Rd. in Elizabethtown.
Turn right (E) onto Brewer Road.

8.4 1.1 Junction Spohn Road and Brewer Road.
Turn right (S) onto Spohn Road.

Stop V - Camillus and Bertie Formations

8.7 0.3 Outcrop on left (E) side of road in passage gulf.

The section in this roadcut is as follows:

- Bertie Fm. (40 ft.)
  - Forge Hollow Mbr. (23 ft.)
  - Fiddlers Green Mbr. (17 ft.)
- Camillus Fm. (25 ft.)

Total	From last Stop	
		The Camillus-Bertie contact can be examined at this stop. This contact is quite sharp. Below the contact, the Camillus consists of gray and green dolomitic shales with mudcracks. The overlying Fiddlers Green Mbr. of the Bertie Formation is medium- to thick-bedded dolomite. Mudcracks are present throughout, especially in the two foot massive bed at the top of the Fiddlers Green Member; this bed also contains eurypterids. The Forge Hollow Member is a shaly dolomite with some mudcracks and is exposed in the gentle slope just above the massive bed.
		Continue southeast on Spohn Road.
10.8	2.1	Junction Spohn Road and N.Y. 472. Petrie Brown Memorial on route.
		Turn right (S) onto New York 472.
11.0	0.2	Proceed into Columbia Center to Junction N.Y. 472 and Jordanville Road.
		Turn left (E) onto Jordanville Road.
		Proceed east.
13.0	2.0	Junction Jordanville Road and N.Y. 28.
		Proceed east (straight across) on Jordanville Road.
15.5	2.5	Junction Jordanville Road and N.Y. 167.
		Remain on Jordanville Road East and N.Y. 167, going through town of Jordanville. N.Y. 167 forks off to north (cemetery). Stay on Jordanville Road East.
21.4	5.9	Turn right (S). Jordanville Road takes a 90° turn here.
		Proceed south on Jordanville Road.
22.4	1.0	Stop VI - Syracuse and Camillus Formations

Road cut on east side of road. Another exposure about 0.1 mile south on west side.

The Salina Group in this area has thinned to less than 150 feet from the 450 feet measured in Ilion gorge. The Vernon Formation is not present as the result of depositional onlap. The easternmost exposure of Vernon shale is about eight miles to the west, north of Jordanville.

About 45 feet of Clinton sandstones, shales, and hematite beds are exposed below the Syracuse Formation. The contact with the Syracuse is at the top of a poorly consolidated conglomeratic sandstone (Herkimer). This contact is disconformable.

Total	From last Stop	
		The Syracuse at Van Hornesville is about 80 feet thick. Although member designations are difficult, the lower 55 feet appears to consist of the transition and Lower Clay Members. The Middle Dolomite Member is about 10 feet thick; the Upper Clay Member, eight feet; and the Upper Dolomite Member, 15 feet. Mudcracks are present throughout the Syracuse Formation. Halite crystal casts associated with mudcracks have been found on some talus slabs. Algal heads and burrow trails are present in the Upper Dolomite Member. Some lenses of fine-grained non-laminated dolomite are present in the well-laminated Upper Dolomite Member. Eurypterid fragments are also found in this member.
		The Syracuse Formation grades upward into the Camillus Formation. The Camillus is a grayish-green to dull red dolomitic shale. In places, fragments of the grayish-green sediment can be found contained in a red matrix. This is the easternmost exposure of the Camillus Formation; the correlative interval to the east is designated Brayman Shale.
		Proceed south on Jordanville Road.
22.5	0.1	Junction Jordanville Road and N.Y. 80.
		Turn right onto N.Y. 80. Proceed south.
24.2	1.7	Herkimer and Otsego Co. Line.
27.1	2.9	Junction N.Y. 80 and U.S. 20.
		Turn left (E) onto U.S. 20.
		Proceed east on U.S. 20, passing through Cherry Valley, east Springfield, and Sharon Springs to Sharon Center.
42.6	15.5	Junction Gilbertville Road in Sharon Center.
		Turn left (N) onto Gilbertville Road.
43.6	1.0	Sharp right (E) turn in - Gilbertville Road.
43.9	0.3	Junction Gilbertville Road and Dirt Road.
		Turn left (N).
44.2	0.3	Stop VII - Syracuse and Brayman Formations
		Quarry set off road (on east side) about 100 feet.
		The Syracuse Formation has thinned to less than 30 feet at this quarry from nearly 100 feet in Ilion gorge 25 miles to the west. In addition to thinning eastward through overlap, the sedimentology of the Syracuse Formation at Stop VII is quite different from Ilion gorge (Stop II). The Syracuse consists of thin-bedded laminated shaly dolomites with very

abundant nodules throughout. The nodules are now filled with calcite which probably is secondary after gypsum or anhydrite. Around these nodules the dolomite has been brecciated. In addition to the nodular fabric, mudcracks are quite abundant in the Syracuse Formation. Some ripple marks, cross laminations, and fossils (ostracodes, gastropods, and brachiopods) are also present. The exposure is probably quite near the eastern depositional limit of the Syracuse Formation and more frequent subaerial exposure should be expected. The abundance and types of sedimentary structures and the nodular fabric suggest a supratidal or near supratidal environment of deposition.

The overlying Brayman Formation is a massive greenish gray shaly dolomite and dolomitic shale. Well-rounded sand grains can be found in this unit; these sand grains may be eolian. A 12 inch dolomite bed near the top of the quarry may represent the influence of Fiddlers Green sedimentation even though the Bertie Formation is not recognizable this far east. The thickness of the exposed Brayman at this locality is about 20 feet.

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