# SEDIMENTARY ENVIRONMENTS AND BIOSTRATIGRAPHY OF THE TRANSGRESSIVE EARLY TRENTONIAN SEA (MEDIAL ORDOVICIAN) IN CENTRAL AND NORTHWESTERN NEW YORK

by

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## INTRODUCTION

The fossiliferous marine limestones and shales of the Ordovician Trenton Group of New York has been studied by many paleontologists and stratigraphers for well over 150 years. Along with the underlying Black River Group (fig. 2), it has become well-known among geologists as part of the medial Ordovician standard reference section of North America. However, the geology of the Trenton Group still poses several relatively complex problems of interpretation for the application of stratigraphic, paleontologic, and paleoecologic principles. Specifically, there is still "...confusion and disagreement regarding the correlation of the upper Black River and lowest Trenton in New York and Ontario" (Kay, 1942, p. 599) (see also Fisher, 1962; Textoris, 1968; Cameron, 1969a, 1969b; Walker and Laporte, 1970).

The modern approaches to the paleoecologic study of carbonate rocks, such as sedimentary petrography (Cameron, 1968), fossil community analysis (Porter and Park, 1969; Park and Fisher, 1969, Cameron and Mickevich, 1972), population paleontology (Ross, 1967), primary sedimentary structures (Chenoweth, 1952; Cameron, 1968), have just recently been applied with emphasis to parts of the medial Ordovician Trenton group of central and northwestern New York. Many previous investigators who have studied these formations have been, by necessity, primarily concerned with lithostratigraphy, such as statistical analysis of rock types (especially Chenoweth, 1952, and Lippitt, 1959), biostratigraphy and correlation, and mapping.

Although many faunal lists have been made for the New York sections (e. g., Cameron, 1968; Fisher, 1957; Chenoweth, 1952; Kay, 1953, 1937, 1933), most major fossil groups are in need of thorough restudy, using modern paleontologic approaches and techniques. However, a few groups in New York have received careful attention and revision in recent years. These include the Brachiopoda (Cooper, 1956), Ectoprocta (Ross, 1964, 1967), conodonts (Schopf, 1966), and calcareous algae (Cameron and Awramik, in preparation).

This field trip will illustrate and summarize a detailed time, lithic, and faunal microstratigraphic framework for the lower Trenton Group, i. e., the Rocklandian, Kirkfieldian, and Shorehamian stages, in central and northwestern New York. The limestones of the upper Black River Group beneath the lower Trenton Group will also be examined at several stops. This will then form the basis and provide the confidence for reconstructing the environments of deposition and determining the paleogeography. Special emphasis will be placed on statistical analysis of the rock types both from detailed field measurements and carbonate petrography, small scale physical and biological correlation, primary sedimentary structures, trace fossils, fossilization, and fossil community analysis. This information should better document the initial and subsequent wider transgression of the Trentonian sea.

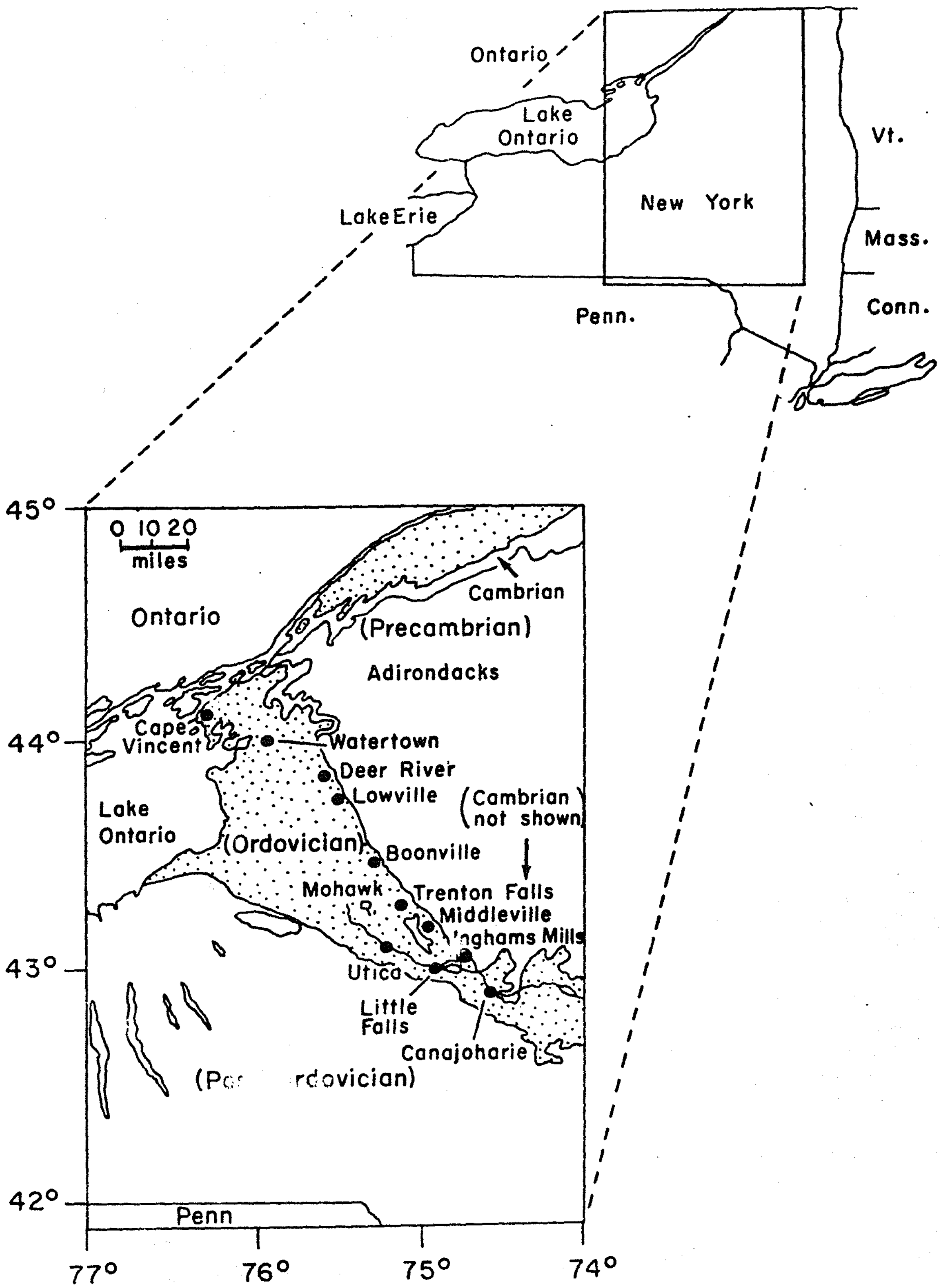
The specific purposes of this field trip are to:

1) Demonstrate the stratigraphic succession and its lateral variations.
2) Discuss and evaluate the age relationships and time correlations of the various formations by
   a) Examining the diverse faunas and
   b) Demonstrating the lateral continuity of major lithic and biologic characteristics.
3) Examine and evaluate the criteria for determining the extent and significance of the disconformity along the Black River-Trenton boundary.
4) Examine and evaluate the criteria for determining the conditions and environments of deposition and paleogeography.
5) Examine fossilization and reconstruct fossil communities
6) Determine temporal and spatial relationships between fossil communities and sedimentary environments in a transgressive sequence.

This field trip guide will summarize previous work on the lower Trenton Group in the Little Falls Port Leyden and surrounding 15' quadrangles and incorporate new data in support of reinterpretations of the stratigraphy and sedimentary environments of the lower Trenton Group in this area. The Little Falls quadrangle is located along the southwestern margin of the Adirondack Mountains and is included in southern Herkimer County. The Port Leyden quadrangle is located in Oneida County north of Boonville, New York, west of the Adirondacks. Good exposures of medial Ordovician limestones are to be found along the Mohawk River, East Canada Creek, West Canada Creek, and Black River valleys and those of their contributaries. Stops for this trip are located in the quadrangles mentioned. Many small abandoned limestone quarries in the Little Falls quadrangle contain excellent exposures of the Black River-Trenton boundary.

## REGIONAL GEOLOGIC SETTING

Lower Paleozoic strata dip gently to the west and southwest from the Precambrian rocks of the Adirondacks in this region; subsurface contours drawn on the base of the Black River-Trenton combined indicate a one-half to 2 degree dip regionally (Flagler, 1966, pl. 5). A few northeast-southwest trending normal faults cut Paleozoic and Precambrian rocks, e. g. near Little Falls and Dolgeville (Cushing, 1905a; Kay, 1937).




Fi. ure 1. Geologic outline map of study area.

The late Cambrian Little Falls Dolomite underlies Ordovician rocks and overlies the Precambrian basement complex of igneous and metamorphic rocks in southern Little Falls Quadrangle. To the northeast, however, the medial Ordovician Gull River Limestone overlaps the Little Falls Dolomite to lie directly on the Precambrian (Cushing, 1905a, Young, 1943), as it does farther north in Oneida County (Young, 1943, fig. 3).

## LOWER TRENTONIAN AND UPPER BOLARIAN STRATIGRAPHY OF CENTRAL NEW YORK

Introduction:

The late Bolarian Black River Group beneath the Trenton Group consists of three formations (Pamelia Formation, Gull River Limestone, and Watertown) which are overlain by the lower Trenton Selby, Napanee, Kings Falls, and Sugar River limestone formations (fig. 2). The Pamelia, Watertown, and Selby formations will not be seen on this field trip. The others are described below in their order of deposition.

The stratigraphic classification used herein (Fig. 2) follows that of Kay (1968b) with modifications for the lower Trenton Group from Cameron (1967, 1968, 1969a, 1969b). A thorough historical review of the early classifications of these limestones can be found in Kay (1937, p. 237-249); for a review of later work, see Cameron (1968, 1969b).

Bolarian Series:

The Gull River Limestone was deposited in supratidal to shallow subtidal marine conditions during the Lowvillian Stage; apparently neither Chaumontian (uppermost Bolarian) (Walker, 1969) nor pre-Lowvillian rocks are present in central New York (Cameron, 1969b). The Bolarian age is indicated by conodonts (Hasan, 1969). The Gull River lies successively on early Ordovician (Canadian) limestones and dolostones along the Mohawk River, on late Cambrian Little Falls Dolomite northward in the Little Falls quadrangle, and on Precambrian along its northwest-trending outcrop belt to the Port Leyden quadrangle (Cushing, 1905a; Young, 1943). The thickness of this formation varies in a southeasterly direction from 54 feet at Lowville, New York, to 30 feet at Inghams Mills (figs. 2 & 3; Stop #1) (Young, 1943; Cameron, 1969b).

The lithology of the Gull River is varied and complex, but it is characterized by light gray weathering, dove gray calcilutite (sublithographic), called "birdseye" limestone by the early geologists in New York State. Granule and flat pebble calcirudites and impure argillaceous calcisiltites are sometimes frequent. Horizontal laminae, fenestral fabric, stylolites, mudcracks (Fig. 5), and burrows are common sedimentary structures. Some of the horizontal laminae originated by current action, but most were probably produced by algal accretion (algal? mats).

Fossils are generally uncommon in the Gull River Limestone (see Young, 1943, for a comprehensive faunal list, and Walker and Laporte, 1970, for a fossil community analysis). The abundant vertical burrow Phytopsis (Fig. 7) and small ostracods occur throughout the Gull River.

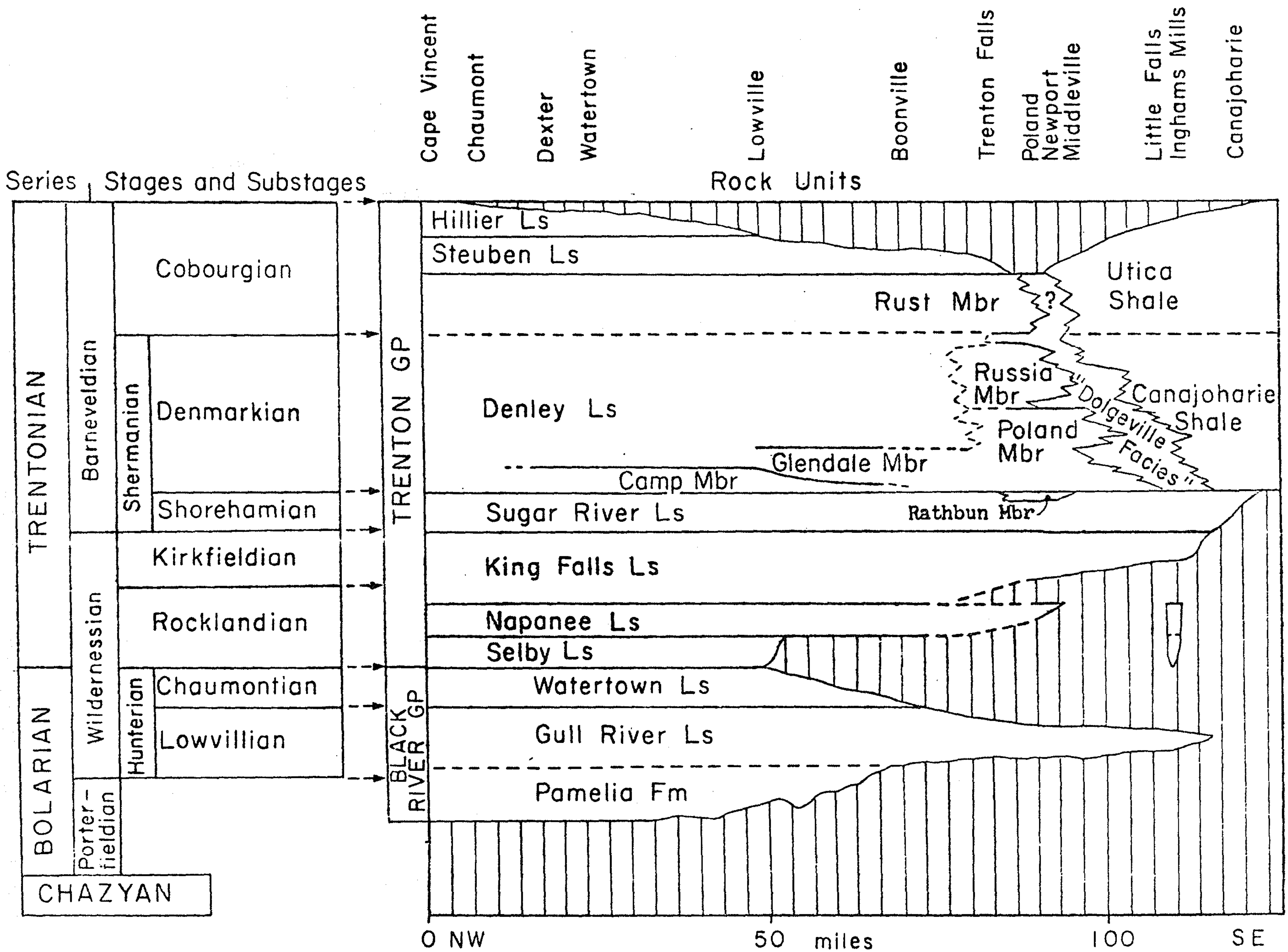





Figure 2. Medial Ordovician stratigraphic classification and nomenclature for central and northwestern New York.

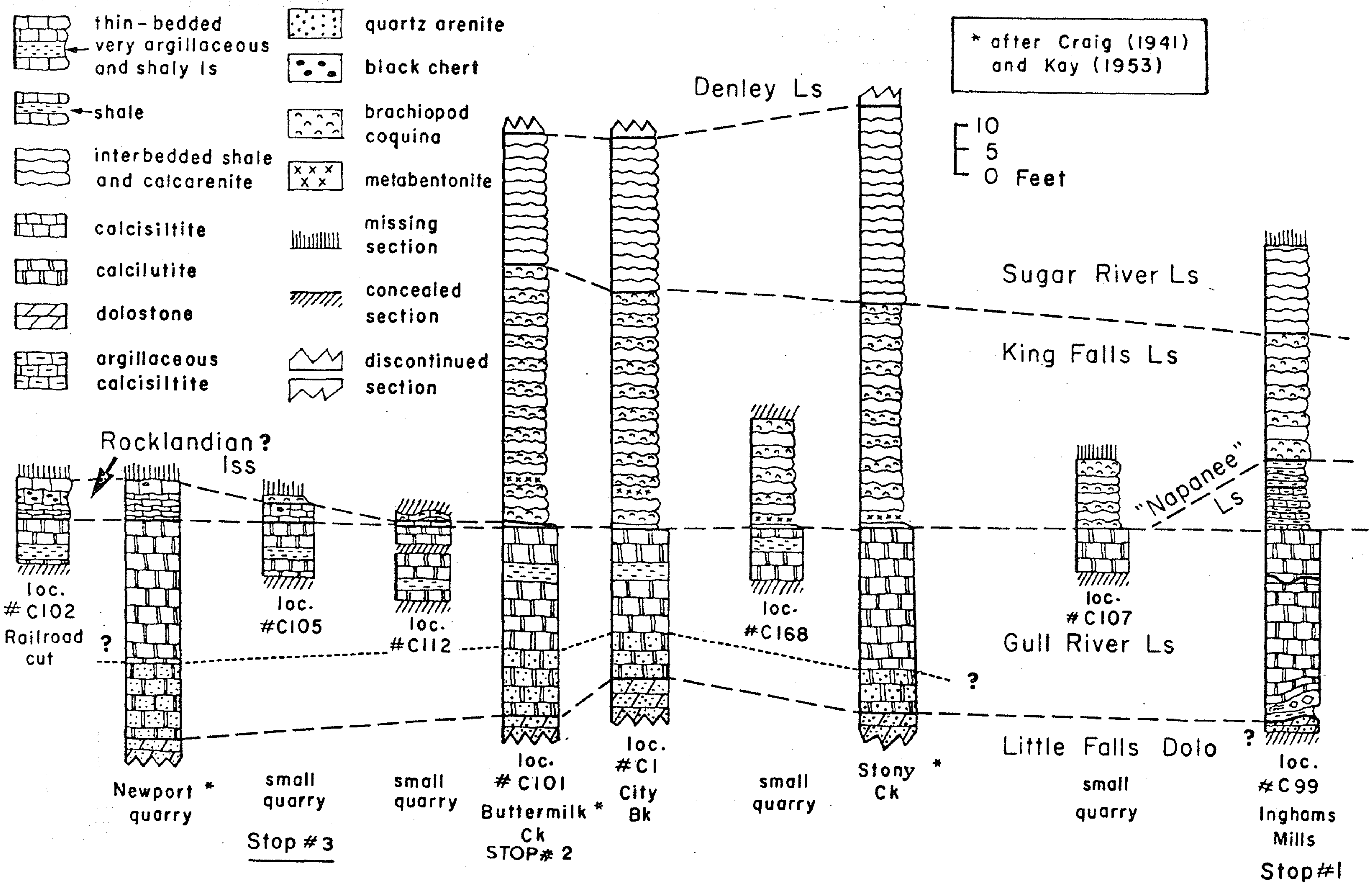



Fig. 3. Measured sections of upper Bolarian and lower Trentonian limestones between Newport and Inghams Mills, New York.

Stop #1. Inghams Mills

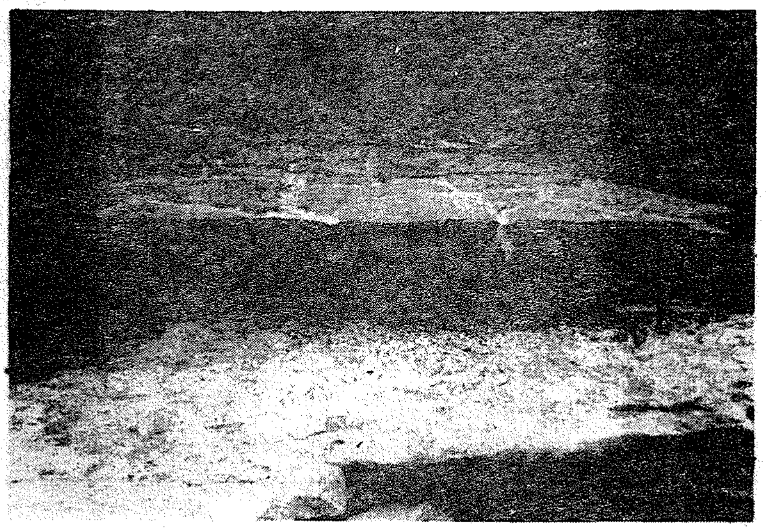


Fig. 5. Mudcracks in Gull River Limestone.

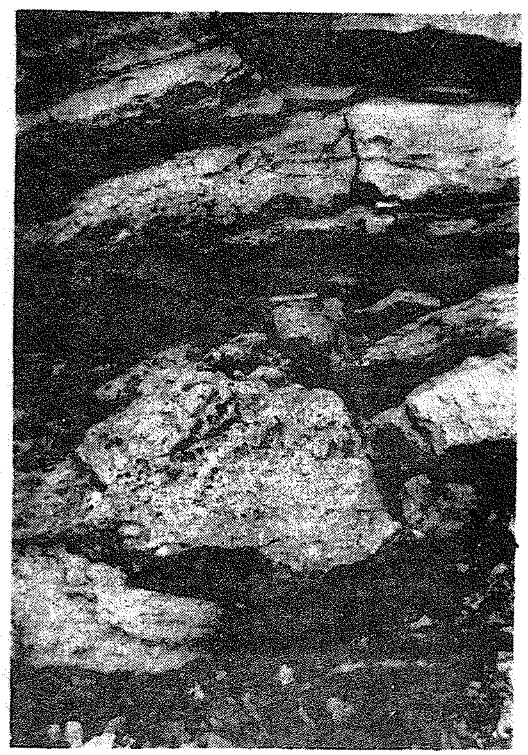
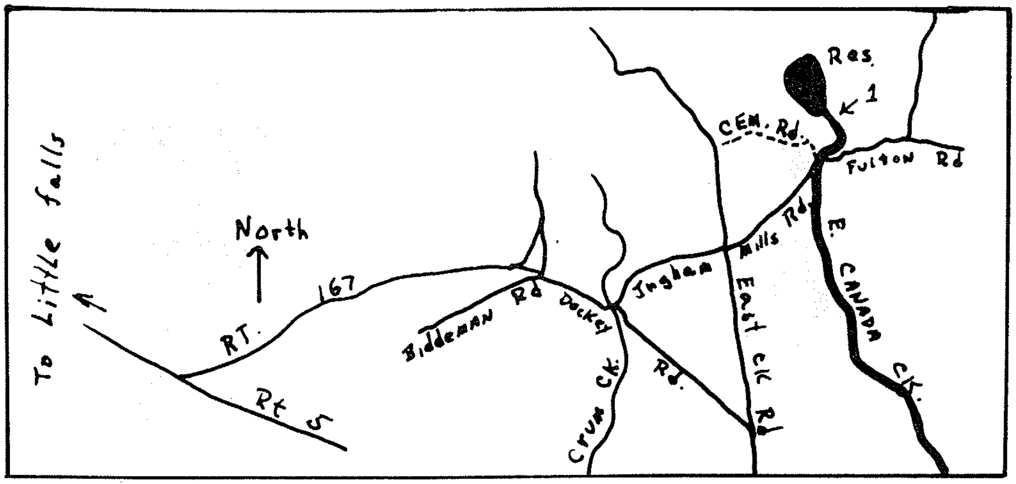
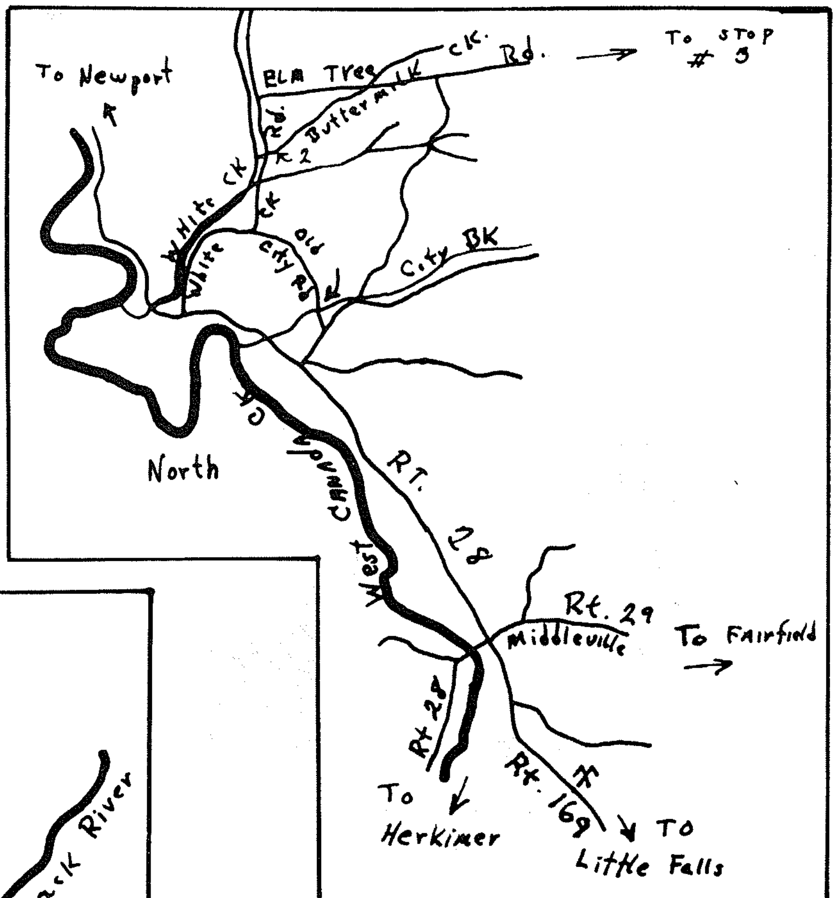


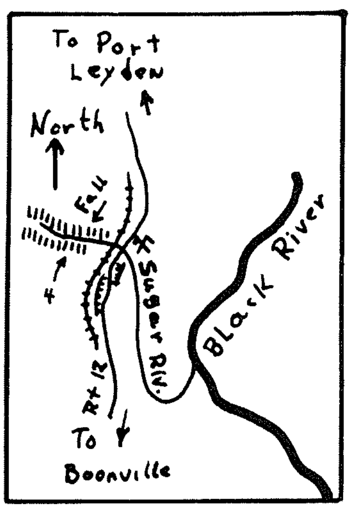
Fig. 4. Slump breccia at base of Gull River Limestone.
(Scale is shown by 6-inch ruler in all photographs.)




stop 1




stop 2




stop 4

Road maps for field trip stops.

FIG. 6

Stop #1. Inghams Mills

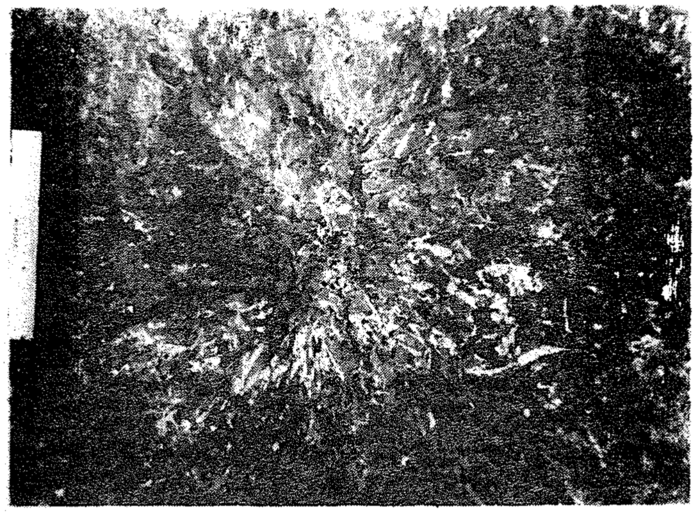


Fig. 8. Top view of whole Tetradium cellulosum colony from top of Gull River Limestone.

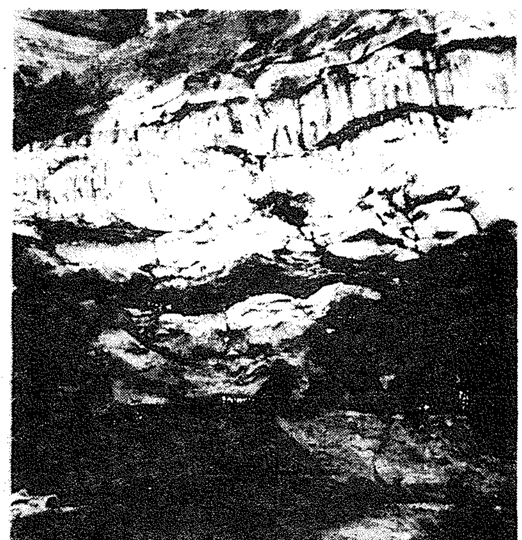


Fig. 7. Upper Gull River Limestone showing vertically burrowed (Phytopsis) beds, darker subtidal facies, and channel deposits.

The large ostracod Eoleperditia fabulites, snails, trilobite fragments, cryptostome bryozoa, and the tabulate coral Tetradium cellulosum are relatively common. T. cellulosum (Fig. 8) and the vertical burrow Phytopsis are characteristic of the Gull River and are often abundant.

Lower Trentonian Series:

The Trentonian Series represents the time during which the limestones and shales of the Trenton Group were deposited. It is subdivided into stages of which the lowest three are in ascending order the Rocklandian, Kirkfieldian, and Shorehamian (fig. 2). The Rocklandian Stage is defined by the Doleroides ottawanus and succeeding Triplesia cuspidata assemblage zones. During the Rocklandian Stage the Selby, Napanee, and lowest Kings Falls limestones were deposited. The lower Rocklandian Selby Limestone at the base of the Trenton Group pinches out north of Boonville, New York, and will not be seen on this field trip (figs. 1-2). The medial Rocklandian Napanee Limestone is continuous from southeastern Ontario southward to Boonville. Farther south, after about 20 miles of non-exposure, it is replaced by an unnamed facies which pinches out about 2 miles north of Middleville, New York (figs. 1-2). East of Middleville, there are no Rocklandian limestones until Inghams Mills, New York, where an unnamed "lens" of early to medial Rocklandian limestones and shales occur. The late Rocklandian Stage is represented only in the lowest 10 to 15 feet of the Kings Falls Limestone from Boonville northward where the upper half of the T. cuspidata Zone is found (Cameron, 1968). The Kirkfieldian Stage is not defined by formally named zones, but lies between the top of the Rocklandian T. cuspidata Zone and the base of the Shorehamian Stage. The Kirkfieldian Stage is represented by the remainder of the Kings Falls Limestone formation. The Shorehamian Stage is defined by the Cryptolithus tesselatus Zone and is represented by the Sugar River Limestone (fig. 2).

Napanee Limestone:

The Napanee Limestone formation (Cameron, 1967, p. 147) was defined by Kay (1937, p. 255) "...as including the beds overlying the Selby limestone...and underlying the..."Kings Falls Limestone in southeastern Ontario and northwestern New York. It is subdivided into the following lithofacies: (1) shaly calcisiltite of central New York, (2) cherty calcisiltite of central New York, and (3) shaly calcisiltite of northwestern New York and southeastern Ontario (Cameron, 1968, p. 79). The third lithofacies is the most widespread and is of medial Rocklandian age (lower Triplesia cuspidata Zone.) The exact age of the cherty calcisiltite is problematic, while the shaly calcisiltite of central New York (Inghams Mills area) ranges from early to medial Rocklandian in age.

Shaly Calcisiltite of Central New York- Thirteen feet of interbedded calcisiltite and calcareous shale, divisable into two unnamed members, comprise the lowest Trentonian limestones in the Inghams Mills area (Stop #1; Figs. 7-8; Kay, 1937, pl. 3, fig. 1). The lower member ($7\frac{1}{2}$ feet) is composed of chocolate brown weathering interbedded shales and argillaceous, burrowed, black calcisiltites, while the upper member ($5\frac{1}{2}$) is composed of medium gray weathering, dark gray to black, less argillaceous, burrowed

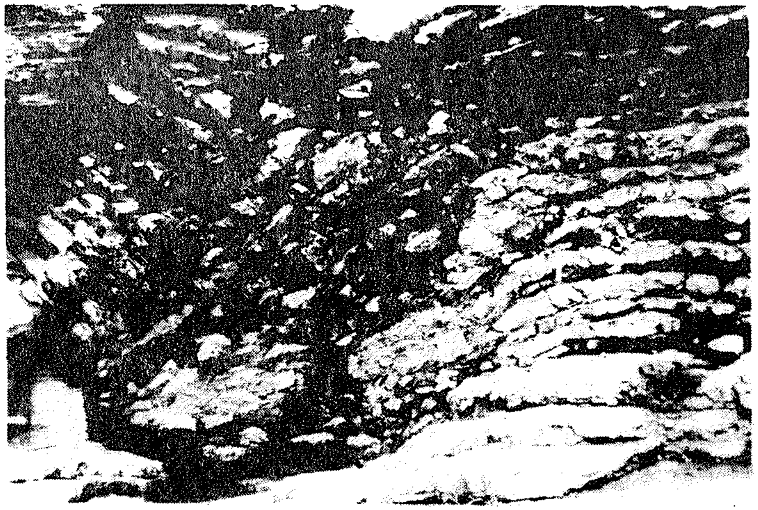


Fig. 10. Subsolifluction fold in lower "Napanee Limestone".

Fig. 11. Limestone conglomerate at base of Kings Falls Limestone.

Fig. 9. Disconformity between lower "Napanee" and Gull River limestones.

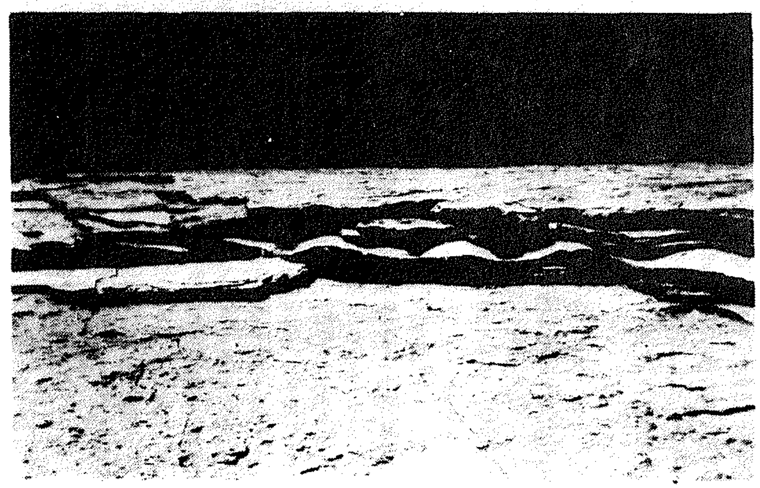


Fig. 12. Pararipples in lower Kings Falls Limestone.

calcisiltites (micrites and biomicrites) and thinner interbedded calcareous shales. Horizontal and cross-laminations are absent, probably due to complete burrow reworking. Skeletal calcarenites (biosparites) are sparse but increase in frequency towards the top of the upper member. The surfaces of these limestones exhibit extremely well-developed loading casts, suggesting that the weight of overlying sediments had deformed these limestones because they were still incompletely consolidated after burial.

Because these Rocklandian limestones (especially the upper member) resemble the upper Rocklandian Napanee Limestone of northwestern New York in that they are composed of interbedded calcisiltites and shales, they are tentatively referred to as "Napanee Limestone". The Napanee also outcrops in the southern Adirondacks, present in the infaulted outlier at Wells where about 10 feet are exposed (Fisher, 1957). Elsewhere in the Mohawk Valley of central New York Rocklandian limestones are absent.

The "Napanee Limestone" at Inghams Mills contains the Doleroides ottawanus Zone in the lower member whose fossil diversity and abundances are much less than those of the upper member (Cameron, 1968, 1969b). The lower member is characterized by D. ottawanus, Isotelus, the burrow Chondrites, Eridotrypa, ostracods, and straight nautiloids; other bryozoa, brachiopods, and trilobites, and snails and clams are rare to uncommon. The upper member contains the Triplesia cuspidata Zone and is characterized by T. cuspidata, Chondrites, Eridotrypa, Dalmanella, diverse snails, diverse brachiopods, diverse trilobites, and corals. Conodonts have been studied from this unit by Schopf (1966) and Hasan (1969).

Cherty Calcisiltite of Central New York - This lithofacies or unnamed member of the Napanee Formation is composed of medium gray weathering, dark gray to black, generally medium-bedded and heavy-ledged, irregularly burrowed, argillaceous, brittlely fracturing, sparsely fossiliferous micrites. A few fossiliferous biomicrites and biosparites are occasionally present. Black chert nodules occur frequently in the thicker northerly sections near Newport where thin shale layers begin to appear in the middle of the facies. Burrows occur as interconnected non-vertical and vertical burrows resembling Camaracladia of the upper Bolarian Watertown Limestone and as burrow reworking which has apparently destroyed any original current laminations. "Corrasion" surfaces mark its contacts with the Gull River and Kings Falls limestones (Kay, 1953. fig. 28). Maximum thickness of this facies is about 7 to 8 feet in the vicinity of Newport but it decreases to zero southward 2 miles north of Middleville. Due to concealment by Pleistocene sediments, no exposures of this interval can be found north of Poland for 23 miles until Boonville where the more typical Napanee Limestone is present at this stratigraphic level. Although few time-diagnostic macrofossils (Rafinesquina reported by Craig, 1941, and Kay, 1953) have been identified from the "calcisiltite lithofacies", conodonts (Hasan, 1969) indicate a Trentonian age.

The fossil assemblages of this facies are relatively large (Cameron, 1968, Table 9, p. 89-90) and is characterized by echinoderm fragments, mollusks, ostracods, bryozoa and corals. Comminuted skeletal material comprise about 17% of the facies in thin-section. Echinoderm fragments, non-vertical burrows, brachiopods, and large ostracods (leperditiids) are common at all exposures, while cup corals (Lambeophyllum), large colonial tabulate corals (Foerstephyllum), and a large stromatoporoid (Stromatocerium) trilobites and snails are rare to common at almost all localities. Collecting is difficult, however, due to the massive nature of these limestones.

Northern Shaly Calcisiltite - The next lower Trentonian outcrops to the north are at Boonville along the Black and Sugar rivers, 23 miles north of Poland and expose $19\frac{1}{2}$ to 21 feet of more typical Napanee limestone lying between the Watertown and Kings Falls limestone formations (fig. 2). This facies doubles in thickness in northwesternmost New York north of Watertown and then thins westward again in southeastern Ontario where it is 20 feet thick in the type section at Napanee (Cameron, 1968). The contact between the Napanee and Watertown is usually a corrasion surface, while the contact with the Kings Falls Limestone is usually gradational and is drawn at the first prominent thick, coarse-grained, shelly calcarenite, such as along Sugar River at Stop #4. Detailed information on the Napanee Limestone can be found in Cameron (1968, p. 91-117).

The Napanee is dominantly burrowed calcisiltites interbedded with thin calcareous shales, but a few calcilutites occur in the lower half and skeletal calcarenites increase in abundance towards the top. The calcisiltites and the few calcilutites are sparsely fossiliferous, mud pellet bearing micrites that contain infrequent, thin, discontinuous, skeletal laminae. X-ray analysis of some calcareous shales from two exposures along the Black River east of Boonville indicate a composition of calcite, illite, quartz, koalinite, and feldspar. The last two occur in small amounts, and in thin-section some dolomite rhombs can be found. The less abundant calcarenites are dominantly poorly sorted (micritic) biopelsparites and biomicrites in which skeletal material is abundant (about 30%) and mud pellets frequent (about 12%). Some of the coarse beds are horizontally laminated or cross-laminated. Apparent current directions measured from cross-laminated beds indicates a strong preference for northeastward to eastward moving currents during the deposition of the Napanee. The few pararippled biosparites in the lower Napanee from Bonville to Lowville indicate a similar dominant current direction.

The fossil assemblages from the Napanee Limestone are characterized by echinoderm fragments, brachiopods, bryozoans, mollusks (mostly gastropods), and trilobites (Cameron, 1968, tables 10 & 14). The most common fossils are the brachiopods Dalmanella and Sowerbyella. Small ostracods, strophomenid brachiopods, the tiny brachiopod Protozyga, the burrow Chondrites, horizontal burrows and the bryozoans Stictopora, Eridotrypa, and Prasopora are common. The brachiopod index fossil Triplesia cuspidata is frequent. Where burrows are abundant, such as in the calcisiltites, skeletal fossils are rare. The burrows in the lower beds of the Naponee include many discrete, near-vertical branching and almost U-shaped burrows.

Kings Falls Limestone:

The name Kings Falls Limestone was proposed by Kay (1968) to replace the lithic use of the term "Kirkfield" which was restricted to use as a stage named Kirkfieldian. The formation has a maximum

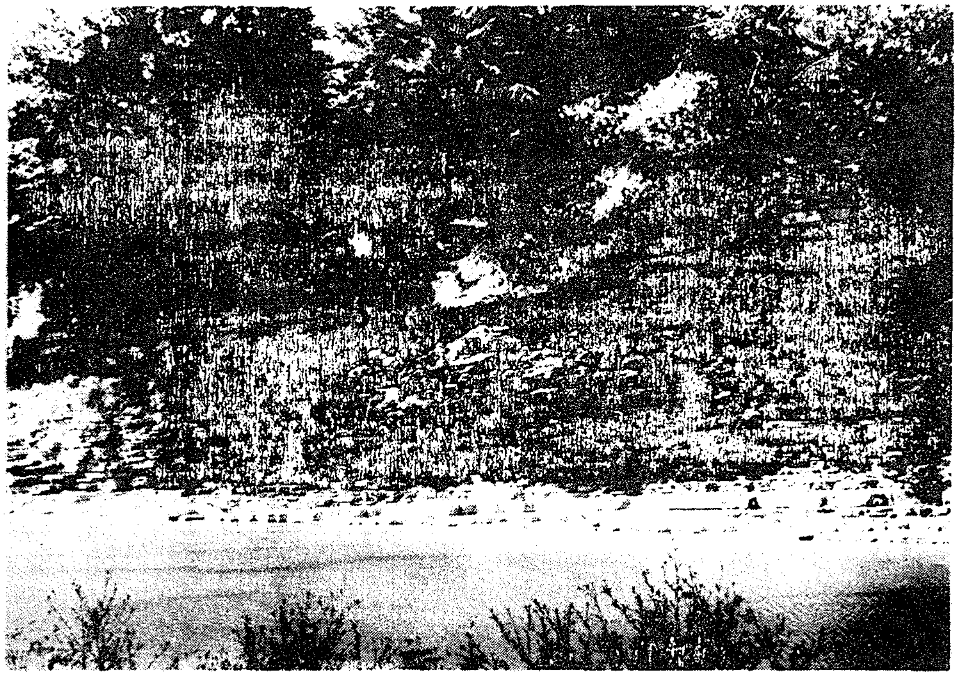


Figure 13. Napanee and lower Kings Falls limestones along Sugar River (Stop #4). Note the thick calcisiltite beds of the lower Napanee (see fig. 14 below), lensing beds of the upper Napanee, and massive overhanging beds of the lower Kings Falls. Senior author in shadows at right-center forms scale.

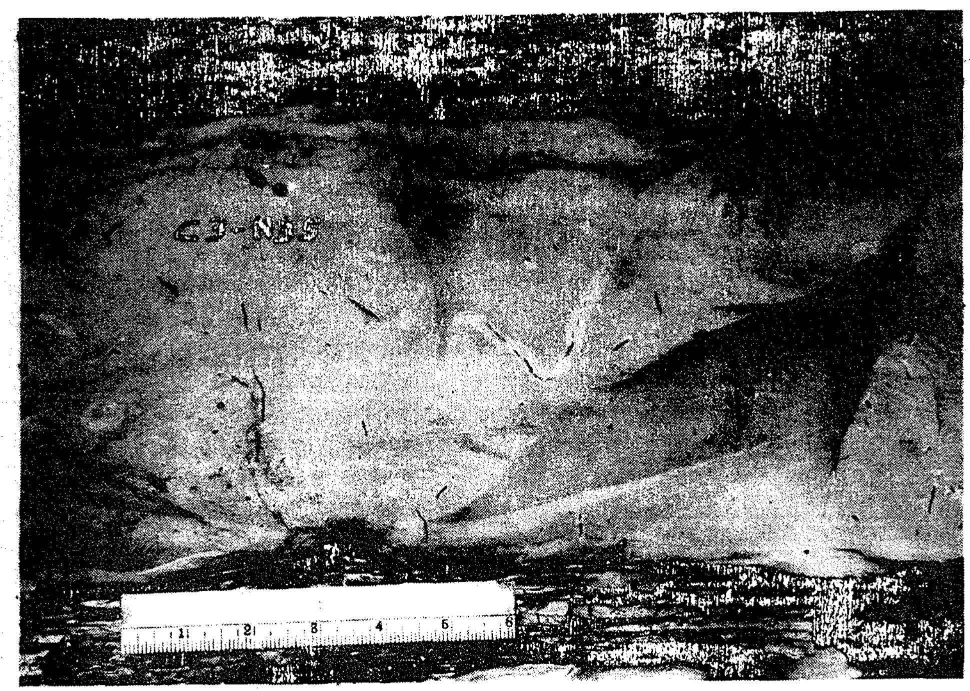


Figure 14. Close-up of a thick, burrowed calcisiltite bed in the lower Napanee Limestone (locality C3, "lower ledges" along the Black River, Boonville, New York).

thickness of about 100 feet at its type section along the Deer River between the towns of Copenhagen and Deer River, New York. To the southeast it thins to about 65 feet at Lowville and maintains essentially the same thickness to Boonville. Further south the formation thins again being about 45 feet in the area of Newport (North of Middleville) 23 feet at Inghams Mills (Stop 1) and 0 feet at Canajoharie. Two broadly defined lithofacies of the Kings Falls are recognized in the field: (1) shelly calcarenite of northwestern and central New York and (2) an overlying non-shelly calcarenite of northwestern New York. The boundary between the two lithofacies is lithically determined by a sharp decrease in the percentage of shelly calcarenite.

Shelly Calcarenite of Northwestern and Central New York - This facies is characterized as dark grey to black, grey weathering, coarse-grained, relatively massively bedded, shelly calcarenite (fig. 16) with interbedded thin calcareous shales. Fine and coarse-grained calcarenites are frequent (fig. 15) and calcisiltites are present also. Silicification, especially of brachiopods, seems to be limited to this facies.

Outcrops of the Kings Falls in central New York are wholly of this facies. In northwestern New York it has been traced as far north as Roaring Brook, south of Lowville. The occurrence of this facies is yet to be determined in outcrops further to the north.

Pararippled, cross-bedded and sheet laminated beds are abundant and characteristic of this facies. Current movement was dominantly southwest to northeast (Cameron, 1968).

Fossil assemblages of the shelly calcarenite facies are heavily dominated by the brachiopods Dalmanella and Sowerbyella. Strophomenids are common along with the bryozoa genera Eridotrypa and Stictopora. The trilobites Isotelus, Flexicalymene, Ceraurus and Encrinurus are present. The snails Hormotoma, Liospira, Sinuites, Phragmolites and Subulites are locally abundant. In the lower levels at Sugar River (Stop #4) the brachiopod Triplesia and the coral Lambeophyllum are common.

Non-shelly Calcarenite of Northwestern New York - This relatively massively bedded facies is lithically distinguished by a dominance of calcarenites and a scarcity of shelly arenites (figs. 15, 16). An increase in horizontal burrows and a decrease in pararippled and laminated beds also serve to discriminate this facies. The facies comprises the upper 30 feet of the Kings Falls at Sugar River and has also been traced as far north as Roaring Brook, South of Lowville.

The assemblages of the non-shelly calcarenite facies are dominated by the bryozoan genera Eridotrypa and Prasopora. Other Bryozoa include the general Eshcaropora, Stictopora and several species of fenestrates. The brachiopods Dalmanella, Sowerbyella and strophomenids are still quite common. Flexicalymene is the most abundant trilobite. Whole specimens of this species are occasionally found. Ceraurus is also abundant. Among the snails only Sinuites, Liospira and Hormotoma are found. Several different varieties of Pelmatozoan columnals have been observed in this facies.

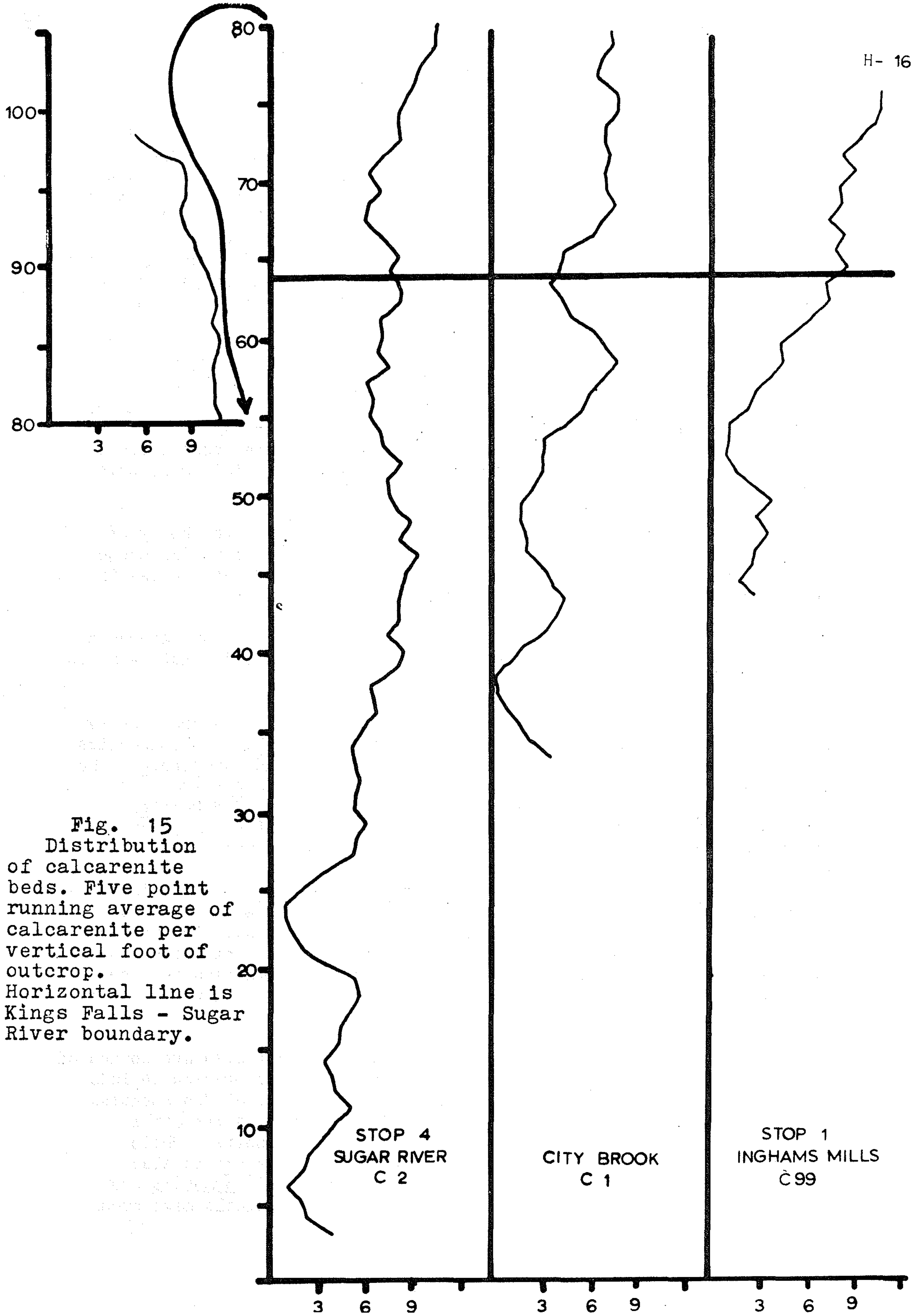



Fig. 15
Distribution of calcarenite beds. Five point running average of calcarenite per vertical foot of outcrop. Horizontal line is Kings Falls - Sugar River boundary.

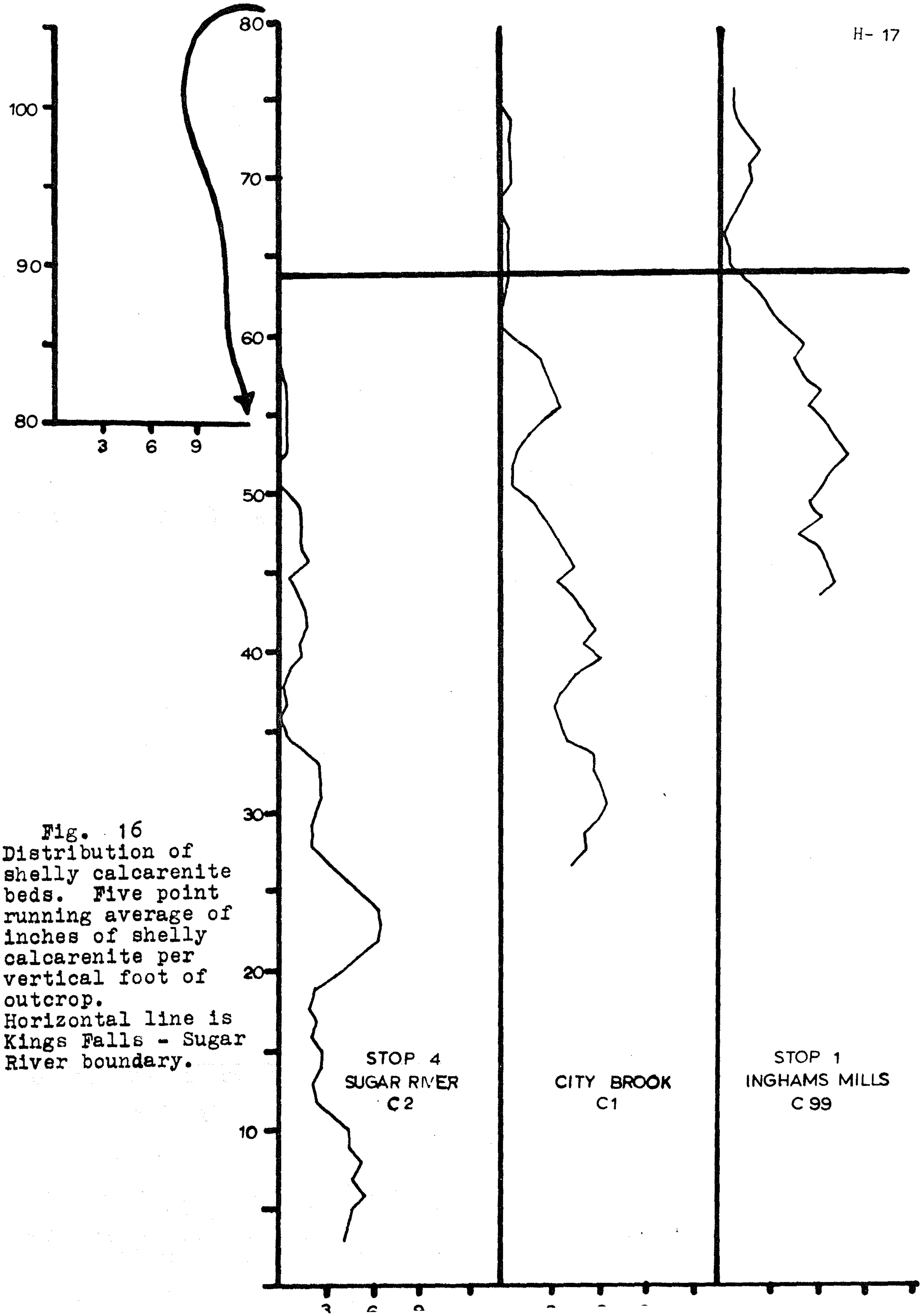



Fig. 16
Distribution of shelly calcarenite beds. Five point running average of inches of shelly calcarenite per vertical foot of outcrop. Horizontal line is Kings Falls - Sugar River boundary.

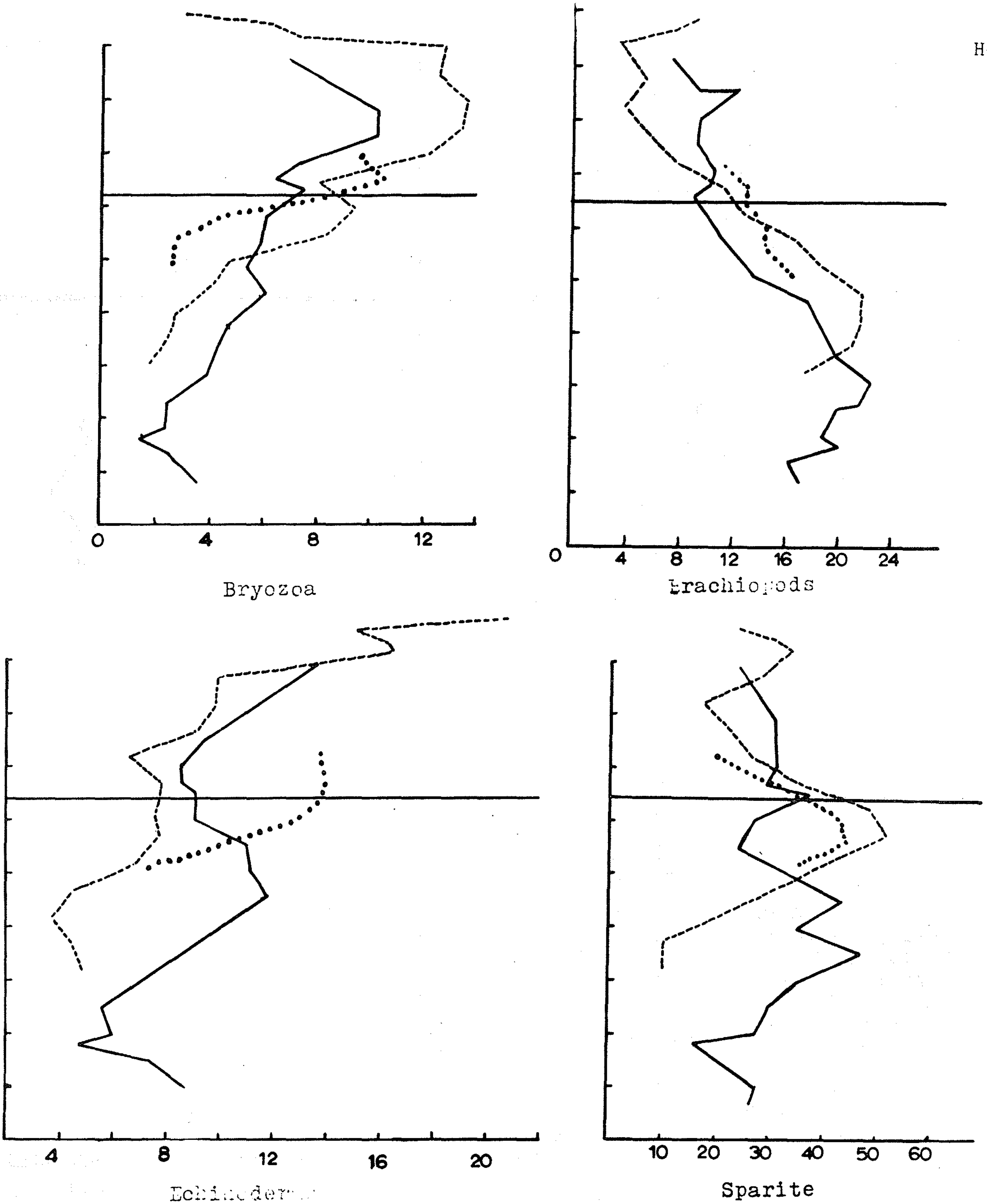



Fig. 17

Five point running average (expressed in percent) of petrographic data. Horizontal line is Kings Falls-Sugar River boundary. Dotted line is Inghams Mills. Dashed line is Buttermilk Creek. Solid line is Sugar River. Vertical axis devided into 10 foot intervals.

Sugar River Limestone:

Kay (1968) proposed the name Sugar River Limestone to replace the lithic use of the term "Shoreham" which is now restricted to use as a stage named Shorehamian. The formation is thickest in northwestern New York where it is about 40 feet thick. In central New York it is about 35 feet thick in the Middleville area and further south it progressively thins to 17 feet at Canajoharie. In central New York, an upper member, the Rathbun Member, is distinguished.

Lithically the Sugar River is a dark-grey to black, thin-bedded, non-shelly calcarenite (fig.15) with interbedded thin calcareous shales. In northwestern New York shales increase in abundance southward to Boonville (Chenoweth, 1952). Farther south, after a covered interval of about 25 miles, the shales of the Sugar River formation decrease southward from Middleville to Inghams Mills and Little Falls (Cameron, 1968b) and decrease even more to Canajoharie. Relatively massively bedded, large Prasopora - bearing calcarenites are found in the upper pre-Rathbun Sugar River Limestone in central New York. The limestones of the Sugar River are dominated by burrow-reworked beds though cross-laminated and pararippled beds are not uncommon.

High diversities of bryozoa, pelmatozoa, and brachiopods characterize the Sugar River formation. Epiboles of the bryozoa Prasopora occur at several levels. Large branched colonies of Eridotrypa are occasionally seen. Other bryozoan genera include Stictopora, Escharopora, Pachydictya and several unidentified fenestrates. At least a dozen pelmatozoan species have been distinguished from their columnals. The brachiopods include Dalmanella, Sowerbyella, Platystrophia, Dinorthis and the inarticulate Trematis. Strophomenids are scarce. Important trilobites of the Sugar River include the index fossil Cryptolithus along with Flexicalymene, Ceraurus and Calyptaulux.

Rathbun Member - The Rathbun Member (Kay, 1943) has been recognized as comprising the topmost Sugar River at outcrops in the valley of West Canada Creek and its tributaries (Chenoweth, 1952; Kay, 1953). The Rathbun is as much as 10 feet of relatively thick-bedded calcisiltites and shales with a few coarse shelly calcarenites. To the southeast, the member rapidly thins to extinction.

## EARLY TRENTONIAN TRANSGRESSION

The Rocklandian, Kirkfieldian and Shorehamian rocks of central New York represent a transgressive sequence in which a medial Ordovician sea transgressed apparently from the west to east according to the NW-SE outcrop belt. Evidence for this transgression can be found in the stratigraphic relationships of the formations. The basal Selby formation, which is found in northwestern New York, thins out to the southeast and disappears altogether in the area south of Lowville. The overlying Napanee formation extends farther to the south but quickly pinches out in the area north of Middleville.

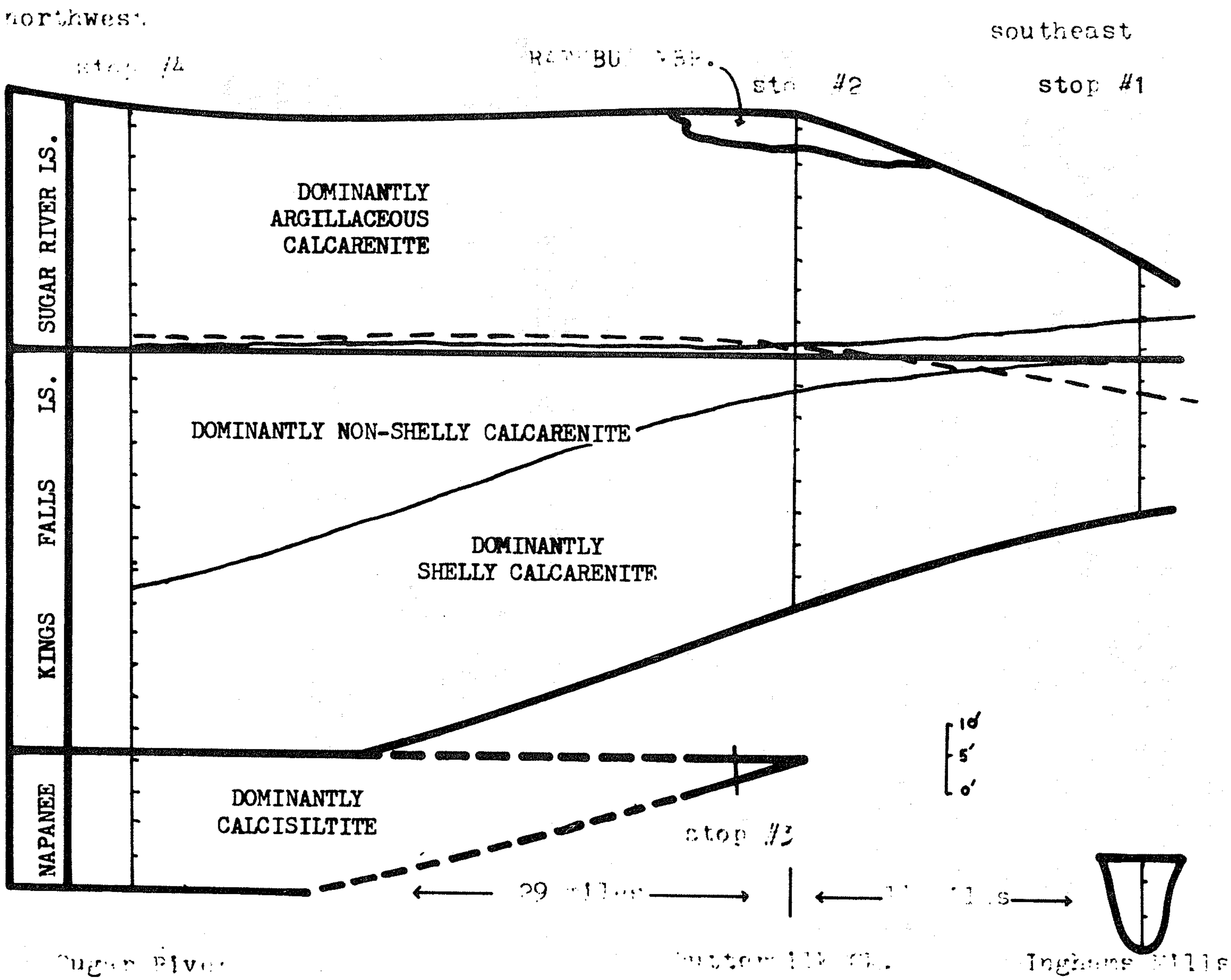



Figure 18. Distribution of the major dominant lithologies in the lower Trenton Group.

The age of the base of the Kings Falls formation becomes progressively younger to the southeast. In the area of Boonville there are 12 feet of Rocklandian aged lower Kings Falls limestones, but in central New York, the Rocklandian lower Kings Falls is absent, indicating the lower Kings Falls is Kirkfieldian in age. At Inghams Mills a basal conglomeratic interval occurs at the base of the Kings Falls, indicating, along with other evidence, a disconformity. The Kings Falls disappears west of Canajoharie, so that the basal Trenton limestones at Canajoharie are represented by a thin (17 feet) Sugar River Limestone. Farther east the Sugar River pinches out entirely (Park & Fisher, 1969).

In the area of Middleville, a thin metabentonite layer (an altered volcanic ash) in the lower Kings Falls occurs progressively lower in the section towards the southwest, being at 9 feet at Buttermilk Creek (Stop #2), 7 feet 1/4 mile south at City Brook, 2 feet 3 miles to the southeast at Stony Creek, and absent further east.

Other lines of evidence for an early trentonian transgression come from the study of primary structures. Cross-laminations, sheet laminations, erosional surfaces and intraclasts, suggestive of a high energy shallow water environment, are relatively common in the Rocklandian and lower Kirkfieldian limestones. These structures become progressively less common in the upper Kirkfieldian limestones and are uncommon in the Shorehamian Sugar River Limestone. Burrow-reworked beds are common in the Sugar River suggestive of quieter, deeper water conditions.

Fossil assemblages change in a manner which can be related to the transgression. This will be discussed in the section below on biostratagraphy.

## SEDIMENTARY ENVIRONMENTS

The sedimentary environments of the Napanee, Kings Falls, and Sugar River limestones will be briefly discussed along with the evidence for them. The northern shaly calcisiltite lithofacies of the Napanee Limestone probably represents a relatively shallow-shelf lagoonal situation protected by land (Adirondackia) to the east and an offshore shoal on the west. This is indicated by the dominance of fine-grained sediment (shales and calcisiltites) and the abundance of burrow-reworking. No mudcracked beds, dolomitized algal mats, abundant intraclasts or well developed vertical burrows are present west of the Adirondacks to indicate either inter or supratidal conditions. Faunal diversity is relatively low. The lower 10 feet may represent the shallowest water sediments of the lower Trenton sequence because it contains some rare vertical burrows, minor scour-and-fill, more cross-laminated beds and some pararippled beds.

The burrowed, dominantly non-laminated, shaly calcisiltite lithofacies of central New York at Inghams Mills probably represents a narrow embayment of the early and medial Rocklandian sea. The massive, burrowed, cherty calcisiltite lithofacies of central New York probably represents a very nearshore shallow water environment with much of the finer-grained lime mud and argillaceous material being carried out into the offshore shelf lagoon. The shelly calcarenite lithofacies of the

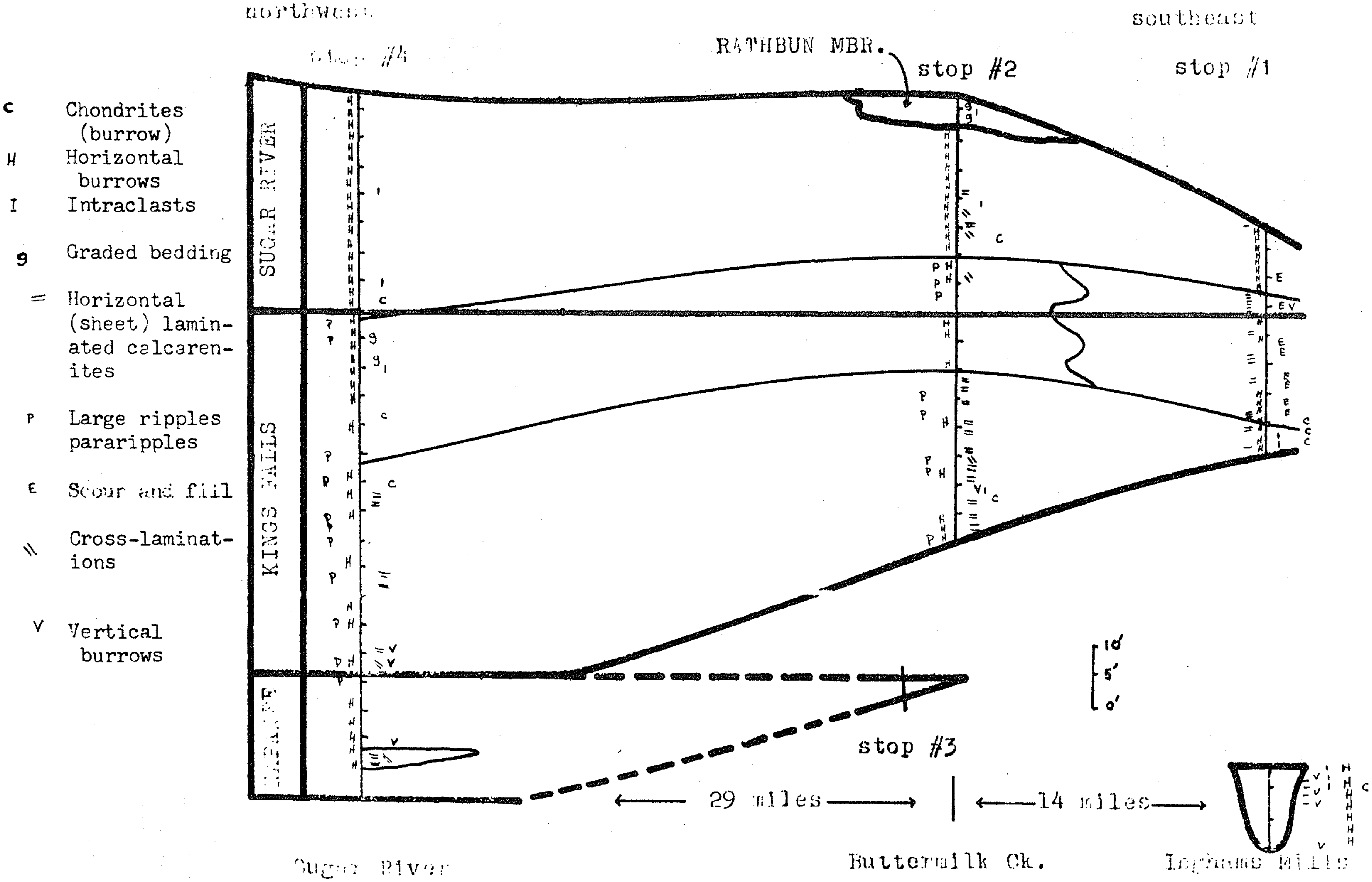



Fig. 19. Generalized distribution of major physical and biological sedimentary structures in Rocklandian and Kirkfieldian limestones. Go to Fig. 20 for interpretations in terms of depth zonation.

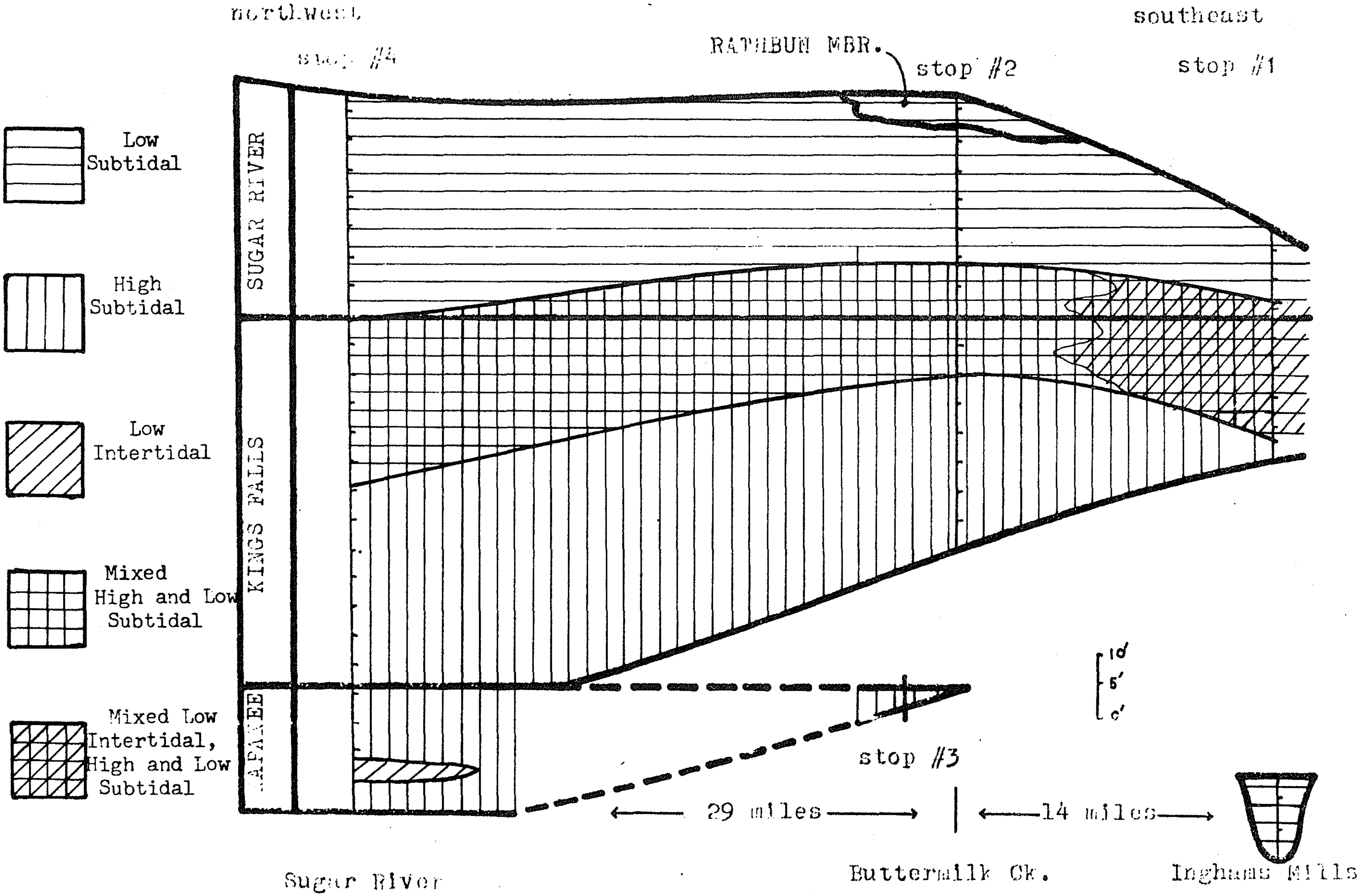



Fig. 20. Generalized depth Zonation of Rocklandian and Kirkfieldian limestones. Based on physical and biological sedimentary structures (see fig. 19).

Kings Falls Limestone contains many cross-laminated, sheet laminated, and pararippled beds, indicative of much wave and current activity, frequently with high flow regimes. We suggest an offshore shoaling environment for much of the Kings Falls Limestone. The lower Kings Falls in northwestern New York is transitional with the lagoonal northern Naponee Limestone. The non-shelly calcarenite lithofacies of the Kings Falls Limestone is also highly laminated, but more burrow-reworked beds are present, indicating somewhat deeper water conditions.

The top of the Kings Falls is transitional with the Sugar River Limestone which almost lacks laminated beds because the limestones are so highly burrow-reworked, producing a lumpy or rubbly outcrop. This formation probably represents the farthest offshore as well as the deepest water conditions of the early Trentonian transgressing sea.

## BIOSTRATIGRAPHY

### Introduction

Lower Trentonian fossil assemblages change in a manner which can be directly related to the transgressing sea. Environments are somewhat arbitrarily divided into low intertidal, high subtidal and low subtidal.

The assemblages of both the Rocklandian and the Kirkfieldian reflect adaptations to the stresses peculiar to their shallow water environments. In both, the shallowness of the water, through current and storm activity, allowed sediment instability. The assemblages which lived on these unstable substrates have a higher percentage (54%) of mobile species than in the deeper water environments of the Shorehamian. Few fragile epibenthonic pelmatozoans or bryozoa are found.

Also related to the stressfull nature of these shallow water environments is the fact that the assemblages are overwhelmingly dominated by specimens of one species or another. In the Kirkfieldian and Rocklandian the brachiopods Dalmanella or Sowerbyella generally dominate. In the Rocklandian the brachiopod Triplesia or the coral Lambeophyllum also occasionally dominate assemblages.

By Shorehamian times the transgression had reached its maximum extent. Assemblages of these rocks reflect quiet, stable conditions on a level sea bottom. A lower percentage (32%) of the species were mobile than in the shallow environments. Many species of fragile pelmatozoan and bryozoa are present. Bedding count diversities are very high but no single species dominates.

### Low Intertidal to very High Subtidal Assemblages

The low intertidal to very high subtidal environment dominated during Rocklandian times. Fossils are scarce in these rocks and the diversity is low compared to other environments; reflecting highly stressfull conditions. The species present can be divided into two groups.

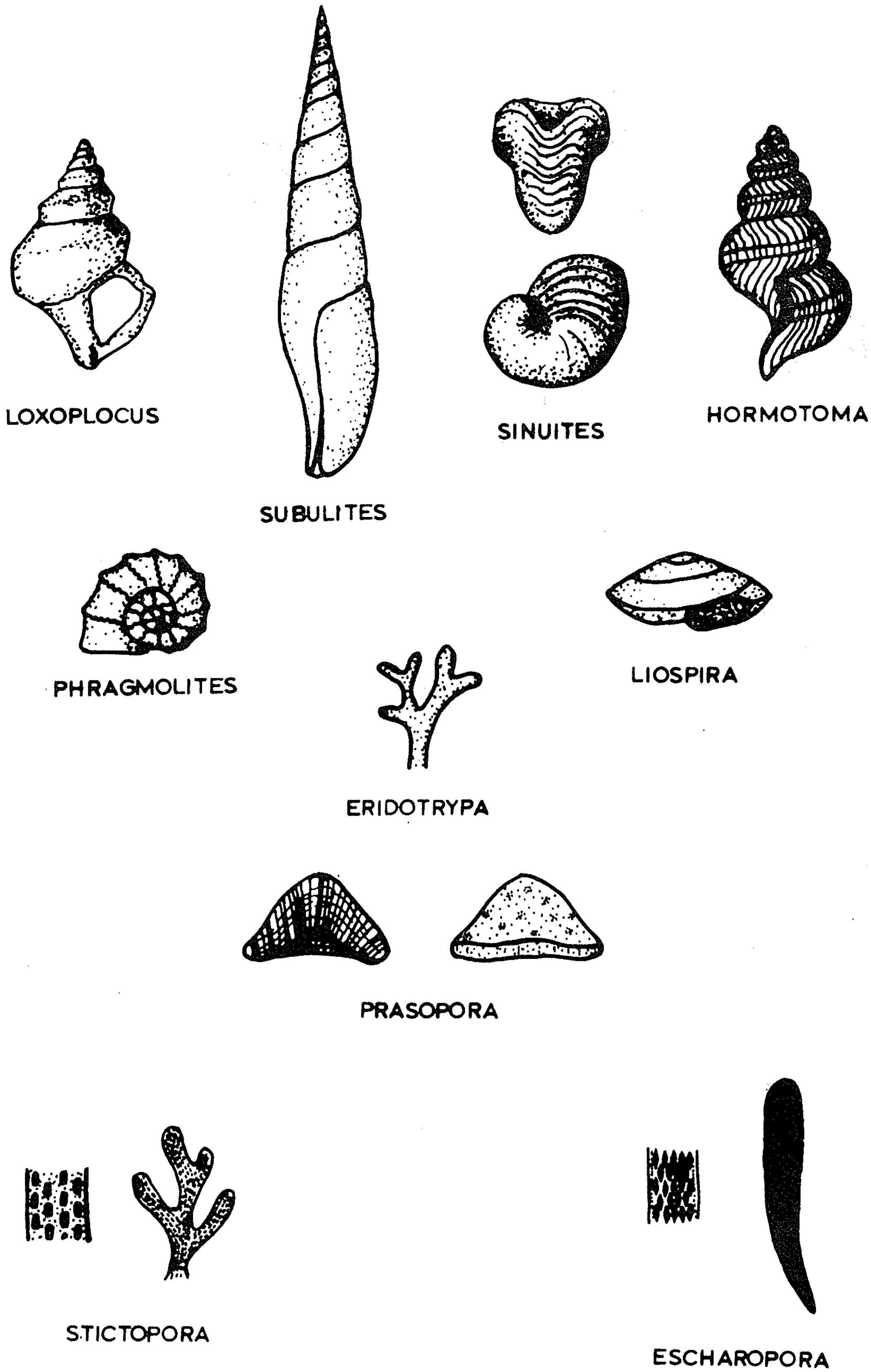



Fig. 21

Snails and bryozoa of the lower Trenton. All figures approximately natural size except for closeups of Stictopora and Escharopora. External and internal views of Prasopora are given.

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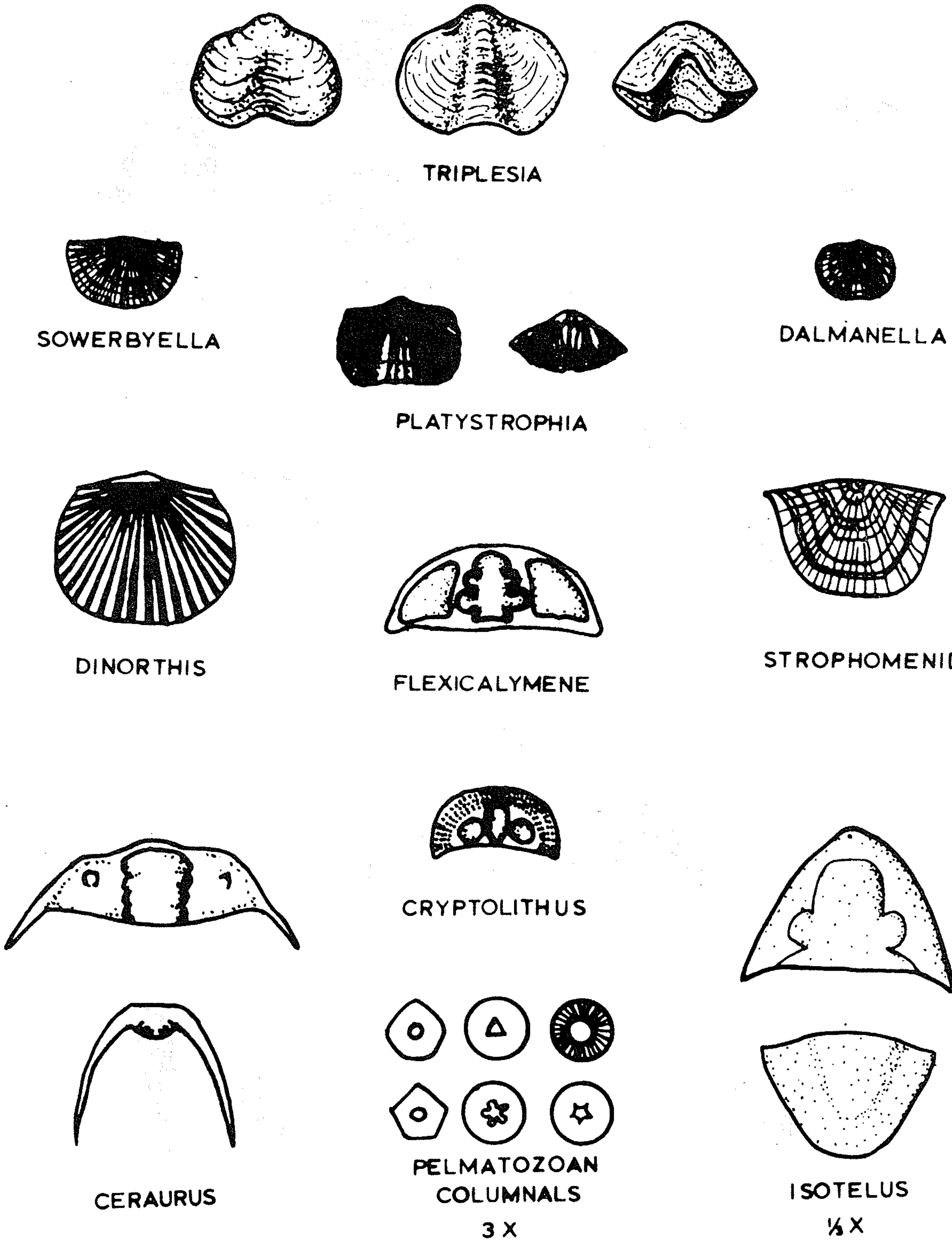


Fig. 22
Brachiopods, trilobites and pelmatozoan columnals of the lower Trenton. All figures approximately natural size unless indicated.

RT

The first consists of many species which are also present in great numbers in the other environments which suggests that they were tolerant of a wide variety of environments and thus were well suited for rapidly changing intertidal conditions. Among these are the brachiopods Dalmanella and Sowerbyella, the strophomenid brachiopods, the trilobites Isotelus and Ceraurus, one crinoid and the bryozoans Prasopora, Eridotrypa, and Stictopora.

A second group consists of a number of species which are highly mobile and restricted to the intertidal environment. Among these are several taxodont clams, some vertical burrowers and the ostracod genus Eolepreditia. Such species may reflect a general adaptation to the substrate instability of the intertidal environment.

High Subtidal Assemblages

The highest diversity of species is found in the high subtidal environment which dominated during deposition of the upper Napanee and Kings Falls sediments. A high diversity of snails and trilobites and a low diversity of pelmatozoa and bryozoa characterize the assemblages of this environment

Characteristic snails are Sinuites, Liospira, Subulites, Hormotoma, and Loxoplocus. The trilobites include Ceraurus, Encrinurus, Isotelus, and Flexicalymene. The brachiopods Dalmanella and Sowerbyella along with the strophomenids are abundant in this environment.

The high subtidal of the Rocklandian stage is characterized by the brachiopod Triplesia, the horn coral Lambeophyllum and abundant and diverse ostracods.

Low Subtidal Assemblages

Towards the end of the transgression during Shorehamian time, a quiet sub-"wave base" environment became established. Without sediment instability, mobility became less important to survival. This is reflected in the faunal assemblages by the decreasing percentage of mobile species and an increasing number of fragile epibenthonic forms. At least 12 species of pelmatozoans have been recognized from their columnals. 10 species of bryozoa have also been identified. Among these are Prasopora, Eridotrypa, Escharopora, Stictopora, and Pachydictya. Neither the bryozoa nor the pelmatozoa make up large portions of the shallow water assemblages. Trilobites are still common and are represented by Flexicalymene, Cryptolithus and Ceraurus. The brachiopods Platystrophia and Trematis are restricted to the deep water environment. Snails, clams, nautiloids and corals are very rarely found.

DESCRIPTION OF STOPS

Stop #1. Inghams Mills (Locality #C99):

Four medial Ordovician formations are exposed at this outstanding

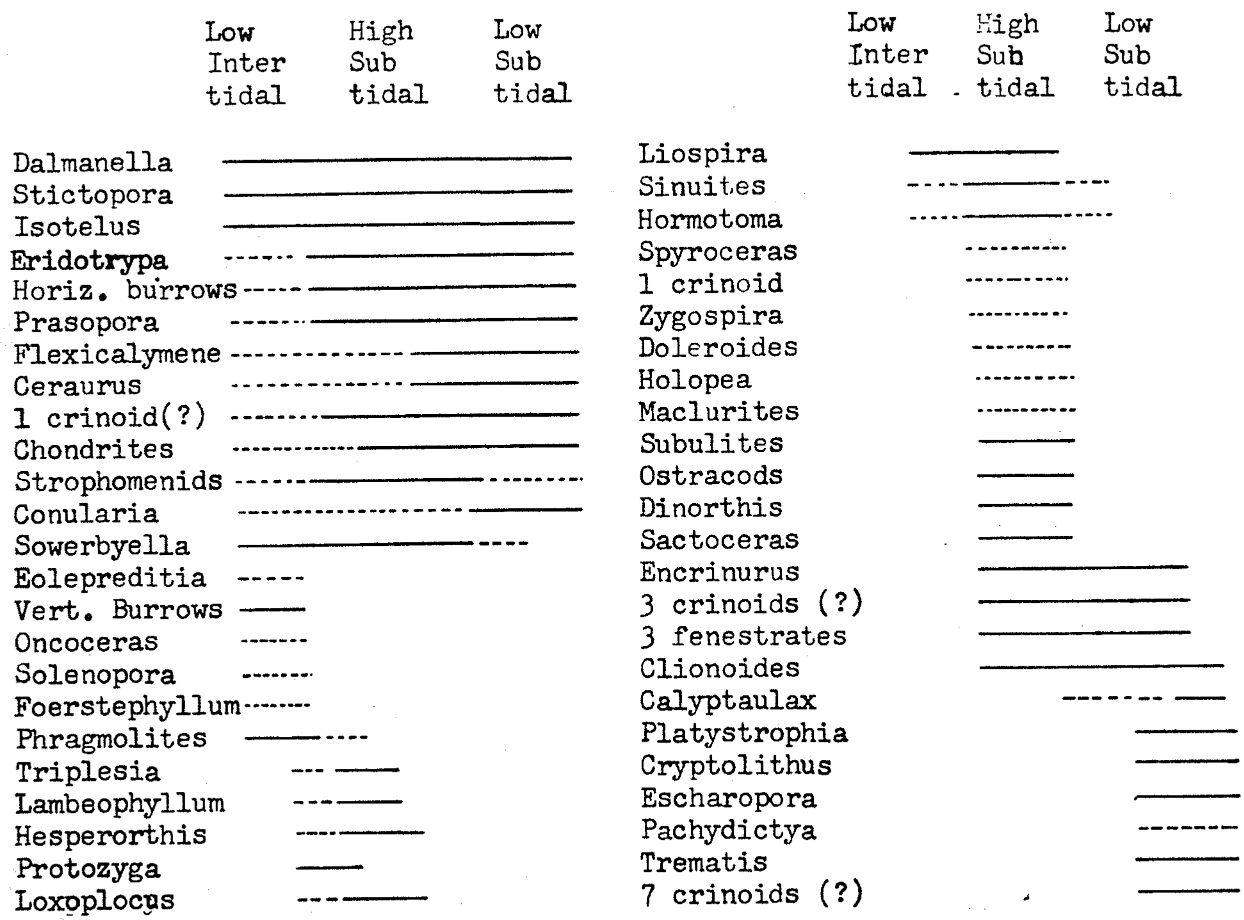


Figure 23. Paleocological distribution of many of the lower Trenton species.

outcrop on East Canada Creek. Lithologies, sedimentary structures, fossil assemblages, formational boundaries and paleoecology will be examined.

Gull River Limestone. About $29\frac{1}{2}$ to 30 feet of Gull River Limestone are excellently exposed here and overly the Little Falls Dolomite of late Cambrian age. A thick dove gray shaly limestone is present at the base. Within the lowest 3 feet is a slump breccia which possesses limestone blocks up to $2\frac{1}{2}$ feet in diameter. This probably formed as a result of instability over the irregular depositional surface of the Little Falls Dolomite.

The next $16\frac{1}{2}$ feet contain horizontally laminated (algal?), dove gray calcilutites with abundant vertical burrows (Phytopsis), a few ostracods, and frequent stylolites. Frequent mudcracks confirm an intertidal or lagoonal origin.

Thin shales are common in the lower 10 feet. The folded limestone layers reported by Cushing (1905a, pl. 6) from the lower Gull River Limestone at this exposure apparently formed as a result of settling over compacting thick shale lenses (Cameron, 1969b, fig. 6).

Between $16\frac{1}{2}$ and $22\frac{1}{2}$ feet an apparently subtidal, irregularly burrowed essentially non-laminated, massively bedded, dark gray to black calcisiltite zone contains Foerstephyllum halle, Lambeophyllum profundum, Hormotoma, Loxoplocus, Isotelus, cryptostome bryozoa, straight nautiloids, andpelmatozoan debris. Most of these species were interpreted as being subtidal by Walker and Laporte (1970).

Immediately above these deeper water sediments, the intertidal or lagoonal facies begins to reappear. This is a vertically burrowed, horizontally laminated (algal?), limestone intraclast-bearing, fossiliferous calcilutite and calcisiltite zone. Fossils from this interval include Tetradium cellulosum, Eoleperditia fabulites, Lambeophyllum profundum, Isotelus, cryptostome bryozoa, and pelmatozoan fragments. Near the base of this zone a sediment filled tidal meander (?) or channel up to 7 feet wide and 2 feet deep is excellently exposed in two faces of the outcrop. Note the structure and composition of the sediment filling it.

At about 27 feet, a 9 inch thick calcilutite bed contains scores of whole Tetradium cellulosum colonies in life position, representing a wave baffle community as described by Walker (1969). They cover 50% to 90% of the bed which contains a thin veneer of limestone pebble conglomerate. One can readily see how the fine-grained sediment was trapped in and around these delicately branching tabulate corals.

The top of the Gull River Limestone is riddled with burrows (dominatly vertical) partially filled with the black lustrous carbonaceous mineral anthroxolite. Several inches of irregular relief over the top of this bed marks the disconformity between the Black River Group and the Trenton Group.

"Napanee Limestone"- The lowest 13 feet of the Trenton limestones can be divided into $7\frac{1}{2}$ feet of chocolate brown weathering interbedded calcareous shales and argillaceous calcisiltites above. The contact between these two subdivisions is slightly gradational. The surfaces of the limestone layers exhibit extremely well-developed loading casts. In addition, the lower subdivision contains an unusually well-developed and fully exposed intraformational fold (Fig.10 ) similar to those described by Chenoweth (1952) from the Sugar River Limestone in northwestern New York. Fossils are common (see text above) in these protected subtidal limestones.

Kings Falls Limestone - Twenty-three feet of the Kings Falls Limestone disconformably overlies the Napanee (Cameron, 1969b). A polymictic conglomerate (dominantly limestone clasts) and shelly calcarenites mark the base of the formation. The upper contact with the Sugar River is determined by a sharp decrease in brachiopod shell calcarenites and an increase in encrinitic bryozoan rich calcarenites (Cameron, 1969b). These field observations are supported by 5 point moving average curves constructed from point-counts of thin-sections (Fig. 17) and analysis of the lithology of each bed of the Kings Falls and Sugar River Limestone (Fig. 16).

Pararippled and/or conglomeratic shelly calcarenites with some horizontal burrows are common in the first 4 feet of the Kings Falls. The succeeding 19 feet of the formation represents rapidly fluctuating environments. Scour-and-fill intraclasts pararipples and laminated beds indicate shallow waters for most of this interval, but there are several feet of rubbly weathering, burrow reworked strata within this interval that reflect deeper water conditions also.

The brachiopods, especially Dalmanella, dominate the assemblages of the lower 20 feet of the Kings Falls formation at Inghams Mills. Other common brachiopods include Sowerbyella, Dinorthis and the strophomenids. Snails are locally abundant in this interval among these are Hormotoma, Loxoplacus, Liospira and Sinuites. The alga Solenopora was common in the lowest bed but has been overly collected. Other common species of the Kings Falls at Inghams Mills include the trilobite Flexicalymene, the bryozoa Stictopora and one crinoid.

Sugar River Limestone: Fourteen feet of the Sugar River Limestone are exposed. The top of the outcrop at the base of the dam is probably near the top of the pre-Rathbun Sugar River because large Prasopora are found there. At this locality the Sugar River has many relatively massive, laminated beds.

Pararippled, sheet and cross-laminated beds and scour-and-fill structures are common in the lower few feet along with thin-bedded, burrow-reworked zones. Higher up there is an alternation of laminated and burrow-reworked horizons.

Diversities in the Sugar River formation are much lower than in the Kings Falls or in the Sugar River elsewhere. Large colonies of the bryozoan Prasopora and Eridotrypa are common and dominate the assemblages. Snails are absent and brachiopods are much less diverse and abundant.

The cryptostome bryozoa and the pelmatozoans are more diverse and common. The trinucleate trilobite Cryptolithus, which is the Shorehamian index fossil, is present in the Sugar River. The inarticluates Trematis and Lingulasma are present near the top of the outcrop.

Stop #2. Buttermilk Creek (locality #C101):

The Gull River, the Kings Falls and the Sugar River (including 5 feet of the Rathbun Member) limestones are exposed here. There are 40 feet of the Kings Falls and 38 feet of the Sugar River Limestones.

Kings Falls Limestone - The Kings Falls disconformably overlies the Gull River. Pararippled, sheet and cross-laminated, horizontally burrowed beds are common throughout the Kings Falls Limestone. A few beds are vertically burrowed and others contain intraclasts. Some intervals have been extensively burrowed causing weathered beds to have a rubbly appearance, especially at the base of the formation. These intervals are uncommon, however, and a dominantly high subtidal environment is postulated.

The contact between the Kings Falls and the Sugar River is again well-defined petrographically by an increase in encrinitic, bryozoan-rich material and an accompanying decrease in brachiopods and sparry calcite cement (Fig. 17). At City Brook, 1/4 mile to the southeast, shelly arenites, decrease markedly at 43 feet above the base of the Kings Falls (Fig. 16), and inferentially at about the same level at this locality.

Assemblages of the Kings Falls are numerically dominated by the brachiopod Dalmanella. Few bryozoa and pelmatozoan species occur. The snails Sinuites, Phragmolites, Loxoplocus, and Liospira occur up to 15 feet. Prasopora begins to occur in small numbers at 10 feet.

Sugar River Limestone - From 40 to 49 feet in the section lithologies and sedimentary structures are gradational between the Kings Falls and the Sugar River limestones. This interval is dominated by thin, burrow-reworked beds, however, and is assigned to the Sugar River formation. Pararippled, sheet and cross laminated beds are common and slightly deeper water conditions are inferred .

Above 49 feet there a few laminated beds and thin, burrow-reworked beds dominate except for the top few feet of the formation. Here several relatively massive beds are found in the pre-Rathbun Sugar River which may indicate shallowing waters.

Several feet into the Sugar River formation at the 44 foot level several species begin to appear which seem characteristic of the deeper water environment. Among these are the articulate brachiopod Platystrophia, the inarticulate Trematis, the trilobite Cryptolithus, and the bryozoa Escharopora. These species continue to occur into the top of the Sugar River formation. The pelmatozoans become more diverse and common in these beds. Above 60 feet fenestrate bryozoa and cystoids plates occasionally appear. Large Prasopora occur in the uppermost pre-Rathbun Sugar River.

Stop #3. Small quarry (locality #C105) :

The purpose of this stop is to examine a black chert-bearing, subtidal "calcisiltite lithofacies" of lower Trentonian age lying between $9\frac{1}{2}$ feet of Gull River and one foot of Kings Falls limestones (Fig. 3). This $3\frac{1}{4}$ foot unit is composed of massively bedded, medium gray weathering, irregularly burrowed, dark gray to black, argillaceous, and somewhat conchoidally to brittlely fracturing limestones with irregular wavy bedding surfaces separating $\frac{1}{2}$ to 3 inch thick continuous and discontinuous layers. Its contacts with the Gull River below and Kings Falls above are marked by "corrasion" surfaces. Although diagnostic Trentonian macrofossils have not been identified from this exposure, conodonts (Hasan, 1969) indicate a Trentonian age for this facies and a Bolarian age for the Gull River limestones below.

The Gull River limestones are composed of light dove gray to medium gray calcilutites and calcisiltites. Fenestral fabric, horizontal laminae (algal?), limestone intraclasts, stylolites, and thin shale layers are frequent. The vertical burrow Phytopsis is common, while infrequent body fossils only occur within the upper $2\frac{1}{2}$ feet, including Eoleperditia fabulites, small ostracods, Loxoplocus, strophomenid brachiopods, and Tetradium cellulosum.

Stop #4. Sugar River (locality #C2):

Four formations are exposed here: the Napanee, Kings Falls, Sugar River, and the Denley Limestones.

Napanee Limestone - The Napanee Limestone formation at this locality is about 20 feet thick and is wholly within the northern shaly calcisiltite lithofacies. The base is under water and the upper contact with the Kings Falls is marked by a prominant 18 inch thick shelly calcarenite bed (Fig. 13). The lower half is dominated by many almost barren conchoidally fracturing calcilutites and calcisiltites several of which are quite thick. Calcarenites occur sporadically throughout but are more common in the upper half. Horizontally laminated calcisiltites are frequent in the lower half, the top of which is marked by a poorly developed popararipple, while the upper half contains frequent shelly sheet laminated beds. Low angle cross-laminations are found in the middle and become somewhat shelly towards the top. The burrow Chondrites and large and small horizontal burrows are present throughout. Note that most of the laminated beds are burrowed at their tops.

The fauna of the Napanee is described generally in the text above. Dalmanella-dominated, bryozoan, brachiopod and trilobite assemblages are present. Cup corals may be found at about 10 feet and snails become more common in the upper half of the exposure along with ocassional clams.

Kings Falls Limestone - The Kings Falls is 64 feet thick at Sugar River. The lower 12 feet of the formation is of Rocklandian age as indicated by the presence of the upper Triplesia cuspidata assemblage zone (Cameron, 1968). The upper contact with the Sugar River Limestone is drawn at the top of a prominent pararippled bed at the top of the water fall (Chenoweth, 1952). The field boundary corresponds well with the petrographic criteria cited previously (Fig. 17).

The lower 35 of the Kings Falls is dominated by shelly (Fig. 16) cross-laminated, sheet laminated, and pararippled arenites. Horizontal burrows are common but are not dominant. A high subtidal environment is inferred.

The succeeding 29 feet of strata is transitional in character between the Kings Falls and the Sugar River limestones. The bedding continues to be relatively massive and cross-laminated strata are common. Horizontal burrowing is more abundant and shelly arenites are infrequent (Fig. 16). On the whole this interval is most similar to the Kings Falls. Water conditions are probably deeper than in the first 30 feet of section where cross-laminated beds were much more common.

The Rocklandian brachiopod Triplesia cuspidata and the horn coral Lambeophyllum occur in the lower 12 feet of the Kings Falls. The snails, Sinuites, Liospira, Phragmoloites, Subulites, Loxoplocus and Hormotoma gracilus occur up to 25 feet. The brachiopods Dalmanella and Sowerbyella dominate the beds of the lower Kings Falls, but not to the extent observed in the more nearshore outcrops to the southeast. Between 25 and 50 feet the diversity drops, but between 50 and 65 feet the assemblages resemble those of the lower 25 feet.

Sugar River Limestone - The formation is about 40 feet thick at this locality, its type section. The Camp Member (Chenoweth, 1952) of the Denley Limestone(Kay, 1968) overlies the Sugar River and is poorly exposed on the cliffs above the water fall on the north side of the river. The Glendale Member (Chenoweth, 1952) of the Denley comprises the top of the cliff. The Sugar River is again dominated by thin, burrow-reworked beds. A few cross-laminated beds are occasionally observed. Relatively calm deeper waters are inferred for the Sugar River Limestone.

Deep water species appear in the Sugar River. The bryozoa and pelmatozoa become more diverse and common. The brachiopods Trematis and Platystrophia appear along with the Shorehamian trilobite Cryptolithus. In the upper few feet of the formation the bryozoa and pelmatazoan diversity drops and the snail Sinuites appears suggesting a shallowing of the water.

ACKNOWLEDGEMENTS

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# MILEAGE LOG

This mileage log is designed to start at the toll booths of the Herkimer Exit (#30) of the New York State Thruway. Mileage was taken from a car's odometer and "hundreds" of a mile are estimated where turns occur in rapid succession. This trip the Little Falls and Port Leyden 15' quadrangles.

| *InMi | CumMi | |
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| 0.0 | 0.0 | Toll booths of the Herkimer Exit (#30) of the New York State Thruway. Leave toll booths and proceed straight ahead. |
| 0.1 | 0.1 | Turn right, taking Route 28 North. Get into left lane. |
| 0.2 | 0.3 | Stop light. Turn left (north), continuing on Route 28 North. |
| 0.25 | 0.55 | Stop light. Junction with Route 5. Turn right (east) onto Route 5. Proceed through Herkimer (6 more stop lights) towards Little Falls. |
| 7.55 | 8.1 | Stop light. Proceed straight ahead. (Do not bear right.) |
| 0.3 | 8.4 | Stop light. Proceed straight ahead. |
| 0.2 | 8.6 | Stop light. Proceed straight ahead. (City Hall on right.) |
| 0.2 | 8.8 | Stop light. Continue straight. (School on left.) |
| 0.15 | 8.95 | Stop light. Bear left. You are now on combined Routes 5 and 167. Get into left lane. |
| 0.65 | 9.6 | Blinking yellow light. Turn left onto Route 167 North. |
| 2.65 | 12.25 | Proceed straight ahead, leaving Route 167 and passing Esso Station on your left. Now on Dockey Road. |
| 0.15 | 12.4 | Intersection with Bidleman Road. Proceed straight ahead. |
| 0.4 | 12.8 | "Y"-intersection after small bridge. Bear left onto Inghams Mills Road. |
| 0.75 | 13.55 | Intersection with East Creek Road. Continue straight. |
| 0.75 | 14.3 | After coming down hill, continue straight onto dead end dirt road. Poor exposures of Napanee Limestone on left. |
| 0.05 | 14.35 | Turn right and cross small wooden bridge. |
| 0.04 | 14.39 | After crossing bridge, take right fork in dirt road. |
| 0.02 | 14.41 | In front of building, turn left. |

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*InMi = Incremental Mileage; CumMi = Cumulative Mileage.

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| 0.02 | 14.43 | Turn left, back onto dirt road. |
| 0.05 | 14.48 | Park on grass along right side of dirt road. |
| | | <u>Stop #1</u>: Walk to right, through the grass, and proceed to the right of the wire fence, walking beneath the power lines. At the stone wall along the edge of the field, bear left and walk along the wire fence. <u>CAUTION</u>: Poison ivy often grows in abundance along this path. Opposite the brick building, turn right and proceed very carefully over the boulders and across the creek towards the base of the outcrop. The boulders you will have to walk over to get to this exposure are sometimes unstable and tend to move when stepped or climbed upon. Be careful! |
| 0.0 | 14.48 | Return to cars and drive straight ahead on the dirt road. |
| 0.02 | 14.5 | Turn left onto dirt road leading from the power plant. |
| 0.05 | 14.55 | Bear right, crossing small wooden bridge. Then, bear left. |
| 0.05 | 14.6 | Intersection with Inghams Mills Road. Proceed straight, uphill. |
| 0.8 | 15.4 | Intersection with East Creek Road. Turn right. |
| 2.15 | 17.55 | Intersection with Route 167. Turn right onto Route 167, heading north. |
| 0.4 | 17.95 | Turn left onto Bronner Road. |
| 0.65 | 18.6 | Intersection with Murphy Road. Continue straight on Bronner Road. |
| 0.6 | 19.2 | Bear right where Bronner Road turns right. Davis Road is to left. |
| 0.2 | 19.4 | "Y"-intersection. Bear left, continuing on Bronner Road. |
| 1.4 | 20.8 | Intersection with Burrell Road. Turn left (south). |
| 0.3 | 21.1 | Intersection with Yellow Church Road. Turn right (west). |
| 0.7 | 21.8 | Intersection with Route 170. Proceed straight ahead. Yellow Church Road changes name to Top Notch Road. |
| 0.7 | 22.5 | Intersection with dirt road. Bear right, continuing on paved road. |
| 1.5 | 24.0 | Intersection with Cole Road. Continue straight. Note that Top Notch Road changes name to Rockwell Road. |
| 0.75 | 24.75 | Acute angle intersection with Route 169. Go north on Route 169. |
| 6.3 | 31.0 | Stop light, downtown Middleville. Proceed straight ahead onto Route 28 North. |
| 1.8 | 32.8 | Turn right and drive straight uphill. |
| 0.25 | 33.05 | "Y"-intersection. Bear left, going downhill, onto Old City Road. |

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| 0.7 | 33.75 | Turn sharp, acute, right onto White Creek Road. |
| 0.55 | 34.3 | Park carefully along right side of road before and after bridge. |
| | | Stop #2: Walk upstream through the edge of the field on the south side of Buttermilk Creek, climb under wire fence, and continue along north bank of stream until you reach exposures of the Trenton Group. |
| 0.0 | 34.3 | Return to cars and drive straight ahead. |
| 0.25 | 34.55 | Intersection with Elm Tree Road. Turn right. |
| 2.35 | 36.9 | Intersection with Hard Scrabble Road. Turn left, continuing on Elm Tree Road towards the village of Norway. |
| 0.36 | 37.26 | Beware: Very bad sharp right bend in road 0.2 miles ahead. |
| 1.1 | 38.36 | Intersection with Newport Gray Road. Proceed straight ahead up the hill. You are now driving on Newport Gray Road. |
| 0.1 | 38.46 | Intersection with Dairy Hill Road. Turn sharp, acute, right. |
| 0.4 | 38.86 | "Y" intersection with dirt road. Bear left and continue on paved road. |
| 3.35 | 42.21 | Intersection with dirt road on left. Bear right, continuing on paved road. |
| 0.55 | 42.76 | Short dirt path for a car on right. A small garbage dump on south side of path. |
| 0.01 | 42.77 | Turn right onto a second dirt path and park. |
| | | Stop #3: Walk along path (an overgrown old dirt road) for about 400 feet to a small quarry. |
| 0.0 | 42.77 | Return to cars, back out, and return (north) the way you came. |
| 0.53 | 43.3 | Intersection with dirt road. Bear left, continuing straight on paved road. |
| 3.35 | 46.65 | Bear right and continue on paved road. |
| 0.45 | 47.1 | Turn sharp, acute, left onto Newport Gray Road. |
| 0.2 | 47.3 | Continue straight downhill on Elm Tree Road. |
| 1.7 | 49.0 | Turn right, continuing on Elm Tree Road. |
| 2.25 | 51.25 | Turn left onto White Creek Road. |
| 1.4 | 52.65 | Intersection with Route 28. Turn right and go north on Route 28. |
| 1.9 | 54.55 | Newport, N. Y. Continue straight uphill on Route 28. |

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| 3.8 | 58.35 | Poland, N. Y. Continue north on Route 28 (bear left at main intersection in village). |
| 1.5 | 59.85 | Fork. Continue north on Route 28 (bear right and cross bridge). |
| 3.9 | 63.75 | Fork. Continue north on Route 28 (bear right and cross bridge). |
| 1.2 | 64.95 | Fork. Bear left. |
| 0.9 | 65.85 | Junction with Route 12. Turn right and go north on combined Routes 12 and 28. |
| 11.4 | 77.25 | Fork. Bear left and continue north on Route 12. |
| 7.1 | 84.35 | Boonville, N. Y. Continue north on Route 12 (road curves to right). |
| 3.0 | 87.35 | Kings Falls Limestone exposures on both sides of Route 12. Quarry in the distance off to the right across Sugar River in foreground is in the Watertown and Gull River limestones of the Black River Group. |
| 0.15 | 87.5 | Exposure of upper Napanee and lower Kings Falls limestones on left side of Route 12. |
| 0.05 | 87.55 | Park on right shoulder of road just beyond entrance to quarry. |
| | | Stop #4: Walk back to bridge and walk upstream along the north bank (nearer side) of Sugar River to the railroad bridge. |
| 0.0 | 87.55 | End of field trip. Return to cars, turn around, and head south on Route 12 which will take you directly into Utica. |