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Deltaic and Shallow Marine Lower Silurian Sediments of the Niagara Escarpment Between Hamilton, Ont. and Rochester, N.Y. - A Field Guide*

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Introduction

The emphasis of this paper in on the Medina Formation which is a Lower and Middle Silurian Unit that outcrops along the Niagara Escarpment between Hamilton, Ontario, and Fulton, New York (AL, Fig. 2). The Medina Formation consists of five Members (Fig. 1) as follows: (1) Thorold, (2) Grimsby, (3) Cabot Head, (4) Manitoulin, and (5) Whirlpool. The upper Member is the Thorold. It is 1 to 14 feet thick and is composed predominantly of light-gray, fine grained, quartzose sandstone and shale. The Grimsby Member is 5 to 74 feet thick, and is composed of red with gray mottling, fine- to medium-grained, quartzose sandstone, and red-gray mottled shale. The Cabot Head is a sequence 0 to 50 feet thick made up of gray, fossiliferous shale with minor thin siltstone and silty limestone interbeds. The Cabot Head has been called Power Glen at DeCew Falls, Ontario (Bolton, 1957). The *Manitoulin, in the Hamilton-Niagara area reaches* 12 feet in thickness and consists of argillaceous dolostone to medium gray, crystalline, bioclastic dolomitic limestone. The Whirlpool is the lower Member. In the Hamilton-Medina area (N.Y., U, Fig. 2) it is up to 20 feet thick. This member is a light gray, fine- to medium-grained, cross-bedded quartz sandstone.

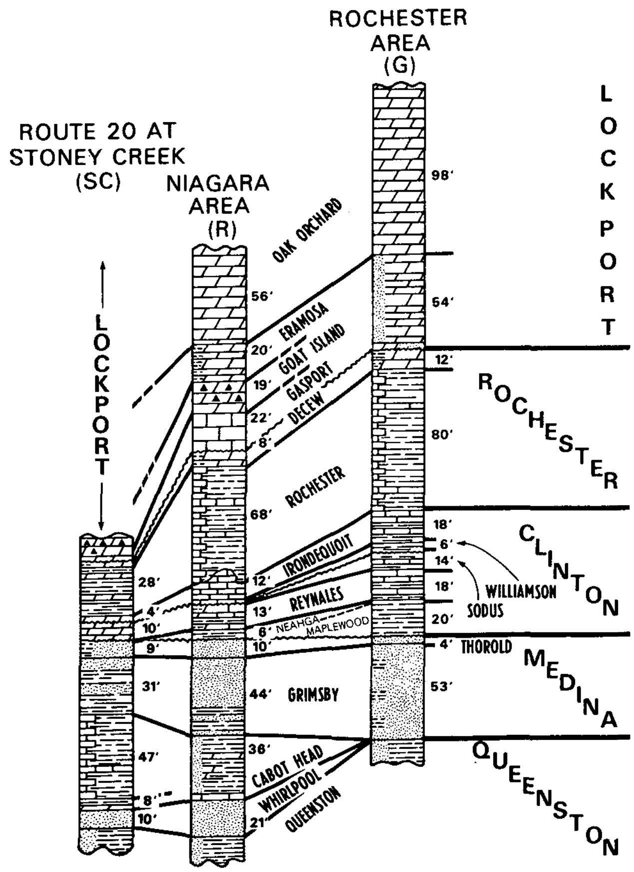


FIG. 1 Regional correlation for the Lower and Middle Silurian (after Chaivre, K.R. and Sanford, J.T., 1972).

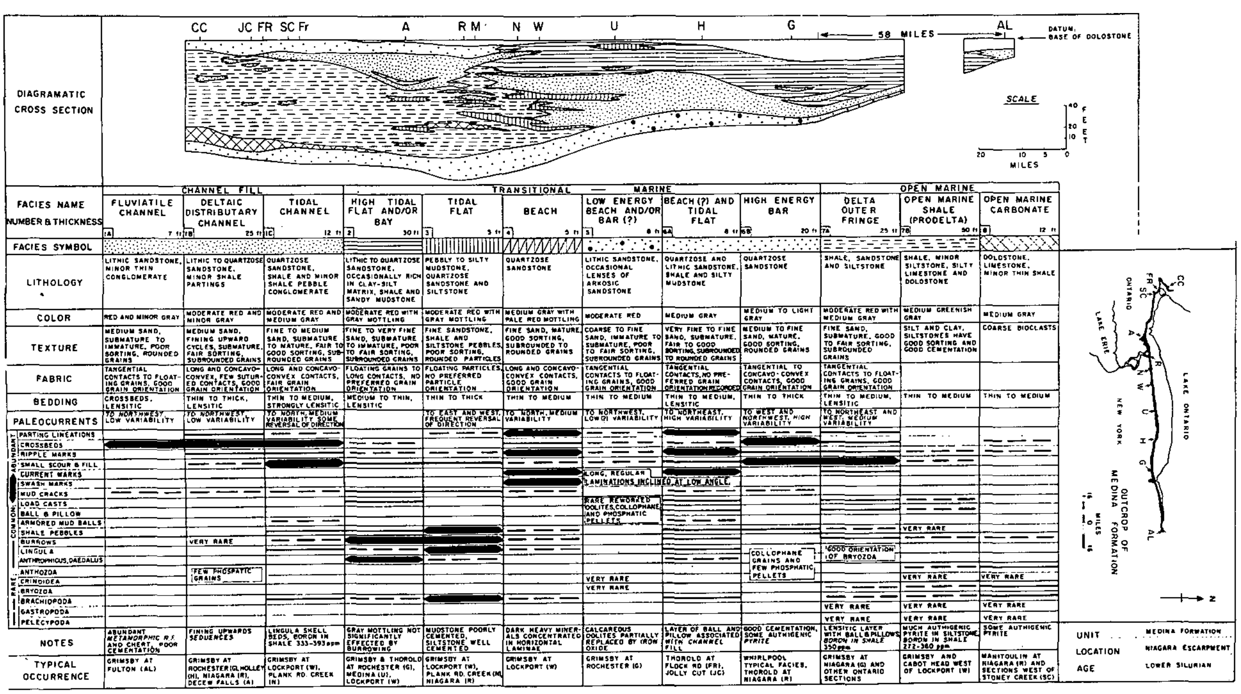


FIG. 2 Depositional Model of the Medina Formation exposed along the Niagara Escarpment.

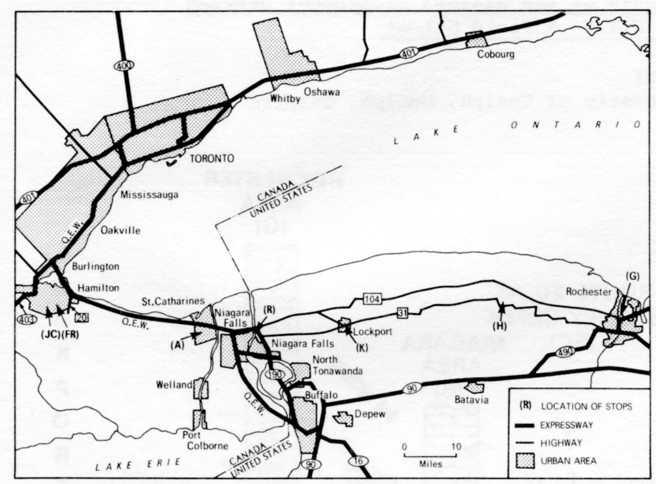


FIG. 3 Location map for major exposures.

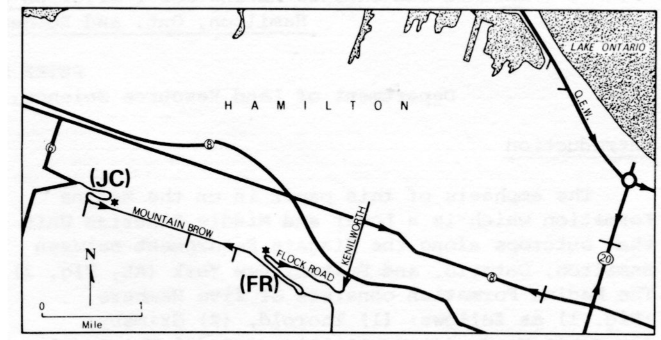


FIG. 4 Location map for sections of Flock Road (FR) and Jolly Cut (JC).

The Medina Formation is underlain unconformably by the red shales of the Queenston (Ordovician) and it is overlain by the shales and carbonates of the Clinton (Middle Silurian) (Fig. 1) (Sanford et al. 1972).

The information available indicates that the Medina sediments were deposited in deltaic and shallow marine environments (Fisher, 1954; Martini, 1971 and 1972; Pelletier, 1953, Lumsden, 1960; Lumsden and Pelletier, 1969). The outcrops along the Niagara Escarpment from Hamilton to Fulton (AL) constitute a natural offset section of such a deltaic shallow-marine environmental complex (Fig. 2). The major constructive phase of these deltas is recorded in the quarries between Medina (U) and Rochester (G) (Fig. 2). A 7-foot channel-fill sandstone constitutes the whole of the Medina Formation at Fulton (AL). Outside these areas, the sandstones of distributary channel fills merge with, or cut into, deltaic fringe sandstone, tidal-flat and sublittoral shale, and siltstone. A set of partly reworked distributary channels (sandstone), tied to one of the Medina deltas, is found in the upper Grimsby at DeCew Falls (A) and in parts of the Niagara Gorge (R) section (Figs. 2, 3).

Tidal flats of the silty mudstone type - poorly preserved - and of the sandy type are found marginal to the deltas, predating, interstratified with, or postdating the deltaic events. From Lockport (W) west, and especially in the Niagara-Ontario-Hamilton area, the prodelta sublittoral environments are characterized by the Manitoulin dolomite and the shales, siltstones and very fine sandstones of the Cabot Head and lower Grimsby. In this Ontario region, although some inter-stratification of different environments occurs, the transgressive-regressive cycle of deposition of the Medina Formation is well defined.

The regional sequence of events that led to the Medina sedimentation began with the Ordovician tectonic activities in the Appalachian area (Taconic Orogeny). The Bald Eagle, Juniata, and Queenston sediments were deposited in deltaic complexes in shallow Ordovician seas (Clark and Stearn, 1960). The end of the Ordovician marked a general retreat of the sea from the Appalachian region, but shallow seas existed over most of the eastern United States, and southeastern Canada. The Taconic Mountains persisted during Early Silurian times, for a period of probably 50 million years. The Shawangunk Conglomerates were deposited in southern New York State and eastern Pennsylvania and the Medina and Tuscarora Formations in the Great Lakes and in the Appalachian region. At the end of the Lower Silurian, the remaining Taconic hills supplied very little clastic material to the southwestern Ontario and northeastern New York areas. Subsequent Silurian deposition consisted of the carbonates and evaporites of the Clinton Group, the Lockport-Guelph Group, and the Salina Group (Clark and Stearn, 1960; Sanford, 1972).

The climate of the Silurian age, in North America, is generally regarded to have been mild and variable during the early part, and arid toward the close of the period. Modern paleo-magnetic results suggest that the equator lay just north of Lake Superior during Silurian times (Irving, 1964).

Brief Description of Selected Localities (Fig. 3)

Many good exposures in natural sections of road cuts and quarries are available along the Niagara Escarpment (Martini, 1966, 1973; Sanford et al. 1972). The selected outcrops described here represent the most complete exposures, and to visit several of them permission to enter private properties must be requested in advance (Appendix 1).

Flock Road, Hamilton (FR, Figs. 3,4)

Several sedimentological facies are recognizable in the Medina. They form a macrocycle of deposition consisting of a lower transgressive phase and an upper regressive phase.

The Whirlpool Sandstone is the lower unit. It has a quartz sandstone lithology and it lies unconformably over the red shales of the Queenston. Its paleoenvironment is related to a near-shore setting where they have been reworked and graded vertically and regionally by long-shore currents. Regionally, the grain size decreases in the

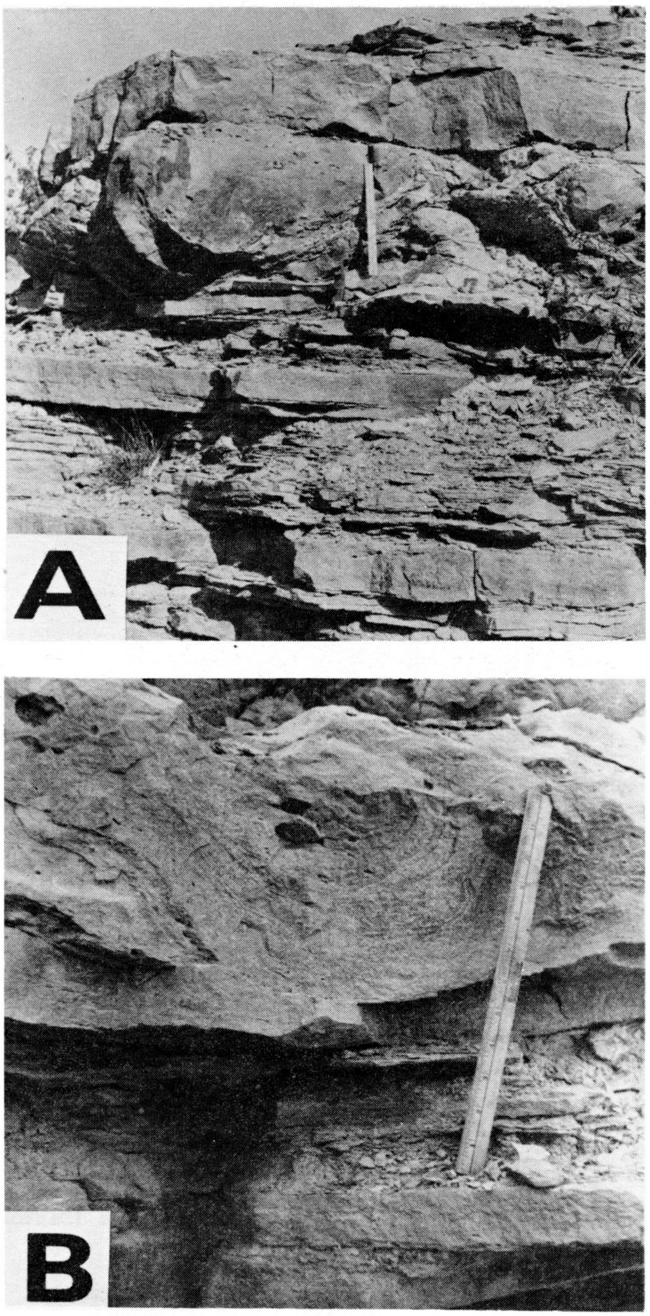


FIG. 5 Ball and Pillows at Jolly Cut (JC).

Whirlpool from Niagara to Hamilton. Vertically, fining upward sequences exist within each one of the cross-bedded and channel-fill units. In many cases the coarser bottom fractions contain fine shale-pebbles deposited in the lower parts of forests. The lowermost, discontinuous, thin layer of the Whirlpool is considered to be a wind-blown sand deposited on the dry, highly mudcracked surface of the Queenston. Well developed mudcracks, filled by sand, protrude from the Whirlpool into the underlying shales, the Queenston, whose topmost layer is characterized by a thin (approximately 1 foot) grayish, leached layer of shale. This gray color is of diagenetic origin, which is also indicated by the leached walls of small but deep cracks that allow penetration of water well within the redbeds of the Queenston.

The Manitoulin Dolomite has a lower gradational contact with the Whirlpool Sandstone. Bryozoa, cup-corals and some *Encrinurus* cf. *ornatus* are easily recognizable. Some layers have been completely reworked by burrowing organisms. The fauna assemblage indicates a shallow, warm sea and a sublittoral environment of deposition (Eller, 1942).

Above the Manitoulin, the sedimentological sequence of the Cabot Head and Grimsby shows an upward increase in grain size, a decrease in calcareous sedimentation and abundant burrows and tracks in the bedding surfaces. Brachiopods, bryozoans and pelecypods have been found as high in the sequence as the upper beds of the Grimsby. The overall depositional environment of these rocks is shallow marine. The influence of a coarser delta-fringe sedimentation is increasingly felt in the high younger beds. Local subaereal conditions are recorded in a few mud-cracked layers.

The maximum influence of the coarse clastic deposition during Medina times is in the Thorold Sandstone. The Thorold is constituted of quartz sandstone interbedded with thin shaly layers and few shale-pebble, intraformational conglomerates. The most common sedimentary structures consist of plane beds, some being slightly inclined and resembling accretionary beds of beaches; ripple marks of various types; and, most characteristic, disrupted beds with well developed ball- and pillow-structure (Potter and Pettijohn; 1963). The disrupted beds are part of channel-fill sequences. At the centre where the fill is thick and sandy, the beds are irregularly disrupted. Toward the margin of the channel where a definite interlayering of sand and clay existed, the sandy beds have been deformed in well developed ball-and-pillow structures. Usually the disturbed bed grades laterally into undeformed sequences of thin beds of shale and sandstone.

Similar well developed ball-and-pillow structures are present in the Thorold at Jolly Cut (Fig. 5) and in the Grimsby in several sections between Hamilton and Niagara Gorge (Fig. 6). Such structures on both large and small scale, are found at well defined horizons. Their formation is generally attributed to the foundering of sandstone layers into a water-logged clay bed that loses its strength during some anomalous strong earthquake-shock or pounding by storm-waves.

Features to be Observed

THOROLD: Sandstone channel fills, disrupted beds, ball-and-pillow structure, and other sedimentary structures, some beach (?) layers.
GRIMSBY: Coarsening upward facies, numerous sedimentary structures, fossils.
CABOT HEAD: Vertical variation in lithology, fossils, trace fossils, authigenic pyrite in lower carbonate and siltstone layers.
MANITOULIN: Fossils, burrowings, wavy bedding.
WHIRLPOOL: Mudcracks, discontinuous lowermost thin bed of probable aeolian origin, channel fills, variable cross-beds, shale pebbles concentrated in lower parts of forests.
QUEENSTON: Gray color of upper layer and cracks, mudcracks at upper contact.

Jolly (or Jolley) Cut, Hamilton (JC, Figs. 3,4)

The top of the Niagara Escarpment offers a good panoramic view of the city and bay of Hamilton. The city is built on the plain and bay-mouth bar of Lake Iroquois that was the post-glacial precursor of Lake Ontario, in the Hamilton-Dundas reentrance of the Niagara Escarpment. This reentrance is one of many that were gouged by pre-Pleistocene rivers and modified by Pleistocene glaciers. In the road cut, rocks ranging in age from the Upper Ordovician Queenston formation to the Middle Silurian Lockport formation are exposed. Limiting this study to the upper layers, the exposed units on the east side of the road are the following:

LOCKPORT FORMATION (Middle Silurian)

It is comprised predominantly of dolostone and it can be subdivided into three Members:

(1) Goat Island Member (4 feet, 3 inches (130 cm) thick). Thin to medium bedded dolostone with numerous lenses of chert except for a chert-free lower one foot bed. Spiculae of sponges are common in the charts. (2) Gasport Member (2 feet, 6 inches (75 cm) thick). Gray crinoidal dolostone with a thin pyritic zone toward the top. Its lower contact is disconformable. (3) DeCew Member (2 feet, 6 inches (75 cm) thick). Buff to brown, fine crystalling dolostone.

ROCHESTER FORMATION (1 foot, five inches (43 cm) thick)

This formation comprises dolomitic shales and finely-crystalline, argillaceous dolostone. A pyritic layer, with rusty red weathering is located toward the middle of the unit.

IRONDEQUOIT FORMATION (4 feet, 6 inches (137 cm) thick)

This is a buff gray, medium crystalline dolostone. A thin zone with well developed geodes is present 12 to 14 inches above the lower "welded" contact. This contact with the underlying Reynales is characterized by a thin dark line, and it is placed on the basis that the Reynales has a relatively abundant insoluble residue whereas the Irondequoit has a very low content of insoluble residue (Sanford et al. 1972).

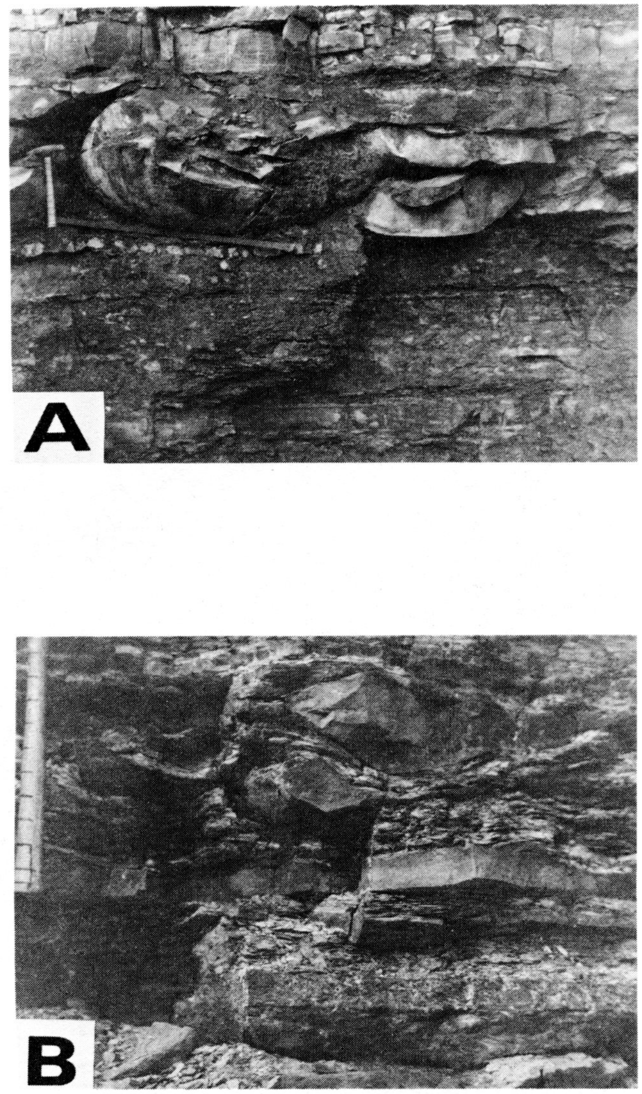


FIG. 6 Ball and Pillows at Niagara Gorge (R).

REYNALES FORMATION (1 foot, 6 inches (289 cm) thick)

This formation is a fine crystalline, slightly silty dolostone with some shale partings. The lower part is marked by well developed pentamerid beds, and the contact with the Thorold is marked by a thin phosphatic and glauconitic layer.

MEDINA FORMATION (only the upper part is well exposed)

Thorold Member (14 feet, 4 inches (4.31 m) thick). It consists of interbedded sandstone and shale. In the lower part, thin beds of well cemented, plane-laminated and ripple-marked siltstone and fine sandstone layers are interlayed with silty shales, locally highly burrowed (Fig. 7). In several cases phosphatic pellets and broken *Lingula* shells are concentrated at the top of the burrowed layers. Casts of armoured mud balls with armour of fine silt pebbles and broken *Lingula* shells are common. This rhythmic sequence was probably formed in a muddy-sandy (tidal?) flat where the "normal sediments" (burrowed mudstones) were rapidly covered by well sorted and later highly indurated siltstone and fine sandstone layers deposited possibly during storms in a beach-like setting and locally, in very shallow, wide channels. This rhythmic sedimentation of the lower Thorold ended when an increased rate of sedimentation and more powerful channelized flows deposited thick layers of sand on the muddy environment. The sand foundered into the mud, and lensitic beds of well developed ball-and-pillow structures formed. Higher still in the stratigraphic sequence the sandy sedimentation continued and the upper beds are characterized by well developed ripple-marks and ripple-drift cross-laminations.

Grimsby Member (upper beds only). The lower contact of the Thorold is placed at the base of the lowermost gray sandstone bed. Consequently, the underlying thin, gray shale bed that caps the red-bed sequence is considered part of the Grimsby, and its gray color is diagenetic in origin. This latter phenomenon is caused by the action of the sulfate-rich waters that percolate from the formations above. The Grimsby is essentially a red-bed sequence. Of interest in the upper part of this section is a thin ironstone bed rich in Bryozoa fragments, which can be found a few feet below the upper contact.

Features to be Observed (exposure east of road)

GENERAL VIEW FROM ESCARPMENT -	Pleistocene and Holocene development of Dundas-Hamilton valley, baymouth bars.
NIAGARAN CARBONATE SECTION -	Nodules and lenses of chert in the upper unit, welded contact between Irondequoit and Reynales, fossils in Reynales.
THOROLD -	Shallow marine rhythmic sedimentation in muddy sandy flats, numerous types of burrows, abundant sedimentary structures including ball-and-pillow, ripple marks, plane beds.
GRIMSBY -	Upper gray layer with relative sharp contact with underlying red beds, ironstone bed, fossils, trace fossils.

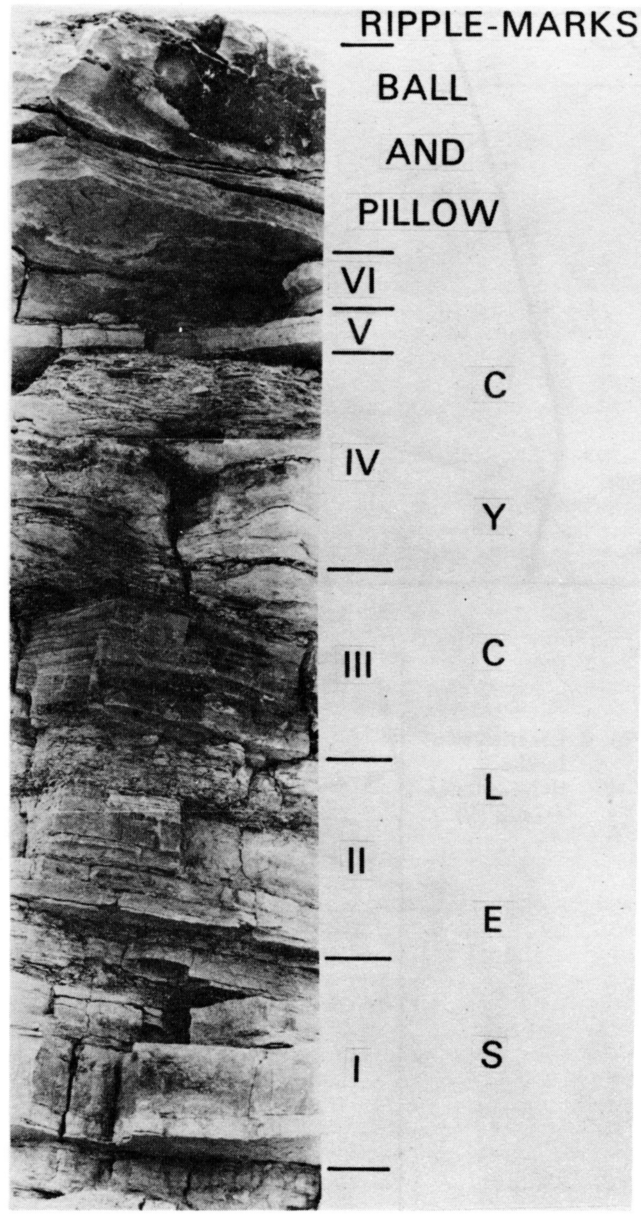


FIG. 7 Cyclic sedimentation in the Thorold at Jolly Cut (thickness of section represented is approximately 2.68 m (104 inches).

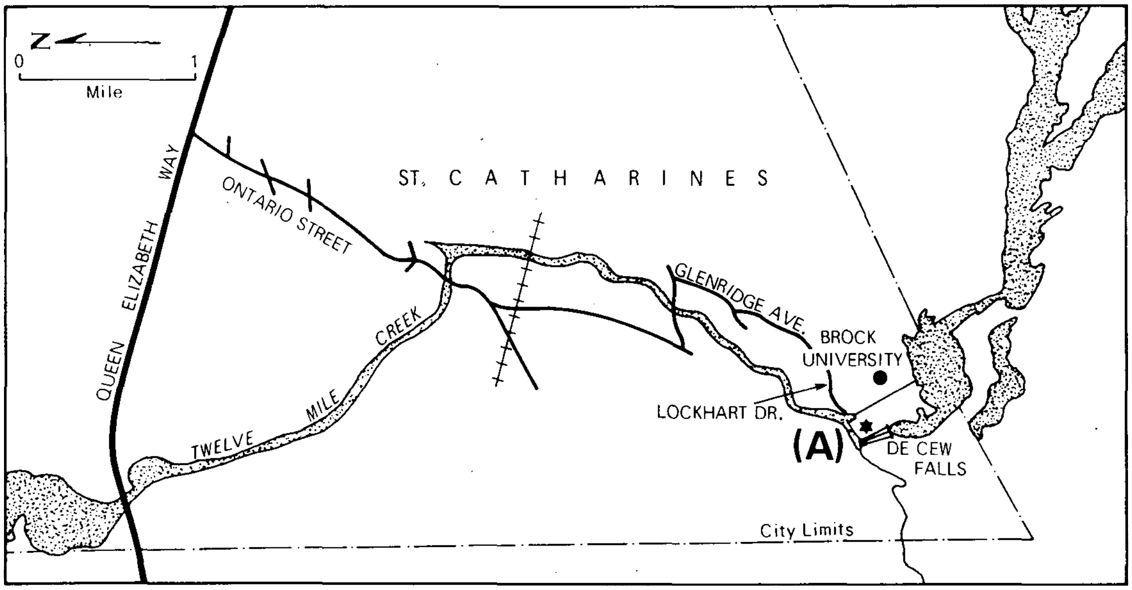


FIG. 8 Location map for the DeCew Section (A).

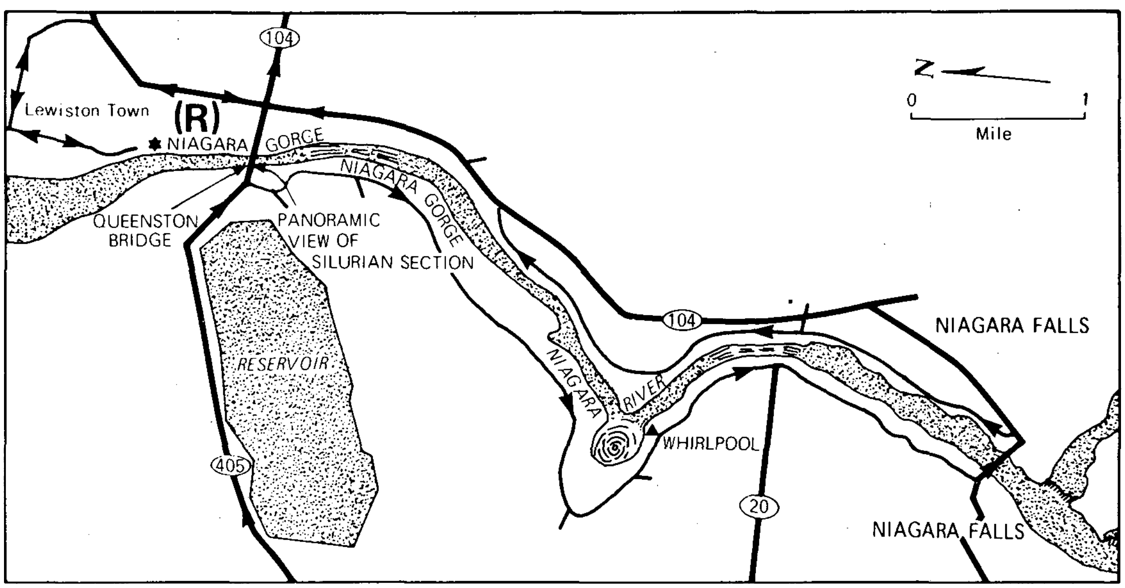


FIG. 9 Location map for the Niagara Gorge Section (R).

DeCew Falls (A, Figs. 3,8)

The sedimentary sequences of the Medina Formation and the highly fossiliferous beds of the Rochester Formation are of prime interest at this location. The Manitoulin Dolomite is absent from the Medina. Above the cross-bedded, quartz sandstone of the Whirlpool, the sequence is characterized by a gray (Cabot Head Member) and red (lower part of Grimsby Member) shale interval (called "Power Glen" by Bolton, 1957) with some siltstone and one thin ironstone bed. This interval contains marine fossils and it was deposited in a sublittoral environment. The overlying unit of the Grimsby is a sandstone channel-fill related to one of the distributary channel complexes of the Medina Formation (Fig. 2). Following the deposition of this thick sandstone unit, a marine transgression is recorded in the upper sandy and shale layers of the Grimsby and in the Thorold. Although only burrowing organisms have been found in these upper beds, the marine environment of deposition is indicated by the presence of *Arthrophycus alleganiensis* and *Daedalus archimedis*, the high concentrations of Boron (up to 343 ppm) in the shales which are similar to concentrations of layers bearing marine fossils, and the variable orientations of the cross-beds that tend to show bimodal distribution with modes 180 degrees apart.

At DeCew Falls, the Neahga shale is present in its westernmost outcrop, in a one-foot thick bed. It is fissile, unfossiliferous and it is believed to have been derived from material washed from the Thorold and deposited in a quiet-water environment.

Above the Neahga, the Clinton carbonates are highly fossiliferous. In the upper part of this section, the most striking regional facies variation that has occurred is that the Rochester has changed from a thin (28 feet), relatively unfossiliferous shale and limestone unit in the Hamilton area, to a thick (68 feet), highly fossiliferous interval in the DeCew - Niagara area. Corals, bryozoans, brachiopods and a well developed trilobite zone in the upper shales characterize the rich faunal assemblage of the formation (Thusu, 1972).

Features to be Observed

CLINTON CARBONATES and ROCHESTER FORMATION -	Good location for collecting fossils.
NEAHGA -	Poorly developed shaly interval.
THOROLD -	Quartz sandstone facies with thin shale interbeds, trace fossils.
GRIMSBY -	Coarsening upward facies, well developed channel sequences in upper layers, red color with gray mottling.
CABOT HEAD -	Calcareous lower beds, fossils, thin red ironstone bed.
WHIRLPOOL -	Gray, well cemented, quartz sandstone, few shale pebbles, variable cross-beds.
QUEENSTON -	Few feet exposed, red shale with gray mottling, a few siltstone beds.

Niagara Gorge, N.Y. (R, Figs. 3,9)

The Silurian rocks and the uppermost layers of the Queenston are accessible along an old road (railroad) in the northeastern side of the Gorge. The Medina Formation shows a well defined cycle of sedimentation. The transgressive portion of the cycle starts from the cross-bedded quartz sandstone of the Whirlpool deposited in a nearshore environment and ends in the sublittoral shales of the Cabot Head - Lower Grimsby. Within the Cabot Head, a low clastic input in the basin of sedimentation is recorded in a middle unit (6.5 feet thick) that is lithologically and faunistically similar to the Manitoulin Dolomite of the Hamilton area. The regressive part of the cycle starts from the top of the Manitoulin, and from typical prodelta shales it grades upward into deltaic fringe shale and sandstone, then into a distributary channel zone and finally, into the uppermost Grimsby and Thorold where reworking of deltaic born sediments in a shallow marine environment has occurred (Fig. 10).

In the prodeltaic and in the deltaic fringe - interdistributary portion of the sequence, several minor cycles of deposition occur. A lower set of cycles is characterized by alternance of shale and silty pebble intraformational conglomerates, thin laminated siltstone layers, and fissile shales. The intraformational conglomerates are occasionally replaced by thin layers of bryozoan coquina, rich in authigenic pyrite. Higher cycles in the delta fringe-interdistributary zone are characterized by well defined sequences of basal, very thin intraformation conglomerates, or erosional bedding surfaces; thin, plane-laminated, siltstone and sandstone beds; occasionally they show well developed load casting, rarely small scale ball-and-pillow structure; thin fissile shale layers; sandy mudstone interval with abundant burrows; and an upper, structureless, highly burrowed argillaceous silty layer (Fig. 11).

In other parts of the outcrop the deltaic fringe zone becomes sandier and it contains two lensitic layers with well developed ball-and-pillow structures, and occasional thin sandy channel fills. The isolated nature of the cross-beds, the variable azimuth of their foreset beds and the presence of few *Lingula* shells indicate a possible tidal or nearshore origin for the channels. The direct deltaic distributary influence is felt, however, in the upper horizons of the Grimsby where the fauna tends to disappear, thicker sandy channel fills are common and the paleocurrent directions, although variable, tend to cluster in the north quadrants of the compass. After this constructive deltaic phase, a period of reworking of the sediments by longshore processes has been recorded in the Thorold. The uniform thickness of this unit, the good sorting of the quartz sandstone, and the variable attitudes of the cross-beds that tend to have a bimodal distribution with modes 180 degrees apart, are a few of the features that indicate that the Thorold is, at Niagara, the uppermost expression of the destructive phase of the Medina delta.

Above the Thorold a 7-feet thick Neahga-Maplewood interval has developed. Clinton carbonates, Rochester shales and Lockport carbonates are easily accessible along the old railroad upstream from the Queenston Bridge.

Features to be Observed

NIAGARAN CARBONATES -	Good section upstream from Queenston Bridge.
NEAHGA-MAPLEWOOD -	Well developed shale interval.
THOROLD -	Gray, well cemented, quartz sandstone facies, small pyrite nodules.
GRIMSBY -	Rapid and gradational vertical and lateral facies variations, good example of marine-deltaic sequence, minor cycles of deposition, fossils, trace fossils, ball-and-pillow structures, channel fills, rich suite of minor sedimentary structures.
MANITOULIN (?) -	Fossils, wavy bedding.
CABOT HEAD -	Marine fossils, siltstone interlayers, gradational upper contact.
WHIRLPOOL -	It maintains the usual facies of unfossiliferous quartz sandstone, cross-bedded with with shale pebbles along forests.
QUEENSTON -	Red shale with some siltstone.

Lockport, N.Y. (K, Figs. 3,12)

The Lockport area presents scattered but important outcrops for the understanding of the regional facies variation of the Medina Formation.

The Whirlpool at Lockport and in eastern outcrops approaching and up to Medina, New York (Fig. 2, U) retains its typical cross-bedded, quartz sandstone facies. Further to the east it appears to grade into a coarse, red sandstone unit which is exposed at Holley and Rochester at the base of the Grimsby red beds. The Cabot Head gray shales are approximately 10 feet thick at Lockport and grade eastward into the Grimsby red beds. In the Lockport-Medina area, the Grimbsy is characterized by sediments deposited in muddy-sandy flats of the inter-distributary area which was occasionally cut by shallow distributary channels. The lower exposed unit the Lower Quarry (K) consists of gray to pale red quartzose sandstone having a massive appearance, and locally, cross-laminations. Very few shale partings are detectable (Fig. 13: K.IV interval). This sandstone body is laterally transitional into three other facies: (i) well developed cross-bedding cosets bearing ostracods and *Lingula* shells. This

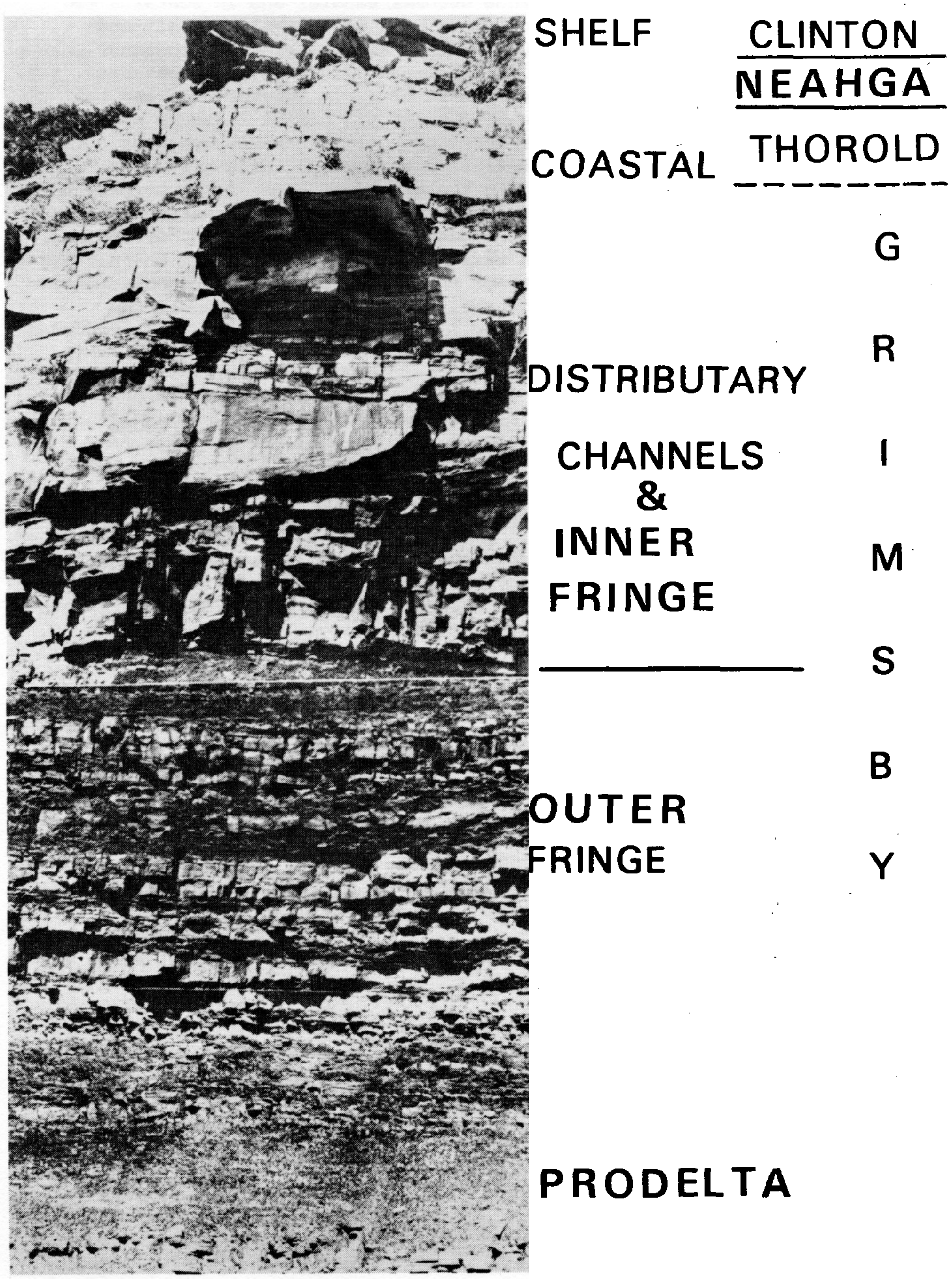
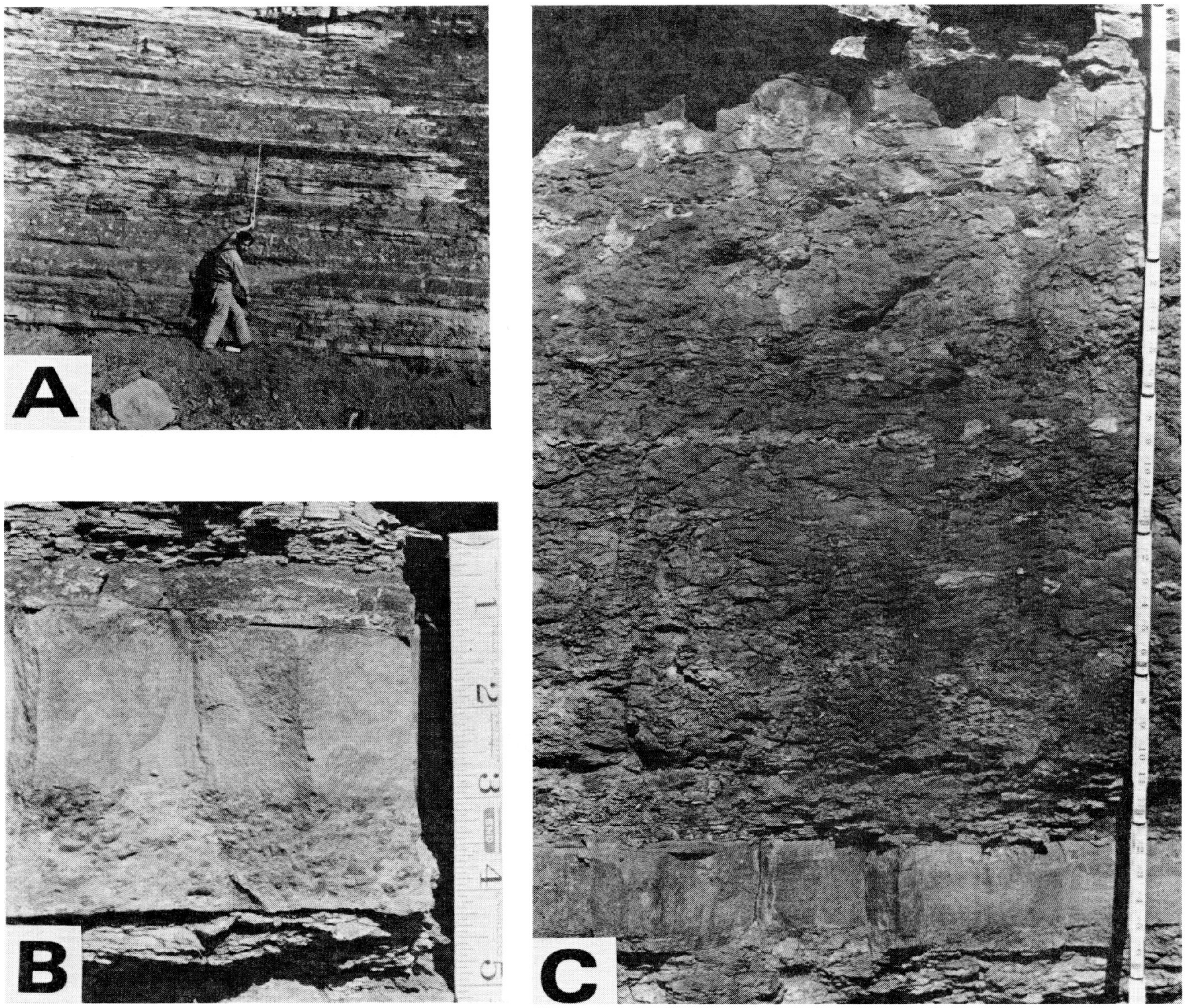


FIG. 10 Deltaic sequence of the upper part of the Medina Formation of Niagara Gorge (R).



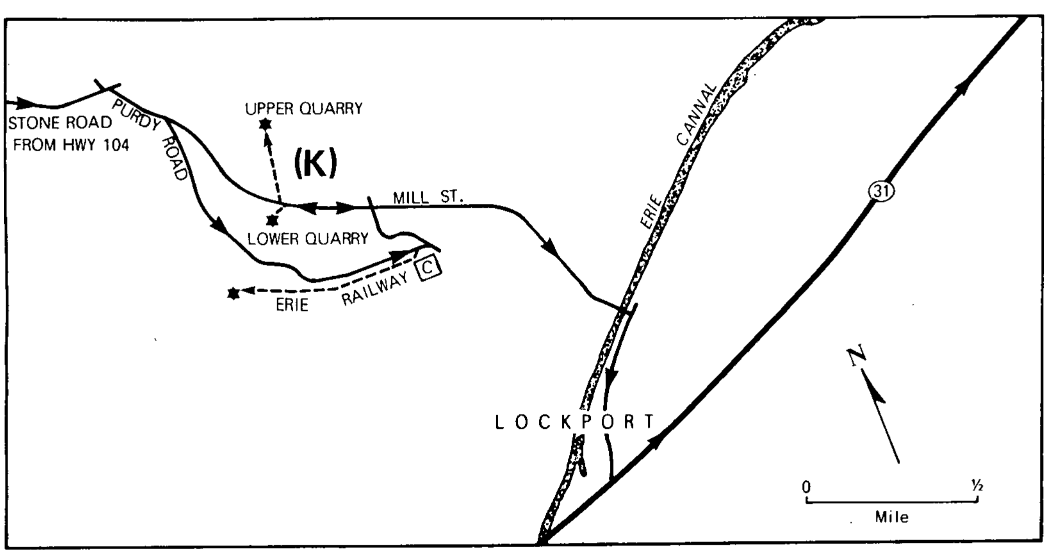


FIG. 11 Cycles of deposition in the lower part of the Grimsby at Niagara Gorge (R). A - General view of cycles; B - Detail of lower silstone bed with basal interformational conglomerate; C - Detail of one cycle.

FIG. 12. Location map of the Lockport sections.

cross-bedded interval changes rapidly into a (ii) thin bedded, sandy and shaly unit which bears *Lingula* shells also in living position, and (iii) in which the *Lingula* shell beds are, still further away, cut by well developed cosets with variable attitudes. The *Lingula* beds record a tidal-flat, to infralittoral environment cut at both sides by channels.

Where the sequence is exposed, the lower sandstone unit is sharply overlain by a lensitic bed of "mudstone". The mudstone is composed of a conglomeratic, argillaceous siltstone, poorly cemented by red silty shale pebbles, highly broken *Lingula*, *Lingula* shells in living position and hematitic (?) ooids. This unit is believed to represent typical silty mud- (tidal) flat sediment of the Medina Formation (Fig. 13: K.V. interval).

An overlying unit is characterized by a variable lithology and a rich suite of sedimentary structures indicating rapidly changing flow conditions (Fig. 13: K.IV interval). The unit, as observed in the line of section, is laterally transitional to a cyclic sedimentation consisting of an alternation of cross-bedded units, shale and massive to laminated sandstone beds. The variable flow conditions recorded in the sediments are not significantly different from the ones that would be expected in a channelled current. The unit is accordingly interpreted as a deltaic channel cutting through a tidal-flat environment. The tidal-flat channel alternative has been discarded because of the variable, but generally unidirectional, azimuth distribution of the cross-beds.

Other outcrops of the Grimsby at Lockport indicate deposition in beach environments (Upper Quarry outcrop, Fig. 12), and muddy-sand flats, similar perhaps to tidal flats (Van Straaten, 1951) where several types of burrowing organisms including *Daedalus archimedis* fluorished (Erie railroad outcrop, Fig. 12). At this last outcrop the Thorold is represented by a few feet of calcareous argillaceous sandstone.

At Lockport, the Medina Formation shows a cycle of sedimentation constituted by a transgressive phase from the Whirlpool to the Cabot Head, a regressive phase from the Cabot Head to the Lower Grimsby and a transgressive phase within the middle and upper parts of the Grimsby and the overlie units. The alternation of transgressive and regressive phases is related to variation in the clastic input and shifting deltaic channels, rather than to any significant change in rate of basinal subsidence.

Features to be Observed

NIAGARAN CARBONATE -	rocks of the Lockport Formation can be observed in several quarries and road cuts around the city of Lockport.
THOROLD -	Erie railroad - burrowed layers.
GRIMSBY -	Lower Quarry - massive and cross-bedded units, three dimensional display of shallow channels, tidal flat sediments, *Lingula* in living position, gray mottlings related to *Lingula* burrows, suite of sedimentary structures. Upper Quarry - channel and beach sandstone. Erie Railroad - *Daedalus archimedis* alias (?) *Diplocraterion yoyo*.
GENERAL -	The Lower Quarry is being used as a disposal site for industrial chemical waste, and fumes from the dump have killed the surrounding vegetation.

Holley-Hulberton Area, N.Y. (H, Figs. 3,14)

Several outcrops of the Medina Formation exist between Lockport (K) and Holley (H) (Fig. 3), where local strong facies variations occur in shallow marine, interdistributary environments (Fig. 2). However the major distributary-channel facies of the Medina delta is exposed in the quarries and river cuts of the Holley-Hulberton area. Only the Grimsby sandstone is exposed and it can be subdivided into three units as follows: (1) a lower unit that is similar to a much better exposed lower Silurian bed at Genesee Gorge. This layer is correlative to the Whirlpool and was deposited as a marine bar. (2) A middle unit, certainly the most important one at Holley, is comprised of a complex sequence of channel fills with well developed sequences of sedimentary structures and fining upward textures. (3) A third unit caps most of the exposures, and it is characterized by thin-bedded sandstone interbedded with red silty shales (Fig. 15). Ripple drift cross-laminations, ripple marks, parting lineations, mud-cracks, rare rill marks and possible swash marks indicate that this unit represents a transition to flood-plain sedimentation, or reworking of the topmost channel fill by shoreline processes. No fossils have been found to date in the middle and upper units of the Grimsby in this area.

Features to be Observed

Various unfossiliferous, channel-fill sequences, rich in sedimentary structures, are well exposed in an active quarry near the Erie canal in the village of Hulberton. Semi-polished sections of major sedimentary structures may be observed in the recently worked cut-stones.

Genesee Gorge, Rochester, N.Y. (G, Figs. 3,16)

The clastic rock sequence in the lower portion of this exposure can be subdivided into several sedimentological units.

The Queenston (Ordovician) is considered to be a deltaic complex by Grabau (1909, 1913). Smith (1938) did not find evidence of long-lasting subaereal conditions in the outcrops of northwestern New York. She considered the Queenston to be of a shallow marine, transitional environment. A rapid alternation of environments is present at the Genesee Gorge section. Channels are well defined by geometric forms and by local well developed trough cross-beds. The surrounding interlayers are even-bedded and slightly lensitic, bearing several small scale scour-and-fills and ripple-marks. The lithology consists of an alternation of calcareous red siltstone to very fine sandstone and red, fissile silty shales. At Rochester, the Queenston is of shallow marine

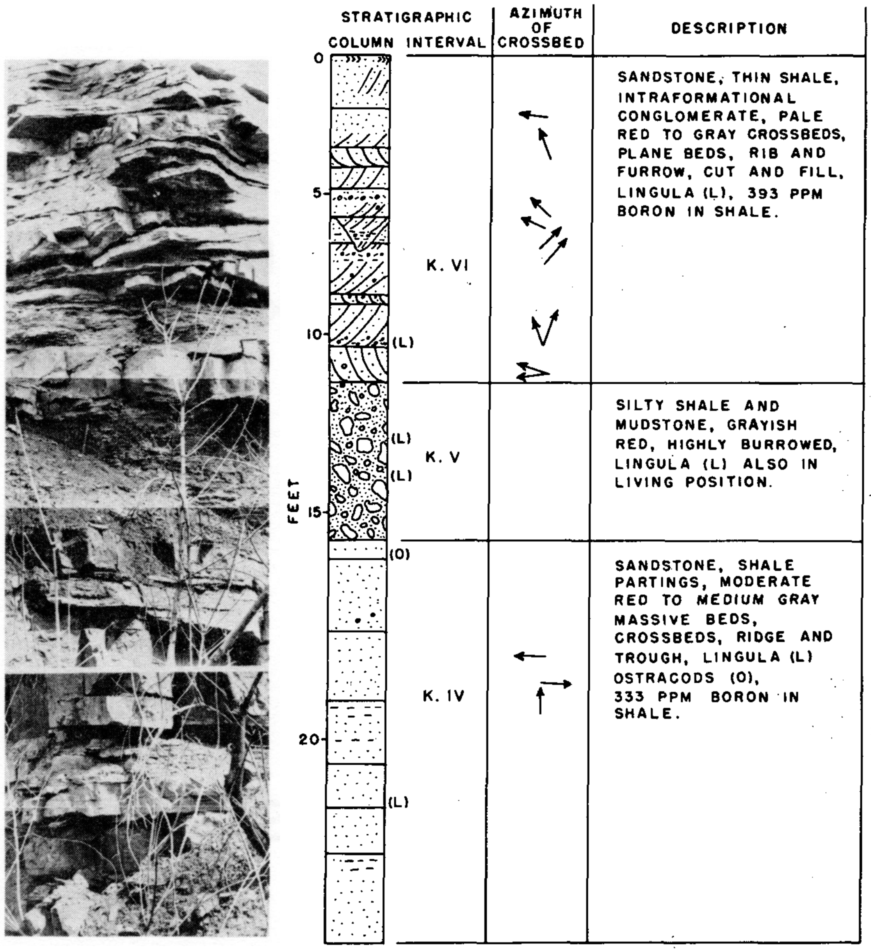
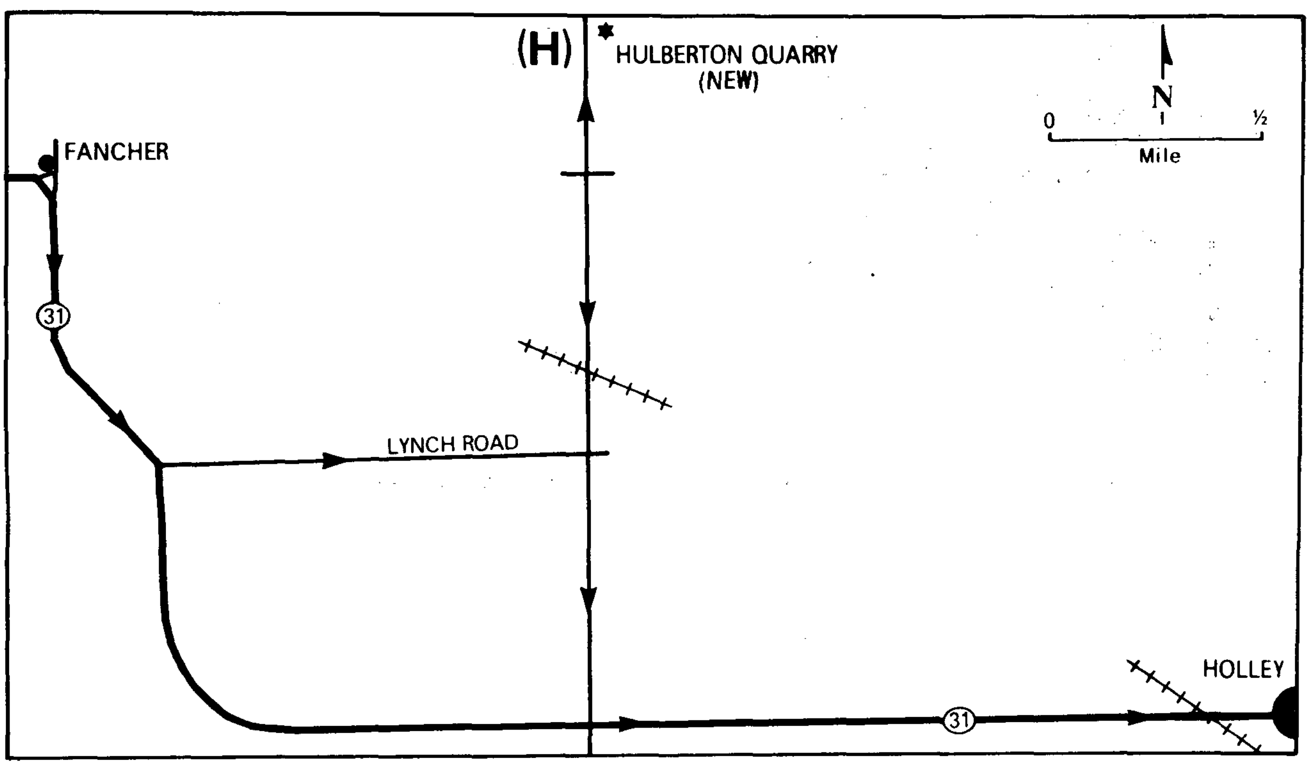


FIG. 13 Schematic representation of the Grimsby sequence exposed in the Lower Quarry at Lockport.

FIG. 14 Location map for an active quarry at Hulberton (H).



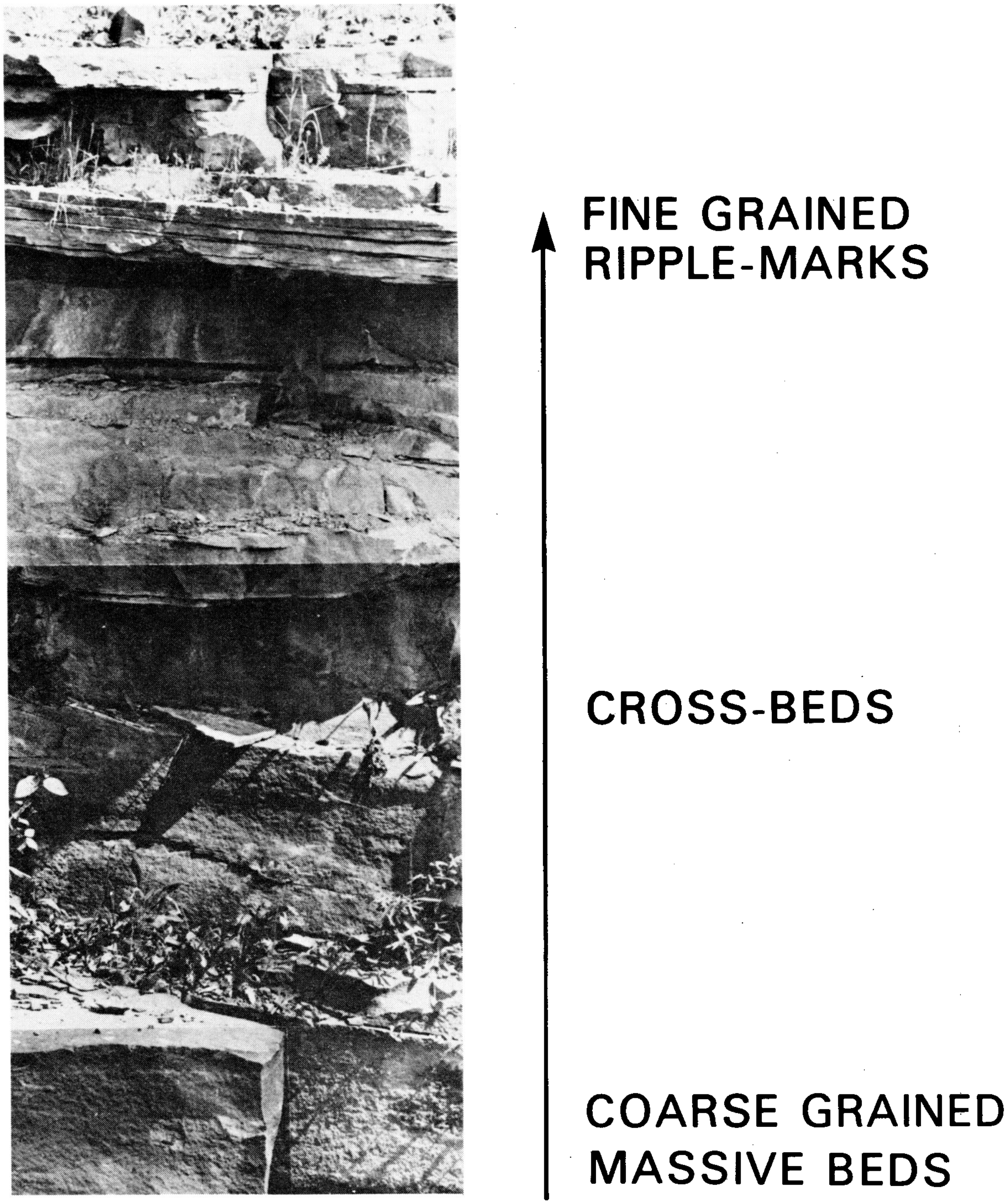


FIG. 15. Typical channel fill sequence of the Grimsby in the Hulberton-Holley area.

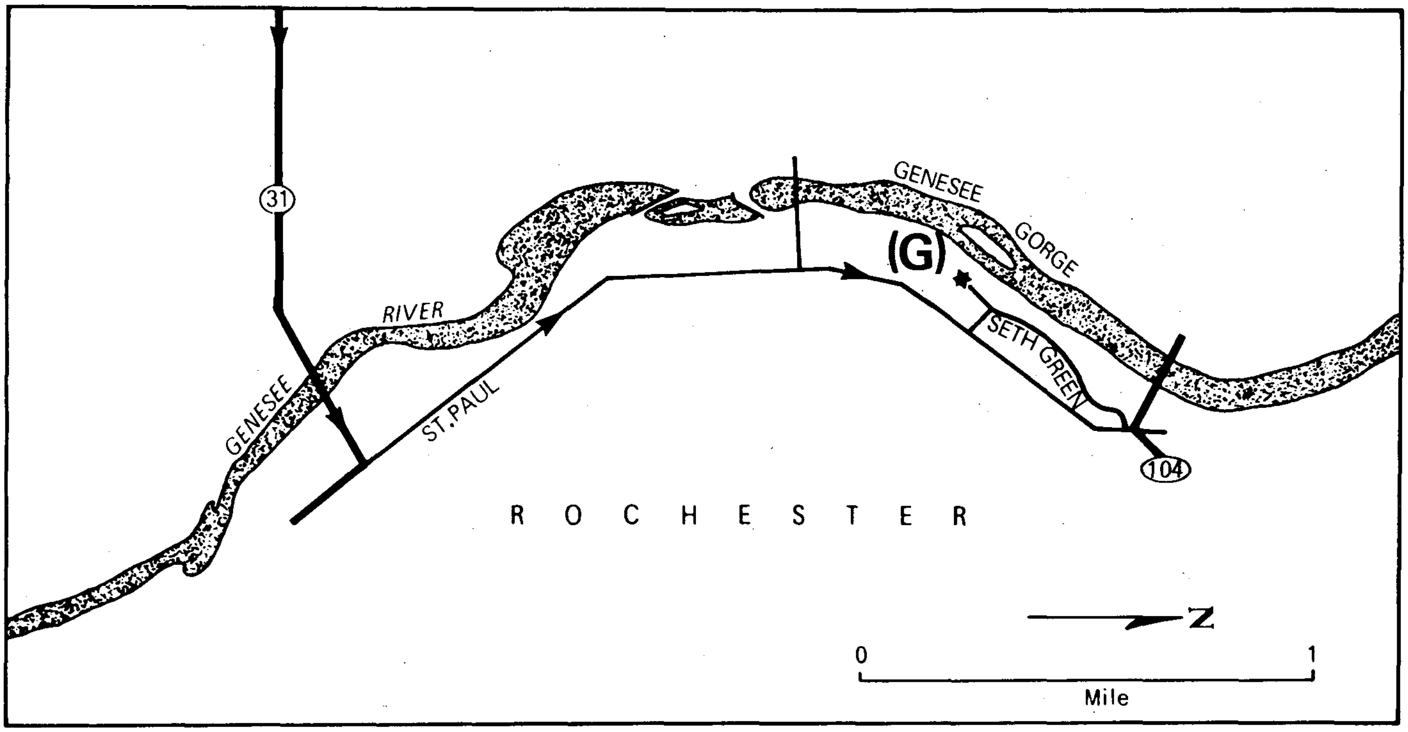


FIG. 16. Location map of the Genesee Gorge section (G) at Rochester (N.Y.).

sedimentation (?) with small paleodistributary channels cutting through the littoral sediments.

Above the littoral to deltaic setting of the Queenston, the lower Silurian sequence of environments records a slow basinal subsidence. The lower unit of the Grimsby is similar to the one exposed at Holley-Hulberton and it is characterized by a variable, lithic sandstone lithology, locally arkosic, red, containing scattered iron ooids and a few crinoidal fragments and phosphatic pellets. The internal structures of the layers are comprised of horizontal laminations and few shallow, small-scale *scour-and-fill structures*. This lower unit is interpreted as one deposited in a shallow marine environment.

Higher horizons of the Grimsby are characterized by alternance of sandstone channel fills cutting into intensely burrowed argillaceous sandy beds (Fig. 17). The intensity of burrowing activities increases in the upper Grimsby and in the Thorold, which is distinguishable because of its gray color. The lower Thorold contact is marked by a well developed phosphatic layer. This upper "burrowed zone" is interpreted as a lagoonal or tidal-flat, or other interdistributary environment.

Above the Thorold, the Silurian section is comprised of a thick unfossiliferous Maplewood (Neahga) shale and the Reynales carbonates, with a thin tongue of Furnaceville-like ironstone made up predominantly of Bryozoa. Load casts and small-scale ball-and-pillow structures are well developed at its base. Above the Reynales an alternance of different shale and carbonate units complete the section (Fig. 1).

Features to be Observed

CARBONATE SEQUENCE ABOVE REYNALES -	Shale and limestone - from bottom up, they have been called: Sodus Shale (Green and purple color), Williamson Shale (black color), Irondequoit Limestone (dark gray color), Rochester Shale (gray color).
REYNALES FORMATION -	Carbonates, thin layer of "Furnaceville" type ironstone, load casts, ball and pillow structures.
MAPLEWOOD -	Equivalent to Neahga shale, well developed shale intervals, limestone pebbles.
THOROLD -	Burrowings, phosphatic layer at the base.
GRIMSBY -	Lower coarse unit is perhaps lateral equivalent to Whirlpool, interstratifications of tidal flat or bay sediments with channel fill sandstones, burrowed layers, mottling.

Acknowledgement

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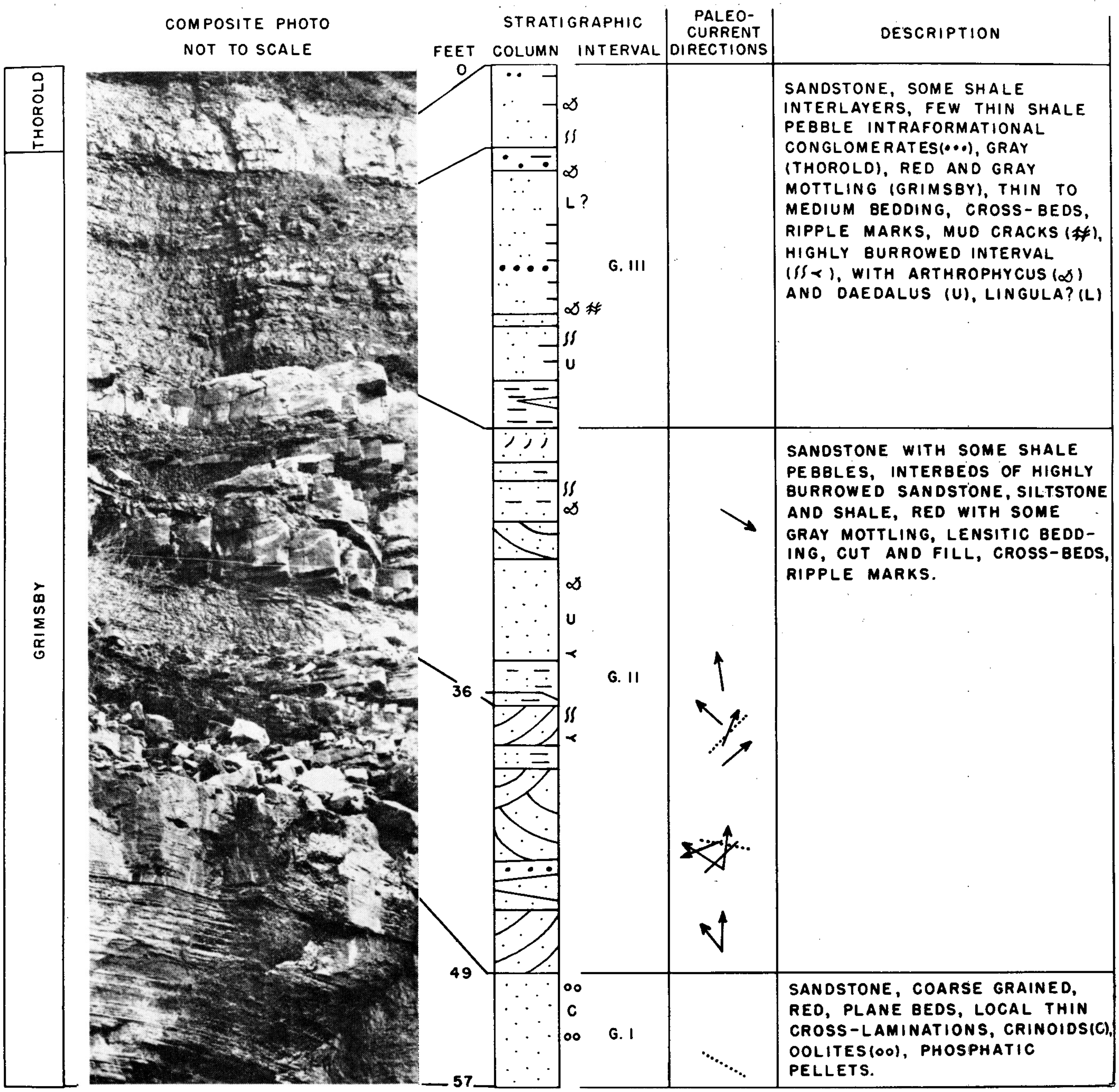

FIG. 17 Schematic representation of the Medina section of Genesee Gorge (G). Paleocurrent directions obtained from grain orientation (full lines), cross beds (arrows) and other directional sedimentary structures (dotted lines).

References

BOLTON, T.E., 1957, Silurian stratigraphy and palaeontology of the Niagara Escarpment in Ontario. Geol. Surv. Can. Mem. 289, 145 p.

CHAIVRE, K.R., and SANFORD, J.T., 1972, Alexandrian-Niagaran regional correlation, in J.T. Sanford, I.P. Martini and R.E. Mosher, Niagaran Stratigraphy: Hamilton, Ontario, 89 p.

CLARK, T.H., and STEARN, C.W., 1960, The geological evolution of North America. New York, Ronald Press Co., 434 p.

ELLER, E.R., 1942, Manitoulin Scolecodonts. Nat. Research Council Rept. Committee on Marine Ecology as related to Pal., No. 2, 4 p.

FISHER, D.W., 1954, Stratigraphy of the Medina Group, New York and Ontario. Amer. Assoc. Petroleum Geol. Bull., vol. 38, pp. 1979-1996.

GRABAU, A.W., 1909, Physical and faunal evolution of North America during Ordovocic, Siluric and early Devonic time. J. Geol., vol. 17, pp. 209-252.

____________, 1913, Early Paleozoic delta deposit of North America. Geol. Soc. America Bull., vol. 24, pp. 399-528.

IRVING, E., 1964, Paleomagnetism and its application to geological and geophysical problems. New York, J. Wiley and Son Co., 399 p.

LUMSDEN, N., 1960, The Grimsby Sandstone in New York State. Unpublished M.S. Thesis, University of Buffalo.

LUNSDEN, N., and PELLETIER, B.R., 1969, Petrology of the Grimsby sandstone (Lower Silurian) of Ontario and New Yori. Jour. of Set. Pet., Vol. 39, No. 2, pp. 521-530.

MARTINI, I.P., 1966, The sedimentology of the Medina Formation along the Niagara Escarpment (Ontario and New York State). Unpublished Ph.D. Thesis, McMaster University, 420 p.

____________, 1971, Regional analysis of sedimentology of Medina Formation (Silurian), Ontario and New York. Amer. Assoc. Petroleum Geol. Bull., vol. 55, pp. 1249-1261.

____________, 1972, Selected facies of the Alexandrian rocks exposed along the Niagara Escarpment, in J.T.Sanford, I.P. Martini and R.E. Mosher, Niagaran Stratigraphy: Hamilton, Ontario, 89 p.

____________, 1973, Selected outcrops of the Medina Formation (Silurian) along the Niagara Escarpment: A field trip. Department of Land Resource Science, University of Guelph, Tech. Memo. 73-2.

PELLETIER, B.R., 1953, The Grimsby Sandstone in the Niagara Peninsual. Unpublished M.S. Thesis, McMaster University, 169 p.

POTTER, P.E., and PETTIJOHN, F.J., 1963, Paleocurrents and basins analysis. New York, Academic Press, 296 p.

SANFORD, J.T., 1972, Niagaran-Alexandrian (Silurian) stratigraphy and tectonics, in J.T. Sanford, I.P. Martini, and R.E. Mosher, Niagaran Stratigraphy: Hamilton, Ontario, 89 p.

____________, MARTINI, I.P., and MOSHER, R.E., 1972, Niagaran Stratigraphy: Hamilton, Ontario. Michigan Basin Geological Society, 89 p.

SMITH, M., 1938, Queeston formation of western New York. Unpublished M.S. Thesis, University of Rochester.

THUSU, B., 1972, Depositional environments of the Rochester Formation (Middle Silurian) in southern Ontario. J. Sediment. Petrol., vol. 42, pp. 930-934.

VAN STRAATEN, L.M.J.V., 1951, Texture and genesis of Dutch Wadden Sea sediments. Proc. Third Internat. Congr. Sedimentology, Netherlands, pp. 225-244.

APPENDIX I - Addresses Where to Ask Permission to Enter Private Property

Flock Road and Jolly Cut - No permission required - for large groups, it is advisable to let the city policy of Hamilton, Ont. know the time of your visit - they may help with traffic, particularly at Flock Road.

DeCew Falls - Manager, Public Relations, Ontario Hydro, Box 1015, Niagara Falls, Ont.

Niagara Gorge - Niagara Frontier, State Park and Recreation Commission, Niagara Falls, N.Y. 14303.

Lockport

Holley and Hulberton - Usually for a brief visit to old quarries it is not essential to ask permission. For new quarry ask Mr. Howard Nichol, Kendall, N.Y.

Genesee Gorge - Rochester Gas and Electric Co., 89 East Ave., Rochester, N.Y. 14606.

Topographic maps can be obtained from: Washington Distribution Sections, Geological Survey. Silver Springs, Maryland, U.S.A. and Ministry of Natural Resources, Toronto, Ont., Canada.