Trip B

PRECAMBRIAN AND LOWER PALEOZOIC STRATIGRAPHY, NORTHWEST ST. LAWRENCE AND NORTH JEFFERSON COUNTIES, NEW YORK

by

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ABSTRACT

The field trip is designed to demonstrate general features of the lower Paleozoic sequence with emphasis on the stratigraphic relations with the Precambrian basement and environments of deposition. The strata form part of a complex Upper Cambrian-Lower Ordovician transgressive sequence that blankets an erosion surface on the Precambrian of low but variable relief. Basal quartzose sandstones (Potsdam Sandstone), with local conglomerate and breccia, grade and intertongue seaward (eastward) through calcareous and dolomitic sandstones and sandy dolomites (Theresa and Bucks Bridge Formations) into purer dolomites in the Champlain Valley. In St. Lawrence County, the Theresa and the Bucks Bridge Formations are overlain by dolomites and sandy dolomites (Ogdensburg Dolomite). Sedimentological and paleontological features (particularly trace fossils and algal stromatolites) will be seen that document and refine the general interpretation of the various facies as shallow water shelf deposits.

The excursion is divided into Saturday and Sunday morning parts (Fig. 1). The Saturday trip begins with a brief examination of the complex flow folding in the Grenville marbles south of Canton followed by examination of outliers of Potsdam Sandstone within the marbles north of Gouverneur, in an area where there have been problems in the differentiation of Paleozoic and Precambrian quartzites and breccias. Lunch will be in a park at Alexandria Bay, overlooking the Thousand Islands; here we will discuss the influence of the Frontenac Axis on the distribution of the Paleozoic rocks.

In the afternoon, the trip continues at an excellent exposure of an angular unconformity between the Potsdam Sandstone and Precambrian meta-sedimentary rocks just east of Alexandria Bay. We will then proceed down the St. Lawrence Valley and examine in stratigraphic succession 1). the Potsdam Sandstone and lower Theresa Formation near Chippawa Bay, 2). the Theresa Formation near Brier Hill and 3). the Ogdensburg Dolomite at Ogdensburg.

The localities to be visited on Sunday are 1). the Allens Falls Fanglomerate or "basal breccia" at Allens Falls, 2). the type exposure of

the Potsdam Sandstone at Hannawa Falls and 3). the dendroid graptolite locality in the Bucks Bridge Formation near Madrid described by Berry and Theokritoff (1966).

INTRODUCTION

The bedrock in the upper St. Lawrence valley includes metamorphosed Precambrian overlain unconformably by Paleozoic sedimentary rocks (Fig.2). The Precambrian rocks are part of the Grenville orogen and are structurally complex (Stops 1-4). The unconformity at the base of the Paleozoic is exposed at very few localities in the upper St. Lawrence valley; three localities, which illustrate distinct aspects of the contact, will be visited (Stops 2, 4, and 8).

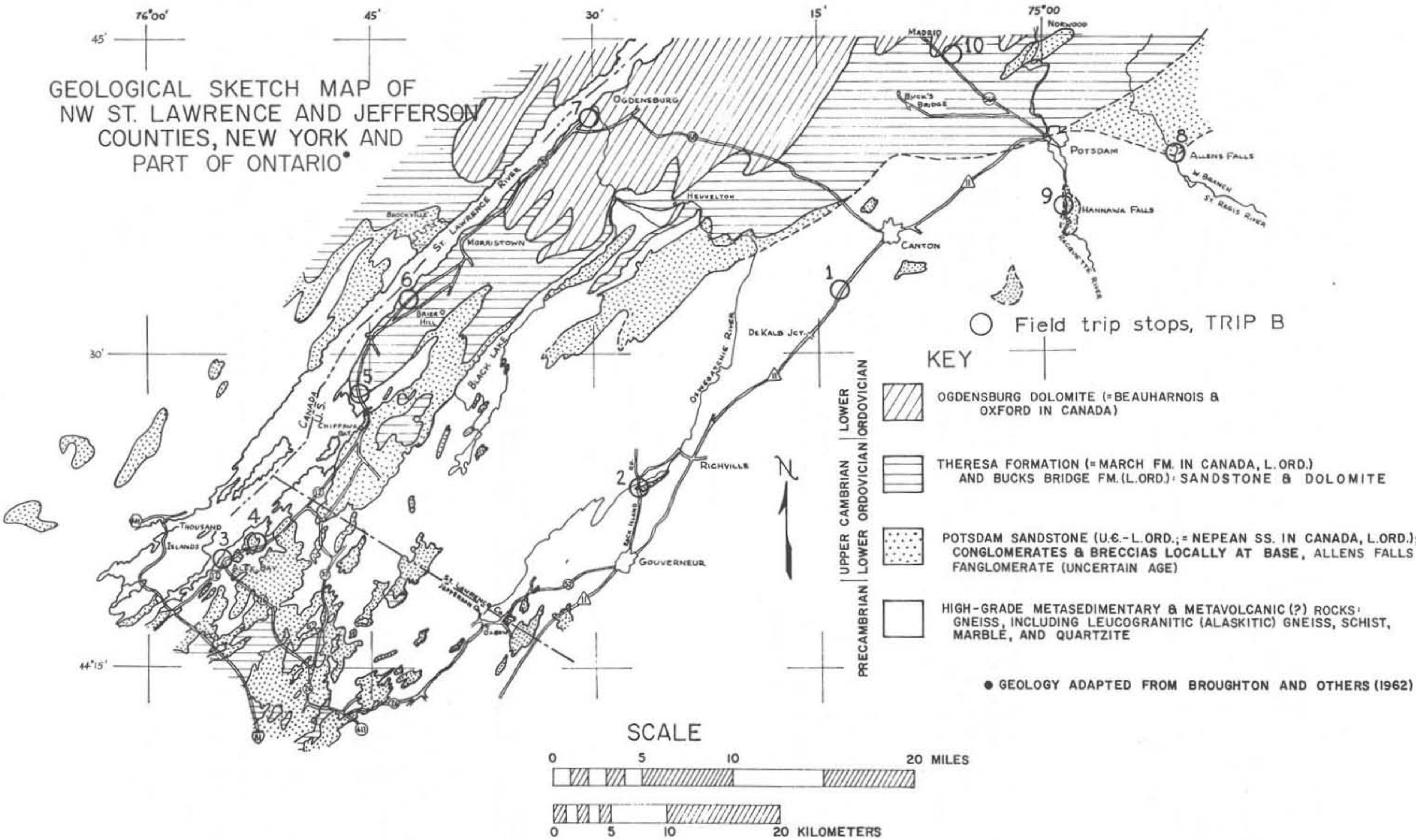
The basal Paleozoic unit is generally a quartzose sandstone (orthoquartzite) named the Potsdam Sandstone (Emmons, 1838). Locally, conglomerates, "basal breccias" and fanglomerates (Allens Falls Fanglomerate), are developed at or near the base of the Potsdam Sandstone. Although the Potsdam Sandstone yields Late Cambrian trilobites from localities in Washington, Clinton, and Franklin counties, New York (Fisher, 1955; 1956; 1968), no chronostratigraphically indicative fossils have been reported from this unit in St. Lawrence or Jefferson counties; in eastern Ontario, the lithologically equivalent Nepean Sandstone yields fossils indicating Early Ordovician age (Kirwan, 1963). Trace fossils, in the form of U-shaped vertical spreite burrows (*Diplocraterion?)* will be seen at Stop 5.

The Potsdam Sandstone is overlain by calcite- and dolomite-cemented sandstones which Chadwick (1915) divided, in stratigraphic order, into three units: Theresa mixed beds, Heuvelton Sandstone, and Bucks Bridge mixed beds (Stop 10). Berry and Theokritoff (1966) were unable to find criteria to support this sub-division in central St. Lawrence County and extended the Bucks Bridge Formation downward to include Chadwick's Heuvelton and Theresa; however, they recognized the Heuvelton Sandstone as a member of their extended Bucks Bridge Formation. Fisher (1968) recognized the Theresa Formation (Cushing, 1908) in the Plattsburgh and Rouses Point areas and applied the names Theresa Dolomite and Bucks Bridge Dolomite in the St. Lawrence Valley (1968, p.29). Neither the Heuvelton Sandstone nor the Bucks Bridge mixed beds of Chadwick are recognized within the Theresa Formation in its type area (Theresa, Jefferson County) or in northwesternmost St. Lawrence County.

The lower part of the Bucks Bridge Formation, as used by Berry and Theokritoff (1966), or the Theresa Dolomite, as used by Fisher, yields rare inarticulate brachiopods (*Lingulepis)*. The Bucks Bridge Dolomite (the upper part of the Bucks Bridge Formation of Berry and Theokritoff) yields poorly preserved discoidal gastropods that suggest correlation with the Tremadoc, as well as, at one locality (Stop 10), *Dictyonema potsdamense*.

A dolomite, locally sandy, overlies the Bucks Bridge Formation and Theresa Formation; this dolomite was named the Ogdensburg Dolomite by Chadwick (1915, p. 289) and recognized by Berry and Theokritoff (1966) and Fisher (1962B; 1968). It is the highest Paleozoic unit to be seen on this trip (Stops 7 and 10). It contains a fairly limited molluscan fauna as well as algal stromatolite horizons.

FIGURE 2.


GEOLOGICAL SKETCH MAP OF
NW ST. LAWRENCE AND JEFFERSON
COUNTIES, NEW YORK AND
PART OF ONTARIO•
76°00'
45'
30'
15'
75°00
44°15'
Ogdensburg
Madrid
Norwood
Buck's Bridge
Potsdam
Allens Falls
W. Branch St Regis River
Hannawa Falls
Raquette River
Heuvelton
Canton
Brockville
St. Lawrence River
Morristown
Briar Hill
Black Lake
DeKalb Jct.
Oswegatchie River
Canada
U.S.
Chippewa Bay
Richville
Gouverneur
Thousand Islands
Alex. Bay
St. Lawrence Co.
Jefferson Co.
1
2
3
4
5
6
8
9
10
Field trip stops, TRIP B
KEY
LOWER ORDOVICIAN
UPPER CAMBRIAN LOWER ORDOVICIAN
PRECAMBRIAN
OGDENSBURG DOLOMITE (=BEAUHARNOIS & OXFORD IN CANADA)
THERESA FORMATION (=MARCH FM. IN CANADA, L. ORD.) AND BUCKS BRIDGE FM. (L. ORD.): SANDSTONE & DOLOMITE
POTSDAM SANDSTONE (U.€.-L.ORD.; = NEPEAN SS. IN CANADA, L.ORD.); CONGLOMERATES & BRECCIAS LOCALLY AT BASE, ALLENS FALLS FANGLOMERATE (UNCERTAIN AGE)
HIGH-GRADE METASEDIMENTARY & METAVOLCANIC (?) ROCKS: GNEISS, INCLUDING LEUCOGRANITIC (ALASKITIC) GNEISS, SCHIST, MARBLE, AND QUARTZITE
• GEOLOGY ADAPTED FROM BROUGHTON AND OTHERS (1962)
N
SCALE
0
5
10
20 MILES
0
5
10
20 KILOMETERS

The relationships of the several Paleozoic units have been variously interpreted. Chadwick (1915; 1920), Cushing and others (1910), and Cushing (1916) interpreted the section essentially in "layer-cake geology" terms, seeing the contacts as isochronous. On the other hand, Fisher (1955; 1956; 1962A) and Berry and Theokritoff (1966) interpreted the section in terms of lateral facies gradations within the deposits of a westward transgressing sea. Interpretation of the Paleozoic of the upper St. Lawrence Valley is complicated by the paucity of chronostratigraphically significant fossils, the low density of outcrops, and the presence of lateral lithofacies gradations.

ACKNOWLEDGEMENTS AND NOTES

We gratefully acknowledge the assistance of Dr. Bradford B. Van Diver in the preparation of Figures 1-5 and thank Mrs. Judy Moriarty for typing the final manuscript. We also wish to thank Mr. C. M. Sandwith of McConville, Inc. of Ogdensburg, New York and Mr. Richard Bicknell of Bicknell Brothers, Inc. of Potsdam, New York for permission to visit their quarries (Stops 7 and 9).

The classification of Folk (1962) was used in the description of the carbonate rocks. Calcite was distinguished from dolomite by staining with Alizarin red-S in dilute-HCL (Sabins, 1962). Figures 10, 11, 13, 14 and 16 were traced from acetate peels and Figures 9 and 15 were traced from photographs of acetate peels.

STOP DESCRIPTIONS

General

Stops 1 and 2. Refer to Stops 1 and 2 of Trip A (p. A-1; A-4) for stop descriptions.

Stop 3. Scenic View Park, Alexandria Bay, New York.- Lunch Stop; leucogranitic (alaskitic) gneiss; Frontenac Axis.

The Frontenac Axis is a narrow southeastward extension of the Canadian Shield connecting the Laurentian Plateau with the "Lowlands" region of the Adirondack Mountains. This terrane of resistant Precambrian crystalline rocks forms the Thousand Islands where the axis is crossed by the postglacial St. Lawrence River a few miles from where the river spills out of Lake Ontario.

In the Thousand Islands area, the basement rocks are a highly folded and intensely metamorphosed complex of metamorphic rocks dominated by pink or red leucogranitic (alaskitic) gneiss (Alexandria Granite; Rockport-type granite in Canada) with white metaquartzites and a variety of layered gneisses; the sequence is broadly monoclinal, with a northwesterly dip (Wynne-Edwards, 1959, 1962, 1963).

The axis separates the lowermost Paleozoic strata of the Ottawa-St. Lawrence Lowland to the northeast from the similar but less complete succession of the

Ontario Lowland to the southwest. It is difficult to document the influence of the axis on early Paleozoic sedimentation because of the scarcity of outcrop in the immediate area (Fig. 2). Numerous outliers of the Potsdam Sandstone (Nepean in Canada) and a few of the Theresa Formation indicate that the axis was covered by a westward-transgressing sea during Late Cambrian-Early Ordovician (Early Canadian) time. In the St. Lawrence Valley, the sandstones and dolomites of the Theresa-Bucks Bridge Formations (March Formation in Canada) are succeeded by the Ogdensburg Dolomite (Oxford Formation in Canada) of Medial and Late Canadian age; the Ogdensburg Dolomite is unconformably overlain by a Middle Ordovician limestone sequence of Chazyan (Rockcliff and St. Martin Formations) and Mohawkian (Ottawa Formation) age(Fisher 1968, p.29).

West of the Frontenac Axis, the Ogdensburg Dolomite and Chazyan limestones are missing and here the limestone sequence of Mohawkian age (Black River and Trenton Groups) rests unconformably on the Theresa Formation and older rocks. The Black River and Trenton limestones were deposited in a transgressing sea that crossed the Frontenac Axis and entered the Ottawa-St. Lawrence basin from the southwest (Wilson, 1946, p.7). There is no indication of later Paleozoic sedimentation over the axis. Any deposits that may have accumulated have since been removed by post-Ordovician erosion that has stripped the lower Paleozoic sequence away from the crest to leave a sequence of stair-like terraces and scarps.

Glacial deposits are rare and thin in the Alexandria Bay area and the Precambrian and Paleozoic rock display evidence of glacial erosion, especially on the Potsdam Sandstone. The features include glacial polishing, striae and grooves (direction to SW about parallel to the St. Lawrence River) and chatter marks (MacClintock and Stewart, 1965, p. 120).

Stop 4. Precambrian-Paleozoic angular unconformity at Alexandria Bay.- Roadcut on N.Y. 12, 2 miles east of Alexandria Bay, N.Y.

The east end of the roadcut exposes a knoll on the pre-Potsdam erosion surface formed on steeply inclined to vertical Precambrian metasedimentary rocks which are overlapped by nearly horizontal orthoquartzites of the Potsdam Sandstone (Figs. 3-5). The Precambrian rocks include medium-grained leucogranitic (alaskitic) gneiss which form resistant masses at the west and east ends of the outcrop. Between these rocks are darker layered gneisses, including red and pink leuco-quartz diorites, pink alaskitic gneiss and green and white diopsidic quartz diorites. The layered gneisses are mostly highly altered, especially in the intensely weathered zone in the first few feet below the erosion surface.

The basal Potsdam Sandstone is well bedded, medium- and thick-bedded, medium-grained, white orthoquartzite. The basal part of the sandstone sequence thins over the crest of the knoll, as the lowermost beds pinch out against the erosion surface. The quartz grains are mostly well rounded, highly spherical, and frosted and are thoroughly cemented by silica overgrowths in optical continuity with the grains, a feature for which the Potsdam Sandstone has long been noted. Cross- and horizontal laminae within the beds are defined by minor fluctuations in grain size from very fine- to coarse-grained,texture and accessory mineral content. Heavy minerals are

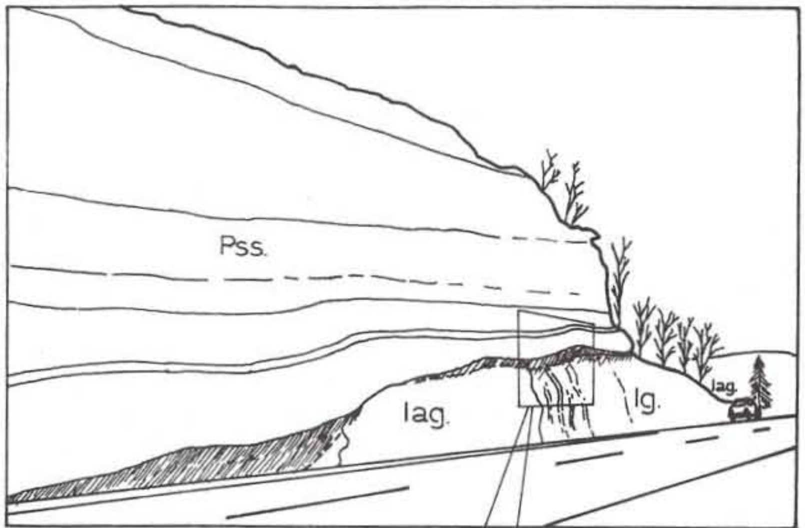


Fig. 3. STOP 4: Precambrian-Paleozoic angular unconformity at Alexandria Bay. Lag, leucogranitic (alaskitic) gneiss; lg, layered gneiss; Pss., Potsdam Sandstone. Ruled area, intensely weathered zone. East end of roadcut on north side of N.Y. 12, 2 mi. east of Alexandria Bay, N.Y.

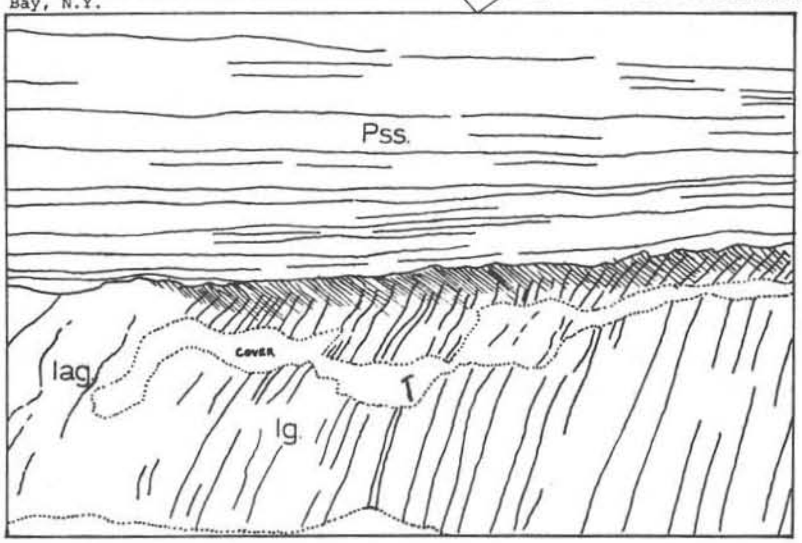


Fig. 4. STOP 4: Detail of unconformity seen in Fig. 3. Geologic hammer is two feet in length.

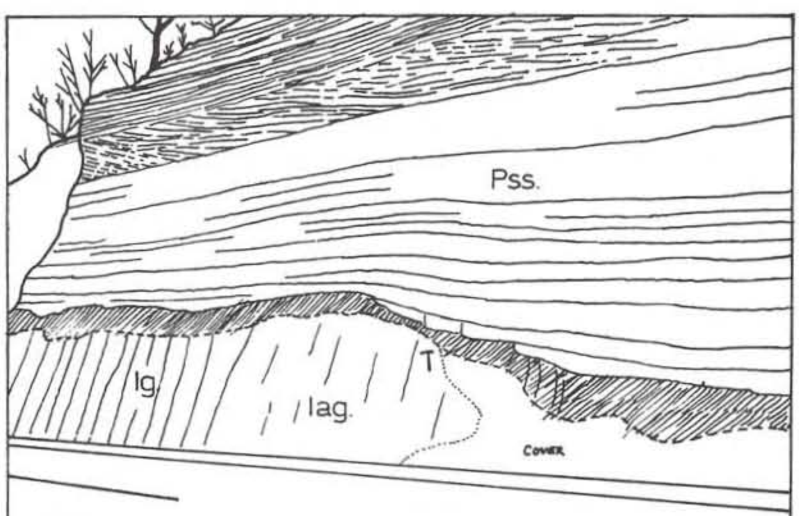


Fig. 5. STOP 4: Precambrian-Paleozoic angular unconformity at Alexandria Bay. Notation as in Fig. 3. East end of roadcut on south side of N.Y. 12, 2 miles east of Alexandria Bay, N.Y.

generally rare throughout the orthoquartzite facies of the Potsdam Sandstone; in this area tourmaline and zircon are the most common.

Above the basal strata the beds become more nearly horizontal and the bed thickness gradually decreases (medium-bedded). The beds include red, pink and white, laminated, medium-grained orthoquartzite with conspicuous "dusty" hematite rimming the rounded quart grains. Similar, but less mature, friable, white, gray and pink, fine- to medium-grained orthoquartzites also occur which weather greenish-yellow. Tourmaline and hematite are conspicuous in these rocks, along with interstitial clay and occasional rock fragments. The red and pink "banded" sandstones continue to the top of the section. In the upper third of the section is a well defined band of large-scale, planar cross-stratified beds.

The high textural and mineralogical maturity and the absence of clasts of the Precambrian rocks in the lowermost beds suggests that the sediments described above were derived from reworking of fluvial sands (floodplain alluvium) by an encroaching sea. The detrital material carried seaward by currents accumulated on and eventually blanketed the irregular pre-Potsdam erosion surface. Sedimentary features in the sandstones (especially the laminated bedding) indicate deposition in the "low energy, littoral to nearshore environment" of the Potsdam Sandstone described by Otvos (1966); Fisher (1968, p. 16) interprets what appears to be a similar facies of the Potsdam Sandstone in the Champlain Valley as, in part, the deposits of low energy outer intertidal and inner subtidal environments. The cross-stratified beds in the upper part of the section may indicate somewhat higher-energy conditions in which currents built solitary banks into shallow water just off a beach (Allen, 1963, p. 101).

Stop 5. Chippawa Bay.- Upper Potsdam Sandstone and lower Theresa Formation exposed in roadcut on N.Y. 12, 0.2 miles northeast of intersection with Pleasant Valley Road, 2.7 miles east of Chippawa Bay, New York.

Potsdam Sandstone

The Potsdam Sandstone exposed at this locality is a thin- to medium-bedded, white orthoquartzite with minor cross-stratification and ripple marks, especially in the lower part of the section (Fig. 6). Vertical U-shaped organismal burrows *(Diplocraterion?)* occur in Horizon 5-1 (Stop 5, Horizon 1) and are well displayed in the southeastern wall at the southwestern end of the roadcut (Fig. 8). Simple vertical burrows are also seen at this level but these are believed to be U-shaped burrows that are only partly displayed by the available section.

Close examination shows that the burrows are *Spreitenbauten* (Seilacher, 1967, p. 418-421) as they display laminations reflecting the shape of the terminal bend that are indicative of a shift of the tube through the sediment. Some of the burrows are infilled and the infilling can be traced into the lowest part of the burrows; the burrows appear to be entirely protrusive in vertical direction and thus reflect a response to growth of the organism rather than a response to fluctuations in the depositional rate (Seilacher, 1967, p. 418-420). The rather deep penetration of the burrows at this horizon indicates a slowing down of the rate of sedimentation.

FIGURE 7.

STOP 6: Brier Hill

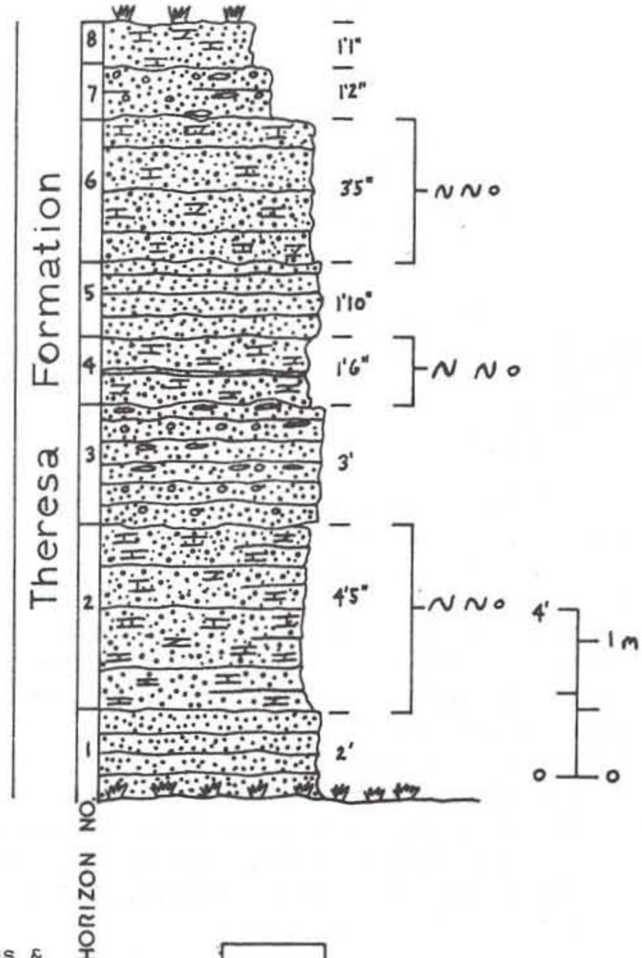
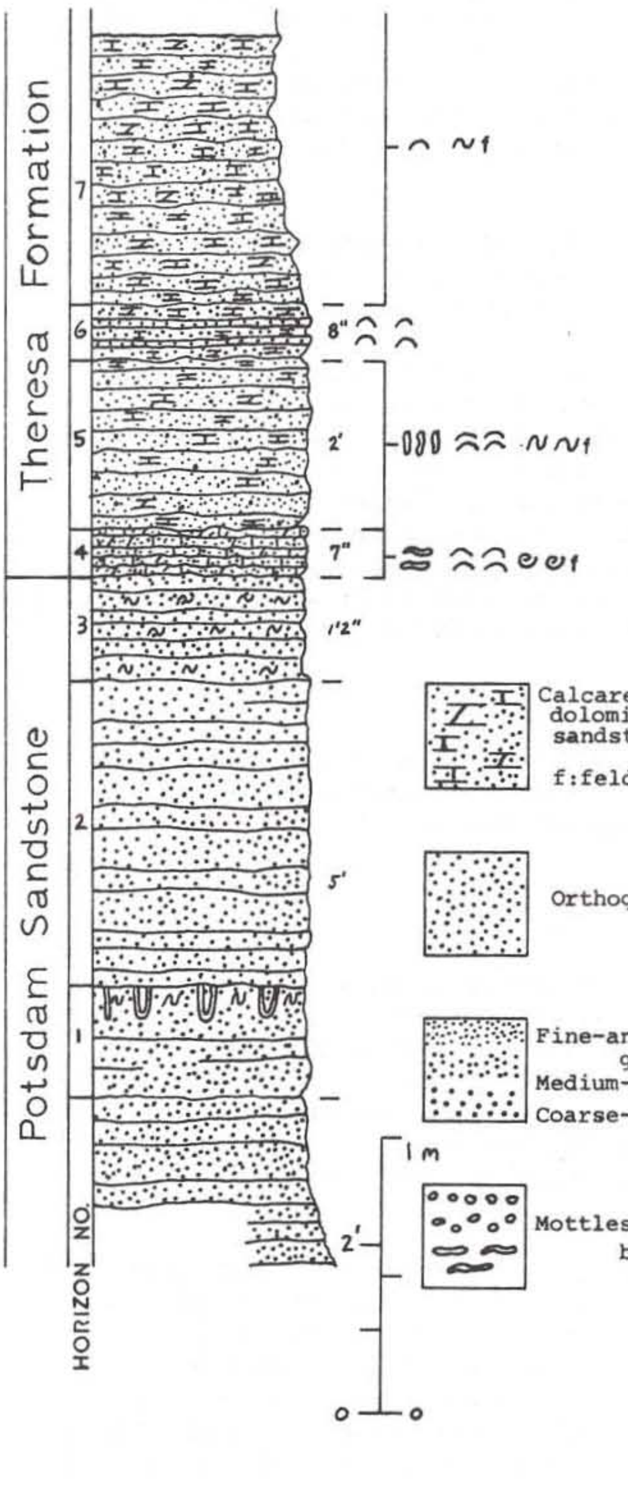
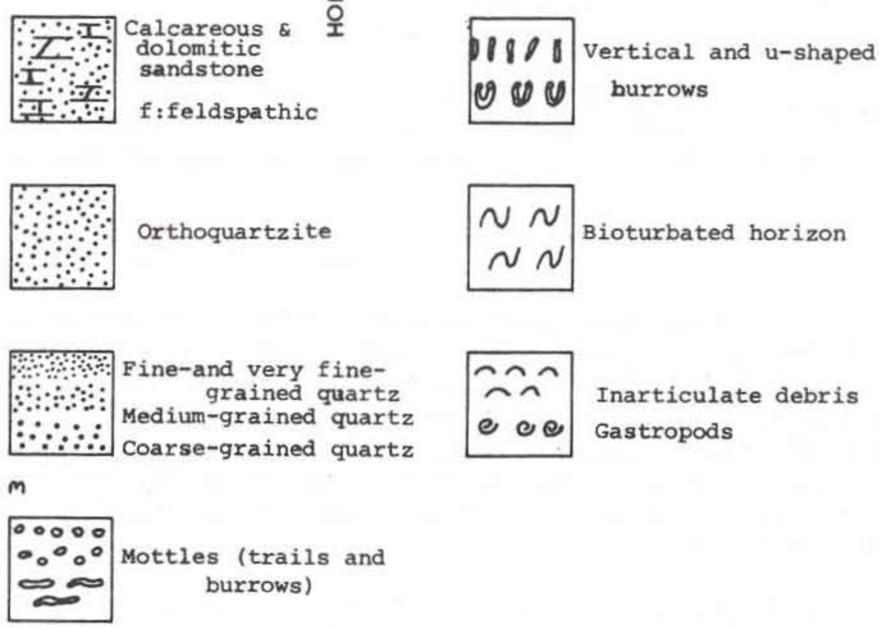


FIGURE 6.

STOP 5: Chippawa Bay





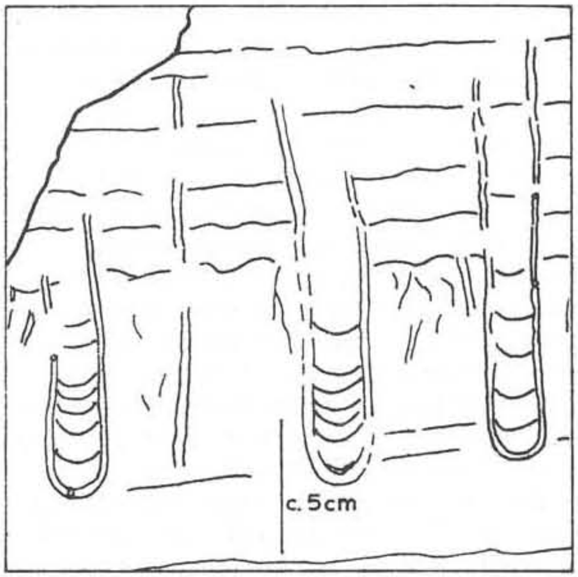


Fig. 8. Spreite burrows (*Diplocraterion?*) in the Potsdam Sandstone. STOP 5-1, N.Y. 12 near Chippawa Bay, N.Y.

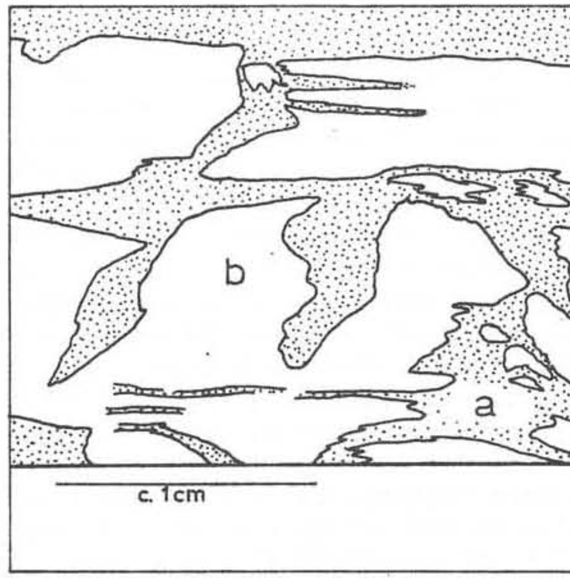


Fig. 9. Mudcracks in Ogdensburg Dolomite. a) very fine-and fine-grained quartz. b) very finely and finely crystalline dolomite. STOP 7-6, McConville Inc. Quarry, Ogdensburg, N.Y.

Fig. 10. Mudcracks and intraformational breccia in Ogdensburg Dolomite. a) very finely crystalline (aphanocrystalline) dolomite b) finely crystalline dolomite with medium-grained, coarse-and very coarse-grained quartz. STOP 7-9, McConville Inc. Quarry, Ogdensburg, N.Y.

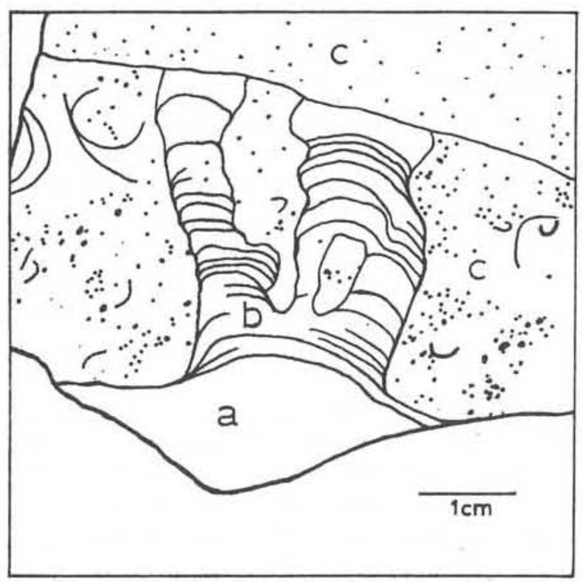


Fig. 11. Algal stromatolites in Ogdensburg Dolomite. a) medium crystalline dolomite b) algal stromatolite: space-linked hemi-spheroids (*Collenia* structure) and digitate vertically stacked hemispherioids (*Cryptozoon* structure) c) interareas:finely and medium crystalline sandy dolomite with oolites, gastropod and orthocone fragments and clasts broken from stromatolites. Quartz grains (bk) are medium-and coarse-grained. STOP 7-12, McConville Inc. Quarry, Ogdensburg, N.Y.

The organism that made these burrows can be postulated as an elongate animal that depended on the development of incurrent and excurrent water movements. It was thus a suspension feeder and its burrow a protective shelter. Currents above the sediment-water interface had sufficient turbulance to transport food particles and keep them in suspension, but not enough to introduce a significant amount of sediment or cause significant erosion. Such burrows are known from modern intertidal and shallow subtidal environments as well as more off-shore areas (Seilacher, 1967; Frey, 1970), and are made by a variety of organisms: amphipod crustaceans (Seilacher, 1967, p. 414, 422), polychaete annelids (Seilacher, 1967, p. 414; Rhoades, 1967, p. 464-467; Frey, 1970, p. 512-513) and hemichordates (Frey, 1970, p. 512). Studies by Rhoades (1967) and Seilacher (1967) indicate that deep burrows are generally characteristic of intertidal environments, in which the burrows provide shelter from fluctuations in temperature, salinity and dessication at the sediment-water interface. Such conditions might account for the relatively low density of burrows and the apparent absence of other fossils in Horizon 5-1 and elsewhere in the section. It thus seems a reasonable hypothesis that the white orthoquartzite facies of the Potsdam Sandstone in this area records a nearshore intertidal environment.

Theresa Formation

The lower Theresa Formation in this section consists of gray and blue-gray, fine-grained, feldspathic, calcareous and dolomitic sandstone. The original sedimentary fabric of the rock has been modified to varying degrees by burrowing and general bioturbation. Remarkably well rounded, spherical, medium- and coarse-grained quartz is scattered throughout the succession. The carbonate cement, which locally approaches 50% of the rock, is predominantly calcite which appears to have largely replaced an earlier dolomite cement. Locally the detrital grains float in a matrix of sparry calcite, forming the distinctive lustrous cleavage surfaces ("sand crystals" or "crystal sandstone") noted by early workers (Cushing and others, 1910; Cushing, 1916). The quartz grains, which appear frosted in hand specimen, are etched and corroded by the calcareous cement; siliceous overgrowths similar to those which characterize the underlying Potsdam Sandstone occur where the quartz grains are concentrated.

Relatively shallow vertical and nearly vertical burrows (*Skolithos*) infilled with calcite-cemented quartz are well displayed in Horizon 5-5. Lenses and lamellae of comminuted inarticulate brachipod debris (*Lingulepis acuminatus*) are concentrated at several levels in the lowermost horizons; the best material may be collected from Horizons 5-5 and 5-6 on the north side of the roadcut. Poorly preserved discoidal gastropods and grazing trails may be seen on some bedding surfaces in Horizon 5-4.

The immaturity of these sandstones and their carbonate content and fauna indicate accumulation in a relatively uniform low energy environment (possibly subtidal), offshore from the intertidal environment suggested for the underlying white orthoquartzites of the Potsdam Sandstone.

Stop 6. Brier Hill- Roadcut along N.Y. 12, just south of turnoff to Brier Hill and Jacques Cartier State Park. Theresa Formation.

The outcrop exposes a gently folded and faulted section in the upper part of the Theresa Formation (Fig. 7) consisting of medium-grained, white orthoquartzites alternating with gray and blue-gray, coarse-, medium- and fine-grained, calcareous and dolomitic sandstones. The white orthoquartzites are like those of the upper Potsdam Sandstone seen at Stop 5. At Horizons 6-3 and 6-7, the quartzites are riddled with dark brown mottles and elongate patches of limonite-stained quartz floating in sparry calcite cement. These features trend nearly parallel to bedding surfaces and are interpreted as infillings of burrows.

The gray calcareous and dolomitic sandstones are thoroughly bioturbated (mottled) and original sedimentary fabrics have been nearly obliterated. Cut-and-fill structure may be seen at several levels, indicating relatively strong current activity. The rock consists of a mixture of about equal amounts of coarse-, medium- and fine-grained quartz, the coarser grains being remarkably well rounded, spherical, and frosted. The grains are notably etched and corroded by the predominantly calcitic cement, but optically conformable silica overgrowths occur where quartz grains are concentrated. The calcite appears to have almost completely replaced an earlier dolomite cement and the lustrous cleavage surfaces produced by pockets of sparry calcite cement (crystal sandstone)are a distinctive feature of the rock in the field (Horizons 6-2, 6-6). Inarticulate debris, detrital feldspar and rock fragments are less conspicuous in the Theresa Formation at this locality than at Stop 5.

The relatively thorough bioturbation of the gray and blue-gray calcareous and dolomitic sandstones (Horizons 6-2, 6-4, 6-6) again suggests that the sediments accumulated in a more offshore (subtidal) environment than that of the less biogenically disturbed orthoquartzites. Moore and Scrutton (1957) and Rhoades (1967) have noted that prolonged activity of subtidal bottom communities near the sediment-water interface under conditions of relatively slow sediment accumulation results in the complete reworking of the sediment.

Cushing (1916, p. 24) reported about 140 feet of Theresa Formation in this area and Dietrich (1957, p. 706) documented the variation in lithofacies within the unit. In addition to the types described above, Dietrich reported blue-gray, sandy limestones and buff and gray, sandy, dolomitic limestones. Chadwick (1915, p. 289) introduced the name Heuvelton Sandstone for a 0 to 20 foot thick lens of white orthoquartzite lying above the Theresa mixed beds in central St. Lawrence County. Although Cushing (1916) used the name, the presence of the unit among the white orthoquartzites in the Brier Hill area is uncertain (Dietrich, 1957, p. 105). As noted above, Berry and Theokritoff (1966) regard the Heuvelton Sandstone as a member of their extended Bucks Bridge Formation. Although the Theresa Formation (northwesternmost St. Lawrence and Jefferson Counties) and the Bucks Bridge Formation (central St. Lawrence County) of Berry and Theokritoff (1966) occupy the interval between the Potsdam Sandstone and the Ogdensburg Dolomite, their precise stratigraphic relationships have yet to be established.

Stop 7. McConville, Inc. Quarry in Ogdensburg Dolomite on the west side of Ogdensburg.- Driving east on N.Y. 37 from Morristown, N.Y. turn left at the Ogdensburg bypass and follow the sign for downtown Ogdensburg. Continue on old N.Y. 37 for 0.8 miles and turn right at the fork onto Ogden Street. Proceed for two blocks and turn right onto Madison Avenue. Park in field opposite intersection with Gates Street (0.1 miles). Ogdensburg Dolomite.

Introduction

Cushing (1916) recognized around 140 feet of Ogdensburg Dolomite in this region and measured sections from roadcuts and quarries (now mostly overgrown) between Morristown and Ogdensburg and northward to Red Mills, New York. In spite of scattered outcrop and apparent rapid facies changes, he pieced together the composite section summarized here, beginning at the base: 1. small thickness of basal sandy beds transitional with the underlying Theresa Formation 2. thick-bedded, blue, sandy dolomites (15 ft.) and thin-bedded, gray dolomites (20 ft.) 3. alternating thick-bedded, dark blue and gray, sandy dolomites, locally with abundant but poorly preserved gastropods (especially in the lower part) and occasional thin sandstones (white ortho-quartzites) and *Cryptozoon* layers (80 ft.) 4. thin-bedded ("flinty") dolomites (20 ft.).

The thirty foot section exposed in the abandoned southeast part of the quarry (Fig. 12; Appendix) represents the transition between intervals 3 and 4 described above. Detailed examination reveals a remarkably varied sequence with numerous structures of sedimentological and paleoecological interest especially in light of the wealth of data now available on the environments and characteristics of recent shallow water carbonate sediments. Walker and LaPorte (1970, p. 931-933) provide a concise review of the literature and a summary of lithologic, paleontologic and primary structural criteria for recognition of subtidal to supratidal carbonate environments in ancient rocks. Reconstructions of paleoenvironments must of necessity follow and build upon an understanding of regional stratigraphic relations (for example, LaPorte, 1969, Walker and LaPorte, 1970, Thompson, 1970) but in the case of the Ogdensburg Dolomite (and the Theresa and Bucks Bridge Formations as well) such a stratigraphic synthesis is not available. Perhaps in the case of the Ogdensburg Dolomite attempts to analyze sedimentological and paleoecologic features of local sections will stimulate new attempts to work out the regional stratigraphy. The horizons are briefly described in the Appendix and some tentative correlations are made with Cushing's (1916) sections.

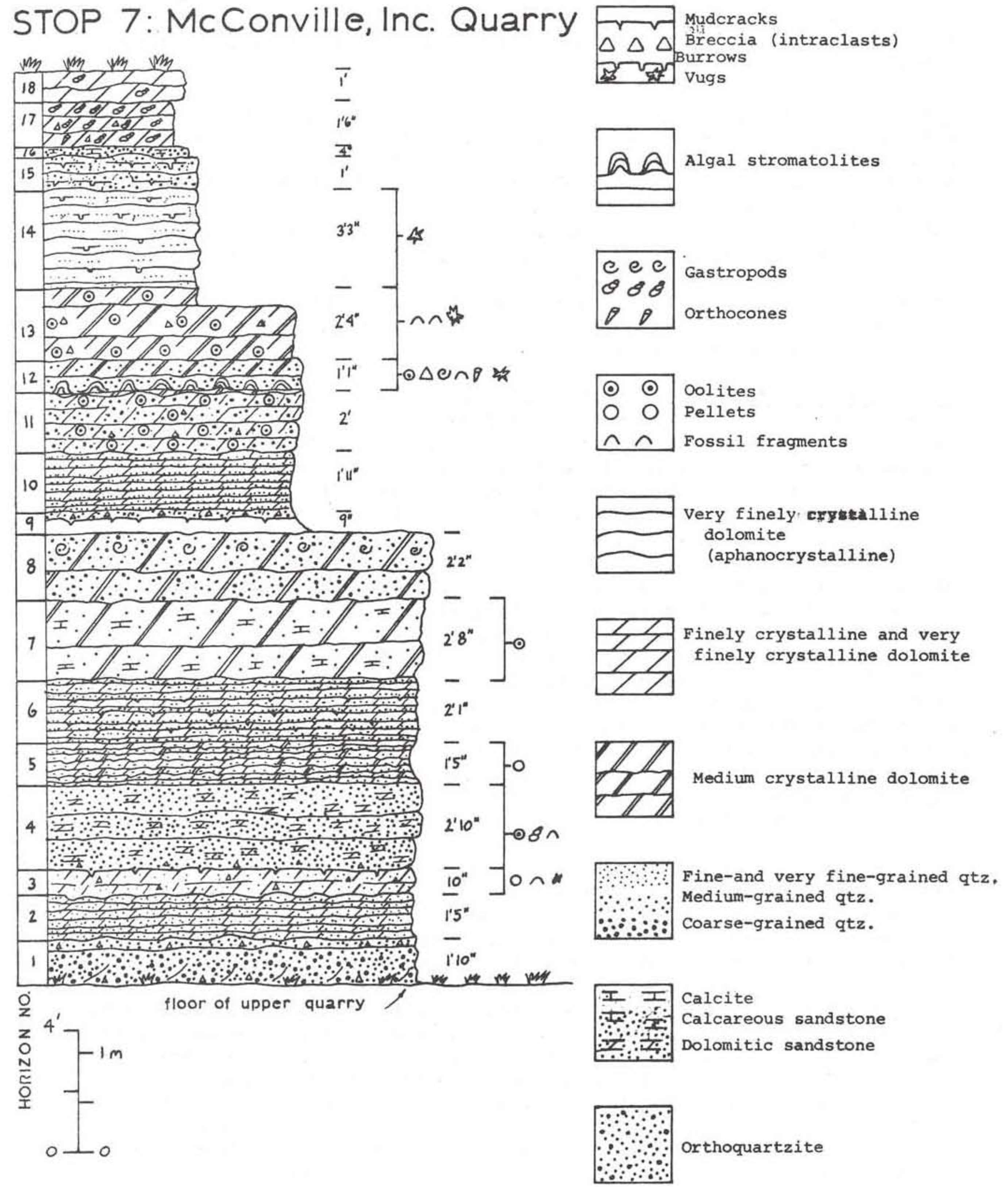
Interpretation

The combination of various features in the section suggests that the sediments accumulated in a protected (high intertidal) carbonate flat environment. Fluctuations in physical conditions are indicated by evidence of alternating flooding (influx of quartz sand, oolites, pellets, shell debris and lime mud) and subaerial exposure.

Laminated, mudcracked, carbonate muds- Thin bedded to laminated (ribbon-laminated), mudcracked, finely crystalline to aphanocrystalline carbonates characterize the tidal flat environment where lime muds are subjected to

FIGURE 12 Ogdensburg Dolomite

STOP 7: McConville, Inc. Quarry



subaerial exposure; the irregular and regularly laminated horizons (e.g. 7-2, 7-5, 7-6, Fig. 9, 7-10) are believed to indicate sediment trapping by algal mats. Flooding of the tidal flat during storms or extreme tides would tend to break up the limy crust and resediment the clasts, forming intraformational breccias (7-9, Fig. 10).

Fossils, oolites, pellets- The lenses of fossil debris, especially the small gastropods (7-8, 7-12, 7-13, 7-17, Fig. 15) and the oolites (7-11, 7-13) and pellets (7-3, 7-5) as well, represent material transported in from more seaward environments (low intertidal to subtidal) during times of flooding. A wind-blown origin of some of the quartz is indicated by frosted grains haphazardly distributed in some beds. The paucity of fossils believed to be indigenous to the deposits and the general lack of evidence of infaunal reworking also suggest the ecologically adverse conditions of the high intertidal environment (Walker and LaPorte, 1970); Horizons 7-3, and 7-5, however, show evidence of bioturbation and vertical burrows occur in Horizons, 7-14 and 7-15 (Fig. 14).

Algal stromatolites- Algal stromatolites are perhaps the least equivocal evidence of intertidal and supratidal environments although they have also been reported from recent subtidal environments (Gebelein, 1969). Studies of present day algal stromatolites indicate that most active mat growth and sediment binding requires subaerial exposure whereas prolonged wetting inhibits mat growth (Logan and others, 1964). Tidal and splash water accumulating in depressions on the mat surface leads to differentiation of the laminae into discrete domes and interareas. Linkage of the lamellae in the interareas between domes is further inhibited by scour-and-fill. Changes in stromatolite morphology with growth reflect minor fluctuations in the physical environment (Logan and others, 1964). For example, the change from initial space-linked hemispheroids (*Collenia* structure) to digitate vertically stacked hemispheroids (*Cryptozoon* structure) seen in Horizon 7-12 (Figs. 11, 13) indicate a change in environment from protected intertidal to a somewhat higher energy, more exposed intertidal environment. Larger, well differentiated, club-shaped, stacked hemispheroids (*Cryptozoon* structure) are known from other levels within the Ogdensburg Dolomite (Fig. 16) and in present day stromatolite environments these occur on exposed intertidal headlands (Logan and others, 1964, p. 80).

Stromatolite growth ceased at Horizon 7-12 when the laminae were flooded and blanketed with skeletal debris and other sediment carried in from offshore. The relatively fossiliferous levels in the upper part of Horizon 12 and Horizon 13 may indicate subtidal deposits, with Horizons 14 and 15 (Fig. 14) marking a withdrawal of the sea and the return of the intertidal conditions.

Early dolomitization- Penecontemporaneous or early diagenetic dolomitization of carbonate sediments is known to occur in tidal flat environments, particularly supratidal, in areas of high aridity (Illings and others, 1965; Shinn and others 1965). Magnesium-rich brines developing on or just beneath the surface in the supratidal and high intertidal environments percolate through and replace the original carbonate sediment. Dolomitization of the original sediment in the Ogdensburg Dolomite appears to have been complete; the minor amounts of calcite occurring at several levels is interpreted as late diagenetic void-fillings (7-17, Fig. 15). Early dolomitization in the Ogdensburg Dolomite

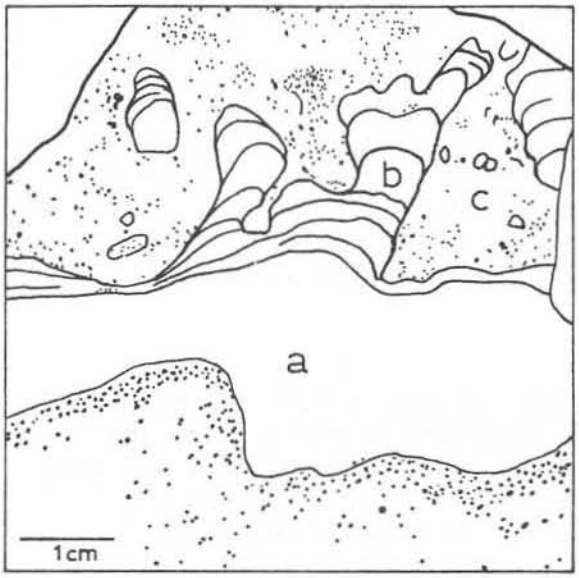


Fig. 13. Algal stromatolites in Ogdensburg Dolomite. Notation as in Fig. 11. STOP 7-12, McConville Inc. Quarry, Ogdensburg, N.Y.

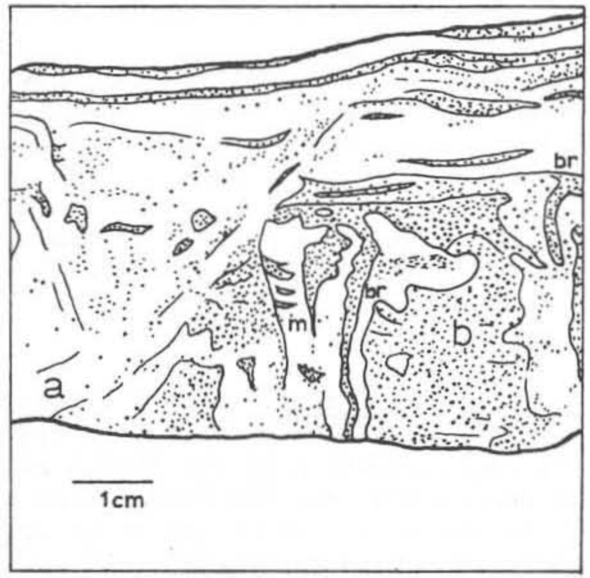


Fig. 14. Mudcracks(m), burrows(br), & slump bedding in Ogdensburg Dolomite. a) very finely crystalline (aphanocrystalline) dolomite b) dolomite as in (a) with coarse- and medium-grained quartz. STOP 7-15, McConville Inc. Quarry, Ogdensburg, N.Y.

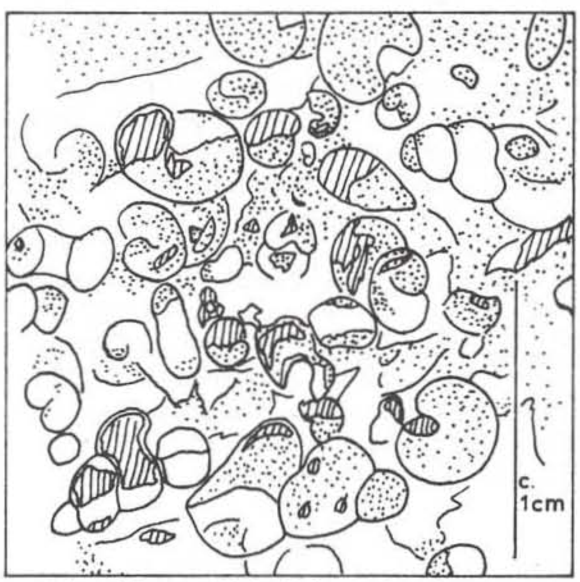


Fig. 15. Snail bed in Ogdensburg Dolomite. Stipple: medium crystalline dolomite, Blank: very finely and finely crystalline dolomite, Ruled: calcite. Clasts include gastropods (abundant), finely crystalline sandy dolomite, oolites and orthocones (rare). *Hormotoma* horizon (?) of Cushing 1916. STOP 7-17, McConville Inc. Quarry, Ogdensburg, N.Y.

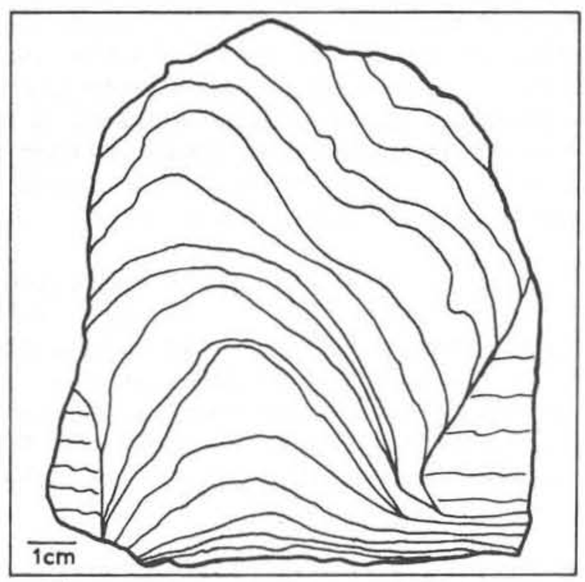


Fig. 16. Algal stromatolite in Ogdensburg Dolomite. Space-linked vertical stacked hemispheroid (*Cryptozoon* structure) with initial constant basal radius giving way to variable basal radius. A few feet above road level and in abandoned quarry on south side of N.Y. 37, west of Ogdensburg, about 0.5 mi. west of turnoff to downtown Ogdensburg.

7-3	0' 10"	Dark gray, irregularly bedded, mudcracked, finely crystalline, slightly calcareous, sandy dolomite with very fine- to fine-grained quartz. Dolomite matrix masks ghosts of fossil fragments, intraclasts of finely crystalline dolomite and pellets(?).
7-2	1' 5"	Dark brownish-gray to light gray, thin-bedded to ribbon-laminated, finely crystalline, sandy dolomite, alternating with very fine-grained, dolomitic sandstone.
7-1	1' 10"	White to light gray,coarse- to medium-grained, slightly calcareous, cross-laminated, orthoquartzite with dark gray clasts of sandy dolomite. Quartz grains well-rounded and spherical and cemented by silica overgrowths. This distinctive white band, which can be traced in all the quarry walls, may correspond to Bed 9 of Cushing's (1916, p. 45) section on the west side of Ogdensburg.
		Base of section.

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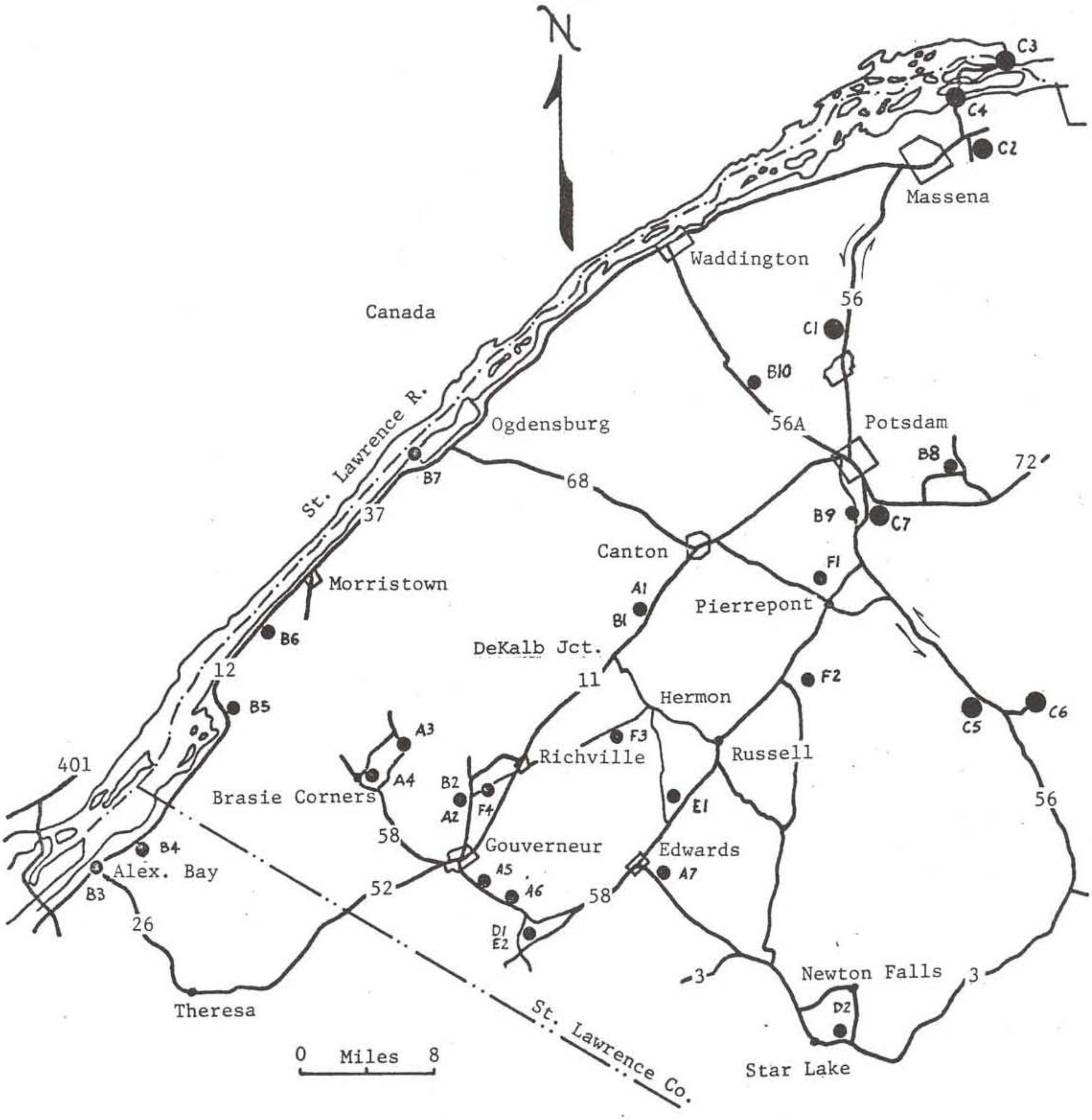

Figure 1. STOP MAP FOR TRIP C

Large dots indicate stops for this trip
and arrows show route.
Stops for other trips in guidebook
are indicated by smaller dots.