Middle Ordovician Section at Crown Point Peninsula

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Location

All the stops for this trip are within the Crown Point Reservation State Historic Site. From the west, take NY Route 22 north from Ticonderoga, continuing north through the Village of Crown Point. Turn east approximately five miles north of the Village of Crown Point, following signs to the 'Bridge to Vermont'. From the east, take VT Route 22A north from Fairhaven, or south from Burlington area, and follow signs to 'Bridge to New York'. Stop locations are keyed to the aerial photo. Stop 1 is in the ditch and wall of a small outpost fort (the Redoubt) on the east side of Route 8, immediately across the highway from the historic site entrance road. We will enter the historic site and park near the main entrance, then walk back to stop 1. No collecting is permitted in the historic area. Note that groups should register at the main gate upon entry to the site.

Chazy Group

The internal stratigraphy of the Chazy Group in the Lake Champlain Valley was defined by Oxley and Kay (1959). Welby (1962) provides a comprehesive synopsis of stratigraphic relationships between exposures in New York and Vermont. Hoffman (1963) presented a regional lithostratigraphic framework for the Montreal-Ottawa area. Fisher (1968) presents descriptions of Chazy Group strata in the northern Lake Champlain Valley. Biostratigraphic correlations of the Chazy Group have been attempted using brachiopods (Cooper, 1956), trilobites (Shaw 1968) and conodonts (Raring, 1973). Speyer and Selleck (1986) summarize major lithostratigraphic trends in the Chazy Group and the appropriateness of biostratigraphic correlation.

The Chazy Group is nearly 250 meters thick in the northern Champlain Valley (Oxley and Kay, 1959) but thins to the south (approximately 90 meters at Crown Point peninsula; less than 15 meters at Ticonderoga, absent at Whitehall). In the type area in the northern Champlain Valley, a three-part subidivision into Crown Point, Day Point and Valcour Formations is applied. The classic biostromes largely occur within the Day Point Formation. Significant biostromal buildups are absent in the southern exposures. In the vicinity of Crown Point, the entire Chazy Group is placed within the Crown Point Formation (Oxley and Kay, 1959), although there is considerable lithologic variation.

The Chazy Group marks the resumption of shallow marine sedimentation following partial emergence and subaerial erosion of the underlying Beekmantown Group during early Medial Ordovician time. In the southern Lake Champlain Valley, the basal Chazy units are clearly in unconformable contact with tilted, eroded upper Beekmantown Group strata. In the northern Champlain Valley, basal Chazy Group beds are in apparently conformable contact with the Providence Island Dolostone of the Beekmantown Group (Speyer , 1982).

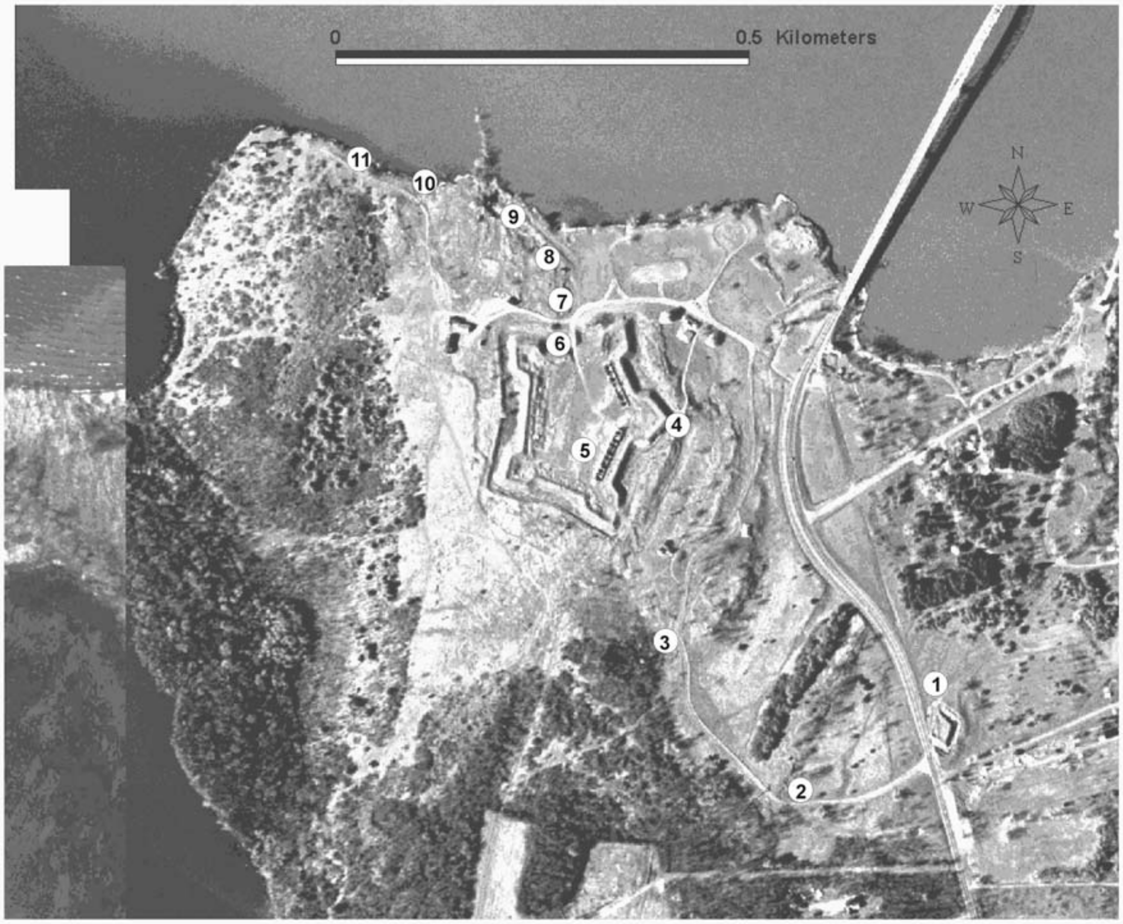

Figure 1 – Location map. See text for location descriptions

Rapid north-to-south thickness and facies changes, and variations in the nature of the basal contact suggest that the Chazy was deposited during or just after a period of block faulting which disrupted earlier Beekmantown and older rocks in some areas. The presence of coarse, angular quartz and feldspar grains within the Chazy Group suggests that Proterozoic basement may have been exposed close to the areas of Chazy deposition (Selleck, et al, 1985). In the Ottawa area, basal Chazy consists of coarse sandstones and pebble conglomerates of braided stream origin, indicating uplifted source terrains in that area (Hoffman, 1963).

The Chazy Group contact with the overlying Black River Group is abrupt, but evidence for significant erosion is generally absent. At Chazy, New York, the contact is apparently confomable (Fisher, 1968; Raring, 1973). The contact is well-exposed on the Crown Point Peninsula and is marked by a coarse quartz sandstone with scattered large, angular feldspar grains.

The Chazy Group at Crown Point consists largely of fossiliferous bioclastic wackestones, packstones and grainstones, with varying degrees of post-depositional dolomitization.   Shaley, nodular limestones are present in the sequence, but are rarely exposed at the surface. Environments of deposition varied from subtidal, storm-dominated shelf settings to inshore sand shoals and lower tidal flats. Muddy peritidal facies are generally absent, but intervals of penecontemporaneous cementation and karstic erosion may mark intervals of subaerial exposure (Selleck, 1983).

Cements within the Chazy Group at Crown Point typically consist of an early equant to prismatic lo-Mg calcite followed by later coarse calcite spar. Dissolution and chert replacement of aragonitic bioclasts is common. Dolomitization of Crown Point carbonates is widespread, and is highly selective in some facies. Variations in primary mineralogy (lo-Mg calcite vs. aragonite) appear to have controlled the dolomitization of some bioclastic materials; grain size, sorting, porosity, intensity of burrowing and distribution of early cements (and thus permeability of materials during burial diagenesis) seem to best explain the highly variable patterns of dolomitization (Selleck, 1988).

Stop 1- Redoubt

Approximately 6 m of variously burrowed, slightly dolomitic, thin to medium bedded bioclastic packstone and grainstone is exposed in this section. Some beds are relatively well-sorted grainstones with sharp bases and are interpreted as storm deposits. Note the large intraclasts in the base of one unit in the low ledge at the southeast corner of the ditch. These indicate rip-up of cemented grainstone, apparently by a storm. Abundant "*Girvanella*" algal oncolites are present in beds approximately three meters from the base of the section. Rounded, dark calcite grains (abraded gastropod fragments?) form the cores of the oncolites, and are scattered in other beds. Fossils are relatively abundant, and are best seen on slighly weathered bedding surfaces. Trilobite fragments, brachipods, bryozoans, pelmatozoan plates, nautiloids and large *Maclurites magnus* are present. Dolomite occurs in shaley weathering laminae and in burrow fills.

The relatively high faunal diversity, general bioturbation, and storm-related sedimentation point to a ‘low energy’, shallow subtidal environment at depths slightly below normal wave base. The abundant algal oncolites and discrete calcarous algal fossils (e.g. *Hedstromia*) suggest depths well within the photic zone. A possible modern analogue is found in the mixed mud and sand shelf to the west of the emergent tidal flats of Andros Island, Bahamas, as described by Bathurst (1971) and Purdy (1963).

The wavy, irregular dolomite laminae result from dolomitization of lime mud, followed by compaction and pressure solution of calcite that produced irregular, clay- and dolomite-rich stylocumulate seams. Preferential dolomitization of burrows is due to contrasts in permeability of burrow-fill versus burrow-matrix sediment. The burrow-fill material retained permeability longer during diagenesis and allowed more pervasive dolomitization. In similar facies exposed on Bullwagga Bay (west shore of peninsula), nodular limestone with shaley dolostone seams and stringers are present (Fig. 2). The limestone nodules appear to have been cemented prior to significant burial compaction, whereas the shaley dolostone material was compacted around the cemented limestone. The early-cemented limestones were resistant to dolomitization. This sort of fabric selective dolomitization is common in the Chazy and Black River Groups throughout the Champlain Valley. Can you find other evidence of early cementation in this outcrop. Are there hardgrounds?

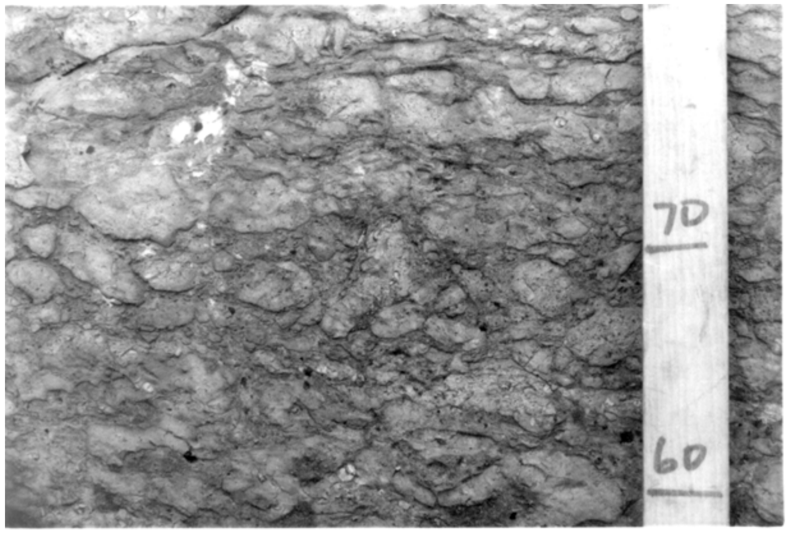

Figure 2: Nodular limestone in shaley dolostone matrix. Note apparent truncation of some nodules by stylolites. Dark fragments are *Maclurites* bioclasts. This fabric suggests early cementation of portions of the sediment by calcite, followed by burial, compaction and dolomitization. The disrupted appearance may be due to burrowing and rotation of cemented nodules, plus later soft-sediment deformation of the cemented nodules while the matrix was still uncemented. Scale is centimeters.

Stop 2 – Ridge outcrop extending NE from near entrance Gate

Cross-stratified coarse bioclastic grainstones are well-exposed near the main gate along the entrance road and adjacent ridge. Nearly three meters of section form a prominent belt parallel to strike extending from the entrance road to the main highway. Foreset cross-strata show bipolar dip directions. Angular quartz and feldspar grains are concentrated in some laminae. The carbonate particles are dominately sub-rounded, abraded pelmatozoan plates with gastropod and brachiopod fragments. Large *Maclurites* fragments and grainstone intraclasts are present on the upper bedding surfaces of the ledges northeast east of the entrance road.

We envision the environment of deposition of this facies as a shallow subtidal wave and current reworked sand shoal. Active transport of abraded grains may have been accomplished by tidal currents (as suggested by bipolar cross-strata), or by storm-generated currents that produced complex, anastomosing patterns of cross-strata and intervening reactivation surfaces. The lack of burrowsing and well-preserved whole-shell body fossils may be due to the inhospitable shifting sand substrate. This environment likely resembled the unstable sand shoal environment of the Bahamas Platform (Bathurst, 1971; Ball, 1967). The scale and style of cross-stratification here are similar to that predicted by Ball (1967) from study of the bedfroms present on Bahamian Platform sand bodies. Similar Chazy Group facies in the northern Lake Champlain Valley are oolitic (oxley and Kay, 1959).

Note that these grainstones are essentially undolomitized. Does this indicate early cementation or diagenetic stabilization prior to deeper burial?

Stop 3 - Low ledges adjacent to entrance road (Picnic Pavilion Ridge) approximately 50 meters north of Stop 2.

Brown-weathering, slightly shaley dolostone exposed here contains lenses and stringers of fossiliferous lime packstone and wackestone. As at Stop 1, trilobites, small brachiopods and *Maclurites* are common. The environment of deposition is assumed to be subtidal shelf, with less storm activity than at Stop 1.

Note that some of the fossils are almost entirely encased in dolomite, which is assumed to be of replacement origin here. Why are some of the fossils so well-preserved, and not dolomitized?

Stop 4 - SE moat of Fort Crown Point:

Approximately 3 meters of thickly laminated limestone and dolostone are exposed in the southeast 'moat' of the British Fort. The dominant facies here is alternating 0.5-2.0 cm thick laminae of limestone and dolostone – commonly termed 'ribbon rock'. The limestone ribbons are very fine peloid grainstones or 'calcisiltites' and appear blue-grey on slightly weathered surfaces, and are indentations on more deeply weathered surfaces. The dolostone ribbons weather tan-brown, and consist of an interlocking mosaic of 20-300 micron dolomite crystals of replacement origin. Quartz silt grains are present in the dolostone ribbons, versus medium to fine quartz sand in the limestone, suggesting that the limestone ribbons were slightly coarser than the dolostone when originally deposited.

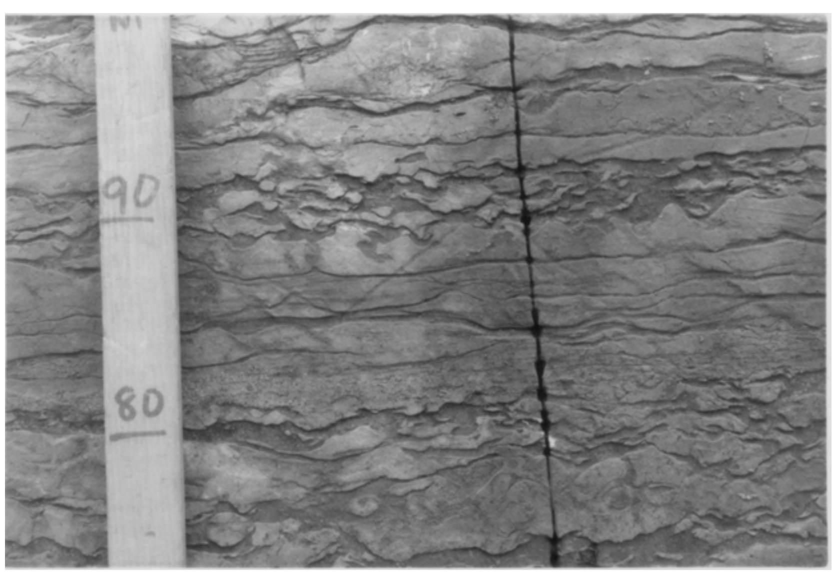

Figure 3: (previous page) Typical ribbon rock facies with limestone (calcite) layers more resistant and dolomite layers weathering in. This surface is exposed to wind abrasion, and the granular. sugary-textured dolomite is less resistant than the well-cemented limestone. Note the scalloped surface of some limestone layers, perhaps due to burrowing or corrosion of cemented layers. Irregular wisps and knots of limestone in dolostone matrix are probably due to deformation of cemented limestone within soft matrix material that is now dolomitized. Scale in centimeters.

An erosional surface with 10-20 cm relief is exposed near the base of the south wall. Similar erosional surfaces occur within this facies in other exposures, and appear to represent micro-karstic solution surfaces on a tidal rock platform that developed during subaerial exposure of cemented limestone (Fig. 5). Typically, the rock below the surface is mostly calcite limestone, suggesting that cementation and diagenetic stabilization of the limestone occurred prior to development of the erosional surfaces. Overlying rock contains more dolomite. *Maclurites* shell hash can be found in pockets on the erosional surface, suggesting wave transport of shells onto the rocky platform of the erosional surface. Dolomitized burrows cut across the limestone ribbons in some parts of the outcrop, and trough cross-strata that appear to fill low scours are also visible.

Figure 4: Burrowed ribbon rock on weathered surface shows preferential dolomitzation of burrow-fill material and section through *Maclurites*. On this surface, dolomitized material weathers out in relief because dolomite is more resistant to chemical dissolution.

On the less weathered prominence on the SE corner of the moat, shallow scours containing brachiopods and gastropod debris are seen. Intraclasts or pseudoclasts of limestone in dolostone are also present. Some 'clasts' appear to be cored by dolomitized burrows.

We interpret this sequence as a tidal flat to shallow subtidal facies. The alternating limestone/dolostone ‘ribbon rock’ may represent rhythms of slightly coarser (limestone) and slightly finer (dolostone) sediment deposited on the lower reaches of a tidal flat, similar to the bedding described by Reineck and Singh (1980) from the mud/sand tidal flats of the North Sea. These coarse-fine alternations might also reflect storm-related, ebb-surge deposition. Early cementation of the slightly coarser limestone ribbons made this lithology less susceptible to later dolomitization, which affected the finer, muddy ribbons that are now dolostone. Variations in intensity of burrowing reflect subtle differences in duration of subaerial exposures of the flat and/or extent of reworking by tidal currents. Limited *in situ* faunal diversity is expected in a stressed tidal flat setting. The absence of mudcracks and evaporite minerals may indicate that only the lower portion of a humid climate tidal flat system is preserved here.

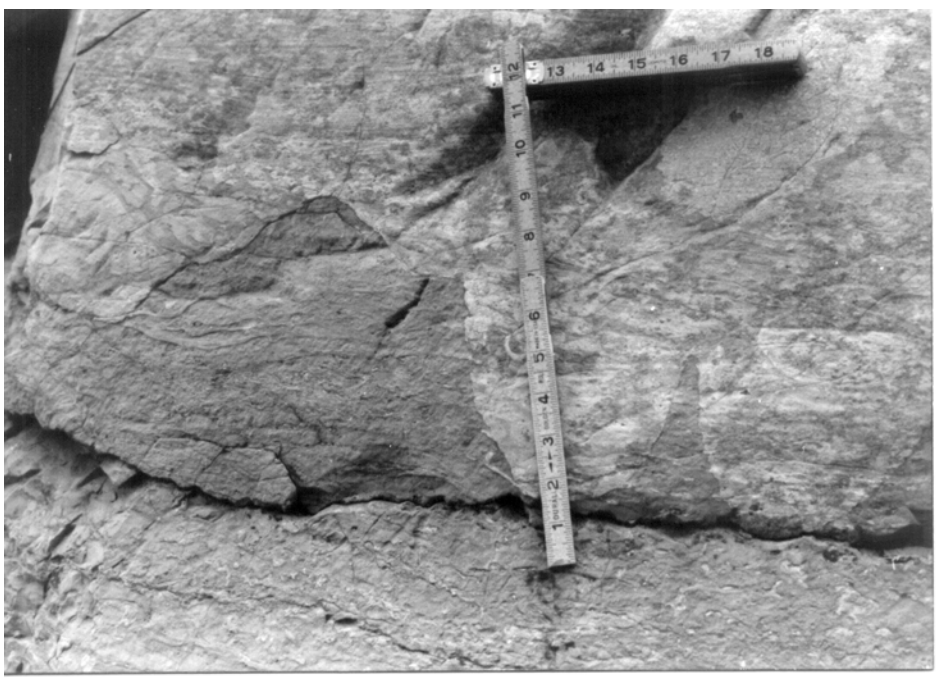

Figure 5: Limestone (dark) forming sharp, scalloped erosional surface beneath dolostone above. The limestone was cemented prior to deposition of overlying sediment. Later dolomitization altered only burrow-fill material in dark limestone, whereas sediment above was throughly dolomitized. Scale in inches.

Stop 5 - Parade Grounds near Barracks:

As we enter the parade ground from the southwest corner of the moat, note the array of carbonate rocks used in construction of the barracks. Chazy, Black River, and rare Trenton lithologies can be identified. Restoration of the barracks began in 1916. More recently, starting in 1976, the New York State Division for Historic Preservation undertook protection and stabilization of the ruins.

The low rock pavement just north of the barracks is within the upper part of the 'ribbon rock' unit seen at stop 4. Immediately up-section, cross-stratified grainstone beds are visible. Coarse quartz and feldspar sand is easily seen on weathered surfaces. Trough cross-strata and 'herringbone' co-sets of planar-tabular cross-strata are visible on the low vertical faces. Large, angular clasts of slightly dolomitic grainstone and *Maclurites* are present on bedding surfaces. We interpret this facies as a current-dominated sand shoal environment similar to that seen at stop 2.

Note the polygonal pattern on some outcrop surfaces. Are these mudcracks?

Black River Group

The Black River Group in the Champlain Valley is a relatively thin unit (85-90 feet thick) consisting of massively-bedded wackestones to packstones representing deposition in lagoonal to shallow subtidal environments. The gradual deepening characterizing this unit and continuing into the Trenton Group and overlying shales is interpreted to represent foreland basin subsidence during the Taconic Orogeny. This gradual deepening was punctuated by both shallowing and deepening events on macroscopic (meters) as well as microscopic (cm) scales, the latter visible only in thin section. The Black River Group is so lithologically variable in New York/Ontario/Vermont that stratigraphic names have proliferated, however the Pamelia, Lowville (House Creek and Sawyer Bay Members) and Chaumont Formations can be recognized in the Champlain Valley. Bechtel (1993) summarizes the evolution of nomenclature applied to this unit.

Stop 6 - West parade grounds

Bechtel and Mehrtens (1993) suggested that the sandstone unit in the westernmost parade ground is the basal sandstone of the Black River Group, an interpretation which differs from that of Speyer and Selleck (1988) who suggested that this unit was part of the underlying Chazy Group. In thin section this sandstone is a quartz arenite in composition, very poorly sorted, containing fewer lithic fragments and phosphatic fragments than Chazy sandstones. Visible at the very easternmost portion of this ridge an overlying buff-colored dolomite bed containing pockets of quartz sand (burrow infills?) is exposed. The sandstone and dolomite lithologies are very similar to those described by Walker (1972) for the

Pamelia Formation at the type locality in New York. Alternatively, placement of the sandstone within the Chazy Group is consistent with the common presence of coarse quartz and feldspar sand within the Chazy here, whereas siliciclastic material in the Black River Group at Crown Point is mainly fine silt and clay. Whatever the stratigraphic placement of this unit, it marks an interval when sands were transported from a nearby (Adirondack?) source area. This period of subaerial exposure of the shelf was followed by marine reworking of the sand, and deposition of the muddy carbonates of the basal Black River Group.

Stop 7 - Northeastern moat

There is approximately 4 feet of covered interval between the parade grounds and moat exposures. The wall of the northeasternmost moat exposes several feet of the lower Black River Group (Lowville Formation, House Creek Member). At the base of this exposure a series of stylolitized gastropod-bearing (*Liospira*) wackestone beds are overlain by thick beds of Phytopsis-burrowed aphanitic mudstones. This sequence can be interpreted as an example of a "classic" shallowing-up cycle consisting of subtidal to peritidal lagoonal muds. Examine the sharp contact of the aphanitic mudstone with the overlying wackestones, a contact which in thin section appears to be a firmground (Bechtel, 1993).

Examination of *Phytopsis* burrows in thin section (Fig. 6) reveals that many are filled with graded (fining-up) geopedal silt, evidence of cementation in the meteroic vadose zone as shown below.

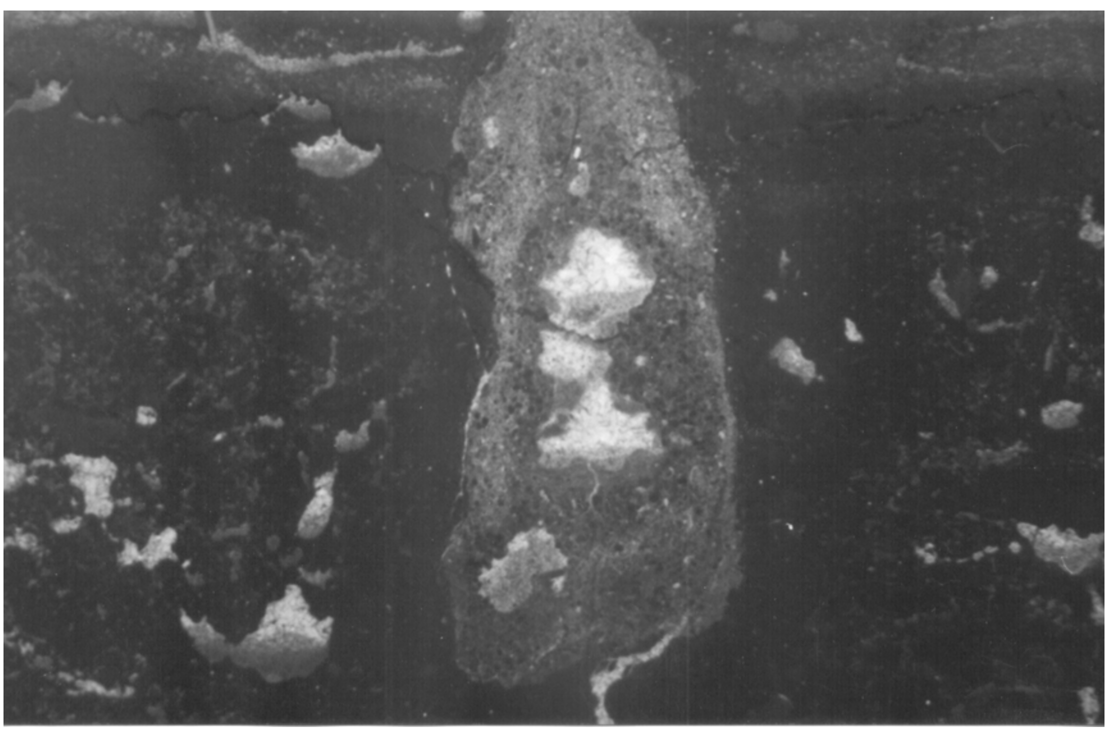

Figure 6

At other localities in the Champlain Valley, several of these cycles comprise the base of the Black River. Of the three motifs of repetitious bedding in the Black River Group, these cycles occur at the largest, macroscopic scale and are interpreted to represent 4th order (10,000 to 100,000 years) or smaller cycles.

Continuing upsection, several thick packstone beds are exposed. More detailed examination of these beds reveals that they consist of alternating one to three inch thick intraclast and oncolite-rich packstone horizons interpreted as tempestites, interbedded with fossiliferous wackestone/packstone horizons. The tempestites, or storm-generated deposits, consist of graded and crudely imbricated intraclasts and skeletal fragments. Note the nature of the upper and lower contacts of these horizons. Horizons of tempestite beds within in situ fossiliferous muds is a second motif which occurs throughout much of the Black River Group.

It is instructive to spend several moments sketching the basal six feet of the moat exposure. Your sketch could illustrate the basal SUC's as well as the upper and lower contacts and internal fabric of the tempestite-rich beds.

SKETCH HERE

The uppermost third of the outcrop appears to be a massive bed of limestone, however closer examination also reveals small scale "cycles" of alternating wackestone/packstone and grainstone, the third motif of bedding in the Black River. These are characterized by a base of thinly laminated or cross laminated grainstone horizons 1 to 2 inches thick, overlain by fossiliferous wackestones and packstones. In thin section the bases of the grainstones can be identified as firmgrounds, recognizable by the truncations of allochems and cements in the underlying mud.

Figure 7 illustrates the nature of the contact between a peloid-rich grainstone of the base of a cycle and the top of the underlying packstone. The scalloped surface and truncated grains and allochems are characteristic of these contacts.

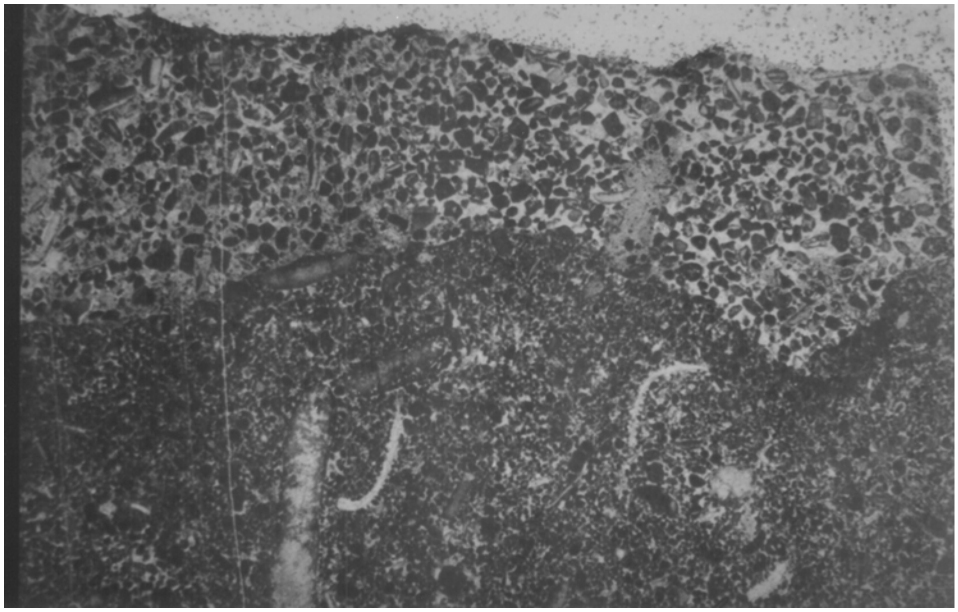

Figure 7

The very top of this exposure (best seen at the next outcrop) exhibits a burrow mottled fabric with selected dolomitization of many burrows. *Tetradium* occurs in life position in these horizons.

Stop 8 - East-west ridge

A black chert layer near the top of Stop 7 provides the correlation to Stop 8, the outcrop across the service road.

The limestone beds on this ridge commonly consist of alternating wackestone/packstone and planar to cross laminated grainstone beds as seen at Stop 7, however bedding plane exposures permit identification of many fossils in these, the most faunally diverse beds in the Black River. Specimens of gastropods (L*iospira, Lophospira, Hormotoma*), *Lambeophyllum, Tetradium,* stromatoporoids, the bivalve *Cyrtodonta*, *Strophomena* sp. and cephalopods are recognizable. This ridge is most notable for its bedding plane exposures of *Tetradium* and *Lambeophyllum* and is interpreted as recording a wave baffle margin lithofacies described by Walker (1972) at the type section.

A sketch of the third type of cycle, laminated grainstone overlain by bioturbated wackestone, with special attention paid to the nature of the contacts between cycles, would be appropriate. These sequences are interpreted to represent smaller scale 4th order 'micro-cycles' that could be the result of facies mosaicing and/or small scale base level changes.

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There are at least two distinct types of chert occurences in the Black River. One appears to be fabric selective: infilling horizontal burrows, for example (many other burrows are dolomitized). The other chert occurrence is less frequent and consists of broad, bedding parallel sheets. The uppermost chert horizon on this ridge, traceable down to the shoreline, is of this latter variety. Clearly, there was a significant source of silica available for chert formation, perhaps a combination of silica derived from sponges (*Tetradium*?) and bentonite alteration (the Ordovician sequence in the Champlain Valley is notorious for the paucity of bentonites compared to equivalent strata in central New York and Quebec). In thin section the chert cross cuts all previous cements, including late fracture-filling calcite, and is therefore the youngest, latest example of diagenesis in these rocks.

Stop 9 - Quarry

Be extremely careful around the quarry - the thick algal scum in the quarry water obscures where the grass begins and the quarry wall drops off.

The older, weathered south walls of the quarry show, by color differentiation, two cycles. Closer examination of the more accessible north wall reveals more occurences of the third motif of Black River bedding: 8 to 10 inch thick beds of planar laminated skeletal and peloidal hash overlain by burrowed wackestones overlain by an intraclast-rich horizon. Interbedded with these cycles are also tempestite couplets of mudstone/wackestone and fossil hash layers in which brachiopod-rich layers are abundant (look for 'nested' pockets of shells).

Sketch the interbedding of the two cycles below:

Before leaving the quarry area, note the numerous quarried blocks stacked between the quarry and the shoreline. See if you can recognize cycles, and from these, topping directions.

Stop 10 - Shoreline

Uppermost horizons in the quarry can be traced down to the shoreline to the north where the Black River section continues (Chaumont Formation of the Black River Group) with small covered intervals up to the Trenton Group limestones. Shoreline bedding planes exhibit horizontal burrows of *Chondrites*, opercula of *Maclurites*, and polished surfaces also reveal large intraclasts, in other words the same internal stratigraphy that could be viewed in cross section on the quarry walls.

Cement Stratigraphy of the Black River Group

There are multiple types of cements present within the Black River limestones which record a complex diagenetic history. The general cement stratigraphy pattern records early nonluminescent cement associated with precipitation in oxidizing waters of the shallow meteoric phreatic zone. With increasing reducing conditions, bright and dull luminescent cements represent precipitation in shallow burial conditions. Ferroan calcite with dull to nonluminescence represents precipitation in a late burial situation from high temperature burial fluids. Early marine Black River Group micritic cement is ferroan and very dull luminescence representing deposition in a reducing, lagoonal environment. Subsequent cementation took place in the shallow meteoric phreatic zone, with nonluminescent cements with bright rims representing oxidizing conditions becoming slightly more reducing with burial. These observations are consistent with those of Mussman, et al. (1988) who interpreted such patterns to be related to a cratonward-dipping meteoric water lens beneath tidal flats. Tectonic uplift would lead to stagnation of the aquifer and increasingly reducing conditions. Within this general pattern, however, there are many variations in the Black River limestones which record frequent base level changes associated with sea level fluctuations and block fault movements in the Taconic foreland basin. These base level changes have produced numerous firmgrounds (at all Black River localities) as well as beachrock (at Arnold Bay) and paleo-karst (at Arnold Bay, Chippen Point and Sawyer Bay localities) horizons.

Fractures are common throughout the Black River and their cements record evolving burial conditions. Figures 8 and 9 illustrate some of the observed patterns. In the first thin section two cement events are visible in the fracture. The first consists of nonferroan scalenohedral crystals extending outward from the fracture wall. These are interpreted to have been precipitated in the meteoric phreatic zone. The later large ferroan equant blocky crystals in the center of the fracture represent a late burial cement precipitated under reducing conditions.

Figure 8 (field of view 1.8cm)

In Figure 9, taken under cathodoluminescence, the zoning of rhombohedral crystals infilling a fracture can be seen. The very symmetrical zoned patterns starts (from the interior outward) with a nonluminescent nonferroan core, a dull rim, a bright orange rim, another dull rim, to another bright rim and fading to nonluminescent outer rims. The nonferroan to ferroan zonation is indicative of increasing reducing conditions during cementation. The cement stratigraphy of the fractures indicates that their formation occured throughout the diagenetic history of the Black River, from early syndepositional events associated with karst and beachrock formation, through to deep burial.

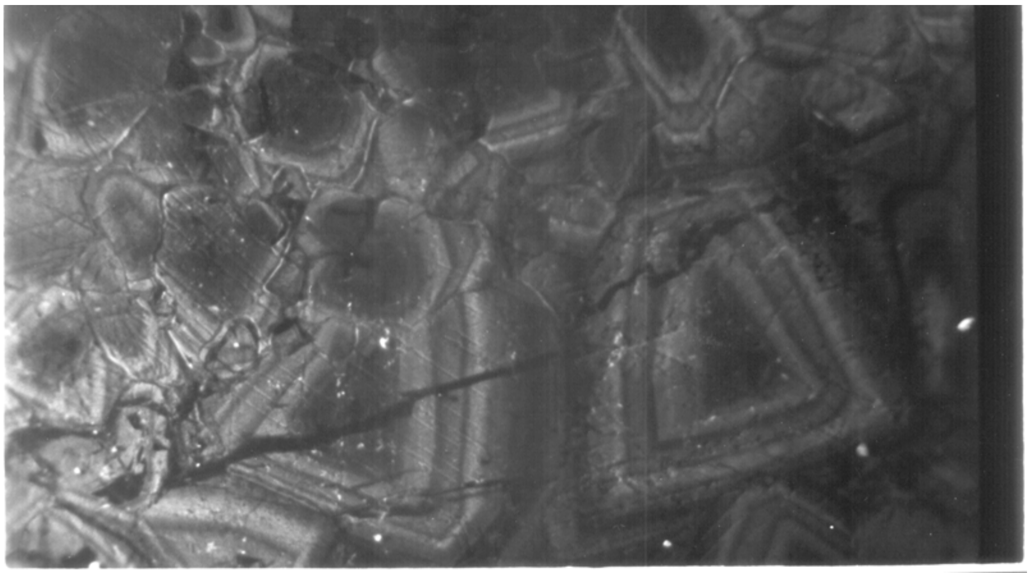

Figure 9 - (field of view 0.5 mm)

Trenton Group

The contact between the Trenton and Black River Groups is covered at most localities in the Champlain Valley, probably because the thinner-bedded and finer-grained Trenton is easily weathered. At Arnold Bay, to the northeast of Crown Point, the contact is exposed and is interpreted to be a disconformity. The dark gray colored, massive homogenous beds of the Black River are in sharp contact with the rubbly, laterally discontinuous beds of the Trenton. Here at Crown Point the Trenton is thinner than elsewhere in the Valley (28 feet), which MacLean (1987) suggested might reflect deposition on a down thrown block in the Taconic foreland basin. MacLean measured 50 feet of Glens Falls in the section at Button Bay (a few miles to the north of Crown Point) which, because it includes both the upper and lower contacts with the Black River Group and Cumberland Head Formation, respectively, represents the only complete exposure of this unit in the Champlain Valley. Bechtel (1993) summarized the variable nature of the Black River/Trenton contact around the Champlain Valley, New York and Ontario and noted that the regional variation seen would be expected in a foreland basin actively undergoing syndepositional block faulting

Stop 11 - Shoreline of eastern Bulwaga Bay

Continuing up the shoreline from the uppermost outcrops of Black River a thin covered interval (4’) occurs before the basal beds of the Glens Falls Formation. The Glens Falls is characterized by thin, nodular to wavy bedded wackestones, mudstones and rare grainstones, a very different type of bedding style and faunal assemblage from the underlying Black River. Bedding planes along the shoreline contain mostly *Chondrites* and *Helmenthopsis* burrows, however as one moves up section recognizable pieces of *Cryptolithus*, *Isotelus*, orthid brachiopods, *Stictopora*, and *Prasopora simulatrix* can be found, the latter is important because it permits the correlation of the lower Glens Falls here in the Champlain Valley to the lower Denley Limestone at the Trenton type section in central New York.

MacLean (1987) interpreted the lithofacies of the basal Glens Falls to represent sedimentation in a shallow subtidal environment periodically influenced by storm activity. In thin section the nodular and wavy bedded wackestones appear thoroughly bioturbated, a process which would influence and inhance subsequent differential compaction. Grainstone beds exhibit more planar bases with basal skeletal fragment lags or finely crushed debris of brachiopod, trilobite and crinoidal material capped by mud (see Fig. 10). MacLean interpreted these as tempestite deposits.

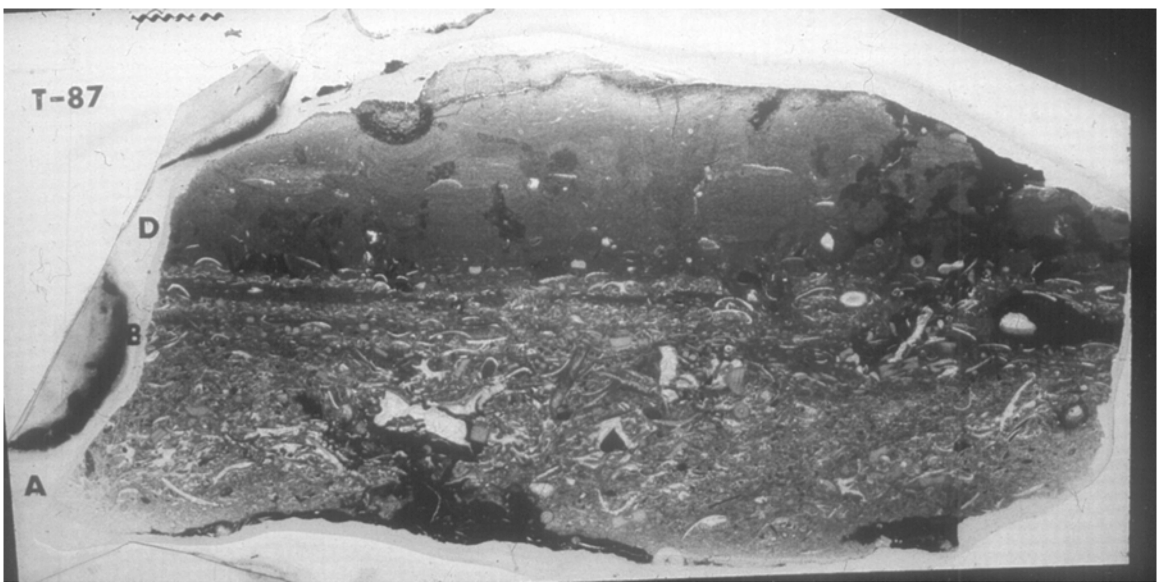

Figure 10

Based on lithologies, fossil assemblages and sedimentary structures, or the lack thereof, the Glens Falls Formation is interpreted to represent sedimentation in a deeper water, subtidal setting relative to the Black River deposits. For those familiar with lower Trenton localities in central New York the paucity of fossiliferous bedding planes here at Crown Point is noteworthy. The overall fine grain size and ichnofauna suggest that bathymetry increased significantly and rapidly from the Black River into the Glens Falls, a transition which might reflect not only rising sea level but base level changes as well. The sedimentologic and faunal transitions from the Glens Falls to the overlying Cumberland Head Argillite and Stony Point Shale are much more gradational that that of the Black River/Glens Falls contact.

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