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DEPOSITIONAL ENVIRONMENTS AND REVISED STRATIGRAPHY ALONG THE BLACK RIVER-TRENTON BOUNDARY IN NEW YORK AND ONTARIO

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ABSTRACT. The Black River Group in New York State and Ontario is redefined to include the 3 m thick Selby Limestone, previously considered to be the lowermost formation of the Trenton Group. Lithic, floral, and faunal data indicate that the Selby Limestone is part of the same submergence that resulted in the deposition of the Black River Group. The Selby represents a quiet, shallow subtidal environment that was slightly deeper than the subjacent Watertown Limestone. An emergence occurred following the deposition of the Selby. In central New York a disconformity marks this event. Northwestward the time span represented by the disconformity narrows, being at most a diastem at Lowville, N.Y., and represented only by a shallowing of the sea in central Ontario. Following this emergence, the lowermost three formations of the revised Trenton Group, the Napanee, Kings Falls, and Sugar River limestones, were deposited in another submergence

The reassignment of the Selby Limestone to the Black River Group requires a redefinition of the Chaumontian and Rocklandian stages. The revised Chaumontian includes, at its top, the *Doleroides ottawanus* Assemblage Zone, previously assigned to the early Rocklandian. Thus, the Watertown and Selby limestones were deposited during the Chaumontian. The Rocklandian Stage is restricted to include only the *Triplesia cuspidata* Assemblage Zone. In northwestern New York, macrofossil and microfossil (conodonts) correlations indicate that the Napanee and lower Kings Falls limestones were deposited during the Rocklandian.

INTRODUCTION

More controversy exists regarding the establishment, division, and correlation of the Ordovician standard section than for any other Paleozoic System in North America (Twenhofel and others, 1954; Cooper, 1956; Kay, 1960, 1962, 1968b, 1969; Sweet and Bergstrom, 1971). This is especially true for the Medial Ordovician standard (Fisher, 1962). The Black River Group and Trenton Group in New York State and correlative formations in Ontario comprise part of the standard reference section for the Ordovician of North America (figs. 1 and 2). Although the stratigraphy of these rocks has been studied for more than 150 yrs, there is still disagreement over the temporal significance, correlation, and nomenclature of the upper Black River and lower Trenton limestones of New York and Ontario (Sinclair, 1954; Winder, 1960; Fisher, 1962, 1976; Barnes, 1967, 1968; Kay, 1968a,b, 1969; Walker, 1973). In this paper some of the stratigraphic problems of the upper Black River and lower Trenton groups are resolved by evaluating the depositional environments and lithologies of these limestones. The area studied follows the Medial Ordovician outcrop belt from Canajoharie, N.Y., northwestward 300 km to southeastern Ontario and includes exposures in central Ontario and the Ottawa Valley (fig. 1).

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STRATIGRAPHIC PROBLEMS

Introduction.—Kay (1968b, 1969) has argued that the Black River and Trenton formations are both lithic and time-stratigraphic units. Wilson (1946) believed that the upper Black River and Trenton subdivisions were originally biostratigraphic units and considered them as zones of faunal associations with the "Black River-Trenton" as a time term. Although the "lithic units" of the Black River and Trenton groups are distinct lithologically in part of their outcrop area, facies changes do

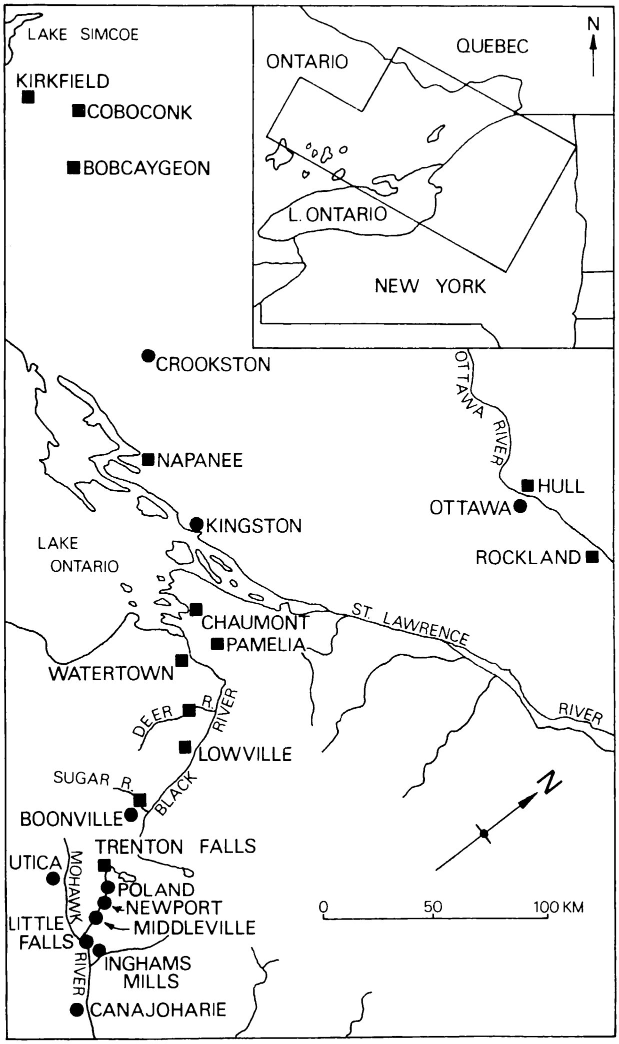

Fig. 1. Index map of study area. Square symbol refers to the general location of type sections of Black River and lower Trenton subdivisions. The correlation chart in figure 2 roughly follows a line from Canajoharie, N.Y. to Napanee, Ontario.

occur, and fossils have been used as a basis of recognition (Kay, 1937). Thus, early workers used the same term to designate both lithic and time-stratigraphic units, relying on context to differentiate their usage. Considerable misunderstanding has been caused by this mixed usage of rock, time-rock, and even biostratigraphic units, all of which have been called formations (Fisher, 1962). Such "formations" formed the subdivisions of part of the North American Medial Ordovician standard relative time-scale. Kay's stages were based on the temporal extension of "formations" from their type areas by use of fossils (Kay, 1968b). Furthermore, the type sections of these groups, formations, and stages are geographically widely scattered (fig. 1) (Kay, 1937, 1943, 1968b; Fisher, 1962), and the Black River-Trenton boundary is not often exposed in the type area of northwestern New York, making correlations even more difficult.

Black River Group.—The Black River Group (fig. 2) is composed of three formations defined from localities in northwestern New York: Pamelia Formation (Cushing and others, 1910), Lowville Limestone (Clarke and Schuchert, 1899), and the Watertown Limestone (Kay, 1968b). The "Chaumont" (Kay, 1929) of northwestern New York has often been used for the Watertown Limestone, but some workers use it as the stage "Chaumontian" (Kay, 1968b; Liberty, 1969).

Walker (1973) and Barnes (1967) have reviewed three current hypotheses of Black River stratigraphy. The argument revolves around whether the formations are time-stratigraphic or facies of one another. As Walker (1973) has pointed out, the various viewpoints have been made from different spatial orientations: one follows the trend of the outcrop belt whereas the others show hypothetical onshore-offshore relationships. However, when the paleogeography is considered, all the hypotheses may be regarded as correct. That is, the outcrop belt in the Black River Valley more or less parallels the ancient strandline, and it is reasonable that the contacts of the formations are more or less time lines. Furthermore, by following Walther's Rule, all the facies exhibited by the Black River Group should be laterally equivalent in a direction perpendicular to the paleoshoreline. Unfortunately, the outcrop belt geometry precludes showing this relationship. Walker (1973) has also shown stratigraphic evidence, a metabentonite, that confirms the near synchroneity of the formational contacts in part of northwestern New York.

Cushing and others (1910) included the "Lowville", with the cherty "Leray" limestone member at its top, in the Black River Group and renamed the upper, non-cherty formation the Watertown Limestone (fig. 3). Kay (1929, p. 664) defined the "Chaumont formation", which included the Leray, Glenburnie, and Watertown members (fig. 3), as a time-rock and a rock term with its type area in northwestern New York. He intended it to include ". . . beds younger than the Lowville and older than the Rockland . . ." Kay (1968a,b) later used the term Watertown Limestone for the combined upper Black River cherty and non-cherty "Leray-Watertown" lithology characteristic of the type area in northwestern New

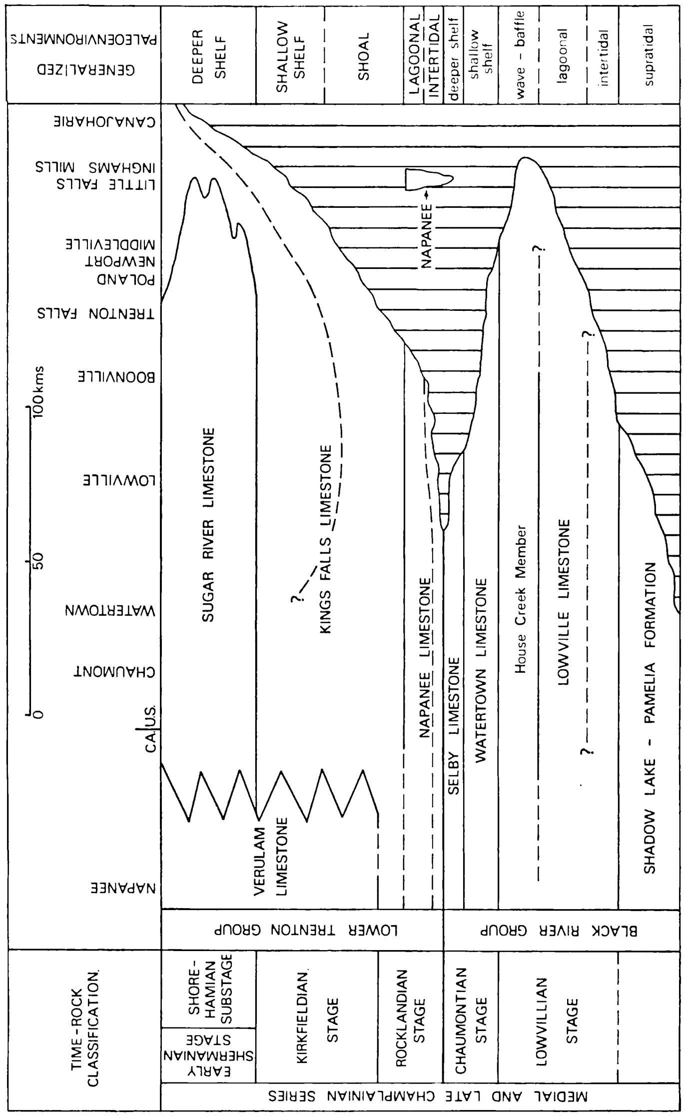

Fig. 2. Generalized correlation chart of Black River and lower Trenton groups from the central Mohawk River Valley in New York to southeastern Ontario. The width of each unit approximates relative thickness which is an estimate of time. Generalized paleoenvironmental framework is shown in the right hand column.

York because (1) there is dual lithic and time-rock usage of the "Chaumont" (= Chaumontian) (Kay, 1975, personal commun.), (2) cherty zones occur more or less sporadically at different levels in different regions (Young, 1943), and (3) the "Leray" has been used in central Ontario for either upper Black River or lower Trenton lithic units (Sinclair, 1954; Barnes, 1967).

Selby- and Watertown-like beds are found at the Black River-Trenton contact along the West Canada Creek Valley (fig. 2; Kay, 1953, fig. 28). These beds, called the Rockland by Kay (1953), thin southeastward from 2½ m at Poland to disappearance at Middleville (Kay, 1953). They are cherty, highly burrow-reworked, commonly contain *Camarocladia*, a distinctive burrow of the Watertown, and have a Watertown fauna and flora (tables 1 and 2). They gradationally overlie the Lowville Limestone. The absence of the *Doleroides ottawanus* and *Triplesia cuspidata* as-

Table 1

Physical and petrographic features of Watertown and Selby limestones*

Features	Watertown northwest New York	Watertown Mohawk Valley, New York	Selby Ontario and New York
Chert	C	f	r-f
Current-laminated beds	r	r	r
Horizontal burrows	C	C	C
Massive lumpy bedding	C	f-C	r-f
Species diversity	moderate	lower	higher
Species dominance (equitability)	low	low	low
Micrite envelopes and algal borings	f	r	f
Coarse calcarenites	r	r	r
Fine calcarenites	C	f	C
Calcisiltites	f	f	f
Total matrix and cement	46.0%	74.0%	59.2%
Micrite	26.3	57.3	34.4
Microspar	4.1	0.1	14.4
Spar	15.6	16.3	10.4
Intraclasts	2.6	2.9	3.1
Pellets	25.3	6.0	8.4
Quartz	0.9	0.3	1.8
Indeterminant and Opaques	4.9	—	—
Total skeletal content	20.2	17.1	27.8
Oncolites	0.1	0.1	0.5
Calcareous algae	6.7	0.3	1.1
Corals	0.4	0.1	0.1
Echinodermata	7.8	7.0	6.4
Mollusca	0.4	2.7	6.2
Brachiopoda	0.8	1.5	4.6
Ectoprocta	1.6	2.0	3.8
Trilobita	0.2	1.5	3.7
Ostracoda	0.2	2.2	0.9
Indeterminant	2.0	0.1	0.6
Number of thin sections	12	9	36

* Comparison is between the Watertown Limestone (northwestern New York and the central Mohawk River Valley of New York). The Watertown of the Mohawk Valley has previously been called "Rockland" (Kay, 1953). Data are from Cameron (ms) and Walker (ms). r-rare, f-frequent, C-common.

TABLE 2
Partial faunal list for the Watertown and Selby limestones*

Genera	Watertown northwest New York	Watertown Mohawk Valley, New York	Selby Ontario and New York
Echinoderms	f	f	f
Calcareous Algae (*Hedstroemia, Vermiporella, Girvanella, Solenopora*)	f	r	r
Stromatoporoid (*Stromatocerium*)	f	vr	vr
Solitary Rugose coral (*Lambeophyllum*)	f	u	f
Colonial Tabulate corals			
Foerstephyllum	f	r	r
Lichenaria	vr	—	vr
Tetradium	vr	—	vr
Ectoprocta			
Eridotrypa	f	—	f
Pachydictya	f	—	f
Prasopora	r	—	f
(unidentified encrusting form)	vr	—	r
Nautiloids			
Actinoceras	f	—	vr
Endoceras	f	—	r
Michelinoceras	r	vr	r
others (for example, *Allumettoceras, Oncoceras, Tripteroceras, Gonioceras,* including *G. Anceps*)	u	u	u
Gastropoda			
Maclurites	vr	—	—
Liospira	vr	r	f
Loxoplocus	r	u	f
Hormotoma	r	u	u
Bucania	r	r	u
others (for example, *Subulites, Salpingostoma, Sinuites, Helicotoma*)	vr	u	u
Bivalvia			
Ctendonta	r	—	u
Cyrtodonta	—	r	u
others (including *Vanuxema, Endodesma*)	vr	r	r
Brachiopoda			
strophomenids	r	f	f
Doleroides	r	—	f
Paucicrura (=*Dalmanella*)	r	r	r
Rhynchotrema	r	u	u
Zygospira	vr	r	r
Hesperorthis	vr	u	r
others	vr	r	r
Trilobites			
Ceraurus	—	—	r
Isotelus	r	u	f
Bumastus	r	u	u
Illaenus	vr	t	r
Bathyurus	vr	r	r
Flexicalymene	—	—	r
Encrinurus	—	—	vr
Ostracodes			
Eoleperditia	vr	f	vr
Small unidentified forms	r	r	u
Burrows			
Camarocladia	A	A	—
bioturbation	A	A	A

*Data from Craig (ms), Young (1943), Kay (1953), Cameron (ms), and Walker (1973). t = trace, vr = very rare, r = rare, u = uncommon, f = frequent, A = abundant.

semblage zones indicates that the upper contact with the Kings Falls Limestone is disconformable. These beds were originally referred to the Black River by Raymond (1903). Although Kay (1937, p. 155) had noted their similarity to the Selby and that their fauna contained both Black River and Trenton forms (Kay, 1953), he correlated these strata with the Napanee based upon fossils from the Newport area that he (1953) and Craig (ms) collected and identified. He considered the species of *Rafinesquina* to be diagnostic of the Trenton, even though his published identifications (Kay, 1953, p. 41-42) are questionable. Walker (1973, p. 32) has found species of *Rafinesquina* in the Watertown of northwestern New York, eliminating their value in determining the Black River-Trenton temporal boundary. These limestones of central New York, therefore, are lithically and faunally most similar to the Watertown (tables 1 and 2). Determining their exact age has been difficult because they contain species and genera found in both Black River and Trenton strata and lack fossils diagnostic of either group. Marshall Kay was working with a time-rock bias with regard to his correlations (Kay, 1968b, 1969), but we consider this lithic unit an extension of the Watertown Limestone, that is thinning from northwestern to central New York. Kay's (1975) last published opinion agrees with this assignment.

Trenton Group.—The Trenton formations were defined as both lithic and biostratigraphic units and were considered by Kay to be time-stratigraphic in nature because of their widespread faunal zones. Kay (1968b) introduced new terms (Kings Falls, Sugar River, and Denley Limestone formations) for some of the lithic units of the middle Trenton Group of northwestern New York to avoid the use of a single term for formations and stages. As is the case of the Black River Group, the Trenton Group outcrop in the type area more or less follows the ancient strandline, and metabentonites (Kay, 1935, 1953) indicate that the formational contacts are more or less synchronous.

Kay (1933) recognized Rocklandian *Triplesia cuspidata*-bearing limestones in northwestern New York. He later (1935) mentioned a subjacent *Doleroides ottawanus*-bearing member. Raymond (1914, p. 348-349) defined the "Rockland Limestone" from the Ottawa Valley outcrop belt as the ". . . lowest Trenton beds in the Ottawa Valley and central Ontario. . . ." The "Rockland" type section is in Stewart Quarry, about 50 km east of Ottawa at Rockland, Ontario (fig. 1). It was described by Wilson (1921) as consisting of two units above what she called Lowville and Kay (1968a) called Watertown lithology: (1) 6 m of non-cherty "Leray beds" and (2) about 12 m of Raymond's "Rockland beds". Kay (1937) considered Wilson's non-cherty "Leray beds" to be post-Watertown rather than the pre-Watertown, cherty "Leray" Limestone of New York. Wilson's "Leray beds" are *D. ottawanus*-bearing. The upper 12 m of Stewart Quarry are *Triplesia*-bearing. The lower unit, however, could have been included in the Watertown as defined by Cushing and others (1910, p. 86-90) or in the Chaumont as defined by Kay (1929, p. 664).

The top of the Watertown as defined by Cushing and others (1910) comprised beds of Selby lithology and fauna, including *D. ottawanus* (then called *Orthis pervetus*, Cooper, 1930, 1956). Although Kay (1931, 1933) had considered these beds in the type area of the Watertown to be in the topmost Black River Group, he (1937, p. 251) redefined the Rockland to include this lower *Doleroides*-bearing unit and defined two new lithic units, the Selby and the Napanee limestones (fig. 3), with type sections in southeastern Ontario. Further confusion resulted because these units were essentially defined faunally. Young (1943, p. 210) recognized that the Selby in northwestern New York, as faunally defined by Kay (1937), could have been included in the Watertown as defined by Cushing and others (1910) and by Kay (1929), but he followed Kay (1937). Cooper (1956, p. 7) has also noted the similarity of the Watertown and lower Trenton faunas.

Both the Selby and the Napanee were extended into northwestern New York and were thought to overlie the Black River Group (Kay, 1937). The discovery of the upper *T. cuspidata* Assemblage Zone in the lower 5 m of the Kings Falls Limestone in northwestern New York has required the recorrelation of the Rocklandian–Kirkfieldian stage boundary (Cameron, ms, 1969; Kay, 1968b). The coarse pararipple-bearing beds of the lower Kings Falls persist northwestward and are correlative with the upper 3.4 m of similar beds in the type Napanee in southeastern Ontario and the coarse half of Raymond's (1914) type "Rockland". Schopf (1966, table 5), using conodonts, correlated Wilson's (1921) upper "Leray" (upper Selby of Kay, 1968a) and Raymond's "Rockland beds" at Stewart Quarry with the Rocklandian beds of northwestern New York, while Barnes (1967), also using conodonts, correlated Wilson's lower "Leray" (lower Selby of Kay, 1968a) and part of her upper "Lowville"

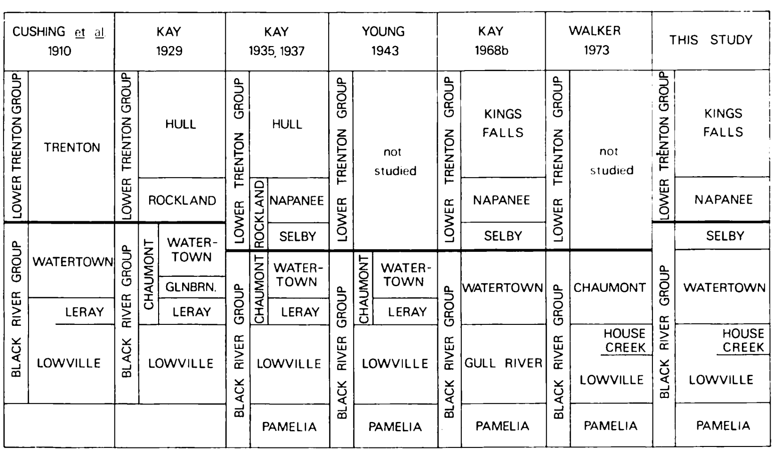

Fig. 3. Tabular history of rock stratigraphic classification of the Black River and lower Trenton formations in northwestern New York. Thicknesses are not to scale. See Kay (1937) for additional and earlier history.

(Watertown of Kay, 1968a) with the Chaumontian. Thus, the revised macrofossil correlation of the late Rocklandian in northwestern New York and the transitional nature of the macrofauna of the upper "Leray" and lower "Rockland" at Stewart Quarry (Wilson, 1921, p. 41) are supported by conodont biostratigraphy.

The contact of the Selby and Napanee limestones is poorly exposed. In northwestern New York, the only known exposure is in Lowville where the upper Selby coral-algal, sparry biopelmicrites conformably underlie lower Napanee *Paucicrura*-rich calcirudites. In southeastern Ontario, very fossiliferous, bioturbated, biomicrites of the Selby are abruptly succeeded by alternating thin calcareous shales and micrites with occasionally current-laminated, intraclast-bearing and scour-and-filled biomicrites and biopelsparites of the lower Napanee. The Selby-Napanee contact appears to be more abrupt lithically than the Watertown-Selby contact to be discussed below (Cameron, 1968). The Selby-Napanee contact is probably diastemic north of Lowville, New York.

Black River-Trenton contact.—An unconformity exists at the Black River-Trenton contact in at least part of the outcrop belt, but the regional extent of the unconformity is debatable within the study area. The unconformity is of greatest duration on the Adirondack Arch in central New York, and it narrows to insignificance at Lowville (fig. 2). In northwestern New York and southeastern and central Ontario, there is no marked break in deposition.

On the western side of the Adirondack Arch, Shorehamian limestones overlie Canadian dolostones. Westward to Middleville, post-Rocklandian Kings Falls Limestone overlies the Lowville Limestone. The Kings Falls increases in thickness westward and northwestward, and a persistent metabentonite in its lower third indicates that the base of the Trenton Group becomes older in these directions (Kay, 1953). Farther northwest from Middleville to Poland, the Watertown Limestone, as recognized herein, intervenes between the Lowville and the Kings Falls limestones, further decreasing the extent of the unconformity.

In the Black River Valley around Boonville, the Watertown Limestone is abruptly overlain by the Napanee Limestone at a corrasion surface. Thence, northward, both these units thicken and the Selby Limestone appears between them at Lowville where the Watertown-Selby contact is abrupt. Between Boonville and Lowville, the topmost meter of the Watertown resembles some of the more massive occurrences of the Selby (Walker, 1973, p. 33). North of Lowville, the Watertown-Selby contact, exposed at three localities in New York and three localities in southeastern Ontario, is gradational and conformable. Thus, there is not a marked, easily recognizable contact, little less a disconformity to the north between the Watertown and Selby limestones.

Certain exposures of the upper Black River and lower Trenton limestones in southeastern Ontario west of Napanee pose further stratigraphic problems. Kay (1942, p. 600) considered that the Selby was overlapped westward by the Napanee Limestone. However, what Kay considered to be "Chaumont" (= Watertown) in the Crookston Quarries, Young (1943, p. 214) subdivided into "Chaumont" and 2.4 m of overlying Selby. The latter contains abundant *D. ottawanus,* conformably overlies Young's "Chaumont", and resembles Watertown limestones. They are abruptly and disconformably overlain by intertidal to shallow subtidal "Napanee" or middle Bobcaygeon limestones of Liberty (1969). In other areas, coarse calcarenites (Coboconk-like) containing *D. ottawanus* overlie the Watertown Limestone, but the contact is not well exposed (Cameron, ms).

Farther westward in central Ontario, the Black River-Trenton boundary has been drawn on either a faunal or lithic basis at five different levels by many workers over the last three decades. The older literature is even more confusing (Liberty, 1969). According to Mukherji (1969), the Trenton Group conformably overlies the Black River Group. The Simcoe Group, the lithic unit of central Ontario correlative with the Black River and Trenton groups of New York and the Ottawa Valley Megagroup of the Ottawa Valley, contains no significant breaks, being apparently the product of virtually continuous deposition (Liberty, 1969). The Bobcaygeon Formation of central Ontario, which spans late Chaumontian and early Trentonian time, indicates a general shallowing of the sea followed by its deepening (Liberty, 1969), corresponding to the unconformity in central New York.

ENVIRONMENTAL FRAMEWORK

Black River Group.—The environmental stratigraphy and paleoecology of the Black River Group in New York and Ontario has received much attention in recent years (Winder, 1960; Barnes, 1965, 1967, 1968; Textoris, 1968; Mukherji, 1969; Walker and Laporte, 1970; Walker, 1972, 1973). In the type area of northwestern New York it represents a somewhat restricted (Walker and Laporte, 1970) submergent cycle with (1) supratidal dolomitic mud flats of the Pamelia at the base, (2) intertidal, lagoonal, and wave-baffle limestone facies of the Lowville in the middle, and (3) level bottom, subtidal, pelletal limestones of the Watertown at the top, representing the deepest, though still shallow, water deposits (Walker, 1973).

Because the Watertown Limestone is important to this discussion, it will be described in greater detail. Important characteristics of this formation are summarized in tables 1 and 2. The Watertown is a marine, biopelmicritic facies deposited offshore from the various facies of the Lowville (Walker, 1973). It contains faunal and floral features, especially at the top, that are gradational with the Selby Limestone above. Rare current-laminated strata and the predominance of burrow-mottled, poorly stratified beds indicate that biogenic reworking exceeded physical reworking of the sediment. Fossils are more abundant and diverse than in any other Black River formation. Some fossils were transported from adjacent environments, but many of the indigenous species are in life position. The fine texture, presence of oncolites, micrite envelopes, abundance of calcareous algae, abundant fecal pellets, normal marine fauna, and burrow-reworking indicate a turbid but relatively quiet, shallow, subtidal, normal marine, nearshore environment with a depth of about 10 m (Textoris, 1968; Walker, 1973).

Trenton Group.—The shaly limestones of the Trenton Group represent another submergence, clearly indicated by the Napanee, Kings Falls, and Sugar River limestones (Cameron and Mangion, in preparation). However, the lowest formation, the Selby, is difficult to place in this environmental sequence (fig. 2). The Napanee is composed of interbedded calcisiltites and thin calcareous shales with some skeletal calcarenites. In its southern exposures the base is a ruditic limestone that is succeeded by sparsely fossiliferous calcisiltites. These are rarely mudcracked and occasionally exhibit birdseye structures and nearly vertical burrows. The middle of the Napanee is more fossiliferous and pararippled, while the upper third is even more fossiliferous, more burrow-reworked, and lacks pararipples. At the top, the Napanee grades into the lower Kings Falls. Environmentally the Napanee represents a basal intertidal sequence followed by a quiet water, shallow, normal marine, lagoonal facies.

The superjacent Kings Falls Limestone contains two informal subdivisions: a lower, brachiopod-rich, shelly calcarenitic facies and an upper, non-shelly calcarenitic facies. Both facies contain thin calcareous shale interbeds. The lower facies contains many current-laminated and rippled beds, scour-and-fill structures, and only a few burrow-reworked beds, attesting to a high energy, shallow water environment, probably an offshore shoal. The upper facies contains fewer laminated and rippled beds and a greater amount of burrow-reworked strata, indicating a quieter and presumably deeper water environment seaward of the shoal.

The overlying Sugar River Limestone contains more argillaceous and micritic calcarenites than the Kings Falls. All the beds have been extensively burrow-reworked, indicating a still quieter and presumably the deepest depositional environment of the lower Trenton Group.

The species diversity and species dominance patterns of biologically and physically controlled environments (Sanders, 1968) and the presence of calcareous algae and algal borings fit these environmental interpretations (Titus and Cameron, 1976). The lower Napanee (intertidal) and the lower Kings Falls (shoal) facies have the lowest species diversities and the highest species dominances, characteristic of physically controlled environments. The upper Napanee, upper Kings Falls, and Sugar River have the reverse pattern. The highest diversity and lowest species dominance occur in the quiet water, level bottom Sugar River Limestone facies. Calcareous algae are rare but are most common in the shoal facies. Micrite envelopes and algal borings decrease in abundance toward the top of Sugar River.

Selby Limestone.—Description: The Selby Limestone is a thin unit, averaging 3 m in thickness, which outcrops from the Black River Valley in New York northwestward to southeastern Ontario. It was defined by Kay (1937, p. 252) as being a limestone *characterized* by the presence of *D. ottawanus* above the Black River Group and beneath the Napanee Limestone. The type section is along Selby Creek, about 3 km north of Napanee, Ontario. Lithically, the Selby resembles the "Leray beds" described by Wilson (1921) at Rockland, Ontario, and the Watertown Limestone of northwestern New York and southeastern Ontario (table 1). It is dominantly composed of 7 cm thick, argillaceous, burrow-reworked, fine-grained calcarenites (biopelmicrites), which are occasionally nodular chert-bearing. Fine-grained micritic calcarenites increase in coarseness and frequency toward the top where biosparites, sometimes ruditic, become common. Small scale ripples and plane- and cross-laminated beds are occasionally found in the upper meter and indicate primarily northward moving currents. About 65 percent of these limestones are matrix, usually micrite (table 1).

The Selby Limestone contains very diverse fossil assemblages (Cameron, ms, table 4). In thin section fossils comprise 27 percent of the limestone (table 1). Micrite envelopes are common, and poorly developed oncolites (type SS, mode R of Logan, Rezak, and Ginsburg, 1964) are frequent. These are best developed at the top of the thickest section (5.4 m) at Lowville. The most common fossils in thin section are echinoderm fragments, brachiopods, trilobites, mollusks, calcareous algae, and ostracods (table 1). In outcrop the assemblages are characterized by frequent echinoderm debris, rare calcareous algae (most common at the top at Lowville), several ectoproct genera, the cup coral *Lambeophyllum* (especially at the top), rare stromatoporoids and tabulate corals (especially at the top), uncommon nautiloids and clams, several gastropod genera, strophomenid, orthid and rhynchonellid brachiopods, trilobites, small ostracods, and horizontal burrows (table 2).

Depositional Environment: The lithology, sedimentary structures, and fossil assemblages of the Selby Limestone suggest a depositional environment much like that of the Watertown Limestone. The diverse fauna and the presence of algae suggest shallow water with good circulation and normal salinities. The paucity of current-laminated strata and the dominance of burrow-reworked beds imply water below effective wave base. In comparison with the Watertown Limestone, the lower abundance of calcareous algae and few oncolites suggest a somewhat deeper subtidal depth for the Selby. Shoaling conditions, however, are persistent at the top of the Selby. These are best developed at Lowville where current-laminated, ruditic, pelsparites and biosparites contain abundant and diverse calcareous algae, well-developed oncolites, and solitary and colonial corals. The shoaling conditions in the uppermost Selby are consistent with the shoaling conditions of the middle Bobcaygeon of south-central Ontario (Liberty, 1969), the apparent diastem between the Selby and Napanee of southeastern Ontario and northwestern New York, and the widening bite of the Black River-Trenton unconformity along the western and southern Adirondack border (fig. 2).

DISCUSSION

The subtidal depositional environment of the Selby Limestone is not easily reconciled within the framework of the lower Trentonian submergence. The sedimentary structures and the relatively restricted fauna indicate that, in at least some regions, the base of the overlying Napanee Limestone is an intertidal deposit. This problem is removed if the Selby is considered a final phase of the submergence associated with the Black River Group. We consider the Selby to represent a facies deposited in similar but slightly deeper water depths than the Watertown Limestone, a conclusion independently arrived at by Fisher (1976). The fauna, lithology, and sedimentary structures are similar in both the Selby and Watertown limestones (tables 1 and 2). Important distinctions lie in the lesser abundance of algae, different burrows, greater faunal diversity, and different species abundances in the Selby. The minor differences between these facies are consistent with the interpretation that the Selby was deposited in a slightly deeper, more open marine, level bottom environment than the Watertown.

The Watertown-Selby contact is gradational and can be placed only with difficulty. Shallowing water depths are indicated at the top of the Selby, and this horizon may be correlative with a shoaling event in the Bobcaygeon of central Ontario. The Selby-Napanee contact is abrupt and represents a more contrasting change of lithology and sedimentary environment than the Watertown-Selby contact. South of Lowville, a disconformity is found between the Watertown and the overlying Napanee Limestone. The unconformity increases in magnitude to the southeast in the Mohawk Valley, where the Napanee and Rocklandian-aged Kings Falls are no longer found (fig. 2). Thus, in northwestern New York and southeastern Ontario the major sedimentologic, environmental, faunal, and stratigraphic break does not correspond to the present Black River-Trenton boundary but occurs at the contact between the Selby and Napanee limestones.

In retrospect Kay's assignment of the Selby to the Trenton Group seems to have been based on understandably insufficient knowledge of the lithologies, paleoenvironments, contact relations of the Selby and the Watertown, and his time-stratigraphic approach to stratigraphic units. We propose that the Selby be assigned to the Black River Group for the following reasons consistent with the Code of Stratigraphic Nomenclature (Am. Comm., 1961): (1) the Selby is part of the same submergence that resulted in the deposition of the underlying Pamelia, Lowville, and Watertown limestones; (2) the Watertown-Selby contact is conformable; (3) the Selby is similar to the Watertown lithically, faunally, and environmentally; (4) the Selby contains almost no shale, a lithology characteristic of the Trenton Group but not the Black River Group; and (5) the Selby belongs in the Black River Group by priority.

The "Leray-Watertown" limestones as defined by Cushing and others (1910, p. 86-90), the "Chaumont", as defined by Kay (1929, p. 664), and the "Watertown" limestone of Kay (1933), by implication, include Selby-like beds at the top. These beds contain *D. ottawanus,* defined by Kay (1937) as being characteristic of the Selby. Thus, the assignment of the Selby to the Trenton Group was a reassignment by Kay (1937), and we are recommending that the Selby be put back into the upper Black River Group. Although the Selby is a facies that is similar to the Watertown Limestone, the same Selby Limestone should be retained because it represents a distinct and mappable lithology.

The redefinition of the Black River-Trenton boundary makes it necessary to clarify the meaning of the Chaumontian and Rocklandian stages. The Chaumontian retains the temporal significance as originally defined by Kay (1929). That is, the Chaumontian includes the interval between the Lowvillian and lowermost Trentonian. The *D. ottawanus* Assemblage Zone is now included in the late Chaumontian. The Rocklandian Stage now includes, as originally intended (Raymond, 1914), only the *T. cuspidata* Assemblage Zone. Thus, the Black River-Trenton boundary still occurs at the Chaumontian-Rocklandian stage boundary.

The proposed change in the Black River-Trenton boundary is compatible with the conodont correlations of Schopf (1966) and Barnes (1967) at Stewart Quarry, the type section of the lower Trenton "Rockland Formation". At this exposure, 6 m of *D. ottawanus*-bearing limestones between the Watertown (of Kay, 1968a) and the Rockland (of Raymond, 1914) were referred to the Black River by Wilson (1921) and to the Selby Limestone of the Trenton Group by Kay (1937, 1968a). Schopf and Barnes followed Kay's (1942) erroneous remeasurement of the section (Kay, 1968a), thereby complicating their biostratigraphy. Barnes included the lower part of these 6 m in the Black River Group. Schopf included the upper part in the Trenton Group. However, considering the similar ages, environments and macrofauna (Wilson, 1921; Kay, 1937; Cooper, 1956) involved in the controversy over the Black River-Trenton boundary, it is not surprising that the conodonts of these 6 m were considered to be either Chaumontian or Rocklandian in aspect.

CONCLUSIONS

1. The Black River Group is redefined to include the Selby Limestone, previously considered to be in the lowermost Trenton Group by Kay (1935, 1937). Early workers (Cushing and others, 1910) originally included Selby lithologies in the upper Black River Group.

2. The Black River-Trenton unconformity progressively decreases in extent from the Mohawk River Valley, where it is greatest, to northwestern New York at Lowville, where deposition was essentially continuous throughout the time of deposition of both the upper Black River and lower Trenton groups. Farther northward in New York and Ontario, there is no marked break in sedimentation at the boundary, but a shallowing sea is indicated in central Ontario.

3. We recommend continuing Kay's (1968a,b) usage of a revised Watertown Limestone expanded to include both the Watertown and Leray limestones of Cushing and others (1910).

4. The Rockland of Kay (1953) in the central Mohawk Valley is reassigned to the Black River Group as a facies of the Watertown Limestone. It gradationally overlies the Lowville Limestone, disconformably underlies Kirkfieldian Kings Falls Limestone, and is faunally and lithically similar to the Watertown Limestone of northwestern New York.

5. The Selby Limestone was deposited during the same submergence as the Black River Group. The Selby's contact with the underlying Watertown Limestone is gradational but is abrupt with the overlying Napanee Limestone of the Trenton Group. The Selby was deposited in a quiet water, shallow subtidal marine environment similar to, but slightly offshore of the Watertown Limestone.

6. The Chaumontian Stage is revised to include the *Doleroides ottawanus* Assemblage Zone, previously considered to be early Rocklandian.

7. The Rocklandian Stage is restricted to the originally defined limits of Raymond (1914) and contains only the *Triplesia cuspidata* Assemblage Zone.

8. The Rocklandian-Kirkfieldian stage boundary is recorrelated in northwestern New York to include the lower Kings Falls Limestone.

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