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Résumé de l'article

De nouveaux releves cartographiques dans la region de Quaco Head au sud du Nouveau-Brunswick demontrent que l'etendue des calcaires du groupe Windsor est plus importante qu'on ne le croyait. Le calcaire a Quaco Head a une epaisseur de 8.5 m et repose en discordance sur des basaltes pre-cambrlens (Coldbrook). Le calcaire, qui consiste surtout de microsparite, presente des feuillets d'algues aailIanta comprenant des formes hemispheriques liees. lateralement et du grandes "teted 1 isolees mesurant jusqu'a 80 cm de hauteur. Un calcaire stratlfie et laroelleux 3 texture pseudo-oolithique occupe les depressions entre les "tetes". Le calcaire est coiffe d'une breche calcaire de 2 a d'epaisseur et recouvert de conglomerats polygeniques rouges a matrice portante, de siltstones sableux lamelieux et de grossiers conglomerats polygeniques se soutenant. Le lithofacies calcaire constitue une sequence en regressivite deposee pres du rivage de la mer Windsor, sur l'estran et en milieu peu profond. Les sediments clastlques qui recouvrent le calcaire retire sen tent probablement le debut d'une vigoureuse sedimentation siliclastlque provenant d'un cone de dejection, le resultat de mouvements de failles locales datant de (?) la fin du Viseen (groupe Hopewell).

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The distribution, biota and stratigraphy of a Windsor Group limestone (Mississippian) and associated sediments in the Quaco Head area of New Brunswick

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Re-mapping of the Quaco Head area of southern New Brunswick has shown that Windsor Group Limestones have a more extensive distribution than was previously recognized. The limestone at Quaco Head is up to 8.5 m thick and rests unconformably on basalts Precambrian (Coldbrook) age. The limestone, which now consists mainly of microsparite, shows prominent algal lamination including laterally-linked hemispheroids and large, isolated 'heads', up to 80 cm high. Stratified and laminated limestone with a pseudo-oolitic texture occupies the troughs between the 'heads'. The limestone is capped by 2 m of calcibreccia, overlain by red, matrix supported polymict conglomerates, laminated sandy siltstones and coarse, clast-supported polymict conglomerates. The limestone lithofacies form a regressive sequence, deposited in shallow subtidal and intertidal environments, close to the shore of the Windsor sea. The overlying clastic sediments probably record the onset of vigorous siliclastic alluvial fan sedimentation in response to local fault movement in ?Late Viséan (Hopewell Group) times.

De nouveaux relevés cartographiques dans la région de Quaco Head au sud du Nouveau-Brunswick démontrent que l'étendue des calcaires du groupe Windsor est plus importante qu'on ne le croyait. Le calcaire à Quaco Head a une épaisseur de 8.5 m et repose en discordance sur des basaltes précambriens (Coldbrook). Le calcaire, qui consiste surtout de microsparite, présente des feuillets d'algues saillants comprenant des formes hémisphériques liées. latéralement et du grandes "têtes" isolées mesurant jusqu'à 80 cm de hauteur. Un calcaire stratifié et lamelleux à texture pseudo-oolithique occupe les dépressions entre les "têtes". Le calcaire est coiffé d'une brèche calcaire de 2 m d'épaisseur et recouvert de conglomérats polygéniques rouges à matrice portante, de siltstones sableux lamelleux et de grossiers conglomérats polygéniques se soutenant. Le lithofaciès calcaire constitue une séquence en régressivité déposée près du rivage de la mer Windsor, sur l'estran et en milieu peu profond. Les sédiments clastiques qui recouvrent le calcaire reérésentent probablement le début d'une vigoureuse sédimentation siliclastique provenant d'un cône de déjection, le résultat de mouvements de failles locales datant de (?) la fin du Viséen (groupe Hopewell).

[Traduit par le journal]

INTRODUCTION

Previous workers in the Saint John area of southern New Brunswick including Bailey 1865, 1898; Hayes and Howell 1937; Alcock 1938; Magnusson 1955; Globensky 1965 noted the occurrence of a pale grey, laminated crystalline limestone at two points on the coast of the Bay of Fundy near Quaco Head, N.B. (Fig. 1). The limestone, which has always been described as 'unfossiliferous', has never been described in detail nor dated with any certainty. Bailey (1865) referred it to the 'Lower Carboniferous' while Hayes and Howell (1937) correlated it with a limestone exposed on the banks of the Hammond River at Upham, N.B. Alcock (1938) grouped it with the Pennsylvanian strata of the area, and, in the absence of fossils, suggested a Westphalian age. Magnusson (1955) placed the Quaco limestone in the Mississippian while Globensky (1965), despite failing to find any microfossils, assigned it to the Windsor Group. McCutcheon (1981) made passing reference to an outcrop of Windsor limestone at Quaco Head, but gave no further details.

Our re-examination of the limestone from the Quaco Head area revealed both micro and macro-fossils indicating an undoubted Windsor age, suggestive of subzone 'A' or possibly 'B' (Bell 1929).

DISTRIBUTION OF THE WINDSOR GROUP LIMESTONE IN THE QUACO HEAD AREA

Recent re-mapping of the Quaco Head

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area (Fig. 1) showed that the Windsor Group Limestone can be traced inland from locality 1, 600 m north of Quaco Head (Fig. 1) in a narrow belt extending southwest and emerging on the coast at locality 4, 2.5 km S.W. of Quaco Head. At two intermediate points, localities 2 and 3, the base of the limestone is exposed in contact with basalts while scattered exposures of limestone are also visible in the woods 1.6 km west of Quaco Head. The limestone, which dips to the southeast locally may form a low but distinct topographic ridge, but elsewhere, it has no obvious topographic expression.

Figure 1 is intended to show only the general geology of the Quaco Head area, in particular the distribution of the Windsor Group Limestone. A more complete discussion of the stratigraphy and structural evolution of this area will be presented elsewhere (Plint and Poll, in prep.).

STRATIGRAPHY

Stratigraphic sections through the limestone at localities 1 and 4 (Fig. 1) are shown in Figure 2.

Locality 1: *Stratigraphic Description*

The limestone at this locality is divisible into five units. Units 1 and 2 rest unconformably on a dark green and purplish-red basalt of Precambrian age (S. R. McCutcheon, pers. comm.). The contact is irregular with a relief of up to 2.5 m. On upstanding areas of basalt are large algal heads (Unit 1, Fig. 3) with scattered basalt clasts at their base. These heads, which are up to 80 cms high and 1.5 m wide have vertical or overhanging sides. Faint lamination is present throughout and is concentric with the top of the head. The uppermost 10 cms of the heads comprise relatively small (2-4 cm diameter) laterally-linked hemispheroids (L.L.H. of Logan *et al.* 1964).

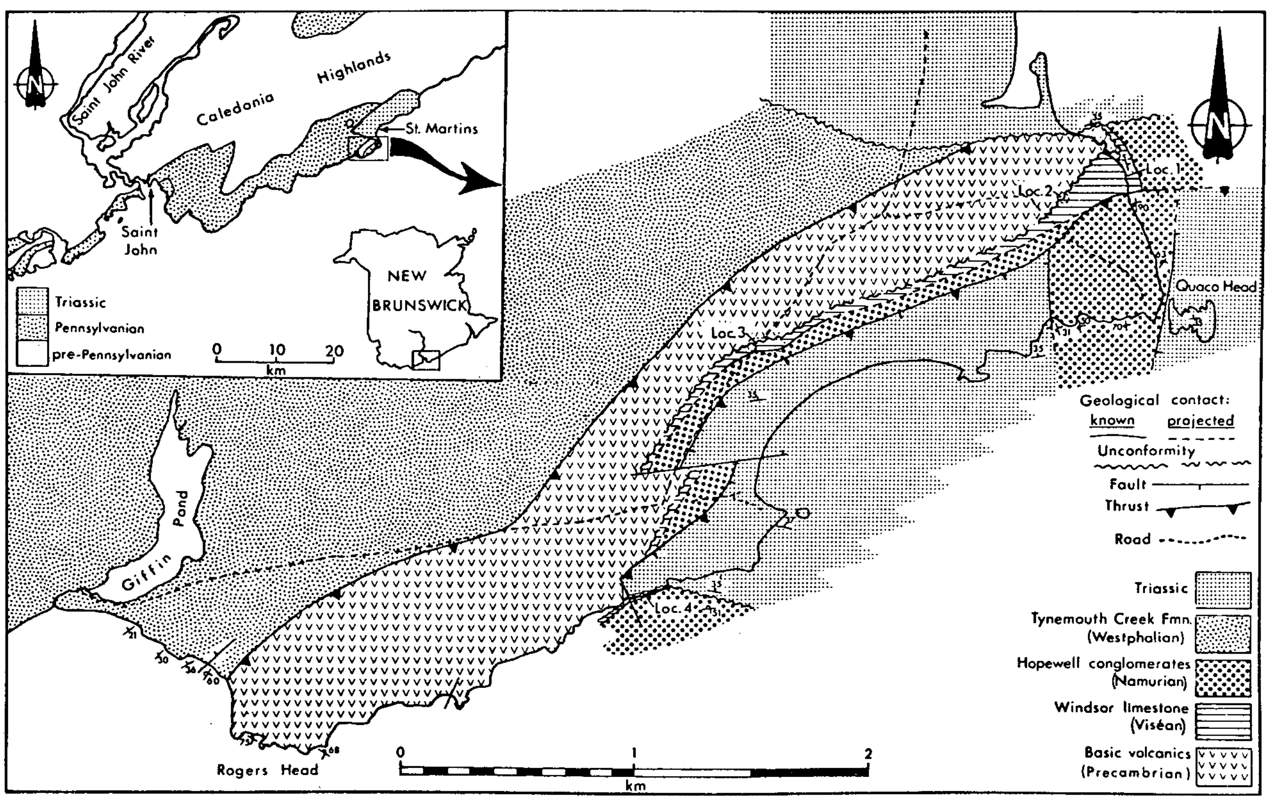

Fig. 1 - Map showing (inset) regional geological setting and a detailed geological map of the Quaco Head area. Windsor Limestone can be traced inland in scattered exposures between Localities 1 and 4.

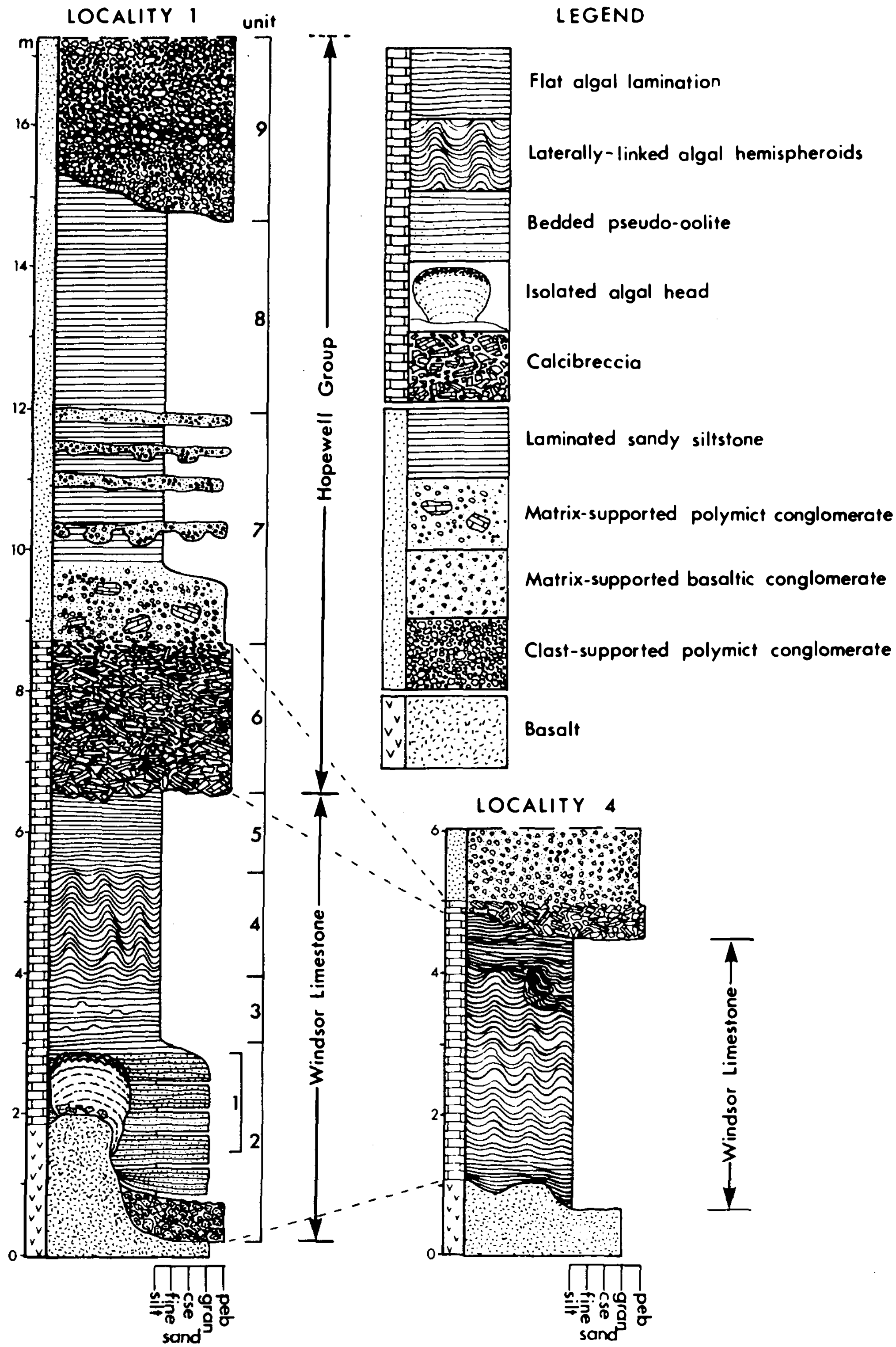

Fig. 2 - Stratigraphic sections for Localities 1 and 4.

Depressions in the basalt surface may contain an angular to sub-angular breccia that is up to 1.2 m thick, and forms the basal part of Unit 2. The breccia consists entirely of basaltic clasts which range up to 22 cms in diameter (Fig. 4).

Overlying this breccia, and between the upstanding algal heads are pockets of horizontally-laminated micrite (micro sparite) interbedded with pseudo-oolite (Bathurst 1975), that contains grains up to 4 mm in diameter (Fig. 5). Laminae within these sediments terminate abruptly against the algal heads. A thin layer of laminated algal limestone sometimes extends from the base of the heads to blanket the basalt breccia lying in the troughs. The upper part of Unit 2 oversteps the algal heads of Unit 1 1.8 m above the base of the limestone.

The limestone of Unit 3 comprises flat-laminated micro-sparite which lacks pseudo-ooliths but contains rare, separate hemispheroids (S.H. of Logan *et al.* 1964), 1-3 cm in diameter. Flat-laminated micro-sparites persist for 1 m before passing into well-developed L.L.H. (Unit 4, Fig. 6) which have a height of up to 7 cm and diameter of up to 12 cm. This growth form persists throughout the next 1 to 1.5 m of limestone before gradually reverting to flat lamination (Unit 5) which persists for 1.3m.

Windsor rocks at Locality 1 are disconformably overlain by redbeds that are divisible into 4 Units labelled 6 through 9 in Figure 2. About 2 m of coarse, angular, clast-supported calci-breccia (Unit 6) abruptly overlies rocks of Unit 5. The contact is highly irregular. The breccia is composed exclusively of laminated micrite clasts, up to 50 cm long, with a matrix of smaller limestone fragments and red silty sand in chaotic arrangement (Fig. 7). The limestone clasts show neither evidence of rounding or subsequent overgrowth by algal limestone. Locally, the red silty matrix is laminated and has the same dip as the underlying, unbrecciated limestone. Whenever present, calcite veins in the breccia cross-cut both clasts and matrix alike.

Unit 6 is abruptly overlain by about 3 m of polymict pebbly mudstone (Unit 7). This contains rounded to subangular pebbles of quartzite, granite, basalt, agglomerate and foliated metamorphic rocks, together with large blocks of limestone, all 'floating' in a matrix of red sandy siltstone. Unit 7 grades up into Unit 8 which contains no pebbles and consists entirely of laminated red sandy siltstone. Laminae range from 1 mm to 5 mm thick and show pronounced grading from fine sand to fine silt (Fig. 8). The siltstone is up to 2.5 m thick and is erosively overlain by coarse, red, clast-supported, polymict conglomerates (Unit 9) which are probably of Hopewell Group age.

Interpretation of the Succession at Locality 1

The angularity of the basalt breccia at the base of Unit 2 suggests that it represents an *in situ* regolith that suffered little reworking during marine transgression. The development of the large algal heads of Unit 1 was clearly controlled by the local topography of the underlying basalt, upstanding areas of which favoured algal growth, perhaps because they afforded sites better protected from the abrasive action of sediment moving back and forth in the intervening troughs. The algal heads closely resemble recent algal structures that develop beneath a colloform mat in shallow subtidal environments (Logan *et al.* 1974).

The pseudo-oolites of Unit 2 comprise detrital peloidal and bioclastic material that was probably introduced from both shallow subtidal and intertidal areas (? during storms) and is closely comparable to Lithology 'A' of the Macumber Formation described by Schenk (1967). Eventually sediments of Unit 2 accumulated so that they smothered the adjacent heads, halting their growth. Prior to burial, these algal heads underwent a change in growth form from faint plane lamination to small L.L.H. perhaps in response to increasing turbulence, abrasion, sedimentation or subaerial emergence.

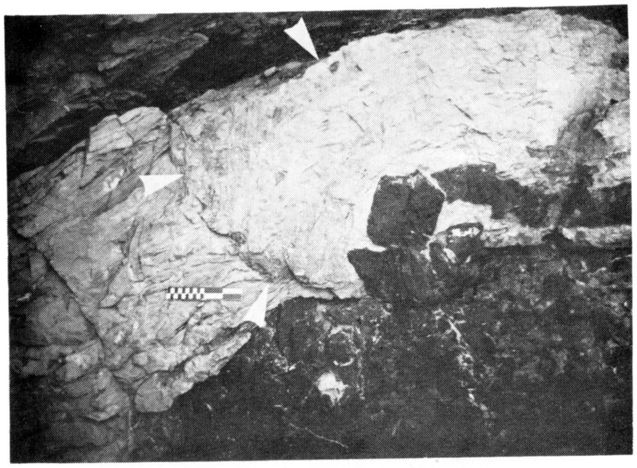

Fig. 3 (left)
Large algal head, indicated by arrows, (Unit 1) developed on the top of an upstanding mass of basalt. Note angular blocks of basalt at the base of the head and bedded pseudo-oolites (Unit 2) to the left of the algal head. Locality 1.

Fig. 4 (right)
Poorly-sorted angular basalt breccia at the base of the Windsor Limestone at Locality 1. (Scale bar in photograph = 20 cms). The breccia is clast-supported and has a carbonate matrix.

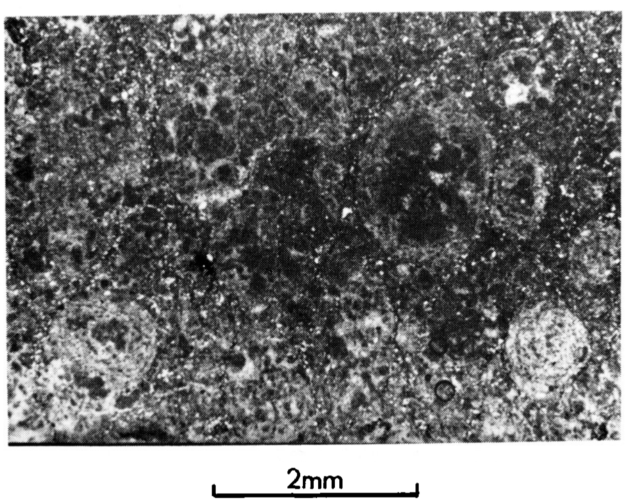

Fig. 5 (left)
Micrograph (x13.5, plane light) illustrating texture of the pseudo-oolite of Unit 2, an indeterminate gastropod and the foraminifera *Biseriammina windsorensis*. Locality 1.

Fig. 7 (right)
Poorly-sorted angular, clast-supported calci-breccia (Unit 6) at Locality 1. Clasts consist of laminated algal limestone and have a matrix of fine red sandstone and siltstone.

Fig. 6
Well-developed laterally-linked hemispheriods in Unit 4, Locality 1.

Fig. 9
Large algal dome (indicated by arrows) near the top of the Windsor Limestone at Locality 4. White scale bar = 20 cms.

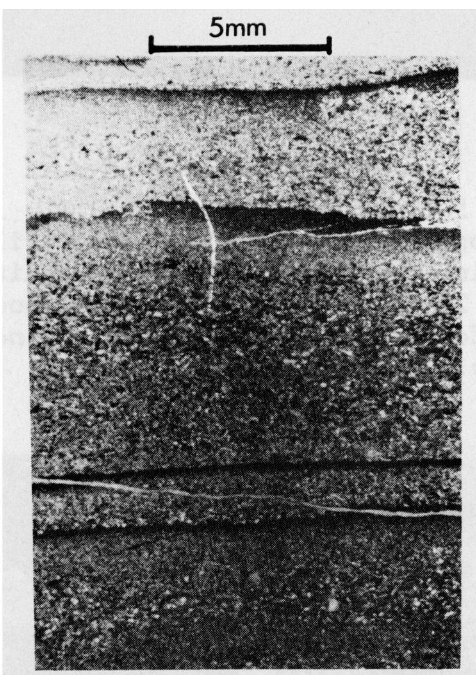

Fig. 8
Micrograph (x5, plane light) showing thin graded layers in Unit 8, Locality 1. Each layer grades from fine sandstone to red siltstone. Minor scouring and loading is sometimes seen.

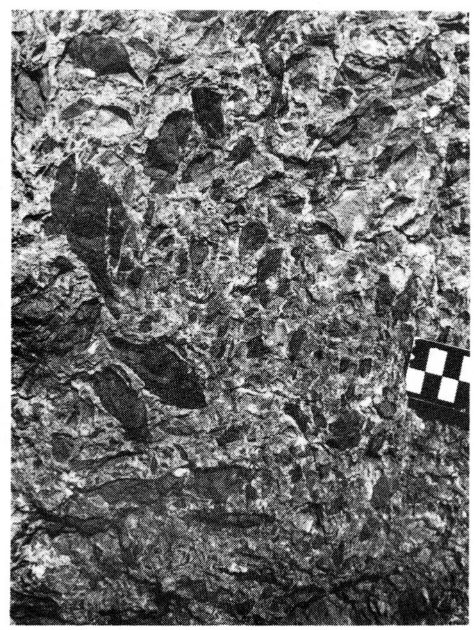

Fig. 10
Angular, matrix-supported conglomerate overlying a calci-breccia at Locality 4. Clasts, which consist exclusively of basalt 'float' in a matrix of red silty sandstone. Scale subdivisions in cm.

Units 3, 4 and 5, which may be equated with Lithology 'B' of the Macumber Formation (Schenk 1967) contain stromatolite morphologies typical of the lower to middle portions of protected tidal flats (Logan *et al.* 1964). Their morphology closely resembles the smooth mat forms of Logan *et al.* (1974) in which two types — flat-laminated, and sheets with domes may be distinguished. These types clearly equate with Units 3 and 5 and Unit 4 respectively. The upward succession from a shallow subtidal (Units 1, 2) to intertidal (Units 3-5) environment may be simply explained in terms of a prograding tidal flat (cf. Schenk 1967, Logan *et al.* 1974).

The calcibreccia of Unit 6 superficially resembles one described by Clifton (1967) that overlies the basal limestone of the Windsor Group in parts of Nova Scotia and New Brunswick. This breccia was attributed by Clifton to the *in situ* collapse of the limestone as a result of the dissolution of interbedded anhydrite during post-Triassic—pre-Pleistocene times. Unit 6 at Quaco differs from the breccia described by Clifton (1967) in the following respects. (i) It is essentially clast-supported, (ii) it has a relatively low matrix content, (iii) it contains no exotic i.e. non-limestone clasts, (iv) the lamintation in the matrix has the same dip as the underlying limestone indicating deposition prior to Alleghenian-Hercynian deformation, (v) it has a sharp upper contact with pebbly mudstones of Unit 7. In view of these differences, it appears that brecciation of the limestone took place relatively soon after its deposition, and before deposition of the overlying clastic sediments. The most likely explanation is that the limestone, perhaps with interbedded anhydrite, underwent solution and collapse, and/or desiccation accompanied by extensive recrystallization during a period of subaerial exposure, prior to deposition of clastic sediments (cf. Schenk 1967, McCutcheon 1981).

The matrix-supported fabric of Unit 7 is strongly suggestive of deposition from debris-flows. This unit thickens and coarsens dramatically on approaching the major fault immediately to the south of Locality 1. These facies changes may be evidence of syn-sedimentary (pre-Hopewell) fault movement. Laminated siltstones of Unit 8 (Fig. 8) suggest a lake with sedimentation from ?turbidity currents, perhaps the result of storm runoff. In contrast, the overlying Hopewell Group conglomerates (Unit 9) were probably deposited by braided streams on a southward advancing alluvial fan.

BIOTA OF THE LIMESTONE

The limestone is dominantly stromatolitic and shows both planar and hemispheroidal algal growth forms. Near the base of the limestone at Locality 1, bedded pseudo-oolites and laminated micrites have yielded highly recrystallized fossils. These include:

Brachiopoda	- Brachiopods - indet fragments
Mollusca	- Gastropods - indet
Echinodermata	- Crinoids - indet fragments
Ostracoda	- *Paraparchites gibbus*
Foraminifera	- *Archaeodiscus* sp.
	- *Biseriammina windsorensis*
	- *Earlandia* sp.
Algae	- *Girvanella* sp.
	Calcisphaera sp.
	Spongiostromid debris

The fauna is most strongly suggestive of a Windsor 'A' age, an interpretation that is supported by the sedimentary lithology which closely resembles the basal Windsor, Macumber Formation of Schenk (1967).

Stratigraphic description of Locality 4

Locality 4 presents a stratigraphic sequence essentially similar to that at Locality 1. Unfortunately, more extensive recrystallization and a stronger cleavage, due to the proximity of a fault, tend to obscure the sedimentary fabric.

Up to 4 m of laminated limestone (sparite) unconformably overlies basalt that has a surface relief of a few cm. Near the base, laminae are plane or gently undulating but upwards, these give way to 2.5 m of well-developed L.

L.H. stromatolites. These L.L.H. are truncated by an irregular erosion surface with a topography of about 50 cms and are blanketed by a laminated limestone which forms low-amplitude domes, up to 5 m in diameter (Fig. 9). Within these broad domes, small hemispheroids are locally developed. An irregular surface separates this limestone from an overlying, clast-supported calci-breccia up to 50 cm thick that is identical to Unit 6 at Locality 1. This breccia is overlain by a matrix-supported conglomerate consisting exclusively of angular basalt clasts up to 10 cm in diameter, in a matrix of fine red silty sandstone (Fig. 10). The total thickness of this conglomerate is unknown as it is truncated by a fault.

Interpretation of the Succession at Locality 4

Deposition of a laminated micritic limestone, consisting largely of L.L.H. algal growth forms, took place after marine transgression, in a shallow subtidal or intertidal environment. A period of erosion, possibly a result of subaerial exposure, was followed by renewed stromatolite growth, leading to the formation of broad domes. As at Locality 1, limestone deposition and lithification was followed by ?subaerial solution and collapse, and the formation of an autochthonous calci-breccia. The fabric of the overlying conglomerate suggests deposition from a debris-flow. The absence of exotic (non-basaltic) clasts suggests very local derivation, perhaps from nearby fault-scarp exposures of basalt.

DISCUSSION

The lithostratigraphy and palaeontology of the Windsor Group Limestone in the Quaco Head area shows a close similarity to that of the 'A' subzone basal Windsor, carbonates that occur widely in the Maritime Provinces. The sediments designated by Schenk (1967) as of "Macumber" type were interpreted as an offlap sequence which recorded the seaward progradation of shallow subtidal and intertidal deposits which were overlain by coarse terrigenous sediments, probably deposited on alluvial fans flanking rejuvenated fault-blocks. A sedimentary history comparable to Schenk's (1967) model is clearly recorded by the Windsor and Hopewell Group sediments in the Quaco Head area. However, although Schenk's model is applicable to the Windsor Limestone at Quaco, it is not typical of the Macumber Formation *sensuo stricto* (Weeks 1948).

In palaeogeographic terms, Quaco Head lay close to the paleoshoreline during the basal Windsor marine transgression (McCutcheon 1981) and, as this model would predict, the sediments are indicative of coastal, shallow subtidal and intertidal conditions. The abrupt onset of clastic sedimentation is presumably related to ?late Visean fault movement (cf. Ruitenberg and McCutcheon 1982) in the immediate vicinity which generated local sources of clastic sediment. Later, during the Namurian, southward-prograding alluvial fans of the Hopewell Group, headed a few km to the north in the Caledonia Highlands deposited a thick sheet of conglomerate over the area.

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