Graptolites from the Benton area of west-central New Brunswick and their regional significance

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Graptolites in black slate underlying volcanics along Eel River near Benton, 20 km south of Woodstock, New Brunswick belong to the *Clonograptus tenellus* Zone of the upper Tremadoc Series. They are essentially the same age as graptolites from the Cookson Formation of southern New Brunswick.

The Belle Lake Slate overlies the same volcanics, and on Belle Brook, 12 km southwest of Benton, contains graptolites referred to the *Nemagraptus gracilis* Zone of the Caradoc Series. The Belle Lake Slate correlates with an unnamed sequence of greywacke and slate in the Hayesville area of central New Brunswick.

The Ordovician volcanics and overlying sedimentary rocks are the same general age as a limestone facies found to the east and northeast of Woodstock. The limestones were deposited in shallow-water at varying distances from volcanically active areas.

The presence of lithologically similar Lower Ordovician and older rocks in the Benton area of west-central New Brunswick and in the Cookson Formation of southern New Brunswick allows both areas to be included in the same suspect terrane.

A 20 km au sud de Woodstock (Nouveau-Brunswick) on trouve, dans une ardoise noire recouverte de roches volcaniques, des graptolites qui appartiennent à la zone *Clonograptus tenellus* de la série du Trémadocien supérieur. Ces graptolites datent essentiellement de la même période que les graptolites de la formation de Cookson du sud du Nouveau-Brunswick.

A 12 km au sud-ouest de Benton, le long du ruisseau Belle, les roches volcaniques mentionnées ci-haut sont recouvertes par l'ardoise Belle Lake qui contient des graptolites de la zone à *Nemagraptus gracilis* de la série du Caradocien. L'ardoise Belle Lake est corrélée avec une séquence de grauwacke et d'ardoise que l'on retrouve dans la région de Hayesville au centre du Nouveau-Brunswick.

Les roches volcaniques ordoviciennes et les roches sédimentaires qui les recouvrent ont environ le même âge qu'un faciès de calcaire situé à l'est et au nord-est de Woodstock. Les calcaires ont été déposés en eau peu profonde à des distances variables d'une région volcaniquement active.

La présence de roches lithologiquement semblables, certaines datant de l'Ordovicien inférieur, d'autres plus anciennes, dans la région de Benton au centre-ouest du Nouveau-Brunswick et dans la formation de Cookson au sud du Nouveau-Brunswick présuppose une parenté entre les deux régions.

[Traduit par le journal]

INTRODUCTION

The two new fossil localities discussed in this paper were discovered by searching the ground in the vicinity of occurrences reported in the geologic literature over eighty years ago. While one of us (L.R.F.) was researching some old reports to prepare a summary of stratigraphic terminology in New Brunswick, it became apparent that L.W. Bailey had found graptolite fragments near Maxwell, 30 km southwest of Woodstock (Fig. 1). A one day search in the area in late summer of 1982 resulted in the discovery of well preserved graptolites on Belle Brook (Fig. 2).

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A better documented graptolite locality discovered by Bailey near Benton, 20 km south of Woodstock, had not been successfully re-collected despite attempts by several geologists. At the Nato Advanced Study Institute Meeting on the Caledonide Orogen held in Fredericton in August 1982, W. H. Poole and R.B. Neuman suggested that Forbes attempt to collect the site in the coming fall.

This paper is intended as a tribute to the pioneering work of L.W. Bailey and G.F. Matthew who began their geological survey of west-central New Brunswick one hundred years ago (Bailey, 1885: In Report of Progress for 1882-83-84).

HISTORICAL PERSPECTIVE

In the summer of 1900, while attempt-

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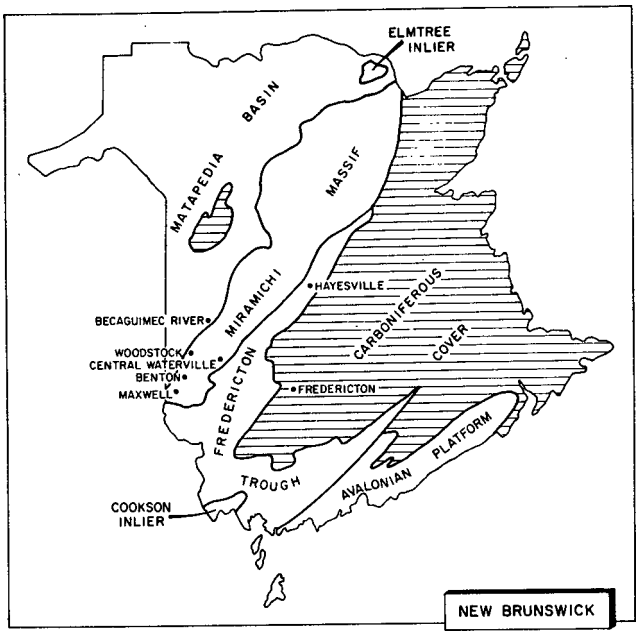

Fig. 1 - Tectonostratigraphic zones of New Brunswick.

ing to delimit the extent of fossiliferous Silurian rocks in west-central New Brunswick, Bailey (1901, 1903) discovered graptolites in black slate on Eel River at Benton. He reported that both Matthew and Ami regarded them as identical to *Dictyonema flabelliforme* (Eichwald) found on Navy Island in Saint John Harbour (Matthew 1891). Bailey's discovery confirmed the Cambro-Ordovician age of the Benton rocks which was previously based only on their lithologic characteristics (Bailey 1885, pp. 16-17).

Bailey (1901, pp. 148-149) described another belt of slate overlying volcanics and quartzite in the vicinity of Monument Settlement (close to the present day community of Maxwell, 12 km southwest of Benton (Fig. 2). Although no fossils had been recovered, Bailey considered the Monument Settlement beds to be equivalent to those of the fossiliferous Benton locality. In the summer of 1904, Bailey (1906) recovered graptolites near Monument Settlement but their poor preservation prevented a definite age assignment (Ami 1906). Nevertheless, Bailey maintained that the two areas of slate were generally of the same age.

Recent mapping in west-central New Brunswick has led to the establishment of a detailed stratigraphic framework (Venugopal 1978, 1979; Lutes 1979) where previously only reconnaissance maps existed (Patterson 1957; Tupper 1957).

STRATIGRAPHY

New Brunswick has been divided into the following tectono - stratigraphic zones from northwest to southeast (Fyffe *et al.* 1981): Matapedia Basin containing Upper Ordovician to Lower Devonian sedimentary rocks and Upper Silurian to Lower Devonian volcanic rocks; Elmtree Inlier containing Ordovician ophiolite; Miramichi Massif underlain by Cambrian to mid-Ordovician sedimentary, and Ordovician volcanic rocks; Fredericton Trough containing Silurian to Lower Devonian sedimentary rocks with abundant volcanics along its southern margin; Cookson Inlier underlain by Cambro-Ordovician sedimentary rocks; and Avalonian Platform containing Precambrian rocks unconformably overlain by platformal Cambro - Ordovician sediments (Fig. 1).

A brief description of the stratigraphic divisions within the southwestern portion of the Miramichi Massif, in which the new graptolite discoveries occur, is given below.

The Cambro-Ordovician rocks of the Benton area (Fig. 2) have been divided into three formations. In ascending order these are: unnamed quartzite-slate unit, the Pocomoonshine Volcanics, and the Belle Lake Slate. The unnamed unit consists of light green to grey quartzite interbedded with light green to grey slate, and minor maroon and black slate. The black slate containing local thin beds of quartzite is exposed along Eel River southeast of Benton. It apparently interfingers eastward with thick beds of green quartzite and slate (Venugopal 1978).

The Pocomoonshine Volcanics comprise felsic tuffs and mafic volcanic rocks interbedded with red ferromanganiferous slate. The volcanics overlie black slate of the unnamed unit on Eel River

but overlie massive quartzite farther east along the Trans-Canada Highway.

The Belle Lake Slate conformably overlies the Pocomoonshine Volcanics and extends from south of Benton westward to Maxwell and Belle Brook. It comprises an interbedded sequence of dark grey slate and greywacke. An outlier of Siluro-Devonian sedimentary and volcanic rocks unconformably overlies the Cambro-Ordovician succession.

The stratigraphy of the Cambro-Ordovician rocks in west-central New Brunswick was established during the recently completed mapping program by comparison with the well-documented section north of Hayesville in central New Brunswick (Poole 1963, Neuman 1968). No fossils were found in the Benton area during this program to confirm the correlation but Ordovician volcanics were traced intermittently along the southeastern margin of the Miramichi Massif from Hayesville to Benton (Fyffe 1982a).

DESCRIPTION AND AGE OF FAUNA

No difficulty was encountered in loccating the Benton exposure on Eel River as it is fairly well described by Bailey (1901). The outcrop of black slate is on the east bank of the river just down-

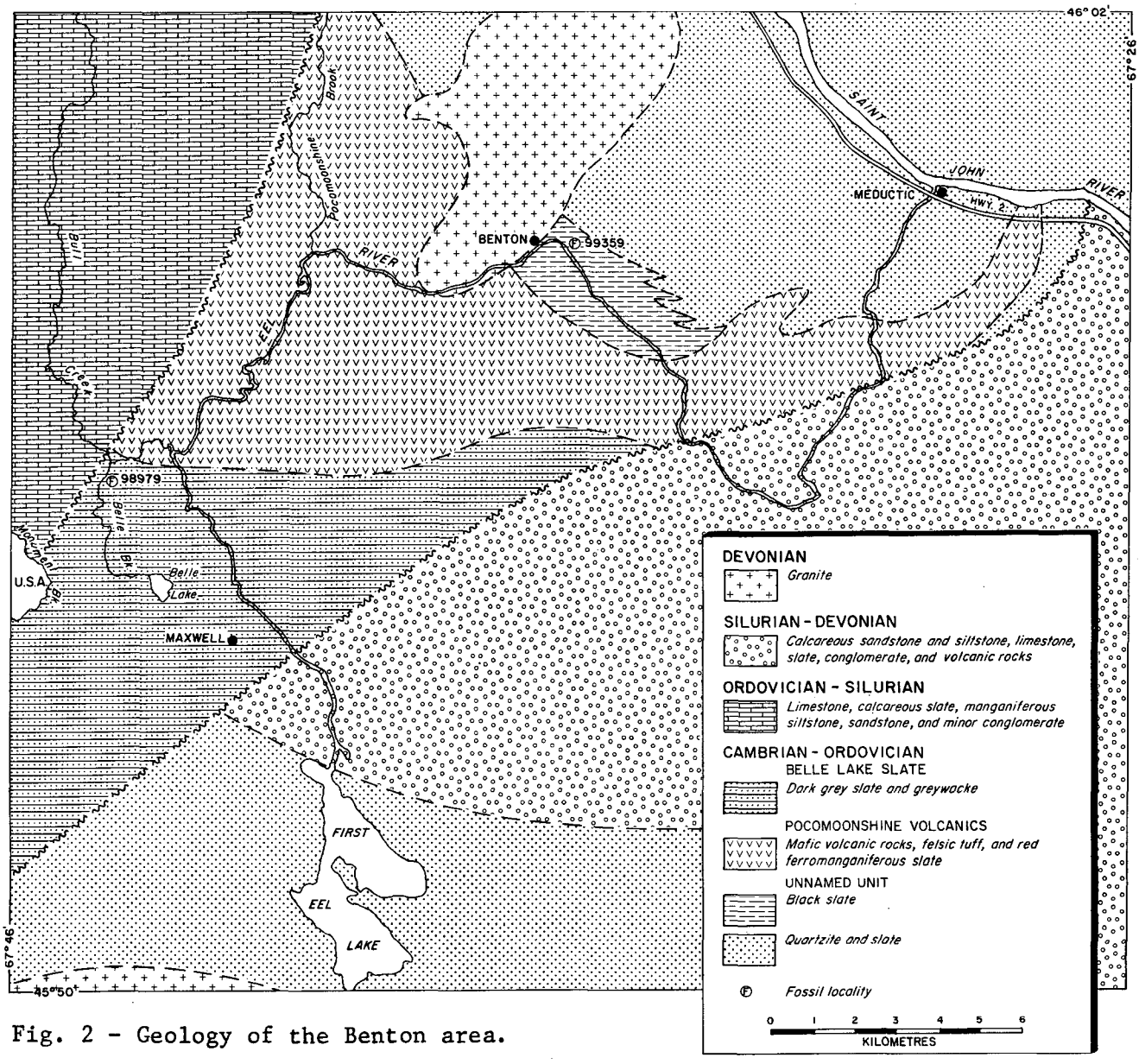

Fig. 2 - Geology of the Benton area.

stream from the bend at Benton. Forbes collected specimens near the southeast margin of a dyke located near the centre of the exposure.

The Benton collection (Geological Survey of Canada locality 99359, latitude 45°59'15"N, longitude 67°36'10W) contains the following graptolites.

Adelograptus hunnebergensis (Moberg)
Clonograptus tenellus (Linnarson)

These graptolites are restricted to the upper Tremadoc (Fig. 3) and are identical in age to those from black slate of the Cookson Formation on Cookson Island in Passamaquoddy Bay, southwestern New Brunswick (Cumming 1967).

Abundant fecal pellets referable to *Tomaculum* (Groom) are also present in the collection (Pickerill, University of New Brunswick, personal communication 1982). This trace fossil has been reported from many North American and European sequences and is commonly regarded to be indicative of Ordovician-aged strata (Häntzschel 1975).

No specimens of *Dictyonema* were found during the recent collecting. The position of Bailey's collection with respect to the above is not known, but Bailey (1901) stated that his fossil-bearing layer is no more than six inches thick and is located in the southern portion of the exposure presumably a few metres southeast of the present graptolite locality. Bailey (1901, 1903) reported that his specimens very closely resemble *Dictyonema flabelliforme* (Eichwald) which is of early Tremadocian age. Examination of Bailey's original *Dictyonema* specimens, stored in the Geology Department of the University of New Brunswick, allowed identification only at the genus level as the proximal ends were absent.

No description of the Monument Settlement site was given by Bailey. However in the same general area, Tupper (1957) showed a fossil location just downstream from the junction of Belle Brook and Bull Creek that Anderson (1968, p. 20) reported as Ordovician. The outcrop shown near the mouth of Belle Brook by Tupper could not be relocated during a visit to the area. The nearest exposure, consisting of greywacke and slate of the Belle Lake Slate, occurs on Bull Creek about 200 m northwest of Belle Brook but no fossils were found there. Graptolites were found, however, in abundance along Belle Brook about 300 m from its mouth in an outcrop on the side of a woodroad that follows the east bank of the stream.

The Belle Brook collection (Geological Survey of Canada locality 98979, latitude 45°56'15"N, longitude 67°44'10"W) from grey slate of the Belle Lake Slate contains the following species.

Climacograptus bicornis (Hall)
Orthograptus calcaratus (Lapworth)
Pseudoclimacograptus scharenbergi (Lapworth)
Climacograptus brevis brevis (Elles and Wood)
Corynoides calicularis (Hopkinson)
?Cryptograptus tricornis (Carruthers)
?Nemagraptus exilis Lapworth *in* Gurley 1896

This assemblage is common to both the *Nemagraptus gracilis* and *Diplograptus multidens* Zones, but the lack of *Dicellograpti* and *Didymograptus* together with the occurrence of *Corynoides* indicates the collection belongs to the upper *gracilis* Zone (Fig. 3).

REGIONAL CORRELATION

The relatively large number of Ordovician fossil localities now known from central New Brunswick allows comparison of widely separated stratigraphic sections in the Benton, Hayesville, Becaguimec River, and Central Waterville areas, and permits improved reconstruction of Ordovician paleogeography (Figs. 1,3).

The graptolites from the Belle Lake Slate on Belle Brook and from the unnamed unit on Eel River establish a biostratigraphic correlation with Ordovician rocks in the Hayesville area. An unfossiliferous greywacke and slate unit in the Hayesville area is virtually identical in age to the lithologically similar Belle Lake Slate since the Hayesville greywacke is underlain by a thin unit of black slate containing grapto-

lites of the *Nemagraptus gracilis* Zone (Irrinki 1980).

The black slate unit is underlain by a thin unit of red ferromanganiferous slate; these two units are intercalcated with mafic volcanics to the north (Poole 1963). Similar red slates are associated with the volcanics in the Benton area (Venugopal 1978, 1979).

The red slate in the Hayesville area lies with erosional contact upon calcareous siltstone containing thin interbeds of felsic tuff (Poole 1963, Irrinki 1980) and Arenigian brachiopods (Neuman 1968). The fossiliferous siltstone is underlain by a thick succession of quartzite and slate. To the north, the siltstone is replaced by conglomerate containing quartzite pebbles derived from the underlying quartzite-slate unit (Crouse 1981).

According to Neuman (1968), the calcareous siltstone and tuffs together with similar rocks in eastern Maine represent shallow-water shoreline deposits adjacent to volcanic islands. In contrast, the older graptolite-bearing Tremadocian black slate of the Benton area shows no evidence of contemporaneous volcanicity.

The mid-Ordovician greywacke - slate unit of the Hayesville area and Belle Lake Slate of the Benton area were deposited in deep basins by turbidity currents carrying volcanic detritus derived from erosion of the nearby volcanic islands. The paleontological evidence thus clearly demonstrates that in central New Brunswick volcanic activity began in the Arenigian, peaked in the Llanvirnian to early Caradocian, and waned in mid-Caradocian time.

A quite different mid-Ordovician stratigraphy is present on the eastern margin of the Matepedia Basin to the northwest of the Benton-Hayesville volcanic belt. In the Becaguimec area, a sequence of interbedded lithographic limestone, crystalline limestone, and black chert occurs in small inliers unconformably overlain by Upper Ordovician and Silurian conglomerates (St. Peter 1982). It is in one of these inliers exposed on the Becaguimec River that Matthew in 1879 discovered a fossil locality that yielded several small brachiopods and the mid-Ordovician trilobite *Cryptolithus* (Bailey 1886, Hamilton 1965). Plant-bearing conglomerate and monograptid-bearing siltstone reported by Bailey (1887) to unconformably overlie the Ordovician limestone along the river are actually in fault-contact with it.

Conodonts recovered from several horizons by G. Nowlan of the Geological Survey of Canada indicate that the limestone sequence extends in age from Llanvirian to early Caradocian (St. Peter 1982). Limestone was thus being deposited in the Becaguimec area during periods of extensive volcanism farther south (Fig. 3). The limestone was laid down in relatively shallow water (St. Peter 1982) possibly off the shore of a non-volcanic island.

Limestone within the Miramichi terrane near Central Waterville (Bailey 1901, 1903; Hamilton 1965; Anderson 1968; Venugopal 1979) to the northeast of Benton is Llanvirian/Llaneilian, the same age as the Becaguimec occurrences (Nowlan 1981, St. Peter 1982) but differs from it in having an abundance of interbedded greywacke containing sparse volcanic fragments. Presumably this reflects the closer proximity of the Central Waterville area to the Benton-Hayesville volcanic source area.

TECTONIC IMPLICATIONS

The regional extent of tectonic events in this part of the northern Appalachians can be ascertained by comparing the stratigraphic columns in west-central New Brunswick with those on the opposite side of the Matapedia Basin in eastern Maine, and across the Fredericton Trough in southern New Brunswick.

Pavlides (1968) and Roy and Mencher (1976) considered mid-Ordovician volcanic rocks on the western margin of, and the calcareous flyschoid rocks within the Matapedia Basin to be coeval. They interpreted deposition to be continuous within the basin from Caradocian to Early Silurian time. Rickards and Riva (1981) showed that the paleon-

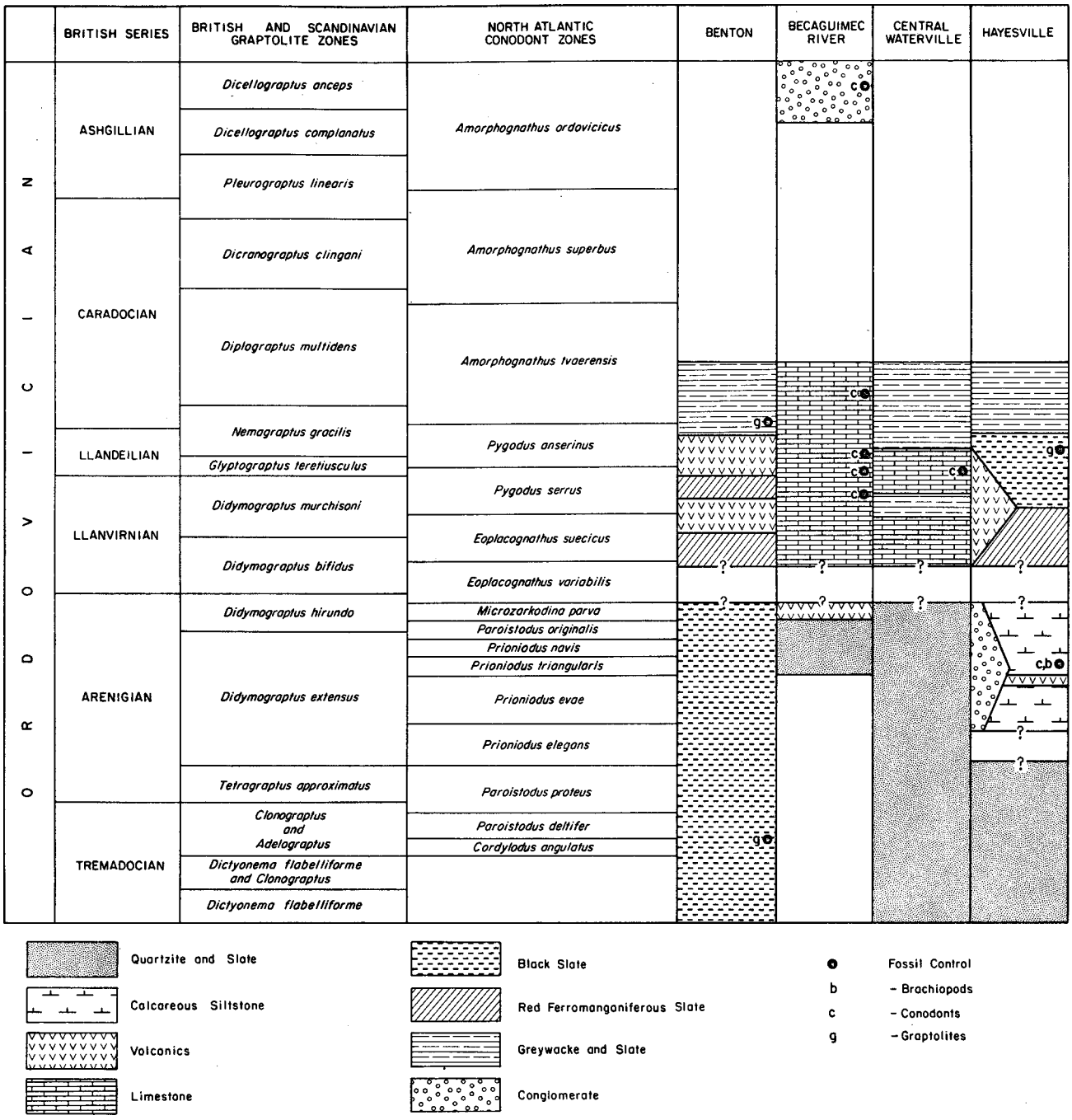

Fig. 3 - Correlation chart for the Ordovician of central New Brunswick (zones after Barnes *et al.* 1981).

tological basis for the Caradocian age of the calcareous rocks was erroneous and that they were, in fact, Early Silurian. This later conclusion is confirmed in the Becaguimec River area on the eastern margin of the basin where an unconformity separates the mid-Ordovician limestone sequence from overlying conodont-bearing late Ashgillian calcareous conglomerate representing a shallow-water facies of the calcareous flysch found farther west (St. Peter 1982).

The unconformity restricts Taconian uplift within the Matapedia Basin of west-central New Brunswick to the inter-

val following deposition of the early Caradocian limestone and their resubmergence in the late Ashgillian. This contrasts with the Late Silurian submergence of Cambro-Ordovician rocks on the northwestern margin of the Massif (Helmstaedt 1971), and Cookson Inlier (Pickerill 1976) within the Fredericton Trough (Fig. 1). However, formation of the Fredericton Trough, which contains Silurian clastic flyschoid rocks ranging in age from Llandoverian to Ludlovian along its northwestern margin (Poole 1963), evidently began about the same time as the resubmergence of the pre-Ashgillian rocks of the Matapedia Basin. The Fredericton Trough would have formed at this time by foundering of Cambro-Ordovician basement as exposed to the northwest at Benton and to the south in the Cookson Inlier. There is little evidence to support the existence of ocean crust flooring in the Trough as proposed by McKerrow and Ziegler (1971).

The presence of coeval and lithologically similar rocks possessing a similar tectonic history in the Miramichi Massif at Benton (Fyffe 1982b) and in the Cookson Inlier of southern New Brunswick (Stringer and Pajari 1982) makes it unlikely that the Fredericton Fault, which occurs along the axis of the Fredericton Trough, represents a terrane boundary as suggested by Williams and Hatcher (1982).

In the summer of 1983, graptolites were discovered in black slate underlying felsic tuff on the Trans-Canada Highway 3 km east of Meductic (G.S.C. Locality 99657). The presence of *Tetragraptus* cf. *amii* and *Didymograptus* sp. are indicative of the mid- to late Arenig and confirms that black slate of the Benton area is a facies equivalent of the calcareous siltstone of the Hayesville area as suggested in Figure 3.

ACKNOWLEDGEMENTS

We wish to thank G. Nowlan and R. Neuman for their critical reviews of the manuscript. C. St. Peter also suggested improvements to the final draft. The Geological Survey of Canada is acknowledged for its paleontological assistance. D. Blair and T. Murray typed the manuscript and R. Phillips drafted the figures.

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Reviewers: G.S. Nowlan
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