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LOWER TO MIDDLE CAMBRIAN TERRIGENOUS–CARBONATE ROCKS OF CHIMNEY ARM, CANADA BAY: LITHOSTRATIGRAPHY, PRELIMINARY BIOSTRATIGRAPHY AND REGIONAL SIGNIFICANCE

I. Knight and W.D. Boyce
Newfoundland Mapping Section

INTRODUCTION

Significant new Middle Cambrian trilobite faunas were discovered in the Hawke Bay Formation along Chimney Arm, Canada Bay (Figures 1 and 2). Possible *Albertella* Zone and definite *Glossopleura* Zone trilobites occur in a mixed carbonate–terrigenous sequence (Figures 3 and 4), 90 m thick, in the upper part of the Hawke Bay Formation, called here the Bridge Cove member.

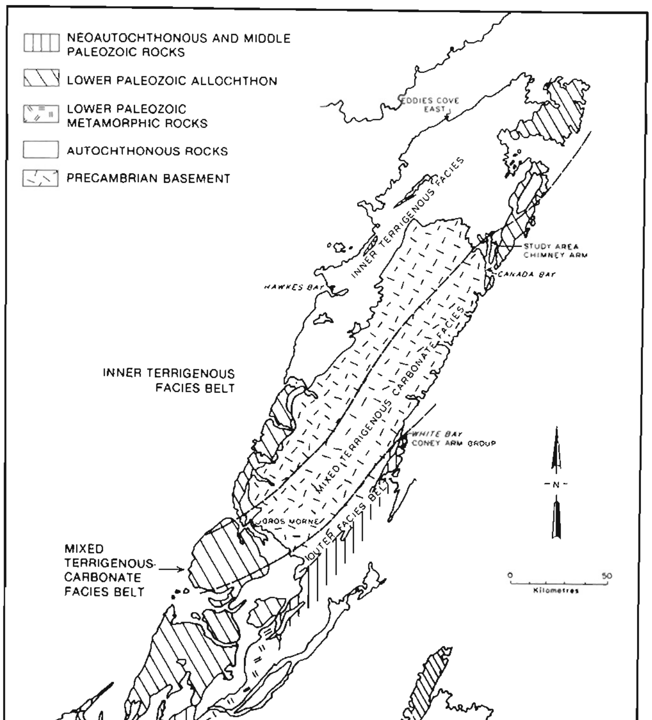

Figure 1: *Location map of the Chimney Arm section and other Lower to Middle Cambrian sections in western Newfoundland. Speculative lithofacies belts for lower Middle Cambrian rocks are also shown.*

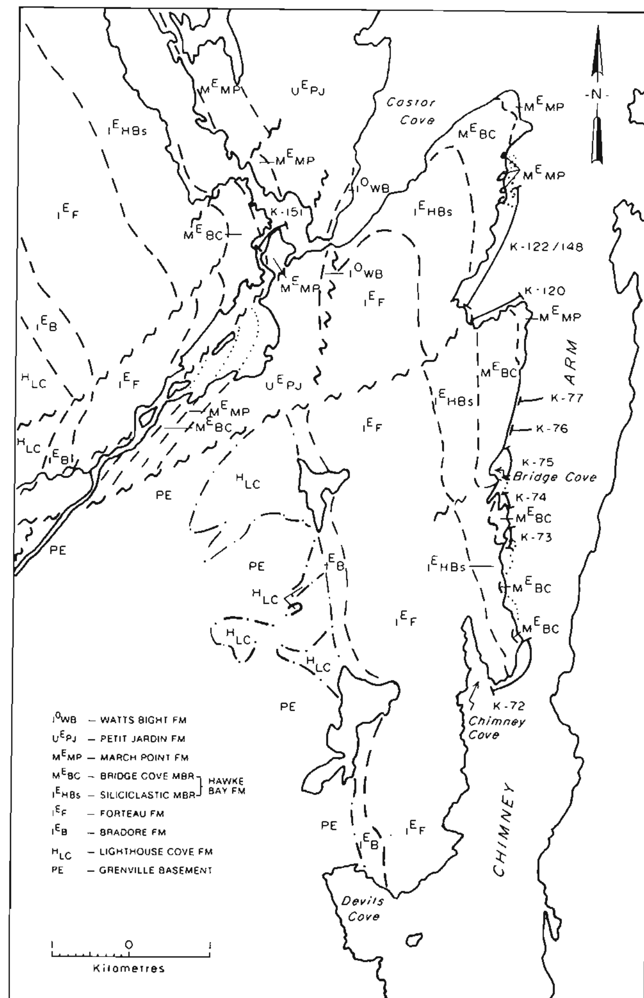

Figure 2: *Geology map of Chimney Arm and location of sections shown in Figure 3.*

LITHOSTRATIGRAPHY

Lithofacies in the Bridge Cove member are arranged in four clastic–carbonate cycles, 17 to 40 m thick (small 'grand

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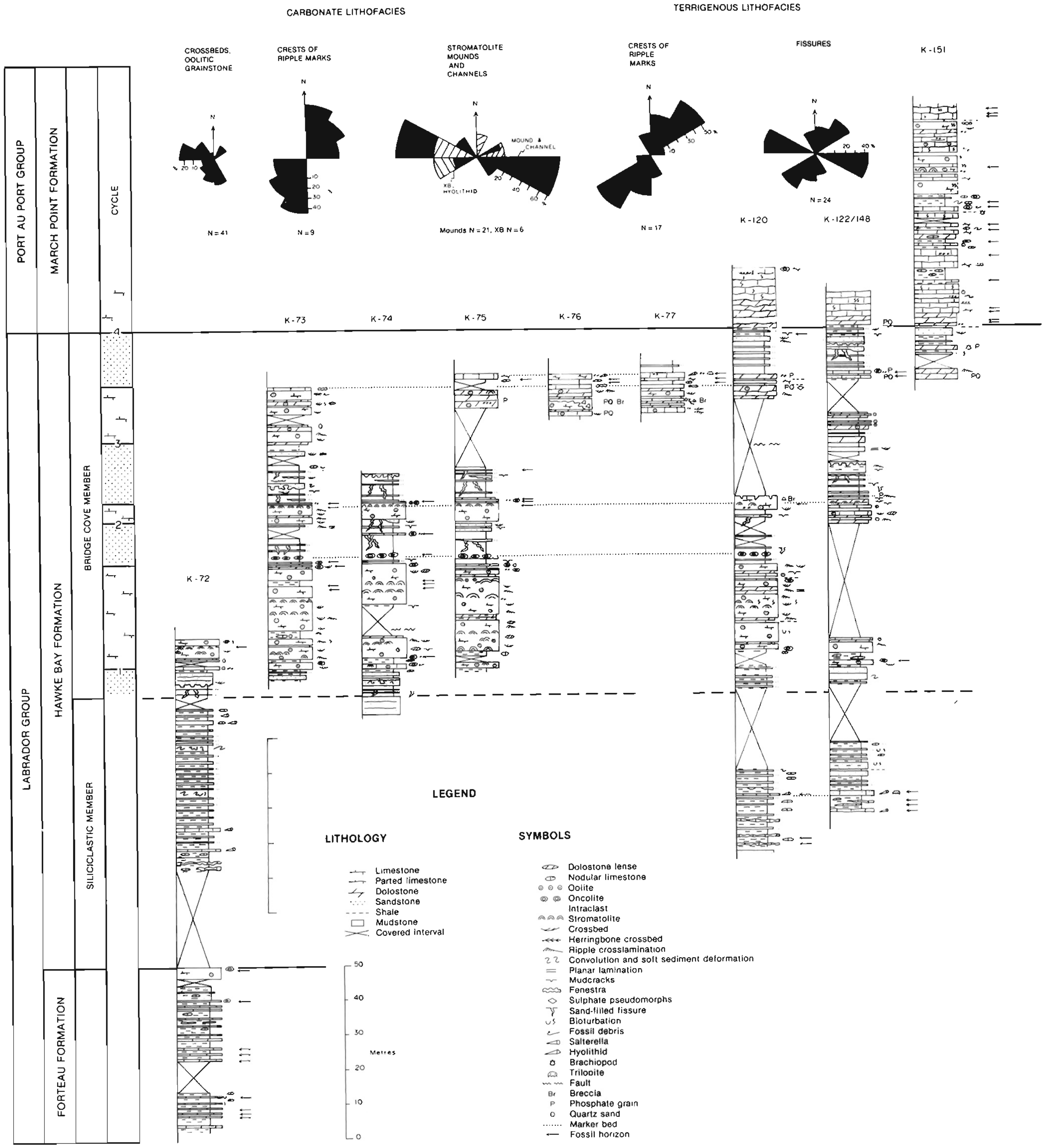

Figure 3: *Lithostratigraphy of Lower to Middle Cambrian rocks of Chimney Arm, Canada Bay. Paleocurrents for carbonate and terrigenous lithofacies, and orientation of sandstone-filled fissures are also shown.*

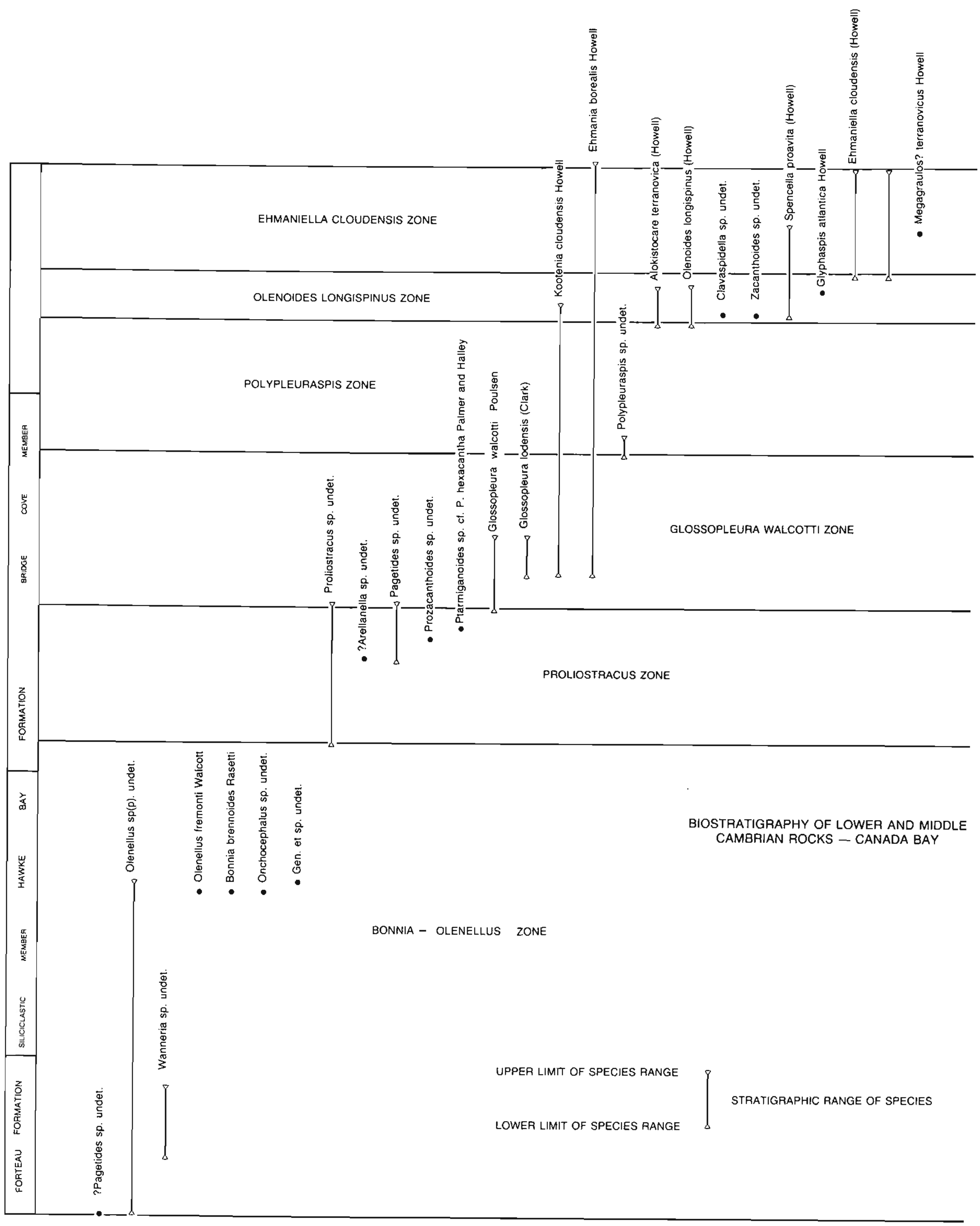

Figure 4: *Trilobite ranges and preliminary biostratigraphy of the Lower and Middle Cambrian rocks of Chimney Arm, Canada Bay. Vertical scale is the same as for Figure 3.*

cycles'; Aitken, 1966, 1981). Lower terrigenous half cycles are composed of mudstone and interbedded sandstone. They are overlain abruptly by upper carbonate half cycles comprising mostly oolitic lime grainstone (Figure 3). Some limestone beds are interbedded at the base of the terrigenous half cycles. Carbonate lithofacies are dominated by cross-bedded oolitic grainstone containing stromatolite mounds and dololaminite lenses and interbeds. Westward-directed paleocurrents dominate in the grainstones and mounds (Figure 3). Intraclastic rudstone, oncolitic rudstone, hyolithid-bearing grainstone and parted limestone are less common lithofacies. Sandy dolostone that contains intraclastic rip-ups and sand–pebble-size quartz and phosphate grains are associated with paleokarst breccias and rillenkarren at the top of the higher carbonate half cycles. Terrigenous lithofacies comprise mostly fossiliferous mudstone, and mudstone exhibiting mudcracks, lenticular and thin bedded sandstone, and sand-filled fissures. Subordinate sheet and channel-bound sandstone is interbedded in the terrigenous half cycles with flaser-bedded sandstone, shale, and laminated and cross-bedded quartz arenite.

The cycles reflect the interplay of dominantly intertidal, high-energy, oolitic lime-sand complexes, behind which subtidal and intertidal muds accumulated. The complexes were later blanketed by sand sheets and crossed by sandy gullies. The oolitic lime-sand complexes were fashioned by westward onshore paleoflow. The complexes became emergent with time and were extensively modified by the development of paleokarst.

The Bridge Cove member of the Hawke Bay Formation overlies shallow shelf and shoreline sedimentary rocks of the Forteau Formation and the lower siliciclastic member of the Hawke Bay Formation (Figure 3). Only the upper 48 m of the Forteau Formation was measured. The section comprises cleaved black shale containing thin limestone interbeds, oncolitic–oolitic lime grainstone, interbedded calcareous siltstone and shale, and rare, very fine grained quartz arenite. The overlying lower siliciclastic member of the Hawke Bay Formation is 85 m thick. It consists of regularly interbedded, rusty-weathering, cleaved gray shale, and brown-weathering, very fine grained quartzose sandstone to coarse grained siltstone. Gray, fine grained limestone occurs as diffuse lumps, discontinuous layers and beds. *Salterella*-bearing lime grainstone and rare beds of intraclastic–oncolitic rudstone are also present.

The Bridge Cove member of the Hawke Bay Formation is overlain by shallow subtidal to intertidal dolostone, limestone and shale of the March Point Formation. The March Point Formation, which was only studied in one incomplete, 75-m-thick section at Cloud Rapids, conformably overlies the Bridge Cove member. The formation comprises wavy bedded parted dolostone and limestone, bioturbated dolomitic limestone, oolitic limestone with minor associated stromatolite, minor skeletal–oncolitic rudstone, fenestral limestone, and shale and mudstone.

BIOSTRATIGRAPHY

More than twenty trilobite species are present throughout the section, twice the number known previously (Howell, 1943). Species of *Onchocephalus, Proliostracus, ?Arellanella, Pagetides, Prozacanthoides, Ptarmiganoides, Glossopleura, Polypleuraspis, Clavaspidella* and *Zacanthoides* are recorded from the Cambrian platformal sequence in western Newfoundland for the first time. Several of the species originally described from the area by Howell (1943) are assigned to different genera.

Six preliminary, trilobite-range zones are proposed in the Forteau, Hawke Bay and March Point formations. These are based on 92 collections, representing at least 68 horizons. Each zone is named for its most common and/or distinctive genus–species. The base of each zone is defined by the first appearance of the nominate genus–species. The top of each zone is defined by the base of the succeeding zone, following Grant (1962), Stitt (1971), Murphy (1977), Johnson (1979) and Ludvigsen *et al.* (1986). The zones, in ascending order, are as follows: *Bonnia–Olenellus, Proliostracus, Glossopleura walcotti, Polypleuraspis, Olenoides longispinus* and *Ehmaniella cloudensis*. The stratigraphic ranges of the trilobite species of each zone are shown in Figure 4.

The Canada Bay trilobite zones are based upon restricted-shelf polymeroid trilobites. These zones are locally more useful than the Middle Cambrian restricted-shelf zones of Robison (1976), with which they are compared (Figure 5). The *Bonnia–Olenellus* Zone correlates with the late Early Cambrian *Bonnia–Olenellus* Zone of Rasetti (1951) and Fritz (1972). The *Proliostracus* Zone is post-*Bonnia–Olenellus* Zone age and pre-*Glossopleura* Zone age. The *Proliostracus* Zone may correlate in part with the Middle Cambrian *Albertella* Zone of Rasetti (1951) and Robison (1976). The *Glossopleura walcotti* Zone and the *Polypleuraspis* Zone correlate with the Middle Cambrian *Glossopleura* Zone of Rasetti (1951) and Robison (1976). The *Olenoides longispinus* Zone and the *Ehmaniella cloudensis* Zone correlate with the *Bathyuriscus–Elrathina* Zone of Rasetti (1951) and the *Ehmaniella* Zone of Robison (1976).

Rocks of the Forteau Formation and the lower siliciclastic member of the Hawke Bay Formation occur in the *Bonnia–Olenellus* Zone. The Bridge Cove member of the Hawke Bay Formation spans the *Proliostracus, Glossopleura walcotti* and lower *Polypleuraspis* Zones. The March Point Formation contains the upper *Polypleuraspis, Olenoides longispinus* and *Ehmaniella cloudensis* Zones. Comparison of trilobites collected from Eddies Cove East (Boyce, 1977), Port au Port (Palmer and James, 1980) and Chimney Arm suggest that the base of the March Point Formation in western Newfoundland is probably diachronous.

For the most part the trilobite faunas of the zones above are of low diversity and are individual-rich, indicative of restricted marine conditions. However, the high-diversity fauna of the *Olenoides longispinus* Zone implies more open marine conditions, suggesting a time of elevated sea level during deposition of the lower part of the March Point Formation.

REGIONAL SIGNIFICANCE

The lithostratigraphy and biostratigraphy at Chimney Arm together provide a better understanding of the nature and extent of the regressive Hawke Bay Event (Palmer and

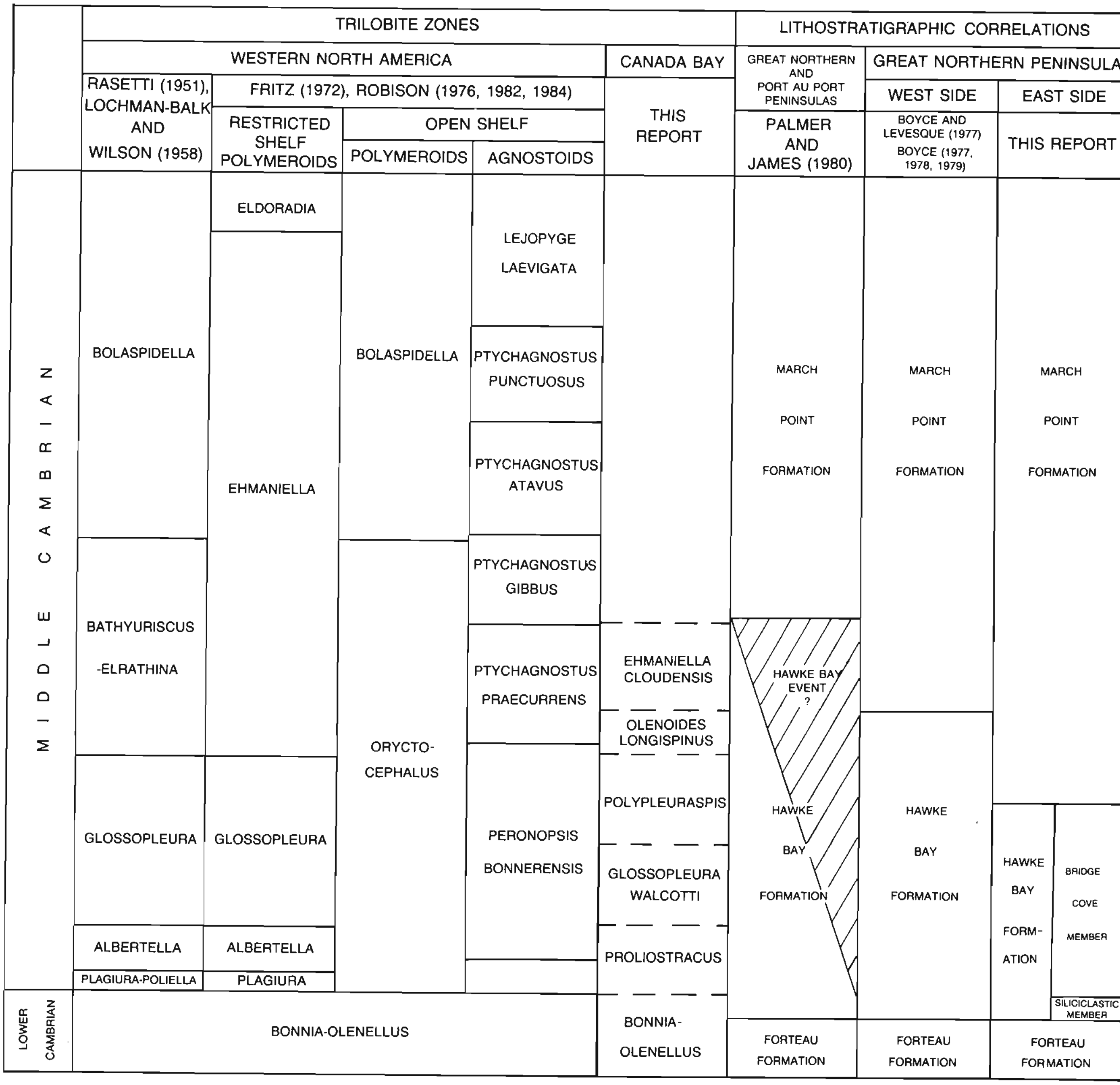

Figure 5: *Revised correlation of western Newfoundland Lower and Middle Cambrian biostratigraphic and lithostratigraphic units with standard trilobite zones of western North America. Trilobite zones of Robison (1976) have been modified to eliminate barren interzones. Lined, triangular area indicates possible faunal gap and extent of the regressive Hawke Bay Event proposed by Palmer and James (1980).*

James, 1980) (Figure 5) than was previously available. They suggest that marine sedimentation was probably continuous across the Lower–Middle Cambrian boundary

The lower siliciclastic member of the Hawke Bay Formation at Chimney Arm correlates with the lower part of the Hawke Bay Formation at its type section at Hawke Bay (Figure 1; 5). The upper part of the type section (equivalent to the Bridge Cove member) is composed essentially of quartz arenite and lacks fossils (Knight, 1977). The early Middle Cambrian shelf was a ramp that consisted of northeast-trending facies belts: an extensive, western, inner terrigenous belt; a narrow, middle, mixed terrigenous–carbonate belt; and an eastern outer belt of deeper water shale and ribbon limestone (Figure 1).

The lithostratigraphy and biostratigraphy of the middle mixed belt suggests that the 'grand cycles' reflect deposition during prolonged sea-level rise. This implies that the influx of large volumes of siliciclastic sand onto the shelf (inner terrigenous belt) was controlled by uplift of the craton and not by eustatic sea-level fall. Early Cambrian intrusive rocks lie unconformably beneath Ordovician carbonates in the Grenville Province (Higgins and Doig, 1981; Higgins, 1982).

This suggests that uplift and erosion of crystalline rocks of the Grenville Province occurred prior to the Ordovician. It is also probable that some of the sandstones of the inner terrigenous belt are fluvial deposits rather than exclusively marine tidalites as suggested previously (Knight, 1977).

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