3. STRATIGRAPHY AND TECTONO-DEPOSITIONAL RELATIONSHIPS OF THE PROTEROZOIC ROCKS OF THE HADLEY BAY AREA, NORTHERN VICTORIA ISLAND, DISTRICT OF FRANKLIN

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Abstract

Proterozoic sedimentation in the northernmost part of the Kilohigok Basin commenced with deposition of shallow marine to nonmarine quartzose clastics of the Hadley Formation in depressions on dissected Archean(?) basement. Fine grained sandstones then accumulated on a periodically-exposed shelf. As terrigenous sedimentation diminished, clastic and stromatolitic carbonates spread across the slowly subsiding basin. Intertidal to shallow subtidal bioherms developed in the northeastern part of the area, while calcareous siltstones were deposited in the southwest. Renewed uplift in the source areas supplied fine grained sands and silts to the again periodically emergent shelf, and their deposition continued until the end of Hadley Formation sedimentation.

Syndepositional faults and regional tilting supplied large volumes of coarse debris to northerly- and northwesterly-flowing fluvial systems. Unsorted conglomerates were deposited close to active faults, while better-sorted congomerates and trough crossbedded sands were deposited in the more distal regions.

Subsequent subsidence of the entire area, coupled with reactivated uplift in the southerly and easterly source areas, caused marine sands to spread over the shallow shelf. These were dispersed by large sand waves which produced the very large scale trough crossbeds characteristic of this unit.

Gentle tilting and regional peneplanation followed, and led to the deposition of fine reddish sands, muds, and coarse white quartzites of the Glenelg(?) Formation.

Paleocurrent and facies analyses of the Hadley Formation, together with data from the Eastern Platform of the Kilohigok Basin to the south, indicate that an east-west trending aulacogen off the Wopmay Orogen was present in the Coronation Gulf area during deposition of the sediments of the Kilohigok Basin.

Introduction

Precambrian rocks of the Hadley Bay area (Fig. 3.1) were initially mapped by Thorsteinsson and Tozer (1962). They identified an older sequence of rocks which they interpreted to be intruded by a granodiorite (dated at 2405 Ma, K-Ar) because of supposedly metamorphic muscovite in the sediments. Dixon (1979) interpreted the muscovite as detrital, and suggested that these sediments were early Proterozoic. During mapping of the Hadley Bay area in 1980, Dixon's interpretation was confirmed. Detrital muscovite is abundant throughout the lower part of the succession, and there is no indication of either regional or contact metamorphism.

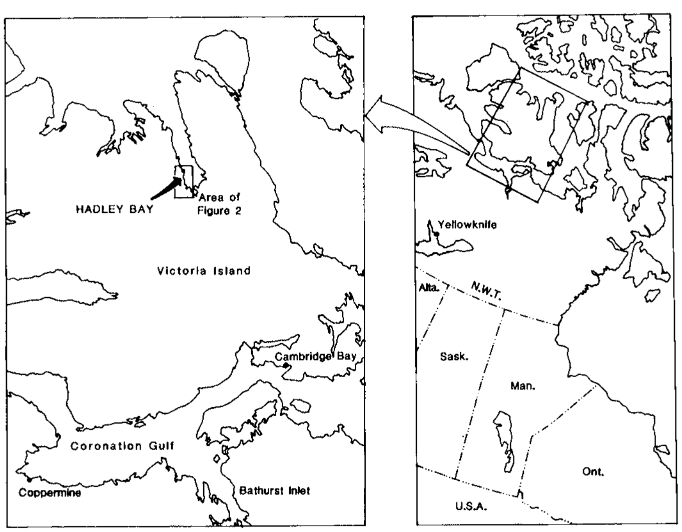


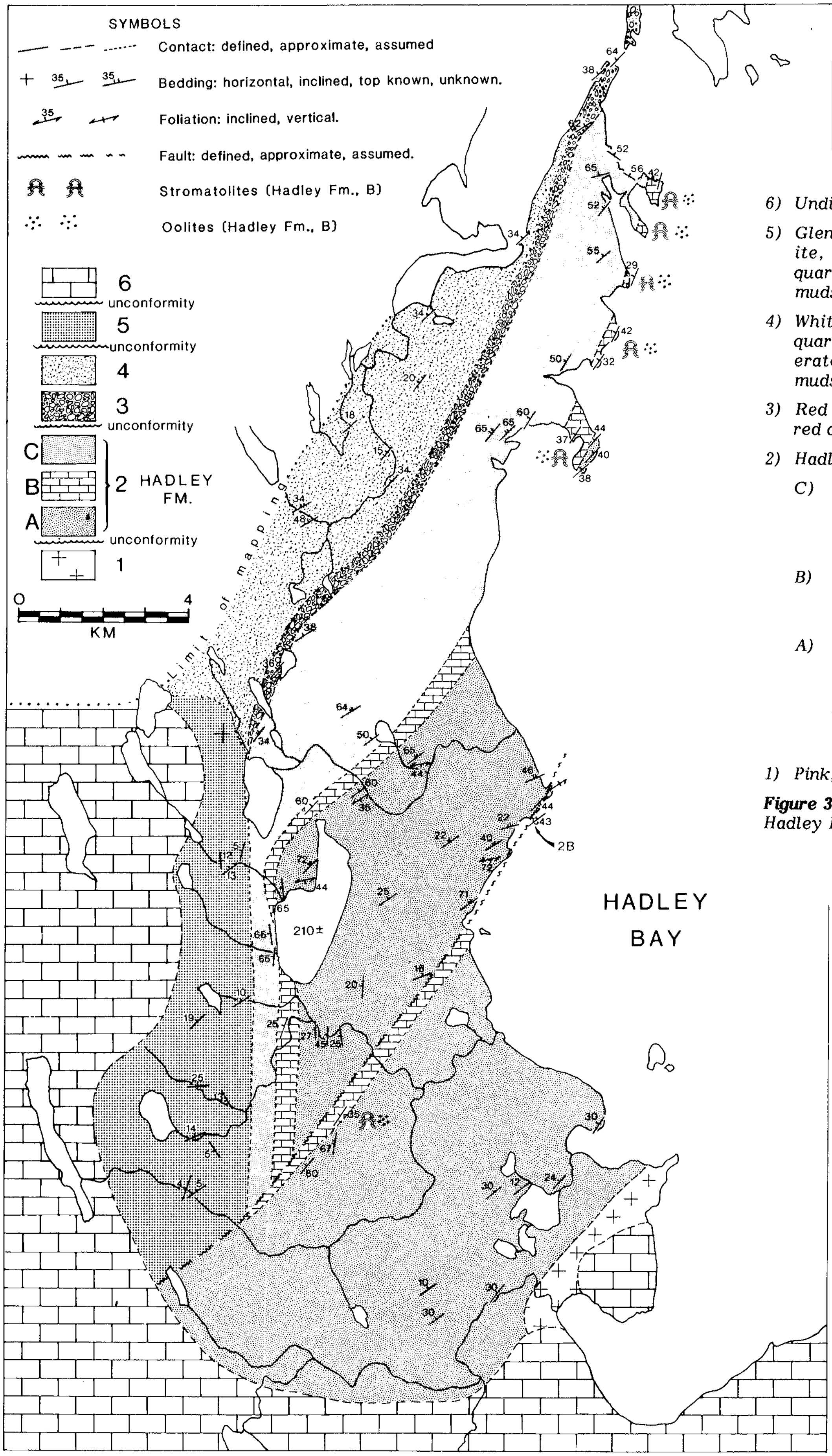
Figure 3.1. *Location map of the area, showing the location of Victoria Island in the northwestern Canadian Shield and the position of Hadley Bay on Victoria Island.*

The stratigraphy of the Proterozoic sediments in the Hadley Bay area has been considerably revised (Fig. 3.2; Table 3.1). Four unconformities are now recognized, separating three distinct successions from one another, and from underlying basement and overlying Paleozoic units. Due to a paucity of topographic names, none of the individual mappable units is formally named, although all merit at least member if not formation status. The lowermost group of three units is here named the Hadley Formation, as all contained units merit at least member rank.

The various rock units of the area are described in ascending stratigraphic order below.

Unit 1

This unit outcrops at the southwestern end of Hadley Bay, and on a small island offshore (Thorsteinsson and Tozer, 1962). It consists of massive, coarse grained, pink granodiorite locally with xenoliths of fine grained micaceous metasediments(?). The contact with the overlying Proterozoic sediments was not observed during the course of mapping. The closest sediments (Fig. 3.2) show no evidence of deformation or metamorphism, nor do they contain clasts which can be identified as having been derived from the granodiorite.



6) *Undifferentiated Paleozoic rocks.*

5) *Glenelg(?) Formation: white quartzite, pink to red fine grained quartzite; minor siltstone and mudstone.*

4) *White, massive, coarse grained quartzite; minor pebble conglomerate and red quartzite or mudstone near the base.*

3) *Red boulder conglomerate; minor red quartzite.*

2) *Hadley Formation:*

   C) *Red and grey quartzite and immature sandstone; siltstone and minor mudstone; rare conglomerate.*

   B) *Doloarenite, stromatolitic dolomite, oolite; grey-green siltstone.*

   A) *White quartzite; red quartzite and siltstone; rare quartz-pebble conglomerate; minor grey immature sandstone and mudstone; micaceous sandstone.*

1) *Pink, coarse grained granodiorite.*

Figure 3.2. *Geological map of the Hadley Bay area.*

Table 3.1

	Hadley Bay Area	Possibly Correlative Unit
	Undifferentiated Paleozoic	Undifferentiated Paleozoic
	----unconformity----	----unconformity----
PROTEROZOIC	Unit 5	Glenelg Formation (Shaler Group)
PROTEROZOIC	----unconformity----	----unconformity----
PROTEROZOIC	Units 3 and 4	Ellice Formation
PROTEROZOIC	----unconformity----	----unconformity----
PROTEROZOIC	Hadley Formation	Western River Formation (Goulburn Group)
	----unconformity----	----unconformity----
	Granodiorite (Archean ? basement)	Archean basement

Hadley Formation (Unit 2)

The Hadley Formation consists of at least three units of member rank, here informally termed the lower (A), middle (B), and upper (C) (see Table 3.1 and Fig. 3.2). All form extensive mappable units throughout the southern part of the area, and extend for unknown distances on small islands to the northeast.

Lower Member (A)

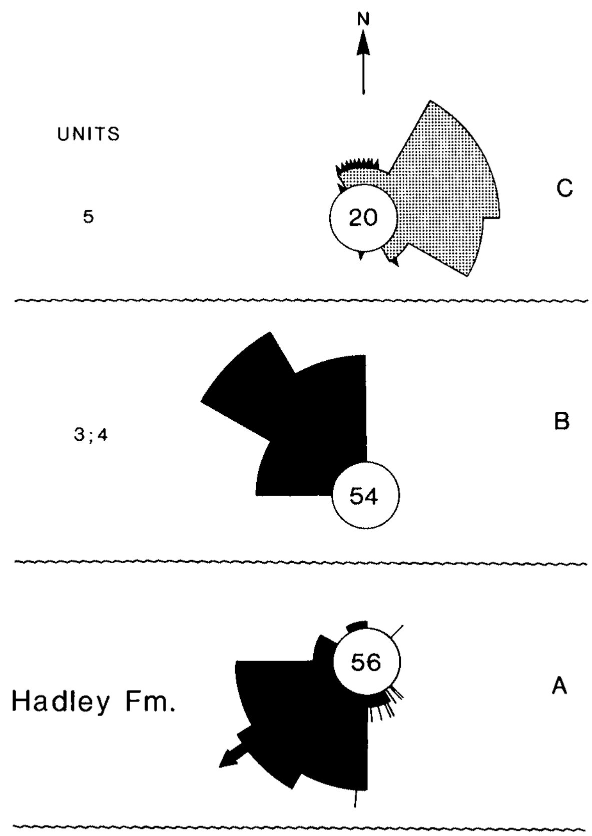
The lowermost member in the Hadley Formation consists of trough crossbedded white, pink, and light grey quartzite near the base, with increasing amounts of red to reddish grey fine grained sandstone toward the top. White quartzite in the lower part of this member contains rare thin beds of quartz-pebble conglomerate, with individual clasts up to 4 cm. Planar crossbedded quartzose doloarenite with small quartz pebbles is also rarely intercalated with this part of the member. The lowermost exposed section of the member is in a creekbed approximately 1 km from the closest exposure of the "basement" granodiorite. There, the sediments consists of medium to coarse grained, locally pebbly, trough crossbedded quartzite. Quartz pebbles are the predominant large clasts. The troughs are typically 1.5-2.0 m wide, up to 0.75 m deep, and are not part of fining-upward cycles. Paleocurrent data from these troughs and others in the Hadley Formation show the dominant transport direction was to the southwest (Fig. 3.3A).

Upward in this member, particularly near the contact with the Middle member (B), the sediments are much finer grained, less quartzose, and show little if any crossbedding. Immediately below the middle member, fine grained, dark grey-red sandstones and siltstones show abundant desiccation cracks. These generally overlie massive, red, fine grained sandstones and mudstones.

Where exposed, the contact with the overlying Middle member is sharp and conformable, with no apparent interbedding of lithologies.

Middle Member (B)

This unit, which outcrops sporadically throughout the area (Fig. 3.2), forms the only marker unit in the Hadley Formation. It consists of clastic, stromatolitic, and oolitic carbonate intimately interstratified with grey-green calcareous siltstones and mudstones. The stromatolitic and oolitic carbonates are abundant in the northern part of the area, while the siltstones and mudstones are dominant in the laterally equivalent part of the member in the south.



A) *Trough crossbeds from the Hadley Formation. The solid arrow to the southwest shows the orientation of the elongate asymmetric stromatolites of the B member. The short lines show individual current ripple directions.*

B) *Trough crossbeds from units 3 and 4.*

C) *Current ripples from unit 5. The arrowheads are individual trough crossbeds from this same unit.*

Figure 3.3. *Paleocurrent roses from various units in the area. The number of readings is as shown, and the diameter of the centre circle is 20 per cent.*

The stromatolites characteristic of this member are nearly continuous throughout the northern part of the area, where they are particularly well displayed in shoreline exposures. The stromatolites, however, occur only rarely in the southern part of the area, south of the major fault (Fig. 3.2). Small to large (0.5-3.0 m) bioherms of pseudo-columnar stromatolites show little evidence of well developed lateral linkage. Both the individual columns and the bioherms themselves are strongly elongated northeast-southwest, and the bioherms are locally inclined to the southwest (Fig. 3.4). The bioherms are separated by channels filled with calcareous siltstone and bioclastic debris presumably derived from the flanks of the bioherms.

Oolite beds up to 1.5 m thick are locally common in the member, particularly where the stromatolites are well developed. They typically over-and underlie the stromatolites. At one locality, a thin (5 cm) stromatolite bed is contained entirely within an oolite bed. The oolites apparently pinch out to the southwest in the semi-continuous section north of the major fault (Fig. 3.2), but are present in the member south of this fault (Fig. 3.2).

Both the oolites and stromatolites appear to increase in number, and the stromatolites in size, to the northeast, suggesting that the paleoslope was to the southwest.

Upper Member (C)

Red, fine grained sandstone and minor siltstone predominate throughout this unit, which conformably overlies the stromatolitic and oolitic carbonate and siltstone at all localities. Sedimentary structures, other than well developed shaly rip-ups, mud-chip conglomerates, and poorly to well developed shaly rip-ups, mud-chip conglomerates, and poorly to well preserved planar crossbedding are rare. Desiccation cracks, however, are common in the lower part of the member.

Typically, the beds in this member are less than 40 cm thick, show no internal grading, and are rarely capped by thin films of shale or mudstone. Some sequences, particularly in the centre of the member, show well developed planar crossbedding which is commonly only identifiable on subvertical joint surfaces. The top of this member, and the whole Hadley Formation, is defined as the base of the characteristic boulder and cobble conglomerate which unconformably overlies the member at all exposed localities.

Unit 3

Cobble and boulder conglomerate, locally interstratified with red coarse grained grit and pebbly sandstone, comprise this unit. The base of the unit rests unconformably on the top of the upper member of the Hadley Formation, and the contact is exposed only in the northern part of the area (Fig. 3.2) at the northeastern tip of the peninsula. Although bedding is obscure in the conglomerate, there is an apparent angular discordance of up to 30° between it and the underlying rocks of the Hadley Formation. This apparent variation in attitude is also maintained on a regional scale (Fig. 3.2), although dips are very similar at some localities.

The conglomerate consists predominantly of boulders of red and grey quartzite, and lithologies typical of underlying

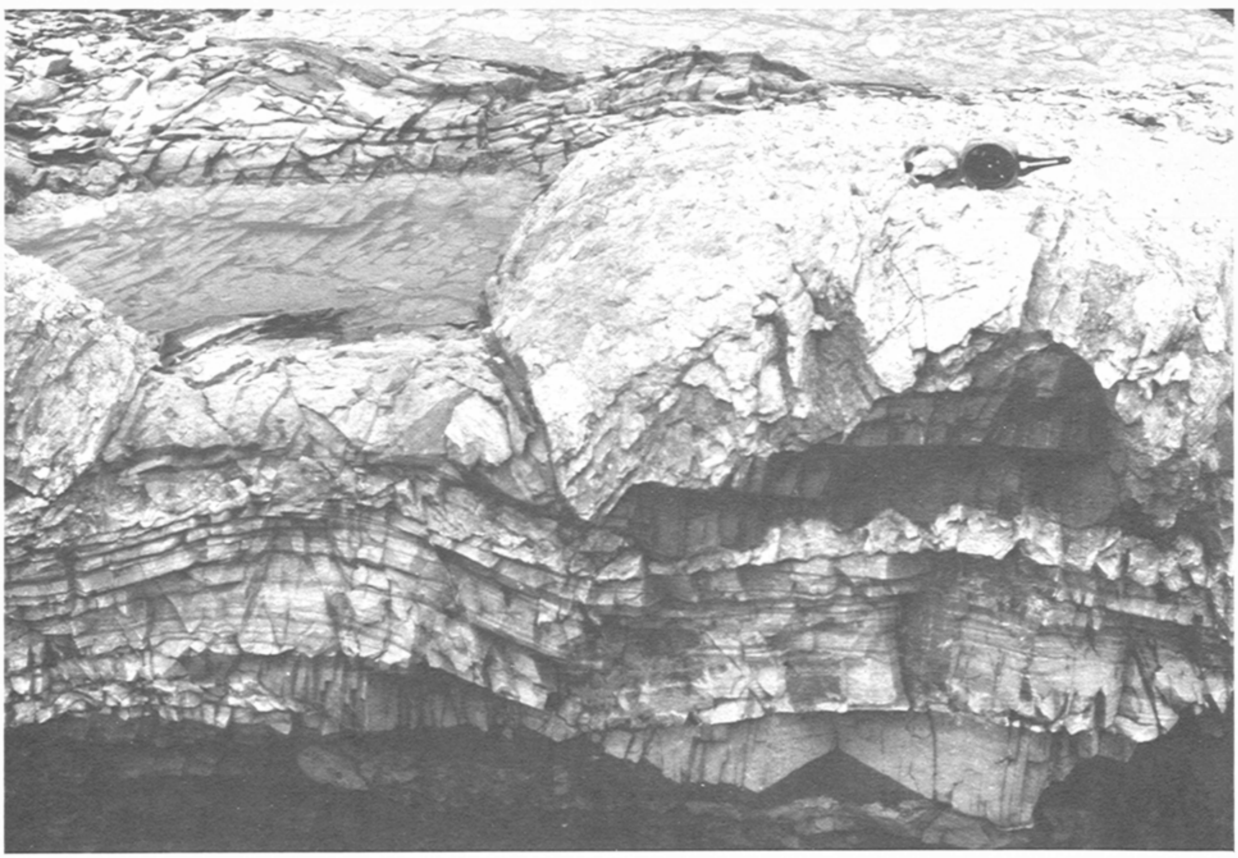


Figure 3.4. *Small stromatolite bioherms from the B member of the Hadley Formation. The bioherms are separated by calcareous grey-green siltstone, and rest on fine grained doloarenite and siltstone. (GSC 203062-K)*

Figure 3.5. Very large-scale trough crossbeds from unit 4, in the northwestern part of the area. Figure 3.6 is from this same exposure, at the left margin of this figure. (GSC 203062-P)

units. No carbonate clasts were noted. Clasts near the base of the unit are relatively angular, but become well rounded within 2 m of the basal contact. The majority of the clasts is less than 30 cm in longest exposed dimension, but clasts up to 50 cm occur locally. There is no apparent change in the clast dimensions from the northeastern to the southwestern part of the unit.

Many of the quartzite clasts contain thin veinlets of quartz which are terminated at the clast margins, indicating that the veining occurred prior to their incorporation in the conglomerate. Clasts of pure quartz, however, are rare, suggesting that the veining was minor and possibly local.

In the northern part of the conglomerate, trough cross-bedded pebbly grit and coarse sandstone in thin (0.75 m) fining-upward cycles directly overlie and are locally interstratified with, the uppermost part of the basal conglomerate. Large boulders which typically occupy the lower parts of these cycles are locally abundant, angular, and up to 45 cm in exposed dimension. Limited paleocurrent data from this part of the unit suggest transport to the west and northwest (Fig. 3.3B).

The top of unit 3 is defined as the first appearance of massive, trough crossbedded quartzite, conformably overlying the conglomerate, red grit and coarse sandstone.

Unit 4

Massive, very large-scale trough crossbedded white quartzite with minor pebble conglomerate and rare red quartzite or mudstone near the base characterize this unit at all localities. It conformably overlies the basal conglomerate (Unit 3) everywhere.

Trough crossbeds of this unit are extremely large – up to 25 m wide and over 4 m deep (Fig. 3.5). Although the succession dips at approximately 30°, measured downcutting of individual troughs is commonly 3 m, and may exceed 5 m in some cases. At most localities the troughs are so large that they cannot be identified on a single exposure, and are inferred from the variable dips within the area. The troughs typically have curviplanar bases, and the filling consists of regularly arranged (10-25 cm) beds of uniform thickness which mimic the contour of the lowermost bounding surface of the trough (Fig. 3.6). There is no apparent change in grain size within the troughs from the base to the top, and no pebble concentrations were noted.

There is no variation in the character of this unit from the base to the top, but the contact with the overlying sequence is not exposed in the area examined, and an unconformity is inferred from variations in lithology and bedding attitudes.

Paleocurrent data from the troughs indicate that transport was strongly unimodal to the northwest (Fig. 3.3C).

Unit 5 (Glenelg(?) Formation)

White, pink to red, fine grained thin bedded quartzite, minor reddish siltstone and mudstone apparently unconformably overlie the white quartzites of Unit 4 in the southwestern part of the area (Fig. 3.2). In turn, these rocks are unconformably overlain by red shaly mudstones, shales, and limestones which form the basal Paleozoic strata in the area (Thorsteinsson and Tozer, 1962).

Figure 3.6. *Detail of intersecting bedding planes from the outcrop in Figure 3.5. The Brunton compass for scale is in the centre right of the photograph. (GSC 203062-O)*

Descriptions of the Glenelg Formation (Thorsteinsson and Tozer, 1962; Young and Jefferson, 1975), together with the stratigraphic succession and various unconformities within the rocks of the area, strongly suggest that these rocks are the basal equivalents of the Glenelg to the northwest.

The quartzites of this unit are thin- to medium-bedded (10-30 cm) throughout the area. However, generally more massive, coarse grained white quartzites commonly occur in beds to 65 cm thick in the upper part of the sequence. Sedimentary structures present in the unit include trough and planar crossbeds, oscillation and current ripples, and rare desiccation cracks. Paleocurrent data from the unit suggest transport to the northeast (Fig. 3.3C).

Interpretation

Hadley Formation

Lithologies and contained sedimentary structures in the formation suggest that the Hadley Formation was deposited in a fluvial to shallow marine environment, on a periodically-exposed, relatively stable shelf.

Paleocurrent data (Fig. 3.3A), together with stromatolite elongations and asymmetry indicate that the southwest-dipping shelf was continuously supplied with terrigenous detritus from rising source areas to the north and northeast. Following the initial transgression, and infilling of the paleotopographic depressions with coarse clastics of the lower member (A), shallow subtidal to intertidal muds, silts, and fine sands of the upper part of this same member were deposited. With decreasing terrigenous sediment supply and periodic emergence, carbonate sedimentation commenced with the gradual accumulation of shallow, possibly intertidal stromatolite banks and subtidal oolite shoals. The northeast-to-southwest pinching out of the stromatolites, together with the increasing amount of possibly resedimented carbonate detritus, suggests that the carbonate platform deepened to the southwest.

With renewed uplift in the source areas, and a consequent increase in terrigenous clastics, the carbonate shelf was rapidly buried beneath a sandy intertidal delta complex.

Units 3 and 4

Following uplift and erosion, a coarse basal conglomerate was deposited during renewed transgression of the underlying succession. As the paleotopography was rapidly buried, rising source areas in the southeast(?) supplied large volumes of quartz sand to the stable shelf. The sands were dispersed across the shallow(?) shelf bay, large marine sand waves, which constructed the trough crossbeds typical of Unit 4.

Unit 5

Following a second period of uplift and erosion, the shallow marine sands of the Glenelg(?) Formation were deposited on the relatively flat surface of the underlying successions.

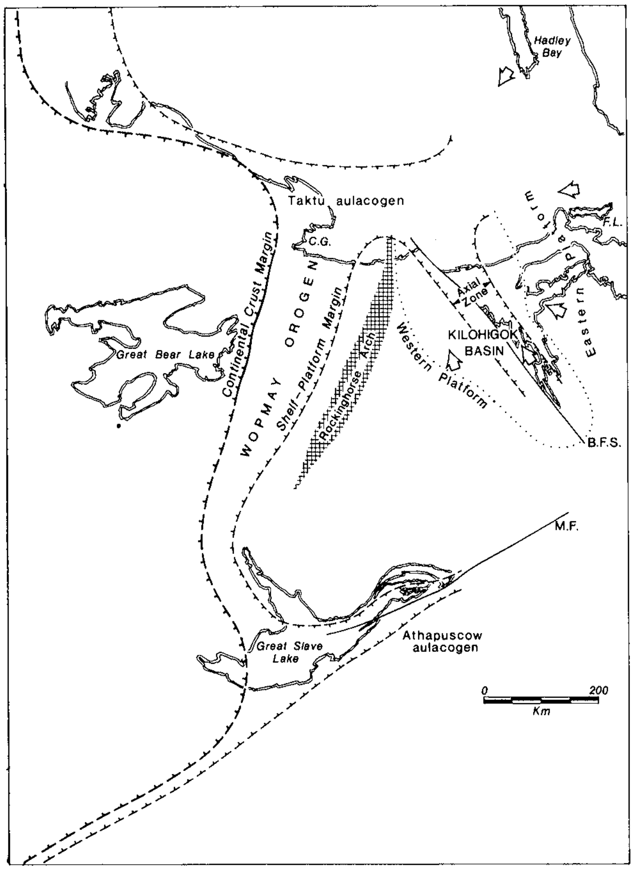


Figure 3.7. *Interpreted tectonic relationships between the Wopmay Orogen, Taktu aulacogen, Athapuscow aulacogen, and the various elements of the Kilohigok Basin. The Bathurst Fault System is shown as restored to its original position. The open arrows show the regional paleocurrent pattern derived from rose diagrams of the Burnside River and Hadley Formations. Lithostratigraphic correlation of the successions in the region are given elsewhere in this volume (Hoffman, 1981). Letter abbreviations are as follows:*

B.F.S. - Bathurst Fault System

M.F. - MacDonald Fault

C.G. - Coronation Gulf

F.L. - Ferguson Lake

Regional Correlation and Tectonics

The pre-Glenelg(?) Formation Proterozoic sediments of the Hadley Bay region were not previously correlated with other successions in the area, although Dixon (1979) suggested that they might be the equivalents of the Goulburn Group to the south.

Campbell and Cecile, 1979 had earlier mapped a continuous sequence of Burnside River and possible Western River Formation in the Wellington High area to the south on Victoria Island (Fig. 3.7). However, there are no sediments in the Hadley Bay area which resemble the rather distinctive red to purple trough crossbedded pebbly quartzites of the Burnside River Formation. The Hadley Formation may be the equivalent of the quartzite and carbonate succession which underlies the Burnside River in the Ferguson Lake area of the Wellington High (Fig. 3.7), which was previously correlated with the Western River Formation of the Goulburn Group of the Kilohigok Basin to the south (Campbell and Cecile, 1979).

Thus, the Hadley Formation is tentatively correlated with the Western River Formation of the Goulburn Group, based on its position in the succession, relationship with the underlying granodiorite, and the fact that it is unconformably overlain by two other Proterozoic successions.

Units 3 and 4, which are bounded above and below by regional unconformities, are similar to a single outlier noted by Campbell and Cecile (1979) in the Ferguson Lake area to the south (Fig 7). There, conglomerate overlain by large-scale trough crossbedded white quartzite, rests unconformably on Burnside River Formation quartzites. Campbell and Cecile (1979) suggested that this succession might be correlative with the Glenelg Formation to the north, based on its relationship to the underlying Burnside River Formation, and its geographic position relative to other possibly correlative units. The presence of Glenelg(?) Formation in southwestern Hadley Bay, unconformably overlying very similar rocks, suggests that the previous interpretation was incorrect.

The Ellice Formation fluvial to shallow marine sediments of the Elu Basin occupy an identical position relative to the Goulburn Group, and closely resemble both Units 3, 4 and the outlier at Ferguson Lake (Campbell, 1979; Campbell and Cecile, 1979). If this interpretation is correct, then the northern margin of the Elu Basin, or an equivalent of the Hiukitak Platform, would have extended at least as far as Hadley Bay. The northwesterly directed paleocurrents in Units 3 and 4 suggest that the continental shelf edge in this area lay to the west and/or northwest. This broad, tentative interpretation is in part supported by paleocurrent data from the equivalent rocks in the Ferguson Lake area, and also from the Ellice Formation outlier on northeastern Kent Peninsula (see Campbell and Cecile, 1979).

Regional Tectonic Implications

Correlation of the Hadley Formation with the Western River Formation of the Kilohigok Basin significantly extends the northern limit of the Eastern Platform (Fig. 3.7). However, lithofacies, paleocurrents, and stromatolite elongations and asymmetry indicate that the Hadley Formation was deposited on a southwest-dipping shallow to emergent shelf. This is in marked contrast to the orientation of the depositional slope in the remainder of the Kilohigok Basin to the south.

Paleoslope trends indicated by palocurrent data from the Western River and Burnside River formations of the Axial Zone and central part of the Eastern Platform of the Kilohigok Basin, together with those from the Hadley Formation, describe a subradial pattern about a proposed east-west trending depositional trough in the Coronation Gulf area. The existence of such a depression was first postulated by Hoffman (in press), which he interpreted as a failed arm developed off the Coronation Geosyncline. The continental re-entrant structure proposed by Hoffman and supported by evidence above, is here termed the Taktu* aulacogen.

The Axial Zone of the Kilohigok Basin, and possibly a similar structure extending toward Hadley Bay, developed as splays off the eastern terminus of the Taktu aulacogen. The scale, orientation, and in part the sedimentary fill, are similar to the Lancaster Aulacogen (Kerr, 1980). The significance of the Taktu failed arm, its control over sedimentation and dispersal patterns in the Kilohigok, Takijuq and Tree basins is the subject of another paper (Campbell and Cecile, in press).

If the admittedly tenuous correlation between Units 3, 4 and the Ellice Formation is correct, then the Elu Basin of the Bathurst Inlet-Melville Sound area (Campbell, 1979) may have developed in an embayment separated from correlative craton-margin basins or embayments by an elevated area approximately in the central part of Victoria Island.

Economic Geology

No significant mineral showings or anomalous zones of radioactivity were located during the course of the mapping.

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*Taktu is the Inuit word for fog, thus an appropriate name for the structure.