STRATIGRAPHIC AND STRUCTURAL RELATIONSHIPS AMONG ROCK GROUPS AT OLD MANS PINE, WEST NEWFOUNDLAND

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STRATIGRAPHIC AND STRUCTURAL RELATIONSHIPS AMONG ROCK GROUPS AT OLD MANS POND, WEST NEWFOUNDLAND.

by

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FRONTISPIECE: View east down Old Mans Pond. Low rounded hills to the north and south of the pond are underlain by shales and siltstones of the Otter Brook Formation, Old Mans Pond Allochthon.

ABSTRACT

The Old Mans Pond area is positioned between the Humber Arm Allochthon to the west and the exposed eastern edge of the Appalachian miogeocline east of Deer Lake, thus providing a unique opportunity to study a complete section across the deformed ancient continental margin of eastern North America. The geology of the area demonstrates virtually all elements of the relict margin including, from northwest to southeast: (1) an autochthonous Paleozoic carbonate bank sequence including the well known St. George and Table Head Groups and lesser known Reluctant Head and Penguin Cove Formations; (2) a previously unrecognized allochthonous rise prism clastic sequence (Old Mans Pond Group) which is similar to, and may have at one time been continuous with, the Curling Group of the Humber Arm Allochthon; (3) a newly recognized structural slice (Hughes Lake Allochthon) involving Grenvillian basement rocks (Round Pond Complex) and a thick clastic cover sequence (Mount Musgrave Group) correlative in part with the Labrador Group and Fleur de Lys Supergroup. Carboniferous strata of the Deer Lake Basin overlie older Paleozoic rocks in the area with profound unconformity.

Structurally the Old Mans Pond area is dominated by an imbricate stack involving the allochthonous assemblages

mentioned above. Structural evidence and regional tectonic considerations indicate that the stack was assembled from the east and emplaced against the autochthonous carbonate sequence during the Taconic Orogeny. Deformation was polyphase in nature and westerly time transgressive. Early fabrics which are evident in the transported sequences are not present in the carbonate sequence implying that the carbonate bank was not involved in the earliest stages of the Taconic. Later involvement is evident from the ommission of much of the carbonate sequence beneath the Old Mans Pond Allochthon.

Subsequent orogenic activity (Acadian?) is responsible for overturning thrusts and fabrics generated during the Taconic, thus producing the marked reversal in structural polarity which characterizes the area. The Acadian Orogeny had little other effect on the area due to its sheltered position northwest of a minor reentrant in the ancient margin.

The Alleghanian Orogeny evidently had little effect on the area since Carboniferous strata along the western margin of the Deer Lake Basin are undeformed.

ACKNOWLEDGMENTS

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CHAPTER ONE

1.1 LOCATION AND ACCESSIBILITY

The study area lies within NTS map sheet 12H/4 (Pasadena,Newfoundland) and comprises roughly 320 square kilometres of the central portion of this sheet between Goose Arm of the Bay of Islands and Deer Lake (see Figure 1).

During the 1981 field season access to the study area was provided by several gravel roads in the vicinity of Old Mans Pond. These had been constructed by Bowaters of Newfoundland for logging purposes. At the time of the study one of the roads leading from Deer Lake to Goose Arm, looping around to the north of the study area, had not been maintained for a number of years and was in disrepair. A second road leading directly to Old Mans Pond provided the primary means of access to the current logging operations and was well maintained and in good condition. This road also provided a superb transect of the area since its construction had exposed abundant new outcrops. In addition

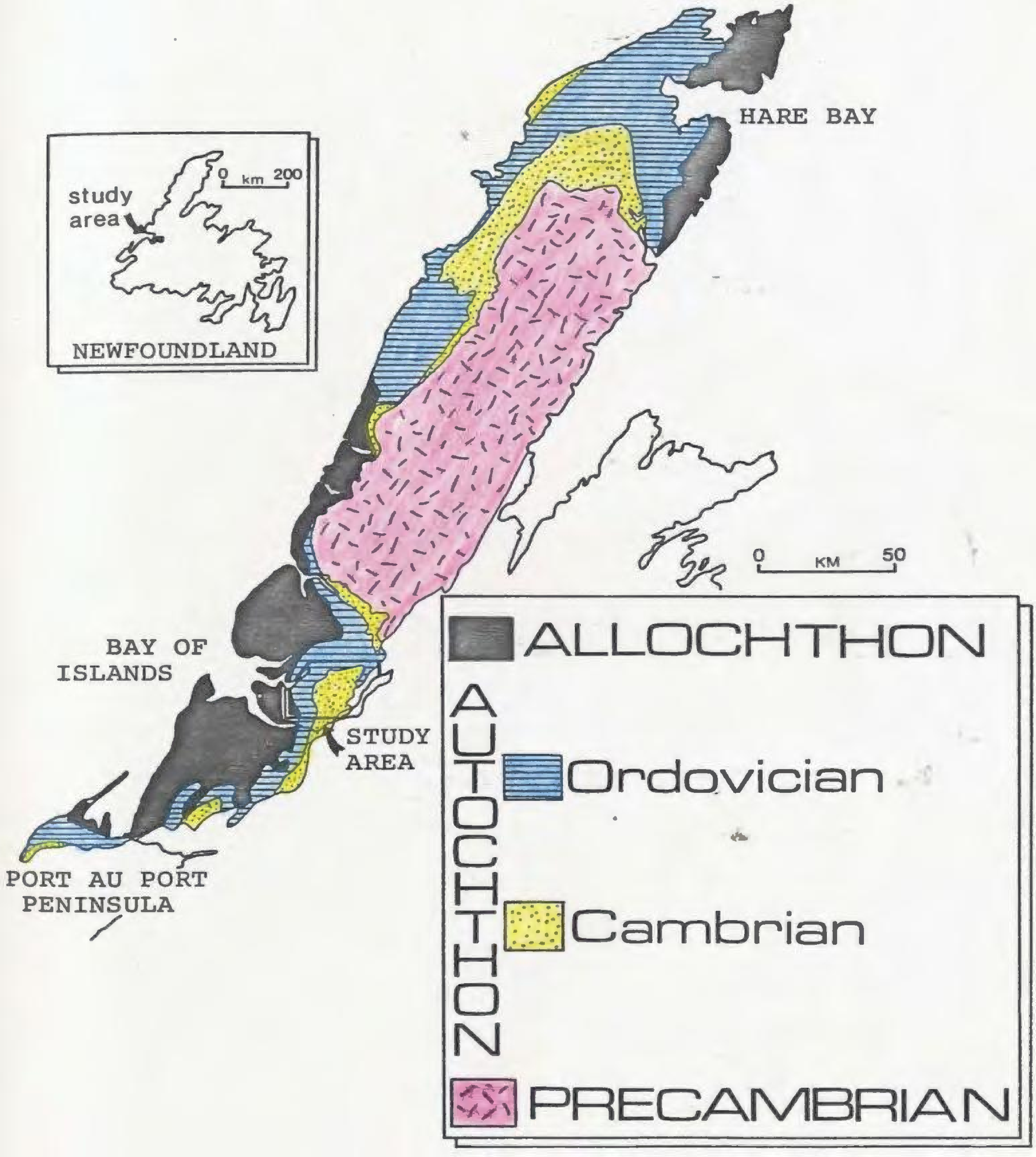


FIGURE 1: Location of Old Mans Pond area, western Newfoundland.

to this much of the area immediately surrounding Old Mans Pond had been recently logged and numerous trails remained which were easily walked and provided adequate exposure.

Areas to the north and south of Old Mans Pond are covered by thick stands of spruce and fir and accessible only on foot or by helicopter which may be chartered in nearby South Brook. The small size of most lakes in the area precludes fixed wing access.

1.2 GEOLOGIC SETTING

The island of Newfoundland lies at the north-eastern terminus of the Appalachian Orogen and provides a well exposed cross-section through this orogen. Based on contrasts in stratigraphy and structural style of mid-Ordovician and older rocks, the Appalachian Orogen in Newfoundland has been divided into four tectono-stratigraphic zones. (Williams,1976;1978a,b;1979).

The Old Mans Pond area lies within the most westerly of these zones, the Humber Zone. The geology of the Humber Zone records the evolution and destruction of the ancient continental margin of eastern North America during opening and subsequent closure of the proto-Atlantic (Iapetus) Ocean during late Precambrian through Paleozoic time. The other three zones: Dunnage, Gander and Avalon, represent a vestige of the Iapetus Ocean and terranes which lay to the east of it respectively (Williams,1979). The eastern boundary of the Humber Zone is drawn at the Baie Verte-Brompton Line (Williams and St.Julien,1978;1982), a steep structural zone characterized by mafic and ultra-mafic rocks of proposed ophiolitic affinity. The western boundary is arbitrarily taken to be the western limit of Appalachian deformation (Williams,1979).

Crystalline rocks formed during the Grenville Orogeny (1000 m.y.) comprise the basement to the Humber Zone. These rocks are overlain by a sedimentary sequence which shows a marked facies variation from west to east. To the west a thin sequence of shallow water, predominantly clastic rocks referred to as the Labrador Group (Schuchert and Dunbar,1934) overlies the Grenville basement and is itself conformably overlain by an eastward-thickening, shallow water carbonate bank sequence (St.George, Table Head). To the east the sedimentary sequence thickens dramatically and is now represented by the Fleur de Lys Supergroup (Church,1969). Basal parts of the Fleur de Lys are also indicative of shallow water deposition; however, the bulk of the sequence, some 10,000 metres, is characterized by shales, siltstones, greywackes and minor poorly sorted conglomerates interpreted as deep water turbidite sequences (Williams and Stevens, 1974).

Broad correlations between the Labrador Group and Fleur de Lys Supergroup are generally accepted; a physical link between them is rarely, if ever, preserved. Rocks representative of those sediments deposited at or near the morphological break between the continental shelf and thicker portions of the rise prism are now either covered by younger rocks or have been structurally removed and are now far to the west of their original site of deposition, for example, in the Humber Arm Allochthon (Stevens, 1970). At no place along the length of the Appalachian system are rocks representative of this particular environment found 'in situ' (Rodgers, 1968).

Mafic volcanic dikes and flows in the lower part of the Labrador Group and amphibolitic units in the Fleur de Lys Supergroup have been related to tensional rifting during the initial opening of the Iapetus Ocean basin (Strong and Williams, 1972).

The closing of Iapetus and subsequent destruction of the continental margin began in the latest part of the early Ordovician (Williams, 1979) and produced a strong structural and metamorphic contrast across the Humber Zone. In the west metamorphism and deformation are slight. Here, the initial closing of Iapetus was heralded first by foundering of the carbonate bank, followed by the progradation of a clastic wedge from the east and, finally, emplacement of an allochthonous assemblage which includes off-shelf, continental rise facies equivalents of the carbonate platform in its lower part (Bird and Dewey,1970; Stevens,1970) and oceanic crust and mantle sequences (ophiolite) in its uppermost part (Church and Stevens,1971) onto the undeformed carbonate platform.

Farther to the east, the platform rocks were progressively more metamorphosed and structurally imbricated with polydeformed clastic sediments and crystalline basement rocks along east-dipping thrusts which are essentially hard and sharp in nature (Kennedy,1980; Smyth,1981). Along the eastern margin of the Humber Zone, Fleur de Lys sediments were metamorphosed to upper greenschist and amphibolite grade and both basement and cover rocks were caught up in polyphase deformation (DeWit,1972; Hibbard,1979; Hibbard et al,1980). The Old Mans Pond area conveniently straddles the transition from undeformed in the west to polydeformed in the east and contains virtually all elements of the original margin in varying degrees of preservation. It thus provides a unique opportunity to study a complete stratigraphic and structural section across the ancient margin.

Rocks with nearly identical depositional and deformational histories to those of the Humber Zone in Newfoundland may be recognized along the length of the Appalachian system (Rankin,1975) and in the Caledonides of the British Isles, Norway and Sweden (Williams,1978b).

1.3 PREVIOUS WORK

"In science, as in all other departments of inquiry, no thorough grasp of a subject can be gained unless the history of its development is clearly appreciated." (Archibald Geike, as quoted by Baird,1975)

The history of geologic investigation in Newfoundland reaches back to the year 1839 when J.B.Jukes conducted the first systematic geological survey of the island (Jukes,1943). Since then, a considerable number of emminent geologists have concentrated their energies towards solving the geological puzzle that is Newfoundland. For a comprehensive account of the early history of geological investigation in Newfoundland the reader is referred to Baird (1975).

Much of the work to date has been focused on the west coast of the island where investigations have been ongoing since the 1800's. The bulk of this work was focused on coastal areas and along inland waterways and, as a result, the area in the vicinity of Old Mans Pond remained virtually uncharted up until the time of the present survey.

A brief examination of the area by the Geological Survey of Canada in 1948 (see Lilly, 1963) took into account the metaclastics between Old Mans Pond and Deer Lake. These rocks had previously been considered to be Precambrian in age and thus correlative with gneisses of the Long Range Mountains. They were reinterpreted as Lower Cambrian in age by the Survey during this study. A second look at the area in 1959 as part of a reconnaissance survey of the Sandy Lake (12H) west half sheet (Baird, 1960) did little to amend the findings of 1948.

At about the same time as Baird was carrying out his study another worker, Hugh Lilly, was working between Humber Arm and Goose Arm of the Bay of Islands (Lilly, 1963). While primarily concerned with the carbonate sequence and clastics of the "Humber Arm group", Lilly was the first and only worker to look at the terrane in the vicinity of Old Mans Pond in any detail. Rocks of this area were assigned to the Mount Musgrave Formation (McKillop, 1961; Lilly, 1963) which was subdivided into a lower arenaceous member southeast of Old Mans Pond and an upper argillaceous member to the northwest. Based primarily on lithic similarities these rocks were correlated with the lower part of the Labrador Group (Bradore and Forteau Formations). To the west of, and therefore presumably above the Mount Musgrave Formation, lay an extensive carbonate sequence including the well known St.George and Table Head Groups and the newly recognized Reluctant Head and Penguin Cove Formations. Portions of this sequence were interpreted to have moved westwards over the Mount Musgrave Formation along a 'zone of detachment' (Lilly,1963,p.25). To the southeast of Old Mans Pond the arenaceous member of the Mount Musgrave Formation was believed to grade into the metamorphic gneisses of the Long Range.

More recently, work in the adjoining area to the south (Kennedy,1981) has delineated a previously unrecognized stratigraphy in a highly metamorphosed clastic terrane and defined a major system of thrust faults which essentially transpose metaclastics in the east against a relatively undeformed carbonate sequence to the west. This thrust system was presumed to extend into the Old Mans Pond area.

1.4 PURPOSE AND SCOPE

Within the framework of recent concepts concerning the geology of the Humber Zone, several of the findings of previous workers in the area warrant further consideration.

The recognition of a crude stratigraphy within the metaclastic terrane of the area (Lilly,1963), which was assumed to be broadly correlative with the Labrador Group, required more detailed consideration in hopes of confirming this correlation and/or linking the stratigraphic sequence with that recognized by Kennedy (1981).

The suggestion made by Lilly (1963) that the carbonate sequence in the area had slid westward over the clastic sequence along a 'zone of detachment' not only contradicts the presently accepted view of an essentially autochthonous carbonate terrane throughout west Newfoundland, and all along the west flank of the Appalachian Orogen, but is also at variance with more recent work to the south of the area which documents thrusting of the metaclastic sequence over the carbonate terrane along a series of major thrust faults (Kennedy,1981). These same thrusts extend northwards into the Old Mans Pond area where they were observed to steepen and then either become overturned (Kennedy,1981), or die out (Baird,1960; Williams,1967). If the latter were the case it would provide a rare opportunity to view the rocks of the carbonate sequence and clastic prism linked throughout their depositional and deformational history.

In addition to all of this, the mere fact that much of the ground between Goose Arm and Deer Lake was virgin territory made this area an extremely alluring prospect.

The purpose of this study then was two-fold:

1) To look at the geology of the area between Goose Arm and Deer Lake with an eye towards delineating the nature and distribution of the various lithologic units and possible correlations with other lithologies outside the area.

2) To outline the structure of the area, especially any contrasts in structural style between the clastic and carbonate terranes, and to attempt to fit the structure into a regional tectonic framework.

To accomplish this three months of field work were completed in the Old Mans Pond area during the summer of 1981. This work formed part of a larger project to map the Pasadena map sheet (12H/4), Newfoundland (Williams et al,1982). Many major advances were made in terms of recognition and delineation of the salient geologic elements of the area and it is hoped that the findings presented here will provide future workers with both a base from which to launch more detailed studies and the impetus to do so.

With regards to the results presented herein, the author wishes to draw attention to the fact that many of the fringe areas within the study region were mapped and interpreted, in whole or in part, by Drs. H. Williams and D. Knapp. In particular, Williams looked at the entire area, as was his responsibility, and kindly allowed the author use of data collected from the northern margin of the Old Mans Pond Allochthon and the carbonate terrane in that area. Knapp provided information from the carbonate sequence in the uppermost northeast corner of the area and also did much of the work on rocks of the South Brook Formation on the eastern and western shores of Deer Lake.

PART TWO

GENERAL GEOLOGY

The Old Mans Pond area is underlain by rocks which are for the most part early Paleozoic (Cambrian-Ordovician) in age. Exceptions to this are crystalline rocks in the vicinity of Hughes Lake which include possible Grenvillian basement of Helikian or earlier age, and Carboniferous strata of the Deer Lake Basin. The early Paleozoic and older rocks lend themselves to subdivision into contrasting lithic assemblages the most fundamental of which involves the separation of predominantly carbonate lithologies to the west and north from a dominantly clastic terrane underlying the central portion of the area. Rocks of the carbonate terrane are essentially autochthonous and correlative with similar carbonate sequences of west Newfoundland (Williams and Stevens, 1974). Rocks of the clastic terrane are allochthonous with respect to the carbonate sequence and have been subdivided into two separate assemblages: 1) a mixed argillaceous-arenaceous group of rocks with some carbonates occupy the central portion of the area. These are named the Old Mans Pond Group and together with a few small metagabbroic bodies make up the Old Mans Pond Allochthon; 2) crystalline (Round Pond Complex) and more arenaceous clastic rocks (Mount Musgrave Group) to the southeast make up the Hughes Lake Allochthon (see Figure 2).

The contacts between these two contrasting clastic assemblages and between the carbonate sequence and the clastic terrane are tectonic in nature and marked by narrow zones of intense deformation. While neither of these contacts are well exposed over any distance a combination of topographic expression and marked lithic contrasts allows delineation of each with accuracy and confidence.

The predominant structural grain of the Old Mans Pond area, as defined by bedding, cleavage and fold axes, trends north-northeast except in the northern part of the area where these features swing through a broad arc to trend nearly due east. Dips vary from moderately easterly in western portions of the area to moderately westwards in eastern and central parts. To the north dips are vertical to slightly inclined either north or south.

The following four chapters concern themselves with the description of the lithologic character of each major assemblage in the area as well as interpretation and possible correlation of these assemblages with rocks outside of the area. As the stratigraphy, age and regional correlation of the carbonate sequence is best understood

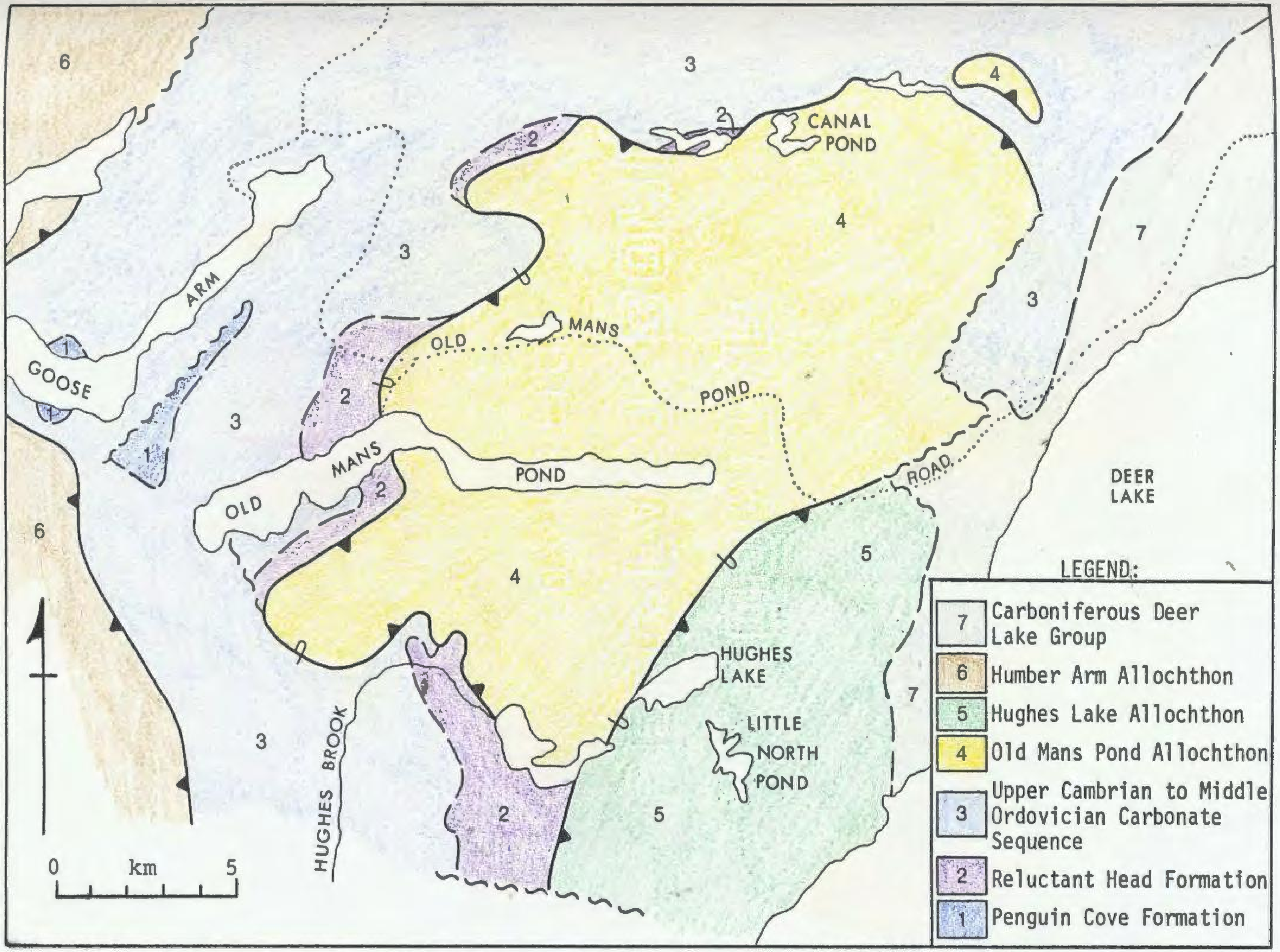


FIGURE 2: General Geology, Old Mans Pond area, west Newfoundland.

these rocks will be discussed first, followed by a discussion of the Old Mans Pond Allochthon in Chapter 3 and the Hughes Lake Allochthon in Chapter 4, Cover rocks of the Carboniferous Deer Lake Basin are described briefly in Chapter 5. A brief introduction and summary accompany each chapter to which the reader may refer for a quick appraisal of the geology of each terrane. A table of formations is given in Table 1.

By way of clarification the reader is advised of certain aspects of format to be used in the chapters to follow. Firstly, in order to facilitate the description and location of specific outcrop localities cited, each locality has been allocated a number. A map on which these numbers have been compiled is given in the back pocket of this report. Second, in many cases unofficial names have been given to certain geographic features within the area. Wherever an unofficial name is used it is placed within single parentheses eg. 'Old Mans Pond Road'. These names are not marked on existing topographic maps but have been marked on the geologic map given in the back pocket.

TABLE 1: Table of formations, Old Mans Pond area.

AGE \ TERRANE		CARBONATE SEQUENCE		OLD MANS POND ALLOCHTHON		HUGHES LAKE ALLOCHTHON
ORDOVICIAN	CARADOC		FAULT		FAULT	
ORDOVICIAN	LLAND		FAULT		FAULT	
ORDOVICIAN	LLANV		FAULT		FAULT	
ORDOVICIAN	ARENIG	ST GEORGE	FAULT		FAULT	
ORDOVICIAN	TREMADOC	ST GEORGE	FAULT		FAULT	
CAMBRIAN	U	BLUE CLIFF (Levesque, 1977)		? METAGABBRO ?	THRUST	
CAMBRIAN	M	RELUCTANT HEAD / PENGUIN COVE	THRUST	BOBBYS BROOK (OLD MANS POND GROUP)	THRUST	
CAMBRIAN	L	PENGUIN COVE / ?	THRUST	OTTER BROOK / CANAL POND (OLD MANS POND GROUP)	THRUST	SOUTH BROOK / LITTLE NORTH POND (MOUNT MUSGRAVE GROUP)
HADRYNIAN		?		?		DEER POND VOLCANICS
HELIKIAN & OLDER						ROUND POND COMPLEX

CHAPTER TWO

CARBONATE SEQUENCE

2.1 INTRODUCTION

Rocks of the carbonate sequence underlie a significant portion of the Old Mans Pond area. They are best exposed at Goose Arm and can be traced northeast and eastward across the northern fringe of the area where they become progressively more metamorphosed and recrystallized. Lowest exposed units along the western margin of the area have been referred to as the Penguin Cove Formation (Lilly,1963) at Goose Arm and the Reluctant Head Formation (Lilly,1963) at Old Mans Pond. Some revision of this nomenclature may be pending (Levesque,1977).

The bulk of the remainder of the carbonate sequence has been correlated with the lower Ordovician St.George Group although, locally, rocks of Upper Cambrian age have been delineated (eg. overlying the Penguin Cove Formation at Goose Arm; Levesque,1977). Rocks of the middle Ordovician Table Head Group (Klappa et al,1980) have been recognized just west of the area of interest (Williams et al,1982, 1983).

The various units of the carbonate sequence are discussed below.

2.2 PENGUIN COVE FORMATION:

(i) Definition and nomenclature:

The Penguin Cove Formation is exposed in the cores of two upright to westerly inclined anticlines on opposing shores of Goose Arm. It is also found between Goose Arm and Old Mans Pond where it has been exposed through a combination of folding and faulting.

Lilly (1963) was the first to recognize and define this formation where it is exposed on the north shore of Goose Arm at Penguin Cove. Levesque (1977) reexamined the Penguin Cove Formation on both the north and south shores of Goose Arm and interpreted it to consist of two separate parts: a lower, clastic sequence which he recommended retain the name Penguin Cove and an upper, predominantly carbonate sequence which he renamed the Wolf Brook Formation. Despite this more recent reclassification the early nomenclature is retained here pending formalization of the stratigraphic names.

(ii) Lithology, stratigraphy and thickness:

At its type section the lowest part of the Penguin Cove is characterized by interbedded white to pinkish quartz sandstones, dark grey siltstones and shale. The sandstones are well sorted and certain beds show features suggestive of soft sediment deformation or slumping (Lilly,1963; Levesque,1977). Middle parts of the section consist predominantly of thin-bedded siltstones, sandstones and shale with minor limestone and dolostone interbeds. Upper beds are predominantly dark grey limestones and buff dolostones with minor shale interbeds and are quite distinctive in that the limestones are commonly oolitic and contain oncolites or "button algae".

Between Goose Arm and Old Mans Pond the Penguin Cove Formation consists of dark grey, oncolitic limestones as well as minor dolostones, black shale and pink quartzites. The stratigraphic order of this section is poorly understood and may be complicated by folding and/or faulting. Lilly (1963) suggested that this exposure constitutes an anticline which is overturned to the west.

At Goose Arm the Penguin Cove Formation is conformably overlain by buff dolomitic carbonates which are Upper Cambrian in age (Levesque,1977). In the vicinity of Window Pond, rocks of the Reluctant Head Formation reportedly unconformably overlap the Penguin Cove Formation (Lilly,1963). The base of the sequence is nowhere exposed.

The exposed thickness of the Penguin Cove Formation at its type section is roughly 200 metres.

(iii) Age and correlation:

Lilly (1963,p.29) reported that exposures of Penguin Cove equivalents near the village of Lomond to the northeast of the study area are separated from rocks of the Forteau Formation of the Labrador Group by a narrow channel and that the upper beds of the Forteau are identical to the bottom beds of the Penguin Cove, thus implying that the Penguin Cove is for the most part younger than middle Lower Cambrian.

Levesque (1977) was able to define the age of the upper part of the Penguin Cove Formation as early Middle Cambrian or younger on the presence of ptychoparioid trilobite and phosphatic brachiopod fragments collected from the base of his Wolf Brook Formation (upper Penguin Cove). By inferrence this suggests a late lower Cambrian age for the lower part of the Penguin Cove making it correlative in part with the Hawke Bay Formation of the Labrador Group (James et al,1980). The upper part of the Penguin Cove may also be correlative with the Hawke Bay Formation which is oolitic and oncolitic in its upper parts at Canada Bay and where it overlies the Indian Head Complex (James et al,1980). Alternatively, it may be correlative with the March Point Formation of the Port au Port Group which is lithologically similar (James et al,1980;in prep; N. James, pers comm 1982).

During the course of this study a fragment of the trilobite Kootenia sp. (identification by D.Boyce,1982; see Plate 1) of upper Middle Cambrian age was found in an oncolitic bed in the section between Goose Arm and Old Mans Pond, lending further support to the above correlation. Kootenia is also found in the base of the Cow Head Group and in the Cooks Brook Formation of the Humber Arm Allochthon (R.K.Stevens, pers comm,1982).

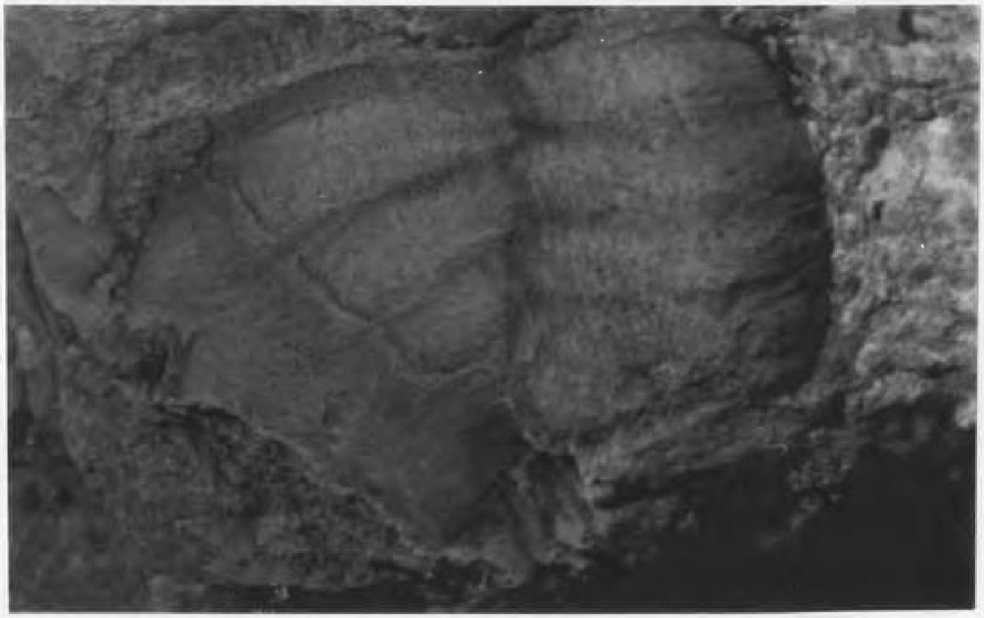


PLATE 1: Kootenia sp. from the Penguin Cove Formation, Old Mans Pond area. Identification and photograph by D. Boyce. Magnification 1.5X.

2.3 RELUCTANT HEAD FORMATION:

(i) Definition and nomenclature:

Lilly (1963) was the first to use the name Reluctant Head to describe that sequence of thinly interbedded limestones and muddy dolostones exposed at 'Reluctant Head' on the south shore of Old Mans Pond. Schuchert and Dunbar (1934) had recognized a lithologically similar sequence in the Humber Gorge 30 km to the south of this locality which Walthier (1949) later allocated to his Grand Lake Brook Series. McKillop (1961) promoted this sequence to group status and, more recently, Kennedy (1981) divided the group into two formations and applied the name Reluctant Head to the upper, more extensive of the two. He also suggested that the type locality of the Reluctant Head Formation be taken as that section exposed along 'Grand Lake Brook'. This suggestion is refuted herein since the Reluctant Head Formation is best exposed and least deformed at the type locality on Old Mans Pond suggested by Lilly (1963).

(ii) Distribution:

Rocks of the Reluctant Head Formation have been recognized and delineated as far north as Long Pond and as far south as Balls Pond during this phase of mapping. Equivalent lithologies were observed to the north of the map area while to the south similar lithologies are known in the Humber Gorge and beyond in a belt which extends to the southern end of Grand Lake (Kennedy, 1980; see Figure 3).

Best exposures occur at 'Reluctant Head' on Old Mans Pond and just north of the bend in Hughes Brook where a large, slightly overhanging cliff face exposes a nearly complete section through the Reluctant Head Formation (Locality 414). Immediately north of Old Mans Pond recent logging operations have exposed numerous outcrops of this formation including a well exposed transect across its

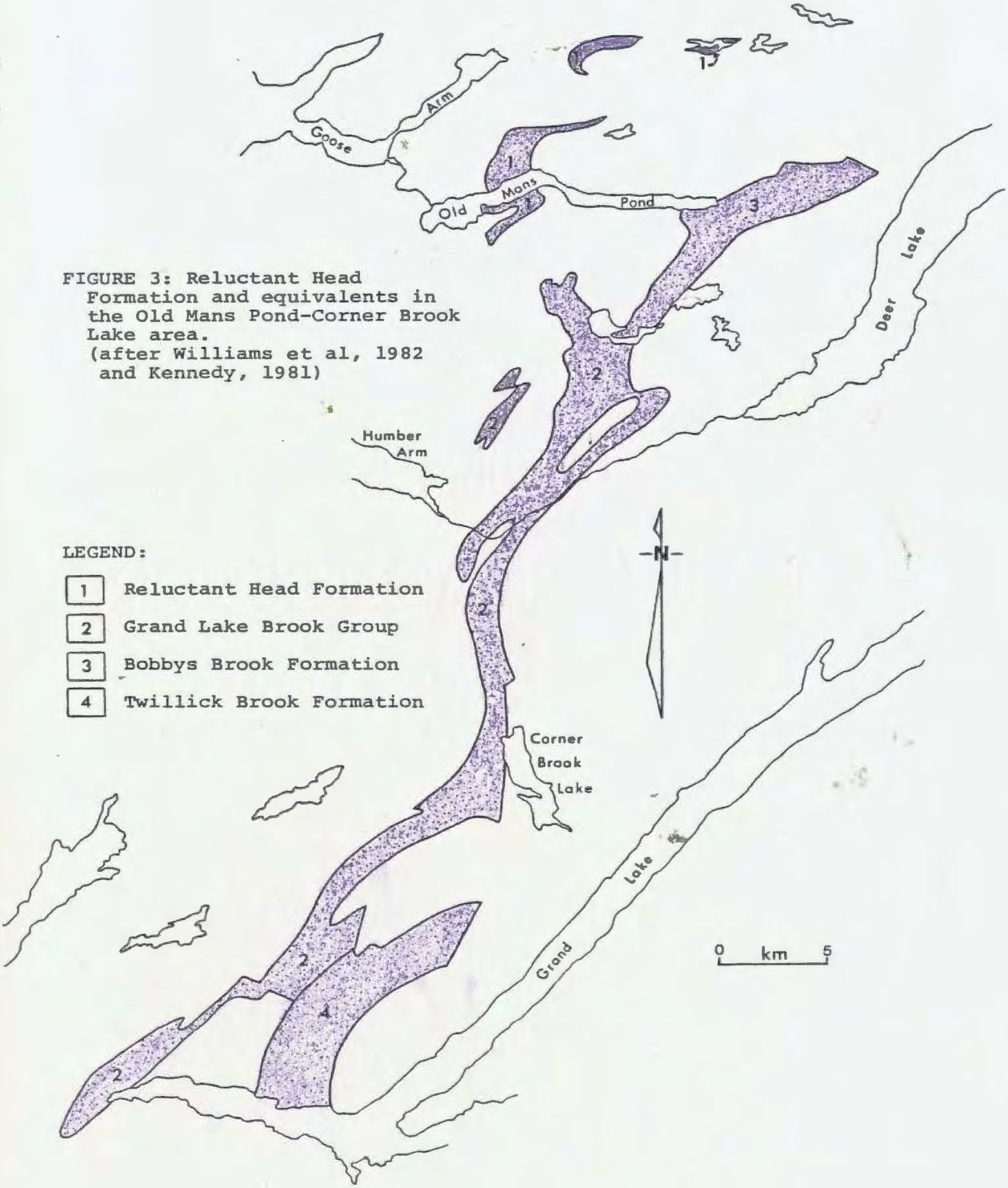


FIGURE 3: Reluctant Head Formation and equivalents in the Old Mans Pond-Corner Brook Lake area. (after Williams et al, 1982 and Kennedy, 1981)

contact with overlying St.George Group carbonates (Locality 28).

(iii) Lithology, stratigraphy and thickness:

The Reluctant Head is a distinctive lithologic unit characterized by thin (2-3 cm) interbeds of limestone and muddy dolostone. Where weathered the limestones are grey and the dolostones a dull brown. In relatively fresh exposures, such as those present along recently constructed woods roads, the limestones are medium grey while the dolostones weather a brillant orange giving the rock a striking ribboned appearance (Plate 2). In these relatively unweathered exposures the limestone and dolostone interbeds may be seen to be comprised of very thin (1-2mm) laminae. No other primary sedimentary features were observed.

Also characterisitic of the Reluctant Head are carbonate breccia or flat-pebble conglomerate units (Plate 3). These breccia units are usually present as lensoid bodies which are no more than two metres thick and 10-20 metres long. Internally the breccia units consist of tabular limestone fragments 2-3 cm thick and up to 30 cm in length which are oriented roughly parallel to one another. Intact strata which bound these breccia lenses above and below generally demonstrate a conformable relationship; ie.

PLATE 2: Thinly interbedded limestone (dark grey) and dolostone (light grey) of the Reluctant Head Formation. Scale is in inches.

PLATE 3: Platy carbonate breccia typical of Reluctant Head Formation.

the breccias do not appear to scour into underlying beds nor do they protrude through overlying strata. The proportion of clasts or fragments to matrix in these breccias varies and the matrix is generally scericitic and variably dolomitic in nature. In most of the occurrences of these breccia units observed north of Old Mans Pond both the limestone fragments and matrix are commonly oolitic.

Lilly (1963) attributed these breccia units as being related to slumping into a basin. Levesque (1977) has described virtually identical "edgewise conglomerate" units in Middle and Upper Cambrian strata which he ascribes to being storm generated in origin. The latter interpretation is preferred here.

The uppermost beds of the Reluctant Head are invariably oolitic nature. A thin-section of one of these oolitic beds revealed the oolites to be slightly flattened and demonstrating a relict radiating structure. Lower and middle portions of the Reluctant Head are poorly understood from a stratigraphic standpoint. Lilly (1963) proposed that the distinctive carbonate breccia units mentioned above characterize lowest portions of the Reluctant Head only. Observations made during this study failed to substantiate this and instead it was found that the breccia units occur throughout the section. Recognition of large, isoclinal, recumbent, east-verging folds in the type section and similar, smaller structures at other locales indicate that, internally, the Reluctant Head is much more complex than first realized and that the order of specific units is structurally rather than stratigraphically controlled.

The thickness of the Reluctant Head at the type locale was quoted as roughly 800 ft (250 m) by Lilly (1963). In view of the structural complexity of the formation this thickness may be considerably exaggerated.

(iv) Structure:

Bedding and cleavage in the Reluctant Head Formation both strike approximately northeast and dip moderately to the northwest. Large, east-vergent isoclines were noted in the section at 'Reluctant Head' and a similar fold style is suggested in the cliff section north of Hughes Brook where rapid alternation in the assymetries of small scale folds across the section indicates large scale recumbent folding. Fold axes are invariably nearly horizontal and trend northeasterly.

Along the shoreline northwest of 'Reluctant Head' a small-scale, east-dipping thrust involving Reluctant Head rocks is evident (Plate 4). This thrust steepens and eventually becomes overturned along strike to the north.

PLATE 4: East-dipping thrust fault exposed along the north shore of Old Mans Pond. This fault places the Reluctant Head above the St.George Group. To the north the fault steepens and becomes overturned to the southeast.

Detailed work on the carbonate sequence in this area indicates that as much as 200 to 300 metres of section is missing beneath this fault (H. Williams, pers comm, 1983).

(v) Contact relationships:

The contact of the Reluctant Head Formation with overlying rocks is well demonstrated in a number of localities including the type section at 'Reluctant Head', the cliff face just north of the bend in Hughes Brook and, along the woods road which leads from Old Mans Pond to Goose Arm. At each locale the overlying lithologies consist of massively bedded, buff to almost white dolostones. These dolostones were correlated with the lower Ordovician St.George Group by Lilly (1963); however, critical identification has not yet been made and the possibility exists that they may be at least partly upper Cambrian in age.

The upper contact of the Reluctant Head is best exposed along the woods road leading from Old Mans Pond to Goose Arm. Here the Reluctant Head becomes progressively more dolomitic near the contact and extensive burrowing is evident (Plate 5). The upper few thin limestone beds only are oolitic and these mark an abrupt contact with the overlying massive dolostones.

The stratigraphic base of the Reluctant Head Formation is nowhere preserved. Its contact with the Old Mans Pond group is a narrow interface characterized by intense deformation. This contact represents an important structural juncture in the Old Mans Pond area.

PLATE 5: Typical burrowed nature of the Reluctant Head Formation near its contact with massive dolostones above. Photograph taken along woods road north of Old Mans Pond

(vi) Age and correlation:

The Reluctant Head Formation was allotted a Cambrian age by Lilly (1963) based on correlation with similar rocks at the Humber Gorge (Grand Lake Brook Group) from which Schuchert and Dunbar (1934) removed a few poorly preserved trilobites. The similar stratigraphic position of both the Reluctant Head and Penguin Cove Formations below more massive carbonate sequences infers approximately equivalent ages for both although a presumed unconformable overlap of the former over the latter near 'Window Pond' suggests a slightly younger age for the Reluctant Head (Lilly,1963).

It is the opinion of this author that the Reluctant Head is in fact slightly younger than the Penguin Cove Formation and may be equivalent to portions of the Petit Jardin and/or March Point Formations of the Port au Port Group (James et al, in prep.) which are late middle to upper Cambrian in age. An attempt to confirm this inferred age through analysis of several samples for conodonts proved fruitless except in revealing a few small worm tubes which remained after dissolution in acetic acid.

Lithic similarities and inferred age considerations suggest that the Reluctant Head Formation represents a proximal, autochthonous facies equivalent of the Cooks Brook Formation of the Humber Arm Allochthon. Both are characterized by thin bedded limestones with either muddy dolostone (Reluctant Head) or shale (Cooks Brook) interbeds and both contain subordinate carbonate breccia units. Upper parts of the Reluctant Head are oolitic and similar lithologies have been reported in blocks within the Cooks Brook Formation (James et al,1980).

2.4 THE ST. GEORGE GROUP IN THE OLD MANS POND AREA:

The bulk of the carbonate rocks exposed in the western portion of the Old Mans Pond area have been at best only superficially examined except where they are exposed at Goose Arm (Lilly,1963; Levesque,1977) and north of Old Mans Pond (this study). In both localities the sequence consists of medium to thick-bedded grey to white limestones and buff dolostones which, in the case of the Goose Arm section at least, conformably overlie strata of Upper Cambrian age and are characterized by abundant ichnofossils, scattered body fossils (including coiled gastropods) and less common stromatolitic and cherty horizons (see Plates 6A and 6B). These features have led to correlation of these rocks, and by inference the bulk of the remainder of the exposed carbonate sequence, with the well known St.George Group of lower Ordovician age.

Based on the better exposed sections, stratigraphic subdivision of these rocks into a number of formations (Lilly,1963) or members (Levesque,1977) has been proposed. Application of this stratigraphy to the remainder of the carbonate rocks of the area has been hampered by generally poor exposure and the rugged nature of the terrain.

St.George Group equivalents in the Old Mans Pond area

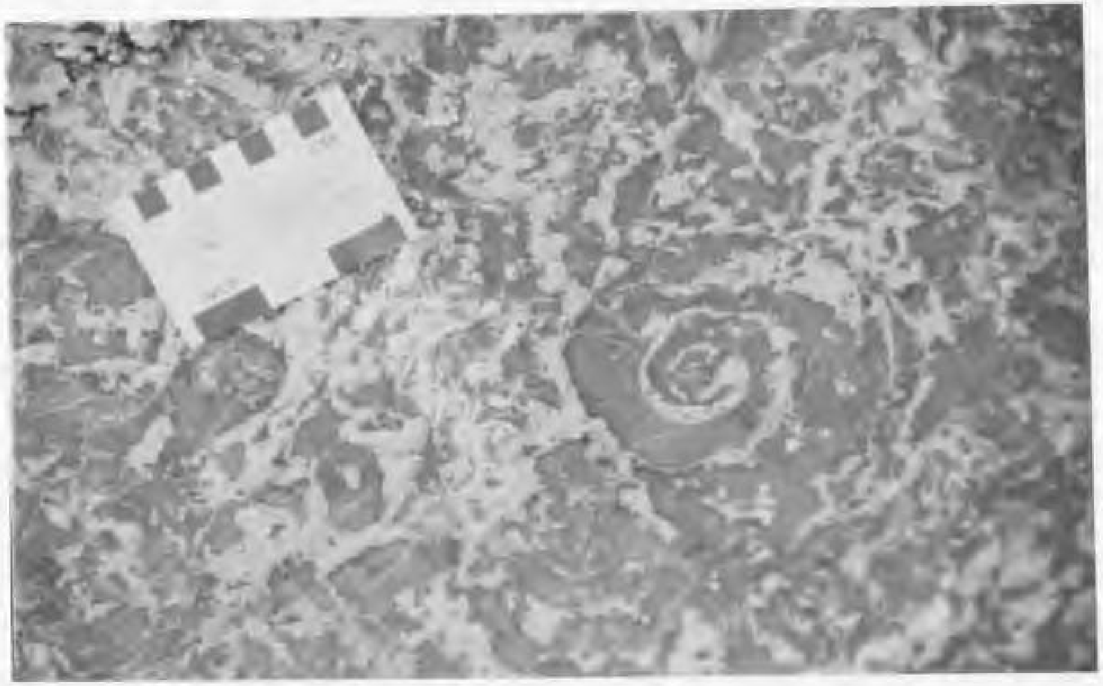


PLATE 6A: Coiled gastropod in St. George Group north of Old Mans Pond.

PLATE 6B: Block of stromatolitic limestone from the St. George Group. Southeast shore of Goose Arm.

are involved in folds which are open and upright to slightly west vergent. At Raglan Head the folds are notably bulbous in nature and were previously dubbed "rabbit ear folds" (Lilly, 1963). Fold axes, bedding and cleavage all trend northeast in the western portion of the area and swing through a broad arc to trend easterly in the northern part of the area. Local recrystallization of these rocks is common adjacent to major faults in the area (H.Williams, pers comm, 1982).

2.5 EASTERN CARBONATE TERRANE:

Those rocks east of Long Pond which are physically continuous with the western carbonate sequence but have been extensively recrystallized are herein referred to as the "eastern carbonate terrane". The bulk of these rocks are considered to be metamorphosed equivalents of the St.George Group; however, a number of exposures of distinctive lithologies unlike any of the known St.George Group do occur and are described below. All of these exposures were observed along a large ridge extending south-southeast from North Brook. This ridge is bounded by a steep fault along its western margin while to the east and south subhorizontal Carboniferous sediments drape its base (see map in back pocket).

The first of the anomalous lithologies occurs along the 'Old Mans Pond Road' (Locality 184) where a massive, white weathering marble containing thin quartz stringers and abundant scattered quartz grains is exposed. In hand specimen these grains are well rounded, 1-2 mm in diameter and appear to be frosted. In thin section this frosting may be seen to be the result of etching by the surrounding carbonate material. More significantly though, petrographic study reveales that roughly half of these grains are feldspar (Plate 7).

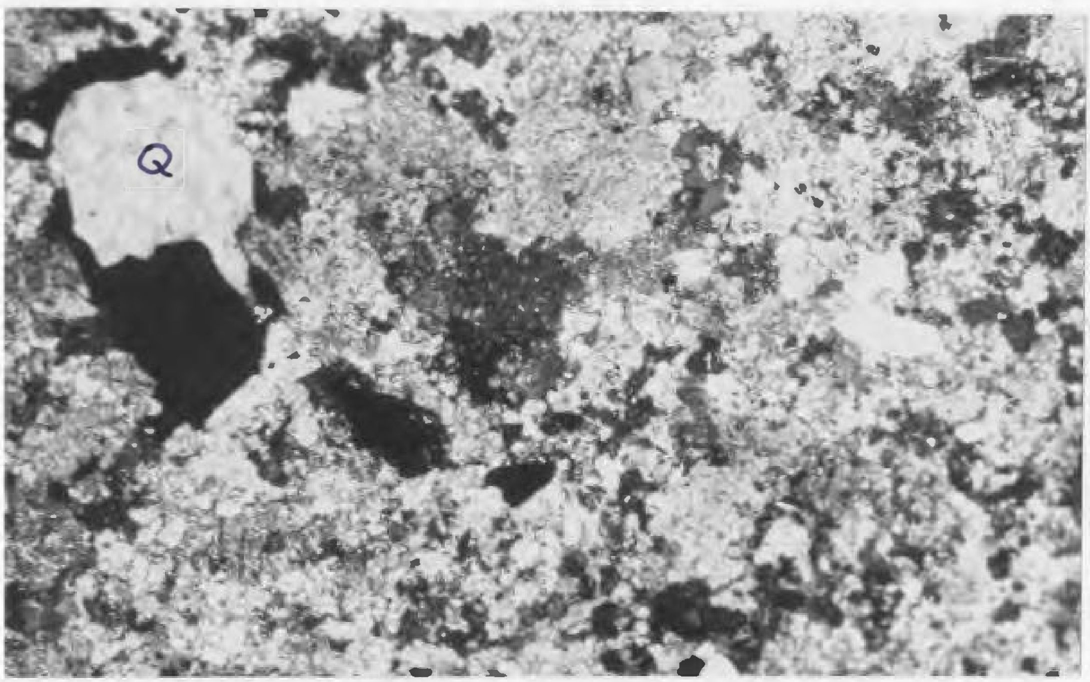


PLATE 7: Polycrystalline quartz grain (Q) in carbonate matrix. Eastern carbonate terrane, Locality 184.

The association of feldspar and quartz and the undulose-polycrystalline nature of the quartz grains themselves indicate derivation from a preexisting crystalline or clastic source area. Similar siliciclastic carbonates are known in the Cow Head Group (beds 5 and 6) and within the Petit Jardin Formation at Felix Cove on the Port au Port Peninsula (James et al,1980; R.K.Stevens, pers comm,1982). Interestingly, both of these siliciclastic horizons are of roughly the same age (Middle to Upper Cambrian). An additional occurence of siliciclastic carbonates was found by H.Williams during the 1981 field season along the 'Goose Arm Road' to the north of the map area. These rocks occur within a structural slice of the Humber Arm Allochthon (H. Williams, pers comm, 1983). For purposes of comparison a sample from this locality and from Bed 6 of the Cow Head Group were sectioned and examined along with the sample from the 'Old Mans Pond Road'. All three were found to be remarkably similar with respect to grain composition, size and shape, all of which would tend to suggest a Cambrian rather than Ordovician age for these rocks in the Old Mans Pond area.

The second lithology of interest in the eastern carbonate terrane outcrops roughly 2 km southwest of the first locale in a large knoll which breaks through the surrounding Carboniferous strata (Locality 314). This knoll consists of a rather spectacular recrystallized carbonate breccia containing equant, angular limestone blocks ranging in size from a few centimetres to a half a metre and set in a darker carbonate matrix (see Plate 8).

PLATE 8: Blocky marble breccia, eastern carbonate terrane, Locality 314. Note equant, angular nature of blocks compared to platy breccias of Reluctant Head Formation (PLATE 3).

These breccias are not at all like the platey breccias of the Reluctant Head Formation but do vaguely resemble some of the breccias found in the Bobbys Brook Formation (Chapter 3, Section 3.4). Some of the breccias at Cow Head are similar in nature to these breccias but insufficient evidence exists to make any direct correlation. In any event, breccias of this type are not known in the St.George Group and again a broadly Cambrian age is suggested.

The last of the anomalous lithologies of the eastern carbonate terrane occurs along the northern end of 'Helens Brook' (Locality 464) and along North Brook just east of the juncture with 'Helens Brook'. Here silver-grey to greenish phyllites interbanded with buff marbles are exposed. Banding is on the order of 1-2 cm and isoclinal folding is common. This lithology is almost identical to portions of the Bobbys Brook Formation of the Old Mans Pond Allochthon and, if one takes into account metamorphism and deformational contrasts, a correlation with the Reluctant Head Formation is feasible. Outcrops of this lithology along 'Helens Brook' are overlain by massive, grey marbles correlative with the St.George Group, suggesting a Cambrian age for these rocks. Along North Brook the thin banded marbles and phyllites are separated from massive grey marbles to the east by an inlier of Carboniferous conglomerate.

2.6 CARBONATE SEQUENCE: SUMMARY

Carbonate rocks make up a significant fraction of the Old Mans Pond area. Except at Goose Arm these rocks are poorly exposed; however, broad correlations with better known portions of the autochthonous carbonate sequence of west Newfoundland are possible (see Table 2). Basal

TABLE 2: Correlation of autochthonous sequence of west Newfoundland with carbonate sequence, Old Mans Pond area.

AGE		TERRANE: AUTOCHTHON WEST NEWFOUNDLAND (James et al, in prep)		CARBONATE TERRANE, OLD MANS POND AREA
ORDOVICIAN	CARADOC			
	LLAND			
	LLANV	TABLE HEAD		TABLE HEAD
	ARENIG	ST GEORGE		ST GEORGE
	TREMADOC			
CAMBRIAN	U	PETIT JARDIN	PORT AU PORT GROUP	BLUE CLIFF (Levesque, 1977)
	M	MARCH POINT		RELUCTANT HEAD / PENGUIN COVE
	L	HAWKE BAY FORTEAU BRADORE	LABRADOR GROUP	?
HADRYNIAN		LIGHTHOUSE COVE BATEAU		
HELIKIAN		LONG RANGE COMPLEX		

portions of the section are referred to as the Penguin Cove Formation at Goose Arm and the Reluctant Head Formation at Old Mans Pond (Lilly,1963) of late Lower and Upper middle Cambrian age respectively.

Overlying these units, and making up the bulk of the carbonate sequence, are massive carbonates correlative for the most part with the lower Ordovician St.George Group. To the north and east rocks of the carbonate sequence have been extensively recrystallized to grey and white marbles, the bulk of which are also correlative with the St.George Group. Notably,minor lithologies not characterisitic of the known St.George Group were observed.

Structures in the carbonate sequence show a marked reversal in polarity. In the western part of the area bedding and cleavage trend roughly northeast and the rocks are involved in open folds which are upright to westerly inclined. In the vicinity of Old Mans Pond folds in the Reluctant Head Formation are isoclinal and strongly east-vergent while bedding and cleavage both trend northeast and dip moderately to the northwest. In the northern part of the area bedding, cleavage and fold axes swing through a broad arc which is convex northwards.

At present only the broad structural and stratigraphic features of the carbonate sequence presented above are known. Local observations suggest that the geology of this terrane is much more varied and complex than presently viewed. More detailed and thorough study of these rocks and equivalents exposed to the north may well prove crucial to the understanding of the overall geologic history of this region.

CHAPTER THREE

OLD MANS POND ALLOCHTHON

3.1 INTRODUCTION

The Old Mans Pond Allochthon occupies the central portion of the map area centered roughly on Old Mans Mountain and extending north to Indian Dock Pond and south to Balls Pond (see Figure 2; also map in back pocket). It is surrounded on all sides by rocks of the carbonate terrane except to the southeast where it is bounded by the Hughes Lake Allochthon.

Rocks of the Old Mans Pond Allochthon have been subdivided into three formations based on lithic contrasts. To the north, in the vicinity of Canal and Long Ponds, and in a small outlier just northeast of Indian Dock Pond, greenish greywackes, sandstones and purple slates make up the Canal Pond Formation. Along the southeast margin of the Old Mans Pond Allochthon lies a belt of thinly interbedded marbles and phyllites which are called the Bobbys Brook Formation. Completing the Old Mans Pond Allochthon is the Otter Brook Formation which is primarily argillaceous in nature, being characterized by slaty to phyllitic grey shales and siltstones with minor coarser clastic beds. Together these three formations are designated as the Old Mans Pond Group.

Also included in the Old Mans Pond Allochthon are a pair of deformed metagabbro bodies which sit on or near the northern contact of the allochthon with the carbonate sequence. In the sections to follow a discussion of each of the lithic units which make up the Old Mans Pond Allochthon are described. This is followed by a discussion of the contact relationship between the Old Mans Pond Allochthon and the carbonate sequence.

3.2 CANAL POND FORMATION

(i) Definition and nomenclature:

The Canal Pond Formation consists of a series of arenaceous metasediments which characterize the northern portion of the Old Mans Pond Allochthon and are well exposed on the shores of Canal Pond. The predominantly arenaceous nature of this formation makes it more resistant to weathering than surrounding rocks and, as a result, it forms large, mostly barren hills and ridges. These barrens were noted by Baird (1960) who thought them to be underlain by slightly older rocks than the surrounding terrain. A small outlier of Canal Pond rocks occurs between Indian Dock Pond and North Brook and probable equivalents underlie the barrens due south of 'Reluctant Head' on Old Mans Pond.

(ii) Lithology:

The Canal Pond Formation consists primarily of greenish to grey micaceous greywackes, grey to white quartz sandstones and quartz pebble conglomerates. Distinctive greenish and purple slates form a minor yet significant part of this formation. All primary features in these sediments, including bedding, have been masked by a strongly developed micaceous cleavage which generally parallels the regional fabric.

In thin section the greywackes consist of undulose to polycrystalline quartz and plagioclase feldspar in a matrix of muscovite, chlorite and fine grained quartz and feldspar. Accessory euhedral to subhedral zircons are also common.

(iii) Structure and metamorphism:

As previously mentioned, the dominant structural element in the Canal Pond Formation is a strongly developed micaceous cleavage defined by the orientation of secondary muscovite. This cleavage generally trends northeast except along the northern margin of the Old Mans Pond Allochthon where it gradually swings around to trend east-west. Commonly a second cleavage is present which is nearly coplanar with the dominant cleavage and lends a reticulate or phacoidal fabric to the rock.

Metamorphic grade in the Canal Pond Formation is generally low. The most common mineral assemblage is quartz-feldspar- muscovite-chlorite indicating lower greenschist facies metamorphism or less (Winkler,1979).

(iv) Age and Correlation:

The greenish greywackes and sandstones and purplish slates of the Canal Pond Formation are remarkably similar to parts of the Summerside Formation of the Humber Arm Allochthon (Stevens,1965). In the southwestern part of the area Canal Pond rocks are separated from exposures of the Summerside Formation by a mere 3-4 km gap and the lithologic character, structural style and metamorphic grade of the two formations in this area is nearly identical (H.Williams,pers comm,1982). If correlation of these two formations is accepted a roughly lower Cambrian age is implied for the Canal Pond Formation.

3.3 OTTER BROOK FORMATION

(i) Definition:

The Otter Brook Formation comprises that series of rocks which underlies the major portion of the Old Mans Pond Allochthon from the east end of Old Mans Pond to Otter Brook. Due to the shaly nature of this formation exposure is generally poor except for newly created outcrops along the 'Old Mans Pond Road' and subsidiary logging roads, and along stream beds in the vicinity of Old Mans Pond and Balls Pond.

Lilly (1963) originally interpreted the predominantly argillaceous lithologies of the Otter Brook Formation as being conformable above that sequence of arenaceous rocks in the vicinity of Hughes Lake and Little North Pond and allocated both to the Mount Musgrave Formation. With the aid of the recently constructed woods roads a new unit has been recognized between the argillaceous and arenaceous members of Lillys Mount Musgrave Formation and the relationship between all three has been reinterpreted. Lillys nomenclature is therefore discontinued.

(ii) Lithology:

The bulk of the Otter Brook Formation consists of predominantly dark grey shales and lighter grey siltstones with subordinate amounts of coarser clastic material ranging from greenish, micaceous sands to pure white quartzites and quartz pebble conglomerates.

Metamorphism of these rocks is slight, not exceeding lower greenschist facies, however development of a strong slaty cleavage and transposition of bedding has all but destroyed primary sedimentary features and stratigraphic continuity within the sequence. As a result of the strong transposition, coarser clastic units are usually present as discontinuous beds or lenses.. In many cases the beds show grading which indicates tops alternately to the west and east suggesting large scale isoclinal folding throughout the sequence. In one instance, what appears to be a single bed is graded outwards from the centre, indicating that it is a single isoclinally folded bed. The hinges of such folds are rarely preserved but are invariably antiformal where observed.

Several anomalous lithologies make up a minor part of the Otter Brook Formation and while it is not possible to place stratigraphic constraints on these occurrences they may be significant in terms of paleoenvironmental interpretation and regional correlation and thus warrant consideration.

In the area between Otter Pond and Tern Pond (Locality 120) several occurrences of carbonate fragments associated with dark grey shales outcrop. In two of these outcrops the fragments consist of white recrystallized limestone augen oriented with their long axes parallel to the slaty cleavage in the shales (Plate 9).

PLATE 9: White limestone fragments in grey, slaty shales of Otter Brook Formation. Scale is in centimetres.

Other outcrops in this area consist of large mounds or hills of carbonate breccia surrounded by dark grey to black shales. Components of these breccias are exclusively grey marble fragments which generally do not exceed 10-20 cm in diameter. The isolated nature of these outcrops makes interpretation difficult.

South of Old Mans Pond (Locality 249), carbonates are again found associated with the Otter Brook Formation. In this locality buff marble fragments up to half a metre in diameter are found in a medium to coarse pebbly sand matrix, along with fragments of dark shale and reddish sandstone. These rocks are obviously conglomeratic in nature. Postdepositional deformation has flattened the fragments into discs. A similar association of carbonate fragments and clastic sediments has been reported from the Irishtown Formation of the Curling Group (Stevens,1965; pers. comm,1982).

A short section of purple shales and siltstones occur in the second stream to the west of the above locality (Locality 254). This is the only documented occurrence of such lithologies in the otherwise uniformly grey Otter Brook Formation although similar rocks are common in the Canal Pond Formation.

Along the 'Old Mans Pond Road' just east of the contact with the Reluctant Head Formation (Locality 48) the Otter

Brook Formation changes character significantly. Here grey shales and siltstones give way to predominantly greenish siltstones, and, in one locality, medium beds of buff dolostone and quartz sandstone occur in dark shales. Again such lithologies are atypical of the Otter Brook Formation and, at present, no known correlatives exist in the area. It may well be that these rocks are correlative with clastic sediments which locally underlie the Reluctant Head Formation to the south (Stag Hill Formation of Kennedy,1981) although more detailed work would be necessary to establish this correlation. Alternatively, similar lithologies have been reported from the Irishtown Formation where exposed at Bonne Bay (Quinn and Williams,1983).

Exposures of white quartz sandstones and coarse pebbly conglomerates in the falls at the mouth of Otter Brook and under the hill east of this locale (Locality 81) are anomalous within the Otter Brook Formation and were formerly thought to be correlative with parts of the Penguin Cove Formation (Lilly,1963). These sediments are thickly bedded and demonstrate grading in places. Clasts in the comglomerates are primarily blue quartz, however, lesser amounts of grey phyllite, red haematitic sandstone and white subhedral feldspar are present. These sandstones and conglomerates are identical to certain parts of the Canal Pond Formation, especially where exposed in the vicinity of

Tomtit Pond and, along with the purple slates typical of the Canal Pond Formation described above, serve to demonstrate the difficulties inherent in separating these two lithic units in the field.

A minor yet ubiquitous component of the Otter Brook Formation is thin, discontinuous quartz-feldspar-chlorite stringers. The significance of these stringers is not fully understood. They may be similar to those described by Kennedy (1981) which he has related to magmatic events to the east (Topsails Batholith). Similar stringers are found in the remainder of the Old Mans Pond Group and in the Hughes Lake Allochthon but none are present in the carbonate sequence.

(iii) Structure:

The predominantly argillaceous Otter Brook Formation exhibits a strong slaty cleavage throughout. This cleavage trends roughly northeast and invariably dips moderately to the northwest. In a few instances this cleavage is demonstrably axial planar to east-vergent tight to isoclinal folds which vary from a few centimetres to one or two metres in size. Alternations in facing direction as determined from grading and variations in bedding-cleavage relationships indicate that large scale isoclinal folding is common throughout the sequence. Other structural elements in the Otter Brook Formation include a weak cleavage which is nearly coplanar with the dominant cleavage, local kink folding of the dominant cleavage about horizontal axial planes and, an open, east-dipping late fracture cleavage.

(iv) Metamorphism:

As previously stated the metamorphic grade of the Otter Brook Formation is low, not exceeding lower greenschist facies. A slight metamorphic gradient does exist from west to east with the shales becoming progressively more phyllitic towards the east.

Along the 'Old Mans Pond Road', just south of Old Man Mountain (Locality 147) a number of occurrences of small incipient porphyroblasts were noted in the slates. Examination of these porphyroblasts under the petrographic microscope revealed them to be chloritoid (Plate 10). Chloritoid is characteristic of metapelites of fairly restricted composition (high Al_2O_3 and Fe/Mg ratio) but may be stable over a wide range of P-T conditions depending upon associated minerals and the partial pressures of water and oxygen in the rock (Miyashiro, 1975).

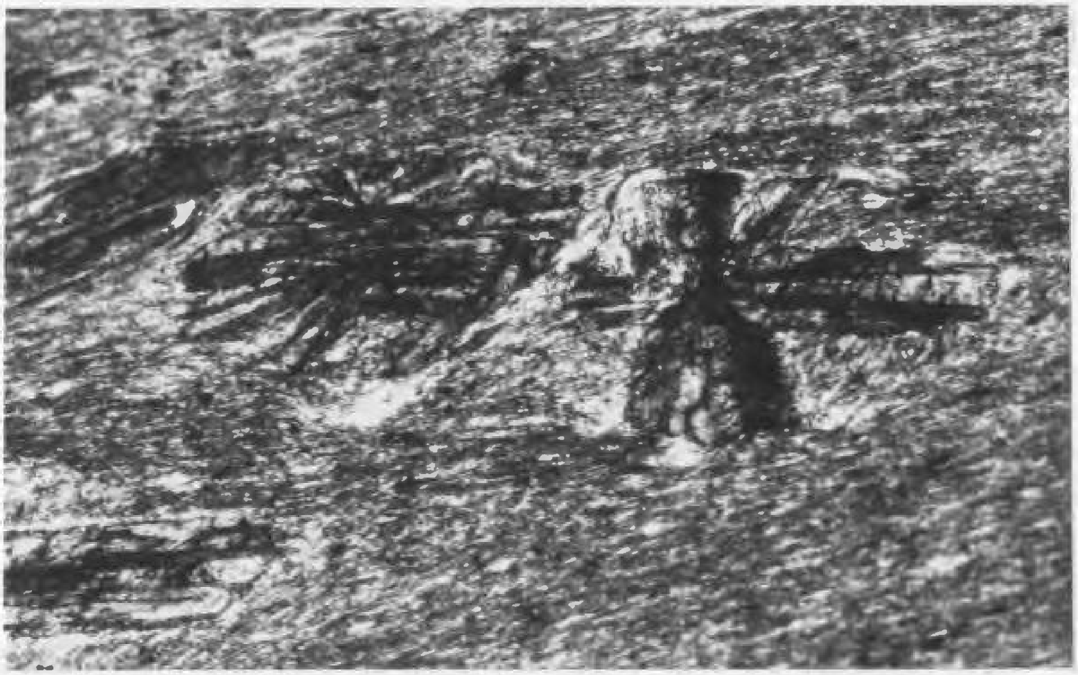


PLATE 10: Chloritoid porphyroblasts in slate, Otter Brook Formation. Magnification 40X.

(v) Contact relationships:

The boundaries between the Otter Brook Formation and the other units of the Old Mans Pond Group are generally poorly defined. The relationship between the argillaceous rocks of this formation and the arenaceous Canal Pond Formation is highly esoteric, involving more of a broad transition than a well defined contact. As mentioned previously it is not uncommon to find rocks typical of the Canal Pond Formation intimately associated with the Otter Brook Formation and vice versa. This intermixing is probably a direct result of structural complexity within the Old Mans Pond Allochthon.

The contact with the Bobbys Brook Formation to the southeast is sharper but nowhere exposed. This results largely from the fact that both units are essentially shaly in nature and therefore not well exposed or easily separated in the field. That the contact between the two is tectonic in nature remains as a distinct possibility which arises largely out of its sharp nature and simple outline and the apparent thinning or omission of the Otter Brook Formation along its northeastern end.

(vi) Age and correlation:

Lilly (1963) correlated the argillaceous rocks of the Otter Brook Formation (upper member of his Mount Musgrave Formation) with the Forteau Formation of the Labrador Group thus inferring a Cambrian age for these rocks. To date no fossils have been found in the Otter Brook Formation.

Lithic similarities suggest that the Otter Brook Formation is a correlative of the Irishtown Formation of the Humber Arm Allochthon, thus implying a late lower Cambrian age. The presence of limestone conglomerates and distinctive quartz pebble conglomerate units in both the

Otter Brook and Irishtown Formations serves to strengthen this correlation. Missing in the Otter Brook Formation are coarser conglomerate units of the Irishtown Formation (Quinn and Williams,1983).

The Otter Brook Formation may also correlate with more distal portions of the Hawke Bay Formation of the Labrador Group which outcrop in the vicinity of Bonne Bay to the north of the map area. These rocks are lithologically similar to the Otter Brook (R.K.Stevens, pers comm,1982); however, detailed sedimentological evidence would be required to prove whether the Otter Brook is in fact correlative with these rocks or with the more distal Irishtown. It is suggested here that rocks of the Otter Brook Formation were originally situated somewhere between the Hawke Bay and Irishtown Formations and are thus partly correlative with both.

3.4 BOBBYS BROOK FORMATION

(4) Definition and nomenclature:

The Bobbys Brook Formation was previously unrecognized in the Old Mans Pond area. Lilly (1963) makes no mention of these rocks and presumably failed to distinguish them from the upper member of his Mount Musgrave Formation.

The type locale for this formation is where 'Bobbys Brook' crosses the 'Old Mans Pond Road' east of Old Mans Pond. Best exposures by far occur along the 'Old Mans Pond Road' and the subsidiary woods road which leads to the south shore of Old Mans Pond.

(ii) Distribution and thickness:

The Bobbys Brook Formation lies in a belt extending along the southeast border of the Old Mans Pond Allochthon from the southern end of the eastern carbonate terrane to Balls Pond. The width of this belt averages two kilometres, however, the true stratigraphic thickness of the Bobbys Brook Formation is certainly very much less than this, having been repeated many times through intense folding and transposition.

(iii) Lithology:

At its type locality the Bobbys Brook Formation consists of 2-3 cm thick interbeds of coarsely crystalline, grey to buff marble separated by layers of silver-grey phyllite (Plate 11). Also present are thick (2-3 m) beds of marble breccia. Blocks in these breccias range from equant

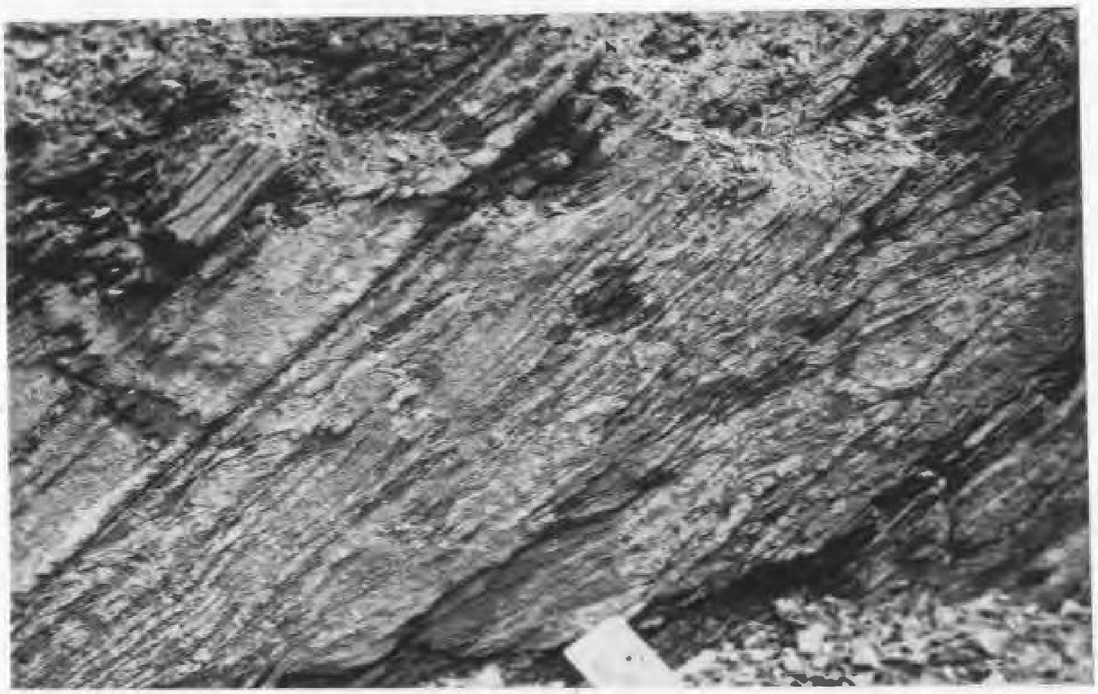


PLATE 11: Thinly interbedded grey marble and silver-grey phyllite, Bobbys Brook Formation, type locality. Note bedding-cleavage relationships. Scale is in inches.

PLATE 12: Well preserved oncolites in breccia matrix, Bobbys Brook Formation, Locality 334.

to tabular and generally do not exceed 30 cm in diameter. Towards the southeast the Bobbys Brook Formation becomes progressively more shaly but still contains thin wisps of marble.

Of special note are two anomalous lithologies within the formation. The first of these occurs at the southeast end of Balls Pond (Locality 334) where coarse carbonate breccia beds containing oolites and oncolites in their matrix outcrop (Plate 12). These breccia beds overlie a sequence of limey shales and phyllites which contain a few sandstone beds and are overlain by interbedded marble and phyllite. The hill to the north of this outcrop is comprised almost solely of a spectacular carbonate breccia containing equant blocks up to half a metre in diameter. The occurrence of oncolites in the matrix of these breccias is significant in that it represents the only fossil locality in the Old Mans Pond Group.

The second lithology of interest occurs near the extreme north end of the belt of Bobbys Brook rocks along the contact with Otter Brook and Canal Pond lithologies to the northwest (Locality 497). Here a single outcrop of dark, thickly bedded oolitic marble was found to outcrop along with thin bedded marble and phyllite and marble breccia. Exposure in this area is poor and the relationship between these three lithologies could not be determined.

It is noteworthy that both of these occurrences of oolitic/oncolitic lithologies lie at or near the northwest boundary of the Bobbys Brook Formation. It may be that these rocks represent a stratigraphic marker within the formation, however, as with the Otter Brook Formation, structural complexity precludes any inferrence as to exactly where in the stratigraphic sequence they may fit.

A number of samples of the Bobbys Brook Formation were dissolved in acetic acid in an attempt to extract conodonts for age dating purposes. While the search for conodonts was unsuccessful, the presence of sponge spicules, bornite and chalcopyrite in the residual heavy fraction provided an interesting sidelight. Also of interest was a thick oil film which developed on the surface of the acetic acid baths during dissolution.

(iv) Structure and metamorphism:

As with the Otter Brook Formation, the predominant structural element within the Bobbys Brook Formation is a well developed northeast-trending, northwest-dipping cleavage. Unlike the Otter Brook Formation, in which this cleavage is axial planar to folds which involve bedding, the cleavage in the Bobbys Brook Formation is axial planar to isoclinal folds which fold both bedding and a well developed bedding-parallel fabric. This early fabric is best demonstrated by the phyllitic inter-layers.

The grade of metamorphism of the Bobbys Brook Formation is higher than that of the Otter Brook Formation. Original carbonate beds have been recrystallized to coarse-grained marbles and argillaceous interbeds have been recrystallized to strongly micaceous phyllites. Aside from mica no other secondary minerals were observed in these rocks.

(v) Contact relationships:

The nature of the contact of the Bobbys Brook Formation with the clastic rocks to the northwest is poorly understood at this time. This contact was never observed, however, it must be a fairly abrupt transition since in a number of localities (eg. along the 'Old Mans Pond Road', Locality 159) the two sequences are separated by a narrow (1-2 metre) gap. Intuitively, this contact is thought to be stratigraphic in nature, however, the possibility that it is structural cannot be ruled out considering the extreme thinning, or omission, of the Otter Brook Formation along its northeastern end. Its abrupt and simple outline contrasts sharply with the contact between the other two members of the Old Mans Pond Group.

The contact between the Bobbys Brook Formation and the Round Pond Complex to the southeast will be discussed in Chapter 4.

(vi) Age and correlation:

Based primarily on lithic similarities the Bobbys Brook Formation may be correlated with a number of units in the immediate area.

Its thin-bedded marbles and phyllites and carbonate breccia units bear a strong resemblance to the Reluctant Head Formation of the carbonate sequence while the presence of oolites and oncolites noted in two localities suggest that at least part of the Bobbys Brook may be correlative with the upper part of the Penguin Cove Formation. By inferrence, the correlation of the Bobbys Brook formation with the Reluctant Head Formation also implies a correlation with the transported Cooks Brook Formation of the Humber Arm Allochthon. Oolitic/oncolitic breccias present along the northwest margin of the Bobbys Brook Formation may be represented by similar breccias found near the base of the Cooks Brook (James et al, 1980).

The Bobbys Brook Formation is physically continuous with, and nearly identical in both lithology and metamorphic grade to, rocks of the Grand Lake Brook Group exposed south of the map area. Of particular interest here is the report by McKillop (1961) of oolites and oncolites in Grand Lake Brook Group rocks very near their contact with overlying St. George Group carbonates south of the Humber Gorge.

In all of the above correlations a broadly middle to upper Cambrian age is suggested for the Bobbys Brook Formation.

3.5 THIN-BEDDED CAMBRIAN CARBONATES IN CENTRAL WEST NEWFOUNDLAND

It is evident from the preceding discussions of the Bobbys Brook and Reluctant Head Formations and their correlatives that there exists an extensive sequence of thinly bedded carbonates of roughly Cambrian age which comprise a regionally significant lithologic unit in the central part of west Newfoundland. To date little detailed work has been done on these rocks and it is felt that it would be timely to digress slightly here to highlight their salient features and possible significance to the regional geology, as well as some of the outstanding problems associated with them. Figure 3 illustrates the distribution of these rocks and the existing terminology which has been applied to various parts of the sequence (see p.24).

The Reluctant Head Formation (Lilly,1963) is essentially unmetamorphosed at its type section at Old Mans Pond but is physically continuous to the south with more highly metamorphosed equivalents which Walthier (1949) and McKillop (1961) assigned to the Grand Lake Brook Group. Kennedy (1981) subdivided the Grand Lake Brook Group into two formations and named that formation comprised of thin bedded carbonates the Reluctant Head Formation. Unfortunately, he also suggested that the type area for the Reluctant Head Formation be taken as that section exposed along 'Grand Lake Brook' in the Corner Brook Lake area. It is recommended here that the original type section at Reluctant Head (Lilly,1963) be retained since these rocks are best exposed and least metamorphosed there. Those thin bedded carbonates to the south of the Old Mans Pond area should be referred to as the Grand Lake Brook Group until such time as the problems of metamorphic grade and minor lithic contrasts with the Reluctant Head Formation at Old Mans Pond can be resolved.

As mentioned in the preceding section, the Bobbys Brook Formation in the Old Mans Pond area is lithologically and metamorphically identical to the Grand Lake Brook Group at

Humber Gorge and shows a much closer affinity to these rocks than does the Reluctant Head Formation. At present, the Bobbys Brook is interpreted as forming part of a structurally imbricated and transported sequence (Old Mans Pond Allochthon) and is separated from the Grand Lake Brook Group by a thrust which runs through Balls Pond. A similar situation occurs in the Corner Brook Lake area where the Twillick Brook Formation (Kennedy,1981) is correlated with, but structurally separated from, the Grand Lake Brook Group.

Age restrictions which may be placed on the Reluctant Head Formation (see Section 2.3) and lithic considerations suggest that these rocks, and by inferrence the rest of the sequence described above, are correlative with the well known Cooks Brook Formation of the transported Curling Group (Stevens,1970). This correlation is significant in that it provides a crucial link between autochthonous (Reluctant Head Formation and Grand Lake Brook Group), structurally imbricated (Bobbys Brook and Twillick Brook Formations) and, highly allochthonous portions of a sedimentary sequence which may have initially formed a laterally continous sedimentary package during the evolution of the ancient margin.

With the above in mind, further work on these lithologically distinct sequences could concentrate on: 1) firmly establishing the correlations suggested above (most essential to this is accurate dating of the individual sequences. The Reluctant Head Formation has the most potential for success here.); 2) documenting the stratigraphy of these sequences wherever possible with an eye towards detailing any changes in thickness and/or facies both along and across strike.

3.6 DEFORMED METAGABBROIC ROCKS:

A pair of deformed metagabbroic bodies were found at or near the northern contact of the Old Mans Pond Allochthon by H. Williams during the 1981 field season (Localities 450 and 82). Both occur as isolated dun-brown coloured knobs in topographically low areas. In hand specimen the rocks are greenish in colour and consist of saussuritized plagioclase feldspar and chlorite with minor biotite and possible relict hornblende.

Similar mafic to ultramafic bodies occur along a tectonic carbonate-metaclastic contact at the south end of Grand Lake (Kennedy, 1981) and have been interpreted there to be of ophiolitic affinity. A similar interpretation has been adopted here. As shall be seen later (Section 3.7(vi)), the presence of these deformed mafic bodies of probable ophiolitic affinity at the carbonate-metaclastic terrane boundary in the Old Mans Pond area lends support to the interpretation of this contact as a major tectonic juncture.

3.7 OLD MANS POND ALLOCHTHON-CARBONATE SEQUENCE CONTACT

A prime consideration of this study was to outline and define the nature of the contact between the metaclastic terrane and the carbonate sequence in the Old Mans Pond area. Recent work to the south of the area (Kennedy,1980) has established that the metaclastic rocks are thrust over the carbonates to the south in the Corner Brook Lake area. The same study also noted that this thrust contact steepened and lost all expression in the Old Mans Pond area. Indeed the contact is generally poorly exposed in the map area; however, existing exposures, combined with a knowledge of the surrounding geology, have allowed for adequate characterization of the contact during this study. A description of each of the locales where the contact was observed is given below, followed by a discussion of its overall character, interpretation and significance.

(i) North of Otter Pond:

The metaclastic-carbonate contact was first observed in a small stream which flows south into Otter Pond (Locality 203). At this locality a small falls and sharp bend in the stream correspond to a narrow, highly cleaved shaly zone between more coherent shales and siltstones to the south (Otter Brook Formation) and more massive carbonates to the north (St. George Group). The Reluctant Head Formation is drastically thinned or missing here. The contact zone itself is roughly 1-2 metres across, dips moderately to the northwest and is characterized by intense calcite veining. The dominant cleavage in the Otter Brook Formation and bedding in the St. George Group on either side of the contact zone are only slightly discordant making recognition of the contact itself difficult (Plate 13).

PLATE 13: Thrust contact between Reluctant Head Formation (right) and Otter Brook Formation (left). Thrust dips moderately to the northwest at this locale. Locality 203.

(ii) Woods road north of Bowaters Camp:

A subsidiary woods road north of the Bowaters camp on Old Mans Pond crosses a small stream very close to the contact between the Reluctant Head and Otter Brook Formations (Locality 90). The actual contact itself is poorly exposed, although intense quartz veining along the contact zone makes it slightly more resistant than the surrounding rocks. Slates and siltstones of the Otter Brook Formation south of the contact zone show a complex and intense deformational history while immediately north of the contact zone the Reluctant Head Formation is only mildly deformed.

(iii) Streams north of Hughes Brook:

East of the bend in Hughes Brook a series of small streams flow across the contact between Otter Brook Formation shales to the north and the Reluctant Head Formation to the south (Locality 410). Because of the predominantly shaly nature of both of these formations the contact itself is generally difficult to discern. Where exposed, it is invariably characterized by black, highly cleaved shales with small blocks of sandstone and carbonate, thus appearing rather melange-like. Abundant quartz-calcite veining characterizes the rocks on either side of the contact zone.

(iv) Cliff face north of Hughes Brook:

The lower portion of the Reluctant Head Formation and the underlying Otter Brook Formation are exposed in a small cliff face northeast of the bend in Hughes Brook (Locality 400). The Reluctant Head at this locale consists of coarse carbonate breccias and thinly interbedded limestones and muddy dolostones. These give way to mostly shales with a few thin beds of sandstone characteristic of the Otter Brook Formation over a narrow covered interval. Conjugate sets of calcite veins were noted in the rocks on either side of this covered interval.

(v) 'Helens Brook':

'Helens Brook' essentially follows the contact between the Canal Pond Formation to the northwest and a large ridge which forms part of the eastern carbonate terrane to the southeast. In a number of places along the middle and northern reaches of this brook the contact itself is exposed (Locality 465). At these localities the shallowly dipping Canal Pond metasediments have been intensely contorted and metamorphosed to highly micaeous schists and phyllites while the more massive carbonates to the southeast have been recrystallized to fine-grained mylonitic marble. The break between the two is sharp and cuts across the fabric of the rocks on either side.

(vi) Discussion:

The essential characteristics of the metaclastic-carbonate contact are as follows: 1) it is always a sharp feature marked by intense deformation and/or quartz-calcite veining; 2) it invariably dips parallel to the regional fabric, except along 'Helens Brook' where the contact is approximately vertical; 3) in places it truncates stratigraphic units (eg. Locality 203 north of Otter Pond).

Based on these features this contact has been interpreted as a sinuous fault. Where not exposed (eg. along the northern margin of the Old Mans Pond Allochthon) a combination of marked topographic expression and stratigraphic omission support this contention. Interpretation of the Old Mans Pond Group as correlative with the transported Curling Group of the Humber Arm Allochthon and recognition of two small deformed metagabbroic bodies along the contact between these rocks and the carbonate sequence leads to the conclusion that this contact is not merely a steep fault but a major thrust. This applies to the entire metaclastic-carbonate contact except for that segment along 'Helens Brook' which represents a late stage block fault. Lilly (1963) was the first to identify this thrust and interpreted it as a "zone of detachment" along which the carbonate sequence had slid westward over the metaclastic terrane. A preferred interpretation here is that the thrust represents a normal east-dipping surface which has been modified into its present configuration by later events. The reader is referred to Chapter 6 for a more detailed discussion of this concept.

3.8 OLD MANS POND ALLOCHTHON-SUMMARY

The Old Mans Pond Allochthon represents a newly recognized allochthonous assemblage in west Newfoundland. It comprises three lithic units of formational status which designated as the Old Mans Pond Group. Two of these, the Canal Pond and Otter Brook Formations, are made up of mainly clastic sediments with the former being more arenaceous and the latter largely argillaceous in character. The third unit, the Bobbys Brook Formation, consists of thinly interbedded marbles and phyllites with local occurrences of marble breccia beds which in places contain oncolites and/or oolites in their matrix. Two deformed metagabbroic bodies comprise a minor yet significant component of the allochthon.

Contact relationships between the three members of the Old Mans Pond Group are poorly understood. The boundary between the Canal Pond and Otter Brook Formations is complex and intimate intermixing of the two is common. The contact between the Bobbys Brook and Otter Brook Formations is much sharper in nature and better defined but nowhere exposed.

Lack of clear contact relationships between formations and poor stratigraphic and palaeontological control within formations preclude determination of the order of stratigraphic units and the absolute age of the Old Mans Pond Group. However, marked lithic similarities between these rocks and lowest units in the Humber Arm Allochthon suggest a direct correlation between these two sequences. The arenaceous Canal Pond Formation is similar to the Summerside Formation, the Otter Brook Formation is in many respects analogous to the Irishtown Formation and, the Bobbys Brook Formation resembles the Cooks Brook Formation. This correlation suggests a lower to middle Cambrian age for the Old Mans Pond Group, with the Canal Pond being the oldest and the Bobbys Brook Formation the youngest.

In addition to the above, the Otter Brook Formation is similar to more distal portions of the Hawke Bay Formation of the Labrador Group such as are exposed in the vicinity of Bonne Bay-Big Pond (R.K.Stevens, pers. comm.,1982). The Bobbys Brook Formation is similar to the Reluctant Head Formation and parts of the Penguin Cove Formation to the west and nearly identical to portions of the Grand Lake Brook Group (Walthier, 1949) to the south, a correlation which is strengthened by the localized occurrence of oolites and oncolites in all three. The Old Mans Pond Group then would appear to share features with both autochthonous and transported sequences of approximately equivalent age. Based on this the Old Mans Pond Group has been interpreted to have been paleogeographically situated somewhere between the proximal shelf sequence to the west and the more distal Curling Group which originally lay much farther to the east (see Table 3). Without better paleoenvironmental and paleontological control this suggestion must remain suspect.

South of Old Mans Pond, rocks of the Old Mans Pond Allochthon are separated by a mere 3-4 km gap from nearly identical rocks which make up part of the Humber Arm Allochthon. This raises the tantalizing prospect of the two being one and the same, a possibility which requires serious consideration when assessing the geological synthesis presented herein (Chapter 7) and when conducting any further work in the area.

The dominant structural element in the Old Mans Pond Allochthon is a pervasive cleavage which generally trends northeast and dips moderately to the northwest except in the northern part of the area where it swings through a broad arc following the border of the allochthon and dips nearly vertically. This cleavage is axial planar to isoclinal folds which, in the Otter Brook Formation at least, are

TABLE 3: Correlation of Old Mans Pond Group with established autochthonous and allochthonous stratigraphy, west Newfoundland.

AGE		AUTOCHTHONOUS SEQUENCE WEST NEWFOUNDLAND (James et al, in prep)		OLD MANS POND ALLOCHTHON		HUMBER ARM ALLOCHTHON (Stevens, pers comm, 1982)	
ORDOVICIAN	CARADOC						
ORDOVICIAN	LLAND						
ORDOVICIAN	LLANV	TABLE HEAD					
ORDOVICIAN	ARENIG	ST GEORGE				? BLOW ME DOWN BROOK	
ORDOVICIAN	TREMADOC	ST GEORGE				MIDDLE ARM POINT	
CAMBRIAN	U	PETIT JARDIN	PORT AU PORT GROUP	? METAGABBRO ?			
CAMBRIAN	M	MARCH POINT	PORT AU PORT GROUP	BOBBYS BROOK	OLD MANS POND GROUP	COOKS BROOK (*Bathyuriscus elrathina*)	CURLING GROUP
CAMBRIAN	L	HAWKE BAY FORTEAU BRADORE	LABRADOR GROUP	OTTER BROOK CANAL POND	OLD MANS POND GROUP	IRISHTOWN (*Olenellus* zone) SUMMERSIDE	CURLING GROUP
HADRYNIAN		LIGHTHOUSE COVE BATEAU	LABRADOR GROUP	?		?	
HELIKIAN & OLDER		LONG RANGE COMPLEX					

demonstrably east-vergent based on primary sedimentary criteria. Later stage structural features include a weakly developed cleavage which is close to parallel to the dominant cleavage, folding of the dominant cleavage about roughly horizontal fold axes and, an open, east-dipping fracture cleavage.

The Old Mans Pond Allochthon has been interpreted as having been thrust over the carbonate sequence to the west along a conventional east-dipping thrust which was subsequently modified to its present configuration by later events (see Chapter 6).

CHAPTER FOUR

HUGHES LAKE ALLOCHTHON

4.1 INTRODUCTION

The Hughes Lake Allochthon lies to the southeast of the Old Mans Pond Allochthon between Hughes Lake and Deer Lake. Metamorphic rocks of the east side of Deer Lake at Pynns Brook have also been included in the Hughes Lake Allochthon (Williams et al, 1982); however, these were not studied in any detail and are therefore discussed only briefly here.

West of Deer Lake the Hughes Lake Allochthon consists of two subdivisions. A series of granitic gneisses, albite-chlorite schists, pink felsites and amphibolites are all assigned to the Round Pond Complex (formerly the Hughes Lake Complex of Williams et al, 1982). The Round Pond Complex is overlain to the southeast by a thick sequence of coarse, arkosic sediments which have been named the Little North Pond Formation. Intervening locally between these two is a thin mafic volcanic unit referred to as the Deer Pond Volcanics. Overlying the Little North Pond Formation to the southeast are pelitic and psammitic schists of the South

Brook Formation which have correlatives across Deer Lake. Together the Little North Pond Formation, South Brook Formation and Deer Pond Volcanics are referred to as the Mount Musgrave Group (formerly the Pasadena Group of Williams et al, 1982).

4.2 ROUND POND COMPLEX

(i) Definition and nomenclature:

The name Round Pond Complex refers to that assemblage of granodioritic gneisses, albite-chlorite schists, pink felsites and amphibolites which consistently underlie a thick sequence of arkosic metasediments along the northwest margin of the Hughes Lake Allochthon. Best exposures of the various lithologies within the complex occur along the Old Mans Pond Road and on the shores of Hughes Lake. The name Hughes Lake Complex previously used to refer to these rocks (Williams et al, 1982) has been abandoned due to a conflict with terminology elsewhere. Lilly (1963) included these rocks in the arenaceous member of his Mount Musgrave Formation.

(ii) Lithology:

As the name indicates the Round Pond Complex consists of an intricately mixed, complicated assemblage of a variety of lithologies. Some of the units within the complex were previously unrecognized while others which were previously recognized have been redefined and reinterpreted during this study. A description of each of the units, including their interpretation and significance, is given below.

(a) Foliated to gneissic granodiorite and granite:

The bulk of the Round Pond Complex consists of a variety of foliated to gneissic granodiorites and granites best exposed on the shores of Hughes Lake (Locality 341). The most common lithology is a pink, medium-grained, foliated granodiorite which in thin-section is seen to consist of undulose quartz and a mixture of plagioclase feldspar, perthite and microcline. Both biotite and muscovite are present and serve to define a prominant foliation in the rocks. This foliation generally trends northeast, dips moderately to the northwest and has associated with it a strong down-dip lineation defined by quartz-feldspar aggregates. These rocks also show varying degrees of secondary albitization and are commonly cut by quartz-feldspar veins and stringers similar to those found in the Old Mans Pond Group.

Also occuring in this portion of the Round Pond Complex, but less common than the foliated granodiorites, is a coarse-grained, weakly foliated granite. This lithology was encountered in a stream flowing into Hughes Lake from the northwest (Locality 345) and its relationship with surrounding rocks is unknown. In thin-section the dominant mineral is a perthitic microcline feldspar. Minor plagioclase is also present along with quartz, biotite, muscovite (<5%) and magnetite. Delicate exsolution textures are evident and the perthite shows no evidence of any granulation or alteration (Plate 14). These preliminary petrographic findings indicate that this lithology is likely a hypersolvus granite of alkaline character (O. van Breemen, written comm, 1983).

Both the foliated granodiorites and granite exposed in the vicinity of Hughes Lake commonly have associated with them massive to lineated amphibolites. This association of granitic crystalline rocks and mafic sub-units is typical of Grenvillian aged basement inliers in west Newfoundland such as the Long Range Inlier to the north of the map area (Baird, 1960); portions of the Fleur de Lys terrane of the Baie Verte Peninsula (DeWit,1972; Hibbard,1979; in press); and segments of the terrane at the south end of Grand Lake

(Knapp et al,1979; Kennedy,1981).

PLATE 14: Photomicrograph of granite from Round Pond Complex. Note unaltered texture. Magnification 25X.

A direct comparison of lithologies in the Old Mans Pond and Corner Brook Lake (Kennedy,1981) areas reveals several similarities and discrepancies. For instance, the granitic rocks northwest of Hughes Lake are remarkably similar to Kennedys Last Hill Adamellite which he has correlated with the Silurian-Devonian Topsails Igneous Complex. Amphibolitic units, interpreted here as mafic dikes of late Cambrian age, associated with these granites in the Old Mans Pond area argue for an older age here. Samples of this granite are presently being analysed by the Geological

Survey of Canada Geochronology Lab in an attempt to verify this interpretation. The foliated and albitized granodiorites of the Old Mans Pond area bear a closer resemblance to portions of Kennedys metasedimentary terrane (Caribou Lake Formation) than they do to the well banded tonalitic and granodioritic gneisses of his basement terrane but do compare favourably with granitic gneisses reported south of Grand Lake (Knapp et al, 1979; Martineau, 1980). The association of deformed crystalline rocks and amphibolites, and their consistent position below a thick clastic sequence to the southeast, create a strong case for the interpretation of these rocks in the Old Mans Pond area as Grenvillian basement. This interpretation is at variance with the view previously held by Lilly (1963) that these rocks represent more metamorphosed equivalents of the Little North Pond Formation (arenaceous member of his Mount Musgrave Formation) to the southeast.

(b) Albite-chlorite schists:

Where the 'Old Mans Pond Road' cuts across the northeast end of the Round Pond Complex a long cliff-section of variably chloritic and albitic schists has been exposed. These rocks are greenish in colour because of the large proportion of chloritic material in them. They range from foliated to schistose in nature. Quartz is a common constituent, as are secondary albite porphyroblasts. The albites range in size from a few millimetres up to 2 centimetres in diameter and their development in the rocks is fairly patchy in nature. Other secondary minerals in these rocks include magnetite euhedra and biotite.

Examination of these rocks in thin-section reveals them to be composed of roughly 50% polycrystalline to undulose quartz, 40% chloritic matrix, 5% poikilitic albite porphyroblasts and 5% biotite plates. Poikilitic opaques, muscovite and calcite all exist as minor components.

Secondary albites in these schists have in some instances been rodded lending a weak lineation to the rock and suggesting that/the growth of the albites was most likely partially synkinematic with the main deformational event responsible for the porphyroblastesis. In contrast, secondary magnetite and biotite in these rocks are undeformed indicating post-deformational growth.

A biotite-chlorite unit approximately one metre wide was found cross-cutting the albite-chlorite schists across the road from the main cliff outcrop. This mafic unit has been interpreted as a retrograded mafic (amphibolite) dike.

The albite-chlorite schists are enigmatic in terms of protolith. Because of their position below easily recognizable sediments of the Little North Pond Formation to the southeast they have been included in the Round Pond Complex; however, aside from the growth of secondary albites and presence of relict amphibolites, they are unlike the more granitic lithologies which characterize the bulk of this complex. It is suggested here that these rocks represent a deformed sedimentary sequence of Hadrynian age correlative with the Bateau Formation of the Labrador Group (Williams and Stevens, 1969).

(c) Amphibolites:

As previously mentioned, amphibolites and sundry micaceous units interpreted as retrograded amphibolites are common throughout the granitic gneisses and albite-chlorite schists of the Round Pond Complex. These amphibolites are most prevalent and best preserved in the rocks around Hughes Lake (Locality 337) where they are commonly medium-grained, strongly lineated and consist of roughly 60% amphibole, 20% biotite and the remaining 20% of plagioclase feldspar. Scattered garnets are common in these rocks.

Although the fabric and contacts of these units generally parallel the fabric in the surrounding rocks they have been interpreted as mafic dikes similar to those which cut Grenvillian basement in the Long Range Inlier (Williams and Stevens, 1969; Strong, 1975). The narrow and discontinuous nature of these amphibolites tends to support this interpretation and later deformational events have been invoked to explain the present contact relationships.

(d) Pink felsite:

A unique lithologic unit, previously unrecognized in the Old Mans Pond area, is a pink, cryptocrystalline felsite which contains abundant ilmenite both as disseminated euhedra and concentrated in bands. This lithology is best exposed along the Old Mans Pond Road just east of the albite-chlorite schists and northeast of the main albite-chlorite schist outcrop (Locality 481).

Most commonly this unit consists of homogeneous pink felsite with disseminated ilmenite euhedra. In thin-section these felsites are composed of very fine-grained quartz and/or feldspar with poikilitic ilmenite euhedra and scattered biotite porphyroblasts. Rarely a ghost outline of a preexisting mineral (possibly feldspar) may be seen. Less frequently, ilmenite is present in thin (1-2 cm) bands which are convolutely folded (Plate 15).

Included with the homogeneous felsites is a unit which

PLATE 15: Convoluted ilmenite bands in pink, cryptocrystalline felsite. Interpreted as felsic volcanic flows. North end of Round Pond Complex. Scale is in inches.

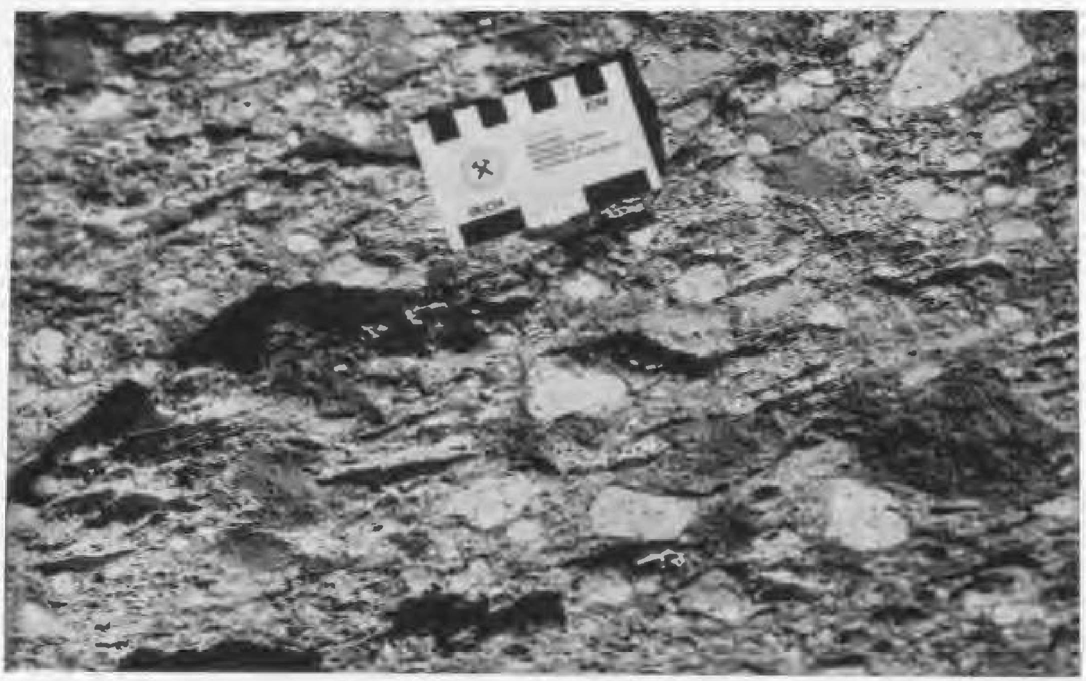


PLATE 16: Rounded blocks or bombs of felsic material in a more chloritic groundmass. Interpreted as a felsic agglomerate. North end of Round Pond Complex.

is distinctly fragmental in nature. This unit occurs north of the albite-chlorite schists, close to the contact with the Old Mans Pond Allochthon (Locality 481) and is well represented by a pair of large erratics along the 'Old Mans Pond Road'. Essentially, this lithology consists of lensoid fragments, up to ten centimetres in length, of pink felsite and more chloritic material set in a chloritic matrix (Plate 16). As with the pink felsites and the albite-chlorite schists, disseminated ilmenite euhedra are ubiquitous. This unit is also unique in that it contains abundant small pink garnets.

The macroscopic and petrographic character of the pink felsites and related fragmental units has led to their interpretation as felsic volcanic flows and agglomerates respectively. Their position between basement rocks and an overlying cover sequence and their close association with mafic volcanic flows (Deer Pond Volcanics, see Section 4.3) lends support to this interpretation. Felsic volcanic rocks are virtually unknown at this level in the Humber Zone of west Newfoundland, however, such lithologies are well documented in the southern Appalachians (Mount Rogers and Catoctin Formations) where they form one half of a bimodal volcanic suite extruded during rifting of the ancient continental margin in the late Precambrian or early Cambrian (Rankin,1975). A similar scenario is envisioned here.

Within this context the granite associated with the granodioritic gneisses of the Round Pond Complex may be a plutonic phase related to this volcanism.

(ii) Structure:

The dominant structural grain of the Round Pond Complex is defined by a strong foliation which trends consistently northeast and dips moderately towards the northwest. This fabric effects virtually all rocks in the Round Pond Complex and serves to mask earlier rock relationships; for example, the presumed original discordance between amphibolites and felsic gneisses in the vicinity of Hughes Lake. As mentioned earlier, a strong down-dip lineation defined by mineral aggregates is associated with this foliation in the rocks along the shores of Hughes Lake. Only rarely are folds preserved and in cases where they are observed they involve amphibolite units exposed along the east end of Long Pond and are isoclinal.

Structural elements other than the main foliation were not observed in the rocks of the Round Pond Complex. This by no means implies an uncomplicated deformational history for these rocks but rather reflects the competent nature of most of the lithologies which makes the recognition of subtle deformational events difficult. Since the structural grain of the Round Pond Complex mirrors the trends on either side of it, it is assumed that this is a Paleozoic fabric. Definite relict Precambrian structural elements were nowhere observed.

(iv) Metamorphism:

The metamorphic grade of the Round Pond Complex is higher than that of rocks to the west and appears to reflect two separate metamorphic events. The first of these events involved the growth of albite porphyroblasts throughout virtually all units of the complex. These porphyroblasts vary in size from a few millimetres up to a centimetre or so and their development is fairly patchy. In the vicinity of the southwest end of Hughes Lake the porphyroblasts are equant and appear to have grown across the dominant fabric of the rocks. Farther northeast there is evidence of a slight rodding of the albites in the albite-chlorite schists. From this it is suggested that albitization occurred both syn- and post-kinematically with respect to the main deformational event responsible for the dominant fabric in these rocks. Kennedy (1975) and Kennedy (1981) have reported albite porphyroblastesis extending through at least two deformational periods in similar rocks to the north and south respectively. Rare garnets present in amphibolites at the east end of Long Pond and in albite-chlorite schists southwest of the Old Mans Pond Road may also relate to an early metamorphic event.

Ilmenite euhedra and biotite flakes common throughout the Round Pond Complex represent a later metamorphic event since they are invariably fresh and undeformed and grow across lithic boundaries and schistosity.

(v) Contact relationships:

The relationships between assemblages within the Round Pond Complex are not at all well understood. The contact relationships between the complex as a whole and rocks on either side of it have been more definitively outlined during this study.

To the southeast of the Round Pond Complex lies a sequence of well defined, well exposed clastic sediments (Little North Pond Formation). Although the actual contact between these sediments and the Round Pond Complex was not observed it can be narrowed down to a gap of a metre or so at the north end of Little North Pond (Locality 419). Here the contact has been interpreted to represent an unconformity based on the marked lithic contrast across it and the coarse conglomeratic nature of the overlying sediments closest to it. This situation is identical to that demonstrated on Belle Isle where coarse conglomerates and arkosic sediments of the Bradore Formation unconformably overlie Grenvillian basement gneisses (Williams and Stevens,1969).

The contact of the Round Pond Complex with the Bobbys Brook Formation to the northwest is exposed in a number of locales. These are described below, followed by a discussion of the interpretation and significance of this contact.

(a) 'Old Mans Pond Road':

Construction of the 'Old Mans Pond Road' has exposed a section across the Round Pond Complex-Bobbys Brook contact. To the west of the contact zone coarse phyllites with thin, discontinuous, highly contorted marble bands dip moderately to the northwest. Immediately adjacent to the contact on its east side is a fairly homogeneous green, chlorite-rich unit with abundant biotite porphyroblasts which grades into albite-chlorite schists over a few metres. The green, chlorite-rich unit was interpreted in the field as a metamorphosed mafic volcanic. The albite-chlorite schists closest to the contact consist of agmatitic mixtures of quartz-albite-chlorite schists with quartz-rich and chlorite- rich pods and ilmenite or magnetite euhedra and schlieren throughout. This same aspect also characterizes the contact further to the northeast.

(b) Southwest of the 'Old Mans Pond Road':

Southwest of the 'Old Mans Pond Road', approximately half way between the road and Hughes Lake (Locality 273), the contact is again well exposed, this time in a stream flowing across it. Here a mixture of micaceous phyllites and marble breccia to the west pass rather abruptly into pure, fine-grained, pink mylonitic marble which then grades into albite-chlorite schists with no apparent structural break. Based on the strong lithic contrasts across this zone and the mylonitic nature of the marble unit the contact has been interpreted as a fault. This fault and the fabric on either side of it dip moderately to the northwest. Downstream from the contact the albite-chlorite schists give way to foliated granodiorites typical of the Round Pond Complex. Large blocks of green micaceous metavolcanic material occur conspicuously all along the trace of this contact.

(c) North of Hughes Lake:

The contact is once again exposed along a stream which flows south into Hughes Lake (Locality 346). From Hughes

Lake northward along this stream massive to weakly foliated coarse-grained granite with minor amphibolitic units becomes increasingly mylonitic approaching the contact with limey shales and phyllites to the northwest. A mylonitic zone roughly 15 metres wide characterizes the actual contact and a thin-section of rock from this zone reveals a characteristic mortared texture and a relative abundance of metamict sphene. This sphene likely resulted from mixing of carbonate material from the shales with ilmenite in the Round Pond gneisses (Winkler,1979).

Once again the contact is interpreted as a fault based on the marked lithic contrast across it and its mylonitic nature. Both the fault and fabrics on either side of it dip moderately to the northwest.

(d) Discussion:

From the above it is evident that wherever the contact between the Round Pond Complex and Bobbys Brook Formation is exposed it is characterized by a sharp juxtaposition of dissimilar rock units, usually marked by intense ductile deformation, and may best be interpreted as a fault. The fault zone invariably dips moderately to the northwest, paralleling the trend of units on either side of it. Development of secondary albite, ilmenite and biotite in rocks to the southeast of the fault and the absence of these minerals in rocks to the northwest serve to document a metamorphic contrast across the fault. Green metavolcanic rocks commonly associated with this fault are most likely structurally emplaced.

Three possibilities exist as to the interpretation and significance of this fault:

1) The fault may represent a high angle normal fault (ie. downthrown on northwest side).

2) It may be interpreted as a high angle reverse fault (ie. upthrown on northwest side) which brings Bobbys Brook over basement material. This situation is possible but improbable since it would require an initial configuration in which the Round Pond Complex lay structurally above the Old Mans Pond Allochthon. It should be pointed out that some component of motion of this type may have occurred along this fault since it was observed in the field to project along a vertical fault involving Carboniferous strata which demonstrates this type of motion. Hibbard (in press) has suggested a polygenetic nature for this fault and its continuation to the south (Corner Brook Lake Thrust).

3) The preferred interpretation for this fault is that

it represents a conventional west-directed thrust which brought basement material (Round Pond Complex) over younger rocks (Bobbys Brook Formation) and was modified by later events into its present configuration. This interpretation is preferred here since it best explains the present disposition of rock units and conforms with a similar situation along strike to the south where juxtaposition of basement against younger rocks along mylonitic thrust contacts has been well documented (Kennedy,1981). This does not rule out the possibility of later movement having taken place along this fault.

(vi) Age, correlation and interpretation:

Based solely on lithic character the pink granodioritic gneisses of the Round Pond Complex have been interpreted as basement material of Grenvillian age and correlated with the Long Range Inlier to the north, the Indian Head Complex to the south and smaller Precambrian inliers in between. Amphibolitic units within the gneisses have been interpreted as mafic dikes and correlated with similar dikes that cut basement rocks elsewhere and have been related to a rifting episode at the initiation of the Iapetus cycle (Strong and Williams,1972; Strong,1975). These dikes feed mafic volcanic flows which in the map area are represented by metamorphosed basaltic rocks (Deer Pond Volcanics) present between the basement gneisses and an overlying clastic sequence. Pink felsites and agglomerates which have been included in the Round Pond Complex may represent a felsic counterpart to these mafic flows. Similar bimodal volcanic suites (Crossnore Group) are well documented in the southern Appalachians (Rankin,1975). The hypersolvus granite associated with the granodioritic basement gneisses may be a plutonic phase related to this volcanism.

Albite-chlorite schists and related micaceous units in the Round Pond Complex most likely represent Hadrynian metasediments equivalent to the Bateau Formation of the Labrador Group (Williams and Stevens, 1969).

4.3 MOUNT MUSGRAVE GROUP

To the southeast of the Round Pond Complex lies a thick sequence of volcanic and sedimentary rocks referred to here as the Mount Musgrave Group. Included in this group are mafic volcanics (Deer Pond Volcanics), coarse arkosic sediments (Little North Pond Formation) and pelitic and psammitic schists (South Brook Formation).

4.3(a) DEER POND VOLCANICS

(i) Definition and nomenclature:

The name Deer Pond Volcanics is herein proposed for a discontinous mafic unit found along the southeast boundary of the Round Pond Complex and well exposed immediately north of Deer Pond. These rocks were previously unrecognised in the Old Mans Pond area.

(ii) Lithology:

Exposures of this unit range from massive to lineated biotite amphibolites and homogeneous, dense basaltic rocks which demonstrate well preserved epidote-filled amygdules where exposed at the north end of Little North Pond (H. Williams, pers comm, 1982, Locality 417) and north of Deer Pond (Locality 375). Locally south of the 'Old Mans Pond Road' these volcanics contain euhedral feldspar phenocrysts (Locality 473). Discontinuous layers of arkosic sediments are commonly associated with these volcanics north of Deer Pond.

(iii) Age, correlation and significance:

The obvious volcanic nature of this unit and its occurrence locally between inferred basement rocks to the northwest and a clastic cover sequence to the southeast suggest a correlation with basaltic flows which occur in the lower part of the Labrador Group at Belle Isle (Lighthouse Cove Formation, Williams and Stevens,1969). As previously discussed, the amphibolitic units in the underlying Round Pond Complex may represent deformed feeder dikes to these volcanics and, possible felsic volcanics presently included in the Round Pond Complex may be related to these mafic flows, making this a bimodal volcanic suite (Deer Pond Volcanic Suite). Discontinous layers of arkosic sediment commonly associated with these volcanics may represent sedimentary interbeds similar to those reported in the Lighthouse Cove Formation (Williams and Stevens,1969).

Mafic flows of the Lighthouse Cove Formation are generally accepted as late Hadrynian to early Cambrian in age and have been linked to initial rifting during the inception of the Iapetus ocean (Williams,1979). A similar age and setting are inferred here for the Deer Pond Volcanics.

A peculiar feature of the Deer Pond Volcanics is their magnetic expression. On the regional aeromagnetic map for the Pasadena area (4467 G) portions of this volcanic unit correspond to strong negative anomalies (for example, north of Deer Pond). This situation is fairly anomolous for volcanic sequences and one possible explanation for it is that the sequence has been overturned thus giving it a reversed magnetic signature (J.Hodych, pers comm, 1982). This fits well with the interpretation of these rocks as forming part of a northwest dipping, southeast facing cover sequence above the Round Pond Complex.

4.3(b) LITTLE NORTH POND FORMATION

(i) Definition and nomenclature:

The Little North Pond Formation is represented by that sequence of coarse arkosic sedimentary rocks which lie to the southeast of the Round Pond Complex and are best exposed over nearly their entire thickness along the shores of Little North Pond. Lilly (1963) originally designated these rocks as part of the lower arenaceous member of his Mount Musgrave Formation.

(ii) Distribution and thickness:

Rocks of the Little North Pond Formation lie in a uniform, northeast trending belt stretching from just south of Deer Pond north to the Old Mans Pond Road. Due to the arenaceous nature of these sediments they form high, barren ridges which provide nearly continuous exposure and allow the delineation of individual units over a distance of several kilometres. The thickness of this belt averages between one and two kilometres and since no structural complications are evident and beds dip nearly vertically this probably represents the true thickness of the sequence.

(iii) Lithology and stratigraphy:

Coarse grained arkosic sandstones, quartz greywackes, quartz pebble conglomerates and minor pelitic schists characterize the Little North Pond Formation. The most abundant of these are the arkosic sandstones which are pinkish grey in colour, massive, coarse-grained and comprised essentially of blue quartz and pinkish feldspar in a micaceous matrix. Depending upon the proportion of matrix material present this lithology grades into a quartz greywacke in composition. Thin magnetite-rich layers constitute a minor yet distinctive feature of these sandstones.

In thin-section, microcline is the dominant feldspar and quartz grains are sub-angular and polycrystalline in nature. Detrital zircons are ubiquitous throughout. All of these factors point to derivation of these sediments from a proximal granitic or gneissic source terrane.

In spite of the massive nature of the arkosic sandstones it is in places possible to recognize relict cross-bedding in outcrop (see Plate 17). Wherever observed, the cross-bedding invariably indicates tops to the southeast and a uniformly overturned section.

Quartz pebble conglomerate units characterize the lowest portions of the Little North Pond Formation adjacent to the Round Pond Complex. Where best preserved, such as along the shores of Little North Pond, the quartz pebbles in these conglomerates are moderately well rounded, up to 5 centimetres in diameter and set in an arkosic matrix (Plate 18). In other locales, such as just south of the 'Old Mans Pond Road', the quartz pebbles have been extremely deformed and drawn out into thin quartz lenses.

Of particular interest is the occurrence of amphibolites intimately associated with the Little North Pond Formation along its western margin. These are virtually identical to parts of the Deer Pond Volcanics and mafic units scattered throughout the Round Pond Complex.

PLATE 17: Relict cross-bedding in coarse arkosic sandstone of the Little North Pond Formation. Locality 419. Top indicated by arrow.

PLATE 18: Slightly flattened quartz pebbles near base of Little North Pond Formation. Locality 419.

(iv) Contact relationships:

As discussed previously (Section 4.2), the contact of the Little North Pond Formation with the Round Pond Complex to the northwest may be narrowed down to a gap of a mere few metres at Little North Pond and represents a zone of marked lithic contrast which has been interpreted as an unconformity.

To the southeast, arkosic sediments of the Little North Pond Formation grade into psammitic and pelitic schists of the South Brook Formation with no apparent structural or stratigraphic break.

(v) Age, correlation and interpretation:

Constant thickness, uniform lithology, consistent relationship with the underlying gneisses of the Round Pond Complex and invariable southeast-facing nature all combine to suggest that the Little North Pond Formation represents a clastic cover sequence overlying the Round Pond Complex. Its arkosic sandstones and quartz pebble conglomerates resemble the Bradore Formation which overlies Grenville basement to the north (Schuchert and Dunbar, 1934; Williams and Stevens, 1969; James et al, 1980) and mafic units associated with the basal portions of the section are similar to those that occur in the lower parts of the cover sequence on Belle Isle (Williams and Stevens, 1969). All of this implies a latest Proterozoic to earliest Cambrian age for the Little North Pond Formation and suggests that these sediments represent the initial cover deposited upon the eastern margin of the North Ammerican continent during rifting and initiation of the Iapetus ocean.

To the south of the map area, rocks correlative with the Little North Pond Formation are considerably more areally extensive (Stag Hill and Caribou Lake Formations, Kennedy,1981) but are more highly metamorphosed and therefore less recognizable. Of note is the absence of potassium feldspar in the Antler Hill Formation where it overlies basement rocks (Kennedy,1981). This is a direct reflection of the tonalitic nature of the basement rocks in this area. In the Old Mans Pond area on the other hand, the Little North Pond Formation overlies more granitic basement and, as a result, contains abundant potassium feldspar.

4.3(c) SOUTH BROOK FORMATION

(i) Definition, nomenclature and distribution:

The name South Brook Formation refers to that series of pelitic and psammitic schists which lie to the southeast of the Little North Pond Formation. These rocks are inferred to be continuous beneath their Carboniferous cover with rocks on the west side of Deer Lake at South Brook. Earlier workers (Lilly,1963; McKillop,1963; Kennedy,1980) referred to these and similar lithologies south of the map area as the Mount Musgrave Formation. This nomenclature is herein revised and it is suggested that these rocks, along with the Little North Pond Formation and Deer Pond Volcanics constitute the newly proposed 'Mount Musgrave Group'.

(ii) Lithology:

To the west of Deer Lake the South Brook Formation is essentially pelitic in nature being characterized by green micaceous schists with minor buff and reddish psammitic units. At South Brook, psammitic schists composed essentially of quartz, feldspar, muscovite, biotite and garnet, and minor quartzitic, feldspathic and metagreywacke units typify this formation. This portion of the South Brook Formation was examined only briefly by the author. Aside from layering no primary sedimentary structures are preserved in these rocks.

Examination in thin-section of some of the more psammitic units northwest of Deer Lake reveals a fine grained interlocking mosaic of quartz and plagioclase feldspar with lesser amounts of biotite and muscovite. The micas define two separate foliations, a dominant one which is visible on outcrop scale and, an earlier, relict foliation defined by oriented mica plates between the main foliation planes. Similar features have been documented by Kennedy (1981) in rocks which are correlative with the South Brook Formation (Mount Musgrave Formation).

(iii) Structure:

Pelitic schists exposed to the west of Deer Lake demonstrate a pair of cross-cutting cleavages which lend a pencilled nature to the rocks (Locality 318). In places an early foliation is involved in tight second generation folds. The dominant foliation in these rocks is a crenulation cleavage as revealed in thin-section.

At South Brook three phases of deformation were recognized by D.Knapp (Williams et al,1982). Here again an early foliation is folded by isoclinal folds which exhibit an axial planar crenulation cleavage. These structures are then overprinted by a later event which produced open, mesoscopic folds with moderately northwest-dipping axial planes.

(iv) Metamorphism:

The ubiquitous development of muscovite+biotite+garnet in these rocks indicate that they have been metamorphosed to upper greenschist facies or higher. A detailed petrographic study may allow accurate delineation of individual isograds; however, for the purposes of this study it will suffice to note that isograds trend roughly northeast (parallel to strike) and metamorphic grade increases towards the southeast. A K/Ar isotopic age from muscovite in the Mount Musgrave Formation to the south (correlative with the South Brook Formation) revealed a Silurian (cf.430 m.y.) cooling age for these rocks (Wanless et al,1965; Kennedy,1981).

(v) Age, correlation and interpretation:

The South Brook Formation is interpreted here to be younger than the Little North Pond Formation to the northwest and, as such, may represent a metamorphosed equivalent of lower parts of the Labrador Group (Forteau and Hawke Bay Formations). In lithology, metamorphic grade and structural style rocks of the South Brook Formation resemble parts of the Fleur de Lys Supergroup of the Baie Verte Peninsula and, as mentioned previously, are correlative to the south of the map area with the Mount Musgrave Formation of Kennedy (1981). These correlations are longstanding and formed the basis of a recent study of the entire 'Fleur de Lys Belt' (Hibbard, 1983).

4.4 HUGHES LAKE ALLOCHTHON-SUMMARY

The Hughes Lake Allochthon has been interpreted as a structural slice involving Precambrian basement rocks (Round Pond Complex) and an overlying cover sequence (Deer Pond Volcanics and Mount Musgrave Group). Granitic gneisses and various other lithologies of the Round Pond Complex have associated with them amphibolitic units which have been interpreted as mafic dikes equivalent to those which intrude the Grenvillian Long Range Complex to the north and have been related to rifting during the embryonic stages of the proto-Atlantic Ocean (Williams,1979). A possible felsic volcanic unit which has been included in the Round Pond Complex may in fact form part of a bimodal volcanic suite along with the newly recognized Deer Pond Volcanics (amygdaloidal mafic flows) which intervene locally between the Round Pond Complex and a clastic cover sequence, the Little North Pond Formation. These volcanics are correlative with flows which intervene between cover and basement at Belle Isle (Lighthouse Cove Formation, Williams and Stevens,1969). Chloritic schists associated with the Round Pond Complex have been interpreted as Hadrynian sediments correlative with the Bateau Formation of the Labrador Group.

The Little North Pond Formation is a two to three kilometre thick, coarse arkosic sedimentary sequence which unconformably overlies the Round Pond Complex. This sequence is characterized by quartz pebble conglomerates at its base and a consistent southeast-facing nature indicated by relict cross-bedding and grading in the coarser units. Similarities in lithic character and geologic setting suggest a strong correlation with the Bradore Formation of the Labrador Group.

Polydeformed psammitic and pelitic schists of the South Brook Formation overlie the Little North Pond Formation to the southeast. This sequence is identical in lithology, metamorphic grade and structural style to parts of the Fleur de Lys Supergroup and constitute part of the Fleur de Lys Belt (Hibbard, 1983; in press). Together the Deer Pond Volcanics, Little North Pond Formation and South Brook Formation make up the Mount Musgrave Group. Recognition of this stratigraphic sequence and its obvious ties to both the Labrador Group and Fleur de Lys Supergroup provides a key link between those two. The marked contrast in structural style between the two members of the Mount Musgrave Group is most likely a direct reflection of the highly competent nature of the Little North Pond Formation although the possibilty that a major thrust separates the two cannot be ruled out.

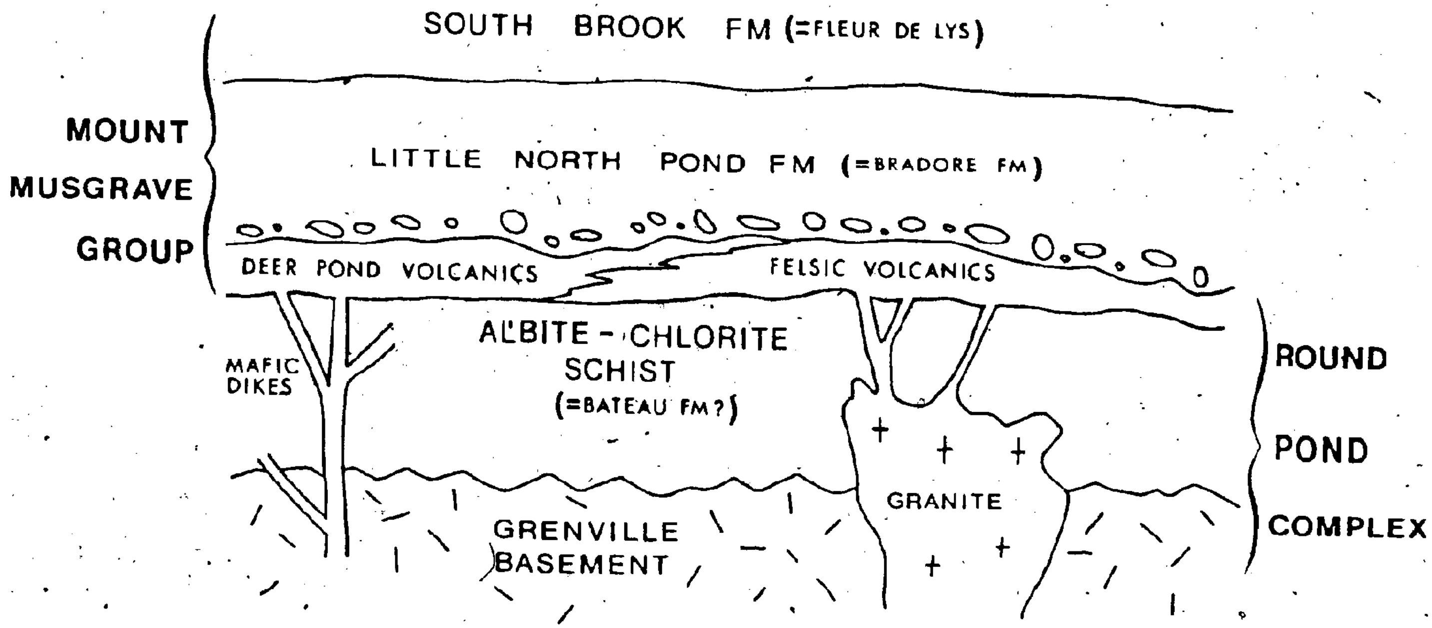


FIGURE 4: Relationships between rock groups in the Hughes Lake Allochthon, Old Mans Pond area.

TABLE 4: Comparison of Hughes Lake Allochthon with autochthonous sequence of west Newfoundland and Fleur de Lys Supergroup, Baie Verte Peninsula.

TERRANE / AGE		AUTOCHTHONOUS SEQUENCE WEST NEWFOUNDLAND (James et al, in prep)		HUGHES LAKE ALLOCHTHON		BAIE VERTE PENINSULA (Hibbard, 1983)			
LOWER ORDOVICIAN		ST GEORGE							
CAMBRIAN	U	MARCH POINT				FLEUR DE LYS SUPERGROUP	WHITE BAY GROUP	? RATTLING BROOK GROUP	? BIRCHY COMPLEX
CAMBRIAN	M	PETIT JARDIN				FLEUR DE LYS SUPERGROUP	WHITE BAY GROUP	RATTLING BROOK GROUP	BIRCHY COMPLEX
CAMBRIAN	L	HAWKE BAY FORTEAU BRADORE	LABRADOR GROUP	SOUTH BROOK LITTLE NORTH POND	MOUNT MUSGRAVE GROUP	FLEUR DE LYS SUPERGROUP	WHITE BAY GROUP	OLD HOUSE COVE GROUP	BIRCHY COMPLEX
HADRYNIAN		LIGHTHOUSE COVE BATEAU	LABRADOR GROUP	DEER POND VOLCANICS		FLEUR DE LYS SUPERGROUP	WHITE BAY GROUP	OLD HOUSE COVE GROUP	BIRCHY COMPLEX
HELIKIAN AND OLDER		LONG RANGE COMPLEX		ROUND POND COMPLEX		GRANITIC GNEISS		EAST POND METAMORPHIC SUITE	

Relationships of the various members of the Hughes Lake Allochthon are shown schematically in Figure 4. Inferred correlations between these rocks and the Labrador Group and Fleur de Lys Supergroup are summarized in Table 4.

A marked contrast in both structural style and metamorphic grade is evident between the Old Mans Pond Allochthon and the Hughes Lake Allochthon. Synchronous structural events may be recognized in both assemlages (See Chapter 6); however, the overall effect of these events on rocks of the Hughes Lake Allochthon was much more intense and pervasive. The metamorphic grade of the Hughes Lake Allochthon reflects at least upper greenschist facies conditions and extensive porphyroblastesis (garnet, albite and biotite) is evident.

CHAPTER FIVE

COVER ROCKS

Subhorizontal Carboniferous strata of the Deer Lake Basin overlap the older Paleozoic sequences along the western side of Deer Lake with marked unconformity. In this area the two lower formations of the Deer Lake Group are recognized. The lower of the two, the North Brook Formation (Belt,1969) is characterized by greenish-grey to red pebble and boulder conglomerates, red and green sandstones and minor red siltstones. The conglomerates range from sub-angular,matrix supported to well rounded, clast supported and are poorly imbricated and demonstrate a crude cross-stratification in places. Clast composition ranges from pink, granitic material to limestone and marble. Wherever the contact with underlying Paleozoic rocks is exposed (eg. along Ninth Brook, Locality 187) abundant fragments of the immediately underlying lithologies are common.

A few thin, buff limestone beds were noted in the North Brook Formation along Little North Brook (D.Knapp, pers comm,1982). Also, an inlier of Carboniferous rocks was found by the author along North Brook which consisted of buff to pinkish laminated limestone and minor pinkish chert which constitute the matrix of a conglomerate containing sub-angular fragments of quartzite, greenish schist and dark grey marble. A similar conglomerate was reported by Belt (1969). According to Hyde (1979) the North Brook Formation is interpreted to represent an alluvial fan deposit. Limestones in its upper parts represent a transition to marine conditions.

Overlying the North Brook Formation and occupying the northern portion of the Deer Lake Basin are grey and red sandstones and siltstones of the Rocky Brook Formation (Hyde, 1979). A number of uraniferous zones have been reported to occur in this formation in the section exposed along North Brook and oil shales have been found in float at the mouth of this stream (Hyde, 1979). The Rocky Brook Formation is interpreted as representing a transition to a mixed fluvial and lacustrine environment from more marine conditions (Hyde, 1979).

The North Brook and Rocky Brook Formations are late Visean to early Namurian (late Mississippian) in age (Hyde, 1979). Relief on the pre-Mississippian erosional surface was considerable as indicated by the older Paleozoic inliers which protrude through the Carboniferous strata along the western margin of the Deer Lake Basin.

Rocks of the Deer Lake Group are essentially undeformed on the west side of Deer Lake except for a gentle warping in places. To the east of Deer Lake these same strata are steeply dipping to overturned where they have been overthrust by older rocks of the Pynns Brook Complex and South Brook Formation (Williams et al, 1982a,b). The Deer Lake Group is in fault contact with the older Anguille Group (early Mississippian) east of Deer Lake. This fault is steeply dipping and rocks adjacent to it show intense deformation. Hyde (1979) and Belt (1969) suggest a strike slip nature for this fault and relate it to the larger Cabot Fault to the south (Wilson,1962; Williams et al,1970).

PART THREE-STRUCTURAL GEOLOGY

CHAPTER SIX

6.1 INTRODUCTION

The Old Mans Pond area is situated between the transported Humber Arm Allochthon and the exposed eastern edge of the Appalachian miogeocline and, as such, provides a unique opportunity to study the structural development of the deformed ancient continental margin of eastern North America. Rocks in the area demonstrate several generations of structural elements, presumably related to distinct deformational events which were active over a protracted period of Paleozoic time. Each deformational event differed from earlier and later events with the earlier events being more pervasive and intense. In general, the complexity and intensity of deformation increases markedly from west to east across the area.

The dominant structural grain in the Old Mans Pond area trends roughly northeast except along the northern margin of the area where structures swing through a broad, convex northwards arc to strike nearly due east. One of the most striking features of the area is a marked reversal in structural polarity from west to east. Rocks of the carbonate sequence to the west are involved in folds which are upright to westerly inclined while east of the west end of Old Mans Pond bedding and cleavage dip moderately to the northwest and folds face southeast on primary sedimentary criteria. Similar reversals in structural polarity have been reported from regions to the northeast (Bursnall,1979) and southwest (Williams and Godfrey, 1980; Kennedy, 1981), however, timing and mechanisms responsible have remained obscure. A portion of this chapter is devoted to a discussion of, and possible explanation for, this enigma as it relates to the Old Mans Pond area.

Also of concern here is to determine what, if any, differences exist between the structural development of the carbonate sequence versus that of the metaclastic terrane. Earlier reconnaissance work in the area (Baird, 1960) had suggested that no significant structural break exists between the two (see Williams, 1967). Thus, the possibility of studying a portion of the ancient carbonate bank sequence and clastic prism essentially linked throughout their deformational history presented itself. This is a rare opportunity in the Humber Zone where rocks interpreted to represent off-shelf rise prism sediments are invariably structurally emplaced against the carbonate sequence and show a more complex deformational history (Rodgers, 1968; Stevens, 1970). Recent work in the ajoining area to the south (Kennedy,1981) has shown that a major thrust separates the two sequences in that area and the suggestion was made that this thrust system continued into the Old Mans Pond area.

The format of this chapter follows a conventional approach to dealing with the description and interpretation of the structural geology of an area. Initially the area is divided into four domains (see Figure 5) and each is described and discussed as an internally consistent entity. Domain boundaries coincide with natural geologic breaks in the area and it is hoped that by treating each domain separately any contrasts, or similarities, in structural style will be highlighted. Following this, a model for the structural development of the area is proposed based on the geology of the area, the sequence and pattern of structural elements observed, regional tectonic constraints and comparison with better understood orogenic belts. It is hoped that the reader will bear in mind that, while an interpretation of the structural history of the area based on the recognition, interpretation and correlation of the various structural elements has been presented, alternative interpretations may be possible at all levels. Wherever possible the most likely alternatives will be briefly

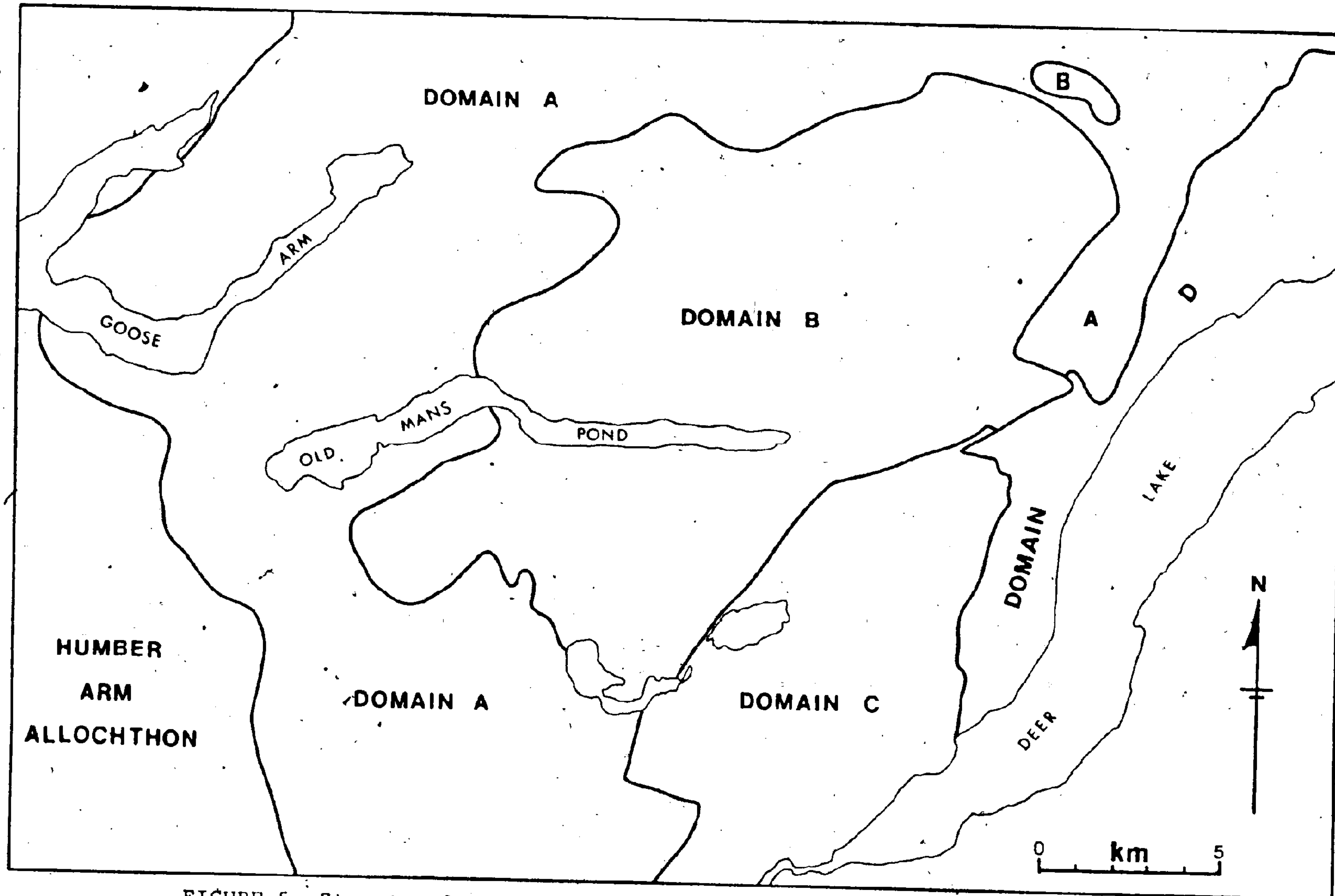


FIGURE 5: Structural domains in the Old Mans Pond area.

discussed.

6.2 TERMINOLOGY

In the sections to follow the essential structural components observed to exist in the Old Mans Pond area are described. For the sake of simplicity each element within a given domain has been given a notation which indicates its temporal relationship with other elements in that domain. For example, D1 refers to the first deformational event recognized in a given domain; planar fabrics related to this event are noted as S1, folds as F1, lineations as L1 etc. It should be emphasized that D1 etc. refer to events which are mutually exclusive to the domain in which they have been recognized and are not necessarily synchronous with elements in the other domains.

The nomenclature used here to describe folds is as suggested by Fleuty (1964) and Ramsay (1967). Usage of the terms schistosity, foliation and cleavage follow the suggestion of Hobbs et al (1976).

6.3 DOMAIN A: CARBONATE SEQUENCE

The rocks of the carbonate sequence comprise the largest and, unfortunately, least well understood domain in terms of structural development. The most remarkable feature of this domain is a marked reversal in structural polarity from west to east across it. In the west (Goose Arm) rocks of the carbonate sequence are involved in folds which are upright to slightly overturned to the west and shallowly plunging either northeast or southwest (see Plate 19). These folds are invariably open and concentric in style and range up to several hundred metres or so in amplitude. In all likelihood this is a reflection of the competency of the rocks affected. A moderate stylolitic cleavage is invariably present which is axial planar to these folds. This cleavage increases in intensity towards the north and east and is especially prevalent in the eastern carbonate terrane.

PLATE 19: Large open syncline typical of fold style in rocks of St. George Group. Cliff face is roughly 30 metres high. Southwest end of Old Mans Pond.

In contrast, rocks to the east of the western end of Old Mans Pond are invariably involved in folds which are overturned to the east and accompanied by a slaty axial planar cleavage which dips moderately to the west or northwest. Typical of this area is the Reluctant Head Formation which is characterized by easily recognizable tight to isoclinal folds where exposed on the shores of Old Mans Pond at 'Reluctant Head' and in the cliff face north of the bend in Hughes Brook. The style of these folds as compared to the more open folds characteristic of the remainder of the carbonate sequence reflects to a large extent the thin-bedded, relatively incompetent nature of the Reluctant Head which allowed for easy fold nucleation. These folds may be up to 100 metres in amplitude (eg. at Reluctant Head) but most are on the scale of a few metres in size or smaller (Plate 20).

PLATE 20: Small angular folds in Reluctant Head Formation, north shore of Old Mans Pond. Note northwest dip of axial trace. Generally folds in the Reluctant Head are more isoclinal than this.

Most are isoclinal and all have roughly horizontal, northeast trending axes. In all cases the folds observed involve only bedding and, as such, constitute F1 structural elements in the carbonate domain. No intrafolial folds or preexisting fabrics indicative of an earlier deformational event were observed.

Bedding, fold axes and cleavage in the carbonate domain all trend roughly northeast except along the northern margin of the area where they swing through a broad, convex northwards arc to trend nearly due east. The resultant pattern has previously been interpreted as a late, regional-scale antiform (Baird, 1960; Kennedy, 1981).

Stereoplots of data collected for bedding, cleavage and fold axis orientations in the carbonate domain are given in Figures 6A and 6B. Figure 6A is a plot of poles to bedding only. A strong great circle girdle is evident with a corresponding Beta-pole oriented 10/035. This pattern reflects folding about a northeast trending, nearly horizontal axis; an interpretation which is borne out by the few measured fold axes. The point maximum in the southeast quadrant is more a function of concentration of readings from the Reluctant Head Formation than it is reflective of asymmetric, inclined folding. A second, weak pi-girdle is also evident. The pole to this plane is oriented 40/285 which is roughly at right angles to the Beta-pole.

Figure 6B contains cleavage data for the carbonate domain. Identical influences to those demonstrated in Figure 6A are evident but are less well developed largely due to the paucity of data. This data set also contains a

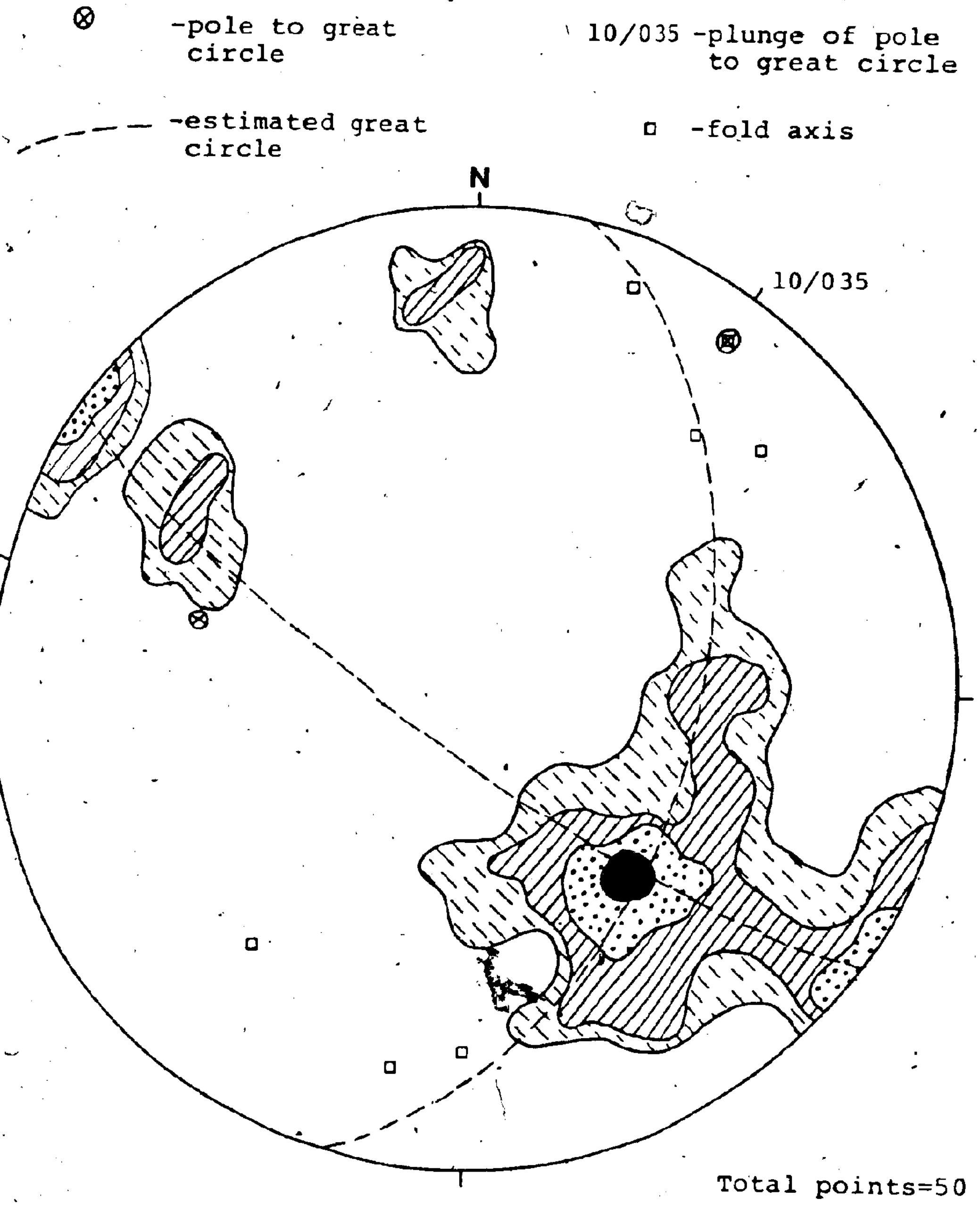


FIGURE 6A: Contoured equal-area stereographic projection of poles to bedding in Domain A. Contours: 1,2,4 and 8 points per 1% area

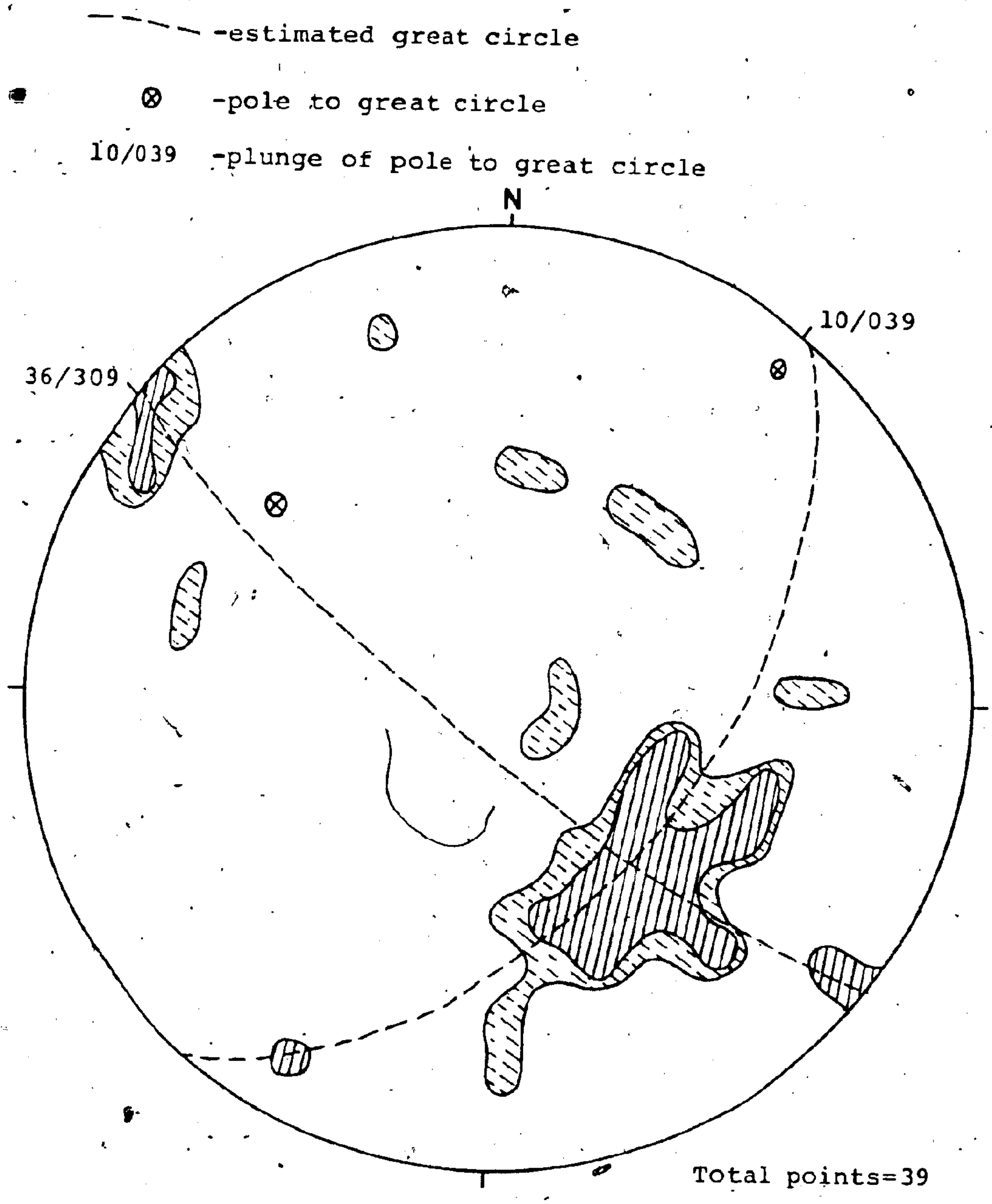


FIGURE 6B: Contoured equal-area stereographic projection of poles to cleavage in Domain A. Contours: 1 and 2 points per 1% area.

fair degree of scatter.

6.4 DOMAIN B: OLD MANS POND ALLOCHTHON

In terms of structural style, rocks of the Old Mans Pond Allochthon are nearly identical to the eastern portion of the carbonate domain. However, the overall deformational history of this domain would appear to be more complex than that of the carbonate domain. The dominant structural element of this domain is a strong planar fabric which trends roughly northeast and dips moderately northwest in the southern and central parts of the allochthon but swings through a broad arc to trend nearly due east and dip close to vertically in the northern part, thus mimicking the pattern shown by the carbonate domain. This dominant fabric, however, is a D2 element within the Old Mans Pond Allochthon. This is most evident in the Bobbys Brook Formation where F2 isoclinal folds, well demonstrated by the thinly bedded carbonates of this formation, may be seen to fold an earlier S1 foliation which is best preserved in the shaley interbeds. This early foliation is generally otherwise indistinguishable since it is most commonly parallel to both primary layering and the strong S2 fabric. A similar situation has been reported by Kennedy (1981) in equivalent rocks farther south (Grand Lake Brook Group).

In the remaining, more westerly portions of the Old Mans Pond Allochthon the effects of an early period of deformation are less evident. Small, irregular bedding folds sporadically preserved in the thinly bedded shales and siltstones of the Otter Brook Formation may be related to this event (Plate 21). These folds do not possess an axial planar cleavage and were interpreted in the field to be a result of soft sediment deformation.

PLATE 21: Possible soft sediment folds (F1) in interbedded shales and siltstones of Otter Brook Formation. These folds lack an axial planar cleavage. Scale is in inches.

A small bedding plane thrust, similar to that described by Stevens (1965) and interpreted to represent primary deformation due to slumping, was observed in a sandstone bed along the western margin of the Otter Brook Formation. This too may represent a manifestation of the earliest deformational event to effect the rocks of the Old Mans Pond Allochthon.

The dominant, S2 fabric in the Old Mans Pond Allochthon varies in expression between the three members of the Old Mans Pond Group. In the predominantly arenaceous Canal Pond Formation it is represented by a strongly micaceous cleavage which masks primary bedding, thus making the recognition of any associated folding difficult. More argillaceous subunits within the Canal Pond are characterized by a slaty S2 cleavage.

In the argillaceous Otter Brook Formation, S2 is represented by a strong slaty cleavage which is axial planar to isoclinal folds (Plate 22). These folds strongly transpose original layering (bedding) in these rocks resulting in bedding and cleavage being parallel and combining to form the dominant fabric throughout much of this formation. In thin-section the cleavage itself is revealed to be a classic domainal slaty cleavage of the type described by Hobbs et al (1976) and Weber (1981) (see Plate 23). Identical fabrics have been interpreted by Weber (1981) to arise through syntectonic recrystallisation under low grade metamorphic conditions.

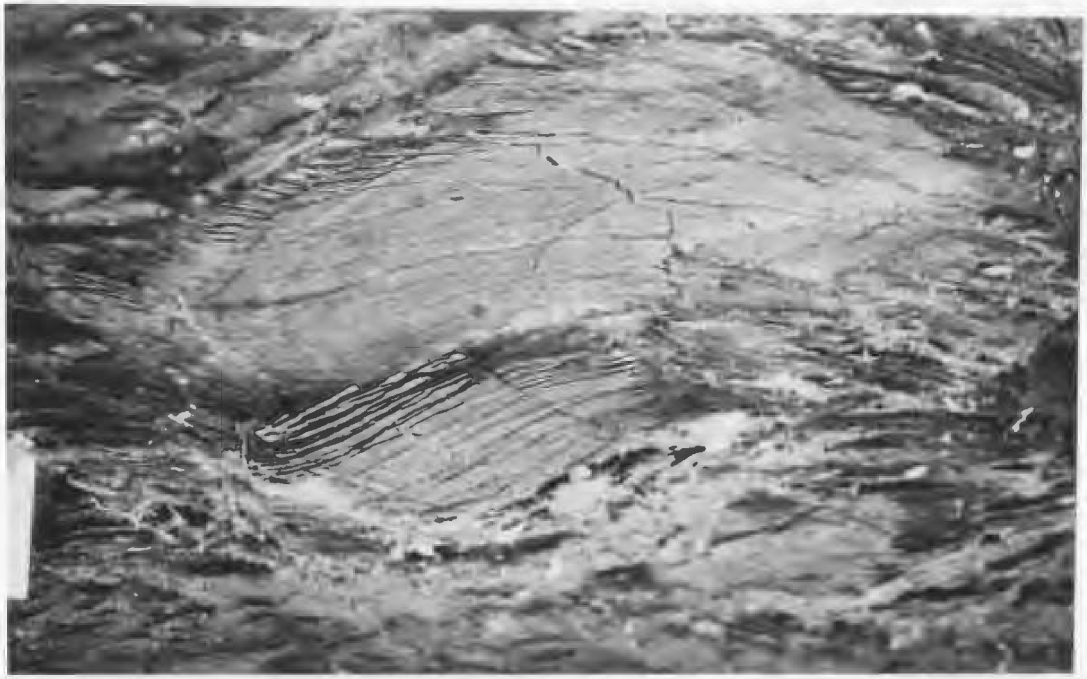


PLATE 22: Isoclinal D2 fold in shales of Otter Brook Formation. Note strong axial planar slaty cleavage. Field of view is roughly 12 centimetres across.

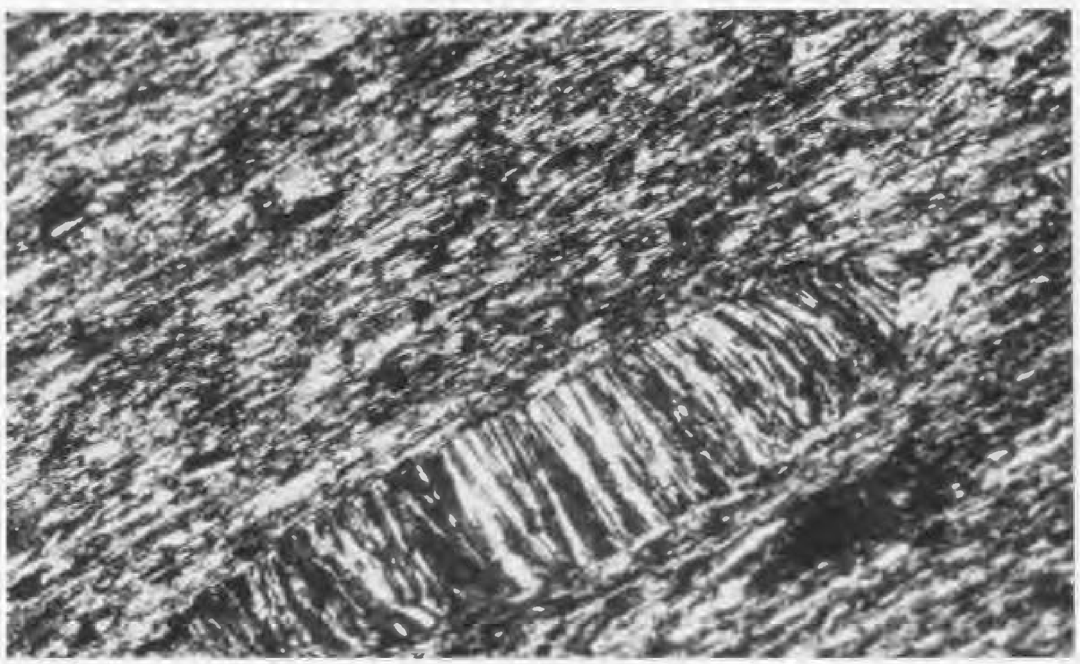


PLATE 23: Well developed domainal slaty cleavage typical of Otter Brook Formation. Large mica domain is roughly 2 millimetres long.

A down-dip lineation defined by pyrite aggregates is commonly developed within the slaty cleavage in these rocks. This lineation is oriented at a high angle to preserved fold hinges and therefore most likely represents the direction of maximum extention within the stress field active during generation of the associated cleavage which, by inferrence, lies in a plane normal to the maximum shortening direction (Hobbs et al,1976; Mitra and Elliott,1979).

As previously mentioned, folds to which the dominant cleavage is axial planar are tight to isoclinal in nature. Fold closures are rarely preserved but, where observed, they are invariably antiformal and fold axes are horizontal to gently northeast plunging. In rare instances these folds may be shown to be anticlinal in the strictest sense. One locality in which this may be demonstrated occurs along the 'Old Mans Pond Road' just south of Old Man Mountain (Locality 146). Here a large fold (2-3 metres in amplitude) in interbedded siltstones and sandstones is anticlinal and southeast-facing on the basis of grading in the sandstone beds. On the north shore of Old Mans Pond (Locality 221) another fold, in this case in a pebbly sandstone bed, is again anticlinal and southeast facing on the basis of grading. Despite the paucity of preserved fold closures extensive folding is suggested by the alternation of facing direction based on grading and bedding-cleavage relationships from outcrop to outcrop within the sequence.

The dominant fabric in the Bobbys Brook Formation is a strong cleavage best developed in its more argillaceous portions. This cleavage is slightly more micaceous than that in the Otter Brook Formation reflecting the slightly higher grade of metamorphism experienced by this portion of the allochthon. Folds associated with the cleavage are well demonstrated by the thin carbonate beds typical of this unit. These folds are invariably small (10-20 cm in amplitude), isoclinal and asymmetric in style. Axial traces of the folds are complex and lineations preserved in the limbs show variable orientations suggesting a complex deformational history for these rocks (see Plate 24). Rapid alternation in cleavage-bedding relationships evident throughout the section indicate large scale isoclinal folding.

There is invariably present in the rocks of the Old Mans Pond Allochthon a weak cleavage which is approximately coplanar with the dominant cleavage discussed above. The age of this cleavage relative to the dominant fabric is uncertain since its relationship with the dominant cleavage and associated isoclinal folds could not be documented. In many areas the two cleavages form an anastomosing or phacoidal pattern. A similar pattern is commonly reported

PLATE 24: Complex asymmetric isoclinal folds (F2) typical of Bobbys Brook Formation. Folds axes tend to be strongly curvilinear. These folds involve a previous (D1) fabric as well as original bedding.

to occur in the transported Humber Arm Supergroup to the west where it is evident both in intact sedimentary sequences (Stevens,1965) and in the melange zones which bound the individual slices within the allochthon. Although varied and often complex explanations for this phacoidal fabric have been suggested (eg. Schillereff,1980) this pattern in the Old Mans Pond area is interpreted to have arisen simply as a result of the superposition of two nearly parallel cleavages, both of which are roughly equivalent in age (see Section 6.9).

The latest structural element in the Old Mans Pond

Allochthon is an open, northeast trending, moderately east-dipping fracture cleavage (see Plate 25) which tends to become more pervasive and closely spaced towards the east. This cleavage may or may not be related to kink or chevron type folds which fold the dominant S2 fabric in these rocks. These folds were observed along the north shore of Old Mans Pond (Locality 207), just west of the contact between the Bobbys Brook and Otter Brook Formations on the 'Old Mans Pond Road' (Locality 156) and, along a logging trail northeast of Otter Pond (Locality 117). They invariably possess horizontal axial planes and northeast trending fold axes (see Plate 26).

The order of structural events recorded in the Old Mans Pond Allochthon then would appear to be: 1) development of an early, bedding parallel cleavage and possible soft sediment folds and thrusts; 2) isoclinal folding accompanied by a strong axial planar cleavage which varies in expression between members of the Old Mans Pond Group; 3) development of a weak cleavage nearly coplanar (and possibly synchronous) with the dominant cleavage and 4) development of a late, east-dipping fracture cleavage and related kink folds.

Figure 7 is a stereoplot of bedding, S2 cleavage and fold axes measured in the Old Mans Pond Allochthon. Later

PLATE 25: Closely spaced, southeast-dipping late fracture cleavage in interbedded shales and siltstones of Otter Brook Formation.

PLATE 26: Late stage kink folds in Otter Brook Formation. Top is to the left. Folds have horizontal axial planes.

stage structural elements have not been included since not enough measurements of these elements were made to constitute a statistically significant population. It is interesting to note that while significant scatter in the plotted data exists there is a strong maximum oriented 50/120. Scatter of the data weakly defines a great circle oriented 071/58SE thus suggesting folding about an axis trending 32/342. A similar but less well developed pattern is also evident in Domain A (see Figure's 6A and 6B). This pattern is interesting in that a cursory examination of the area suggests folding about a northeast trending axis. While not conclusive, the pattern demonstrated by the data collected during this study certainly refutes such an interpretation.

Kennedy (1981) suggested a late stage, regional cross-folding event which produced folds with northwest trending axes in this region which were most evident in the regional sinuosity of structural trends. To this might also be added the apparent folding evident in the Old Mans Pond area but for one consideration- Kennedy (1981) believed this event to be a D5 event and the last to effect rocks in the area. In the Old Mans Pond area it would be a D3 feature at best. Kennedy admits that the F5 cross-folds are defined on regional patterns alone and that no known or consistently oriented D4 fabrics exist which could be used to uniquely

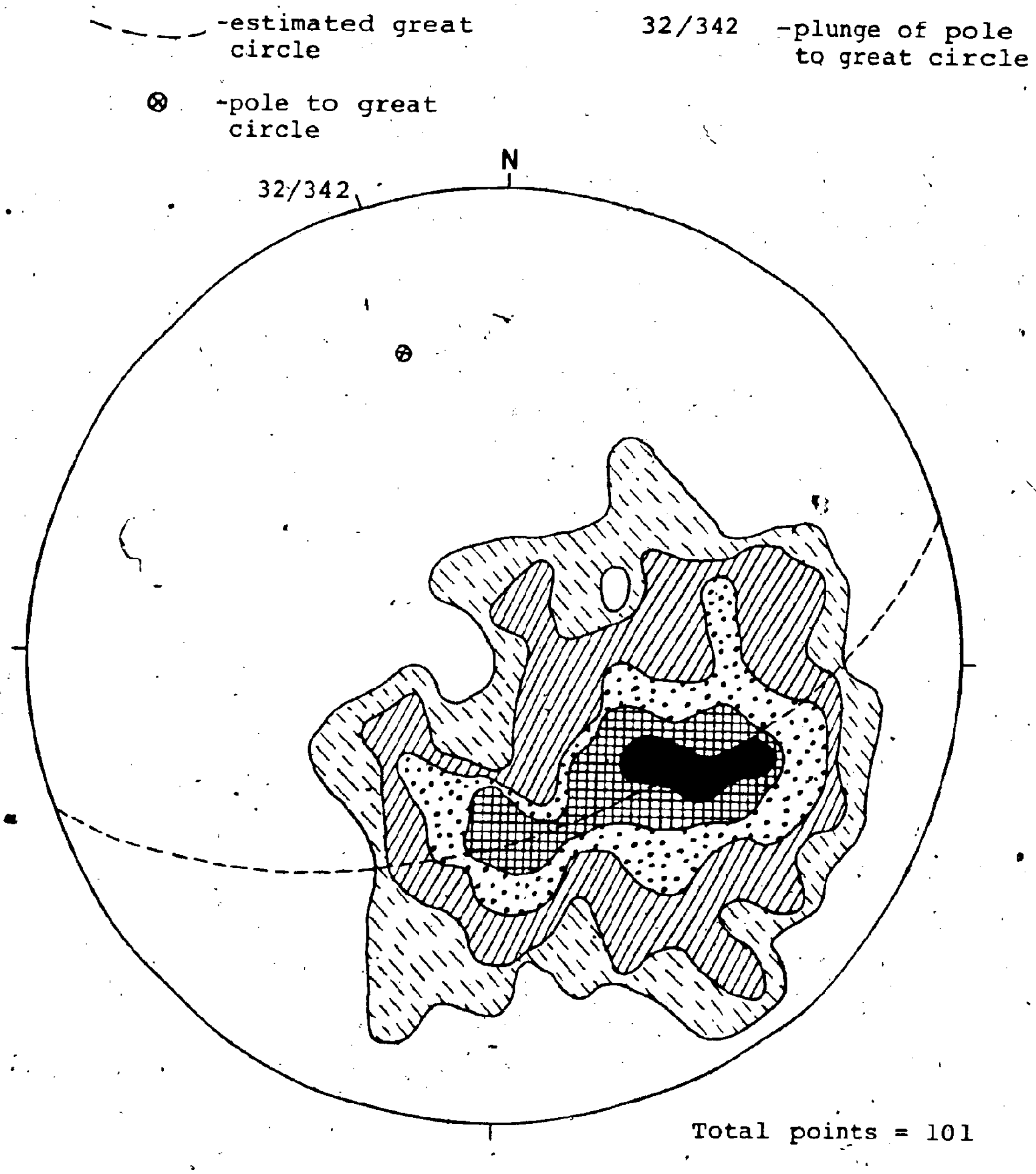


FIGURE 7: Contoured equal-area stereographic projection of poles to cleavage in Domain B. Contours: 1,2,4, 9 and 17 points per 1% area. Maximum = 23 points per 1% area.

determine D5 elements. Such discrepancies have led to the search for an alternative explanation of the observed pattern in the Old Mans Pond area.

One possible explanation, adopted here, is that the arcuate pattern represents a primary geometry related to thrusting. Such arcuate patterns are common in the Moine thrust belt (Elliott and Johnson,1980) where they have been termed 'arcuate contractional imbricate zones' (Coward,1982). A detailed discussion of this geometry and its development is given in Section 6.8.

6.5 DOMAIN C: HUGHES LAKE ALLOCHTHON

The Hughes Lake Allochthon, like the Old Mans Pond Allochthon, demonstrates a rather complex deformational history. The earliest recognizable element in these rocks is a bedding parallel foliation, similar to that in the Bobbys Brook Formation of the Old Mans Pond Allochthon, now preserved as a relict fabric in the psammitic and pelitic schists of the South Brook Formation. This fabric is most easily recognized in thin-sections of the South Brook Formation where it is commonly defined by weakly oriented mica plates between the dominant cleavage planes. Kennedy (1981) has described a virtually identical early cleavage in his Mount Musgrave Formation to the south of the area while to the northeast Hibbard (1979) has documented a similar pattern.

As in the Old Mans Pond Allochthon, it is D2 elements which dominate in the Hughes Lake Allochthon. These vary in expression between different portions of the allochthon. Crystalline rocks of the Round Pond Complex are characterized by a strong micaceous foliation representing S2 which has associated with it a down-dip lineation defined by mineral aggregates. The interpretation of this fabric as a D2 element is tenuous since no earlier fabrics are preserved in these rocks. Presumably its development followed the sequence of events envisaged by Mitra and Elliott (1979) and Mitra (1979) for the development of cleavage in crystalline basement rocks of the Blue Ridge in Pennsylvania and Virginia.

The significance of the down-dip lineation is poorly understood at this time. Traditionally the formation of such linear elements and their relationship to the stress field responsible has been a matter of controversy. In many cases lineations lie at a high angle to fold axes and represent stretching lineations oriented normal to the plane of maximum shortening (for example the lineation associated with S2 in the Old Mans Pond Allochthon). This is common in slate belts where strains were low. In other instances lineations have been found to be parallel to fold axes suggesting a peculiar stress field (Hobbs et al,1976, p.285). Hobbs et al (1976) have suggested that such a situation could arise through rotation of the fold axes under high states of strain (eg. during thrusting) into parallelism with the lineations which, in this case would represent the stretching direction associated with tectonic transport. This model may be particularly applicable to the Round Pond Complex considering its position at the base of a major thrust assemblage. The few folds observed in these rocks are in fact isoclinal with steeply-plunging fold axes which parallel the orientation of the lineations (Plate 27).

PLATE 27: Tightly folded amphibolite in Round Pond Complex. Fold axis plunges steeply to the northwest.

The schistosity in the chlorite-albite schists of the Round Pond Complex is also interpreted to represent a D2 fabric. The presence of rodded albite porphyroblasts in these schists indicates that a certain amount of porphyroblastesis must have either been contemporaneous with or predated the D2 event. Kennedy (1975) and Kennedy (1981) have reported albite porphyroblastesis spanning several periods of deformation in similar rocks to the north and south.

The Little North Pond Formation is surprisingly void of major structural elements. Individual beds of this formation are traceable over considerable distances and invariably face southeast on primary sedimentary criteria (grading and cross-bedding). The structural simplicity of this unit has been attributed to its exceedingly thick, homogeneous nature and the ability of the matrix in the arkoses and greywackes to absorb most of the strain. There is a weak fabric preserved in these rocks which manifests itself in the trend of hills and outcrops, particularly on the shores of Little North Pond. This fabric is interpreted as a combined S0/S2 feature.

The most conspicuous and pervasive structural element in the pelitic and psammitic schists of the South Brook Formation is a strong, micaceous cleavage (S2) which is axial planar to mesoscopic isoclinal folds. The cleavage itself generally trends northeast and dips moderately to the northwest and is a crenulation cleavage. The folds have approximately horizontal axes and curvilinear hinge lines are common. Fold axes trend northeast parallel to the cleavage trend.

D3 effects on the Hughes Lake Allochthon are weakly preserved or absent except in the South Brook Formation where they are represented by open folding of the earlier S2 cleavage about moderately northwest dipping to upright axial planes.

From the above discussion it is obvious that a minimum of three deformational events effected the Hughes Lake Allochthon. All three are best represented in the South Brook Formation but presumably effected the remainder of the allochthon as well. The sequence of events appears to have been: 1) Formation of an early bedding parallel fabric. This is only evident in the South Brook Formation; 2) Development of a strong, northeast trending, northwest dipping cleavage and associated tight to isoclinal folds. This is the most obvious structural element and is responsible for the overall structural grain of the allochthon; 3) A late deformational event which refolded the dominant cleavage in the South Brook Formation but had little obvious effect on the remainder of the allochthon.

Figure 8 is a stereographic projection of the major structural elements observed in the Hughes Lake Allochthon. As with the carbonate domain and the Old Mans Pond Allochthon, poles to the dominant fabric in this domain cluster in the southeast quadrant of the stereogram and a weak pi-girdle is developed which has a pole oriented 38/303. This pattern is similar to that developed in Domain B which is interpreted as an arcuate, thrust-related pattern. Notably, the Beta-pole shows roughly the same

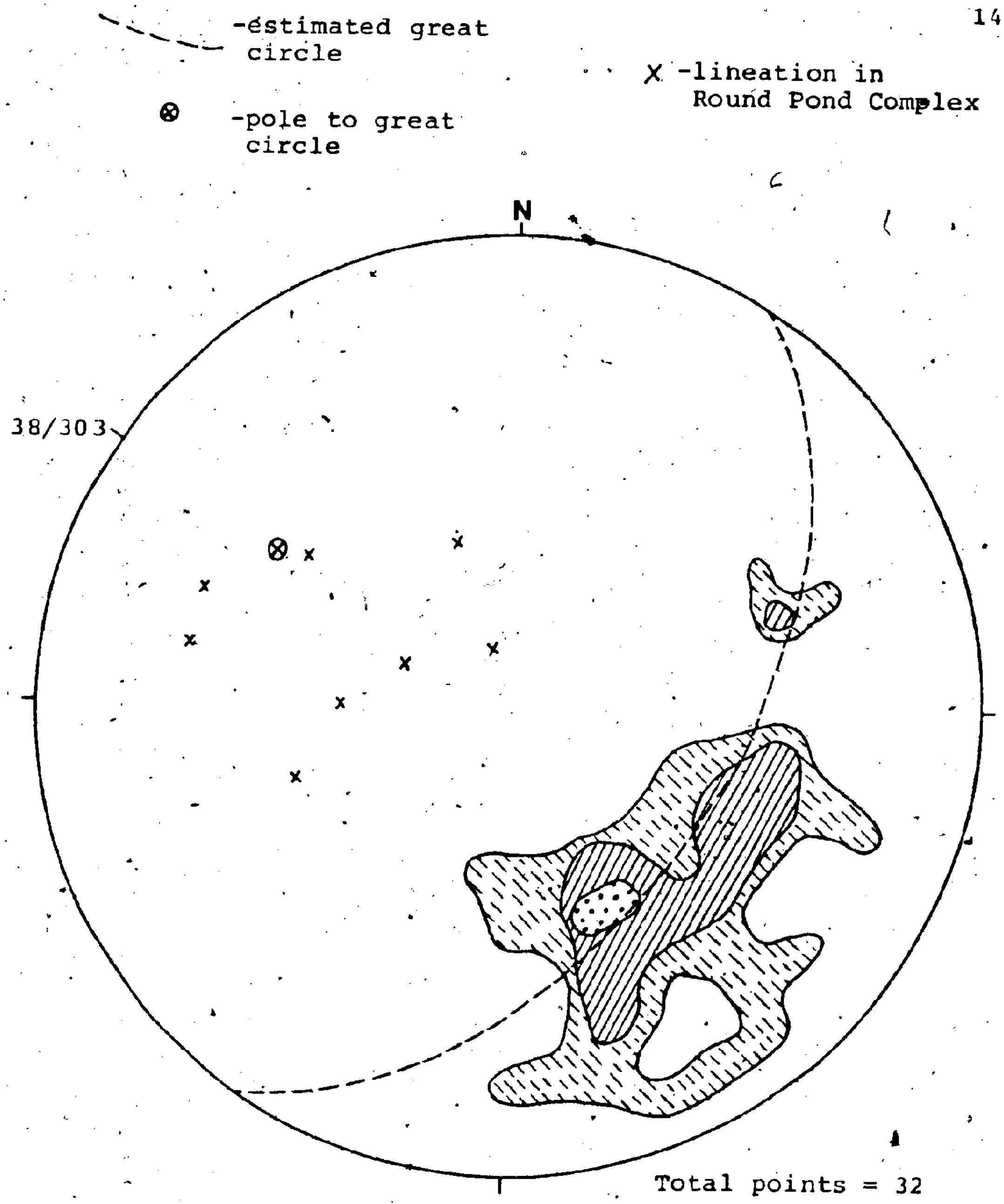


FIGURE 8: Contoured equal-area stereographic projection of poles to dominant fabric in Domain C. Contours: 1,2 and 4 points per 1% area.

orientation as lineations in the Round Pond Complex. As was discussed earlier, these lineations most likely give some indication of thrust transport direction.

6.6 DOMAIN D: DEER LAKE BASIN

Within the map area, Carboniferous strata of the Deer Lake Basin dip shallowly towards the east and show no evidence of any deformation aside from minor late stage block faulting (eg. contact along 'Old Mans Pond Road'). East of Deer Lake this situation changes and strata of the Deer Lake Group have been steepened and locally overturned to the west by thrusting of the Pynns Brook Complex (Williams et al,1982). Considering the age of the rocks affected, this thrusting is obviously post-Carboniferous in age and, as such, is almost certainly attributable to the Alleghanian Orogeny. It thus represents the only deformational event to effect rocks in the region which may be allotted an accurate absolute age. Recognition of these effects east of Deer Lake which have failed to effect rocks of equivalent age along the western shore of the lake indicates that this represents the Alleghanian structural front in this area. By inferrence, all pervasive structural elements in rocks to the west of Deer Lake must be older than Carboniferous (ie. pre-Alleghanian).

6.7 THRUST FAULTS IN THE OLD MANS POND AREA

Prior to considering the overall structural development of the Old Mans Pond area a brief review of the major thrust faults in the area, previously described in Sections 3.6 and 4.2, and a more detailed consideration of their geometry is in order. These thrusts correspond to, and largely define the boundaries of, two major structural assemblages - the Old Mans Pond and Hughes Lake Allochthons- and, as such, they represent the single most important structural elements contributing to the overall geology of the area. Much of the proposed geologic history hinges on their recognition, delineation and interpretation.

Both thrusts are poorly exposed but have been reasonably accurately delineated during this study. The thrust bounding the Old Mans Pond Allochthon is characterized by a thin zone of intense shearing and is generally difficult to recognize, except for locally associated quartz and/or calcite veining. Where not directly observed (eg. along the northern boundary of the allochthon) this thrust has been delineated through a combination of marked topographic expression, truncation of geologic units and the localized occurrence of small metagabbro bodies interpreted to be retrograded ultramafic rocks (see Section 3.5).

The thrust bounding the western margin of the Hughes Lake Allochthon is much more distinctive in the field, being characterized by a fairly wide ductilely deformed zone. This thrust juxtaposes more highly metamorphosed rocks to the southeast against less metamorphosed rocks to the west but is generally less topographically expressive than the thrust bounding the Old Mans Pond Allochthon. Coincidence of this thrust with a younger block fault along its northern end suggests that it has been the locus of more than one phase of movement.

Both of the major thrusts parallel the regional structural grain of the area. The thrust bounding the Hughes Lake Allochthon trends roughly northeast and dips moderately to the northwest while the thrust bounding the Old Mans Pond Allochthon follows a much more complex pattern which is roughly arcuate in form but generally northwest dipping as well. This general northwest dipping nature is anomalous within the overall tectonic framework of west Newfoundland and is also at variance with the southeast dipping nature of thrusts to the south of the area with which they form a continuous, regional fault system (Kennedy,1981; Hibbard,1983; see Figure 9). Both of these thrusts have been interpreted as modified conventional east-dipping, west directed thrusts. The relationship between them based on field observations is uncertain. In

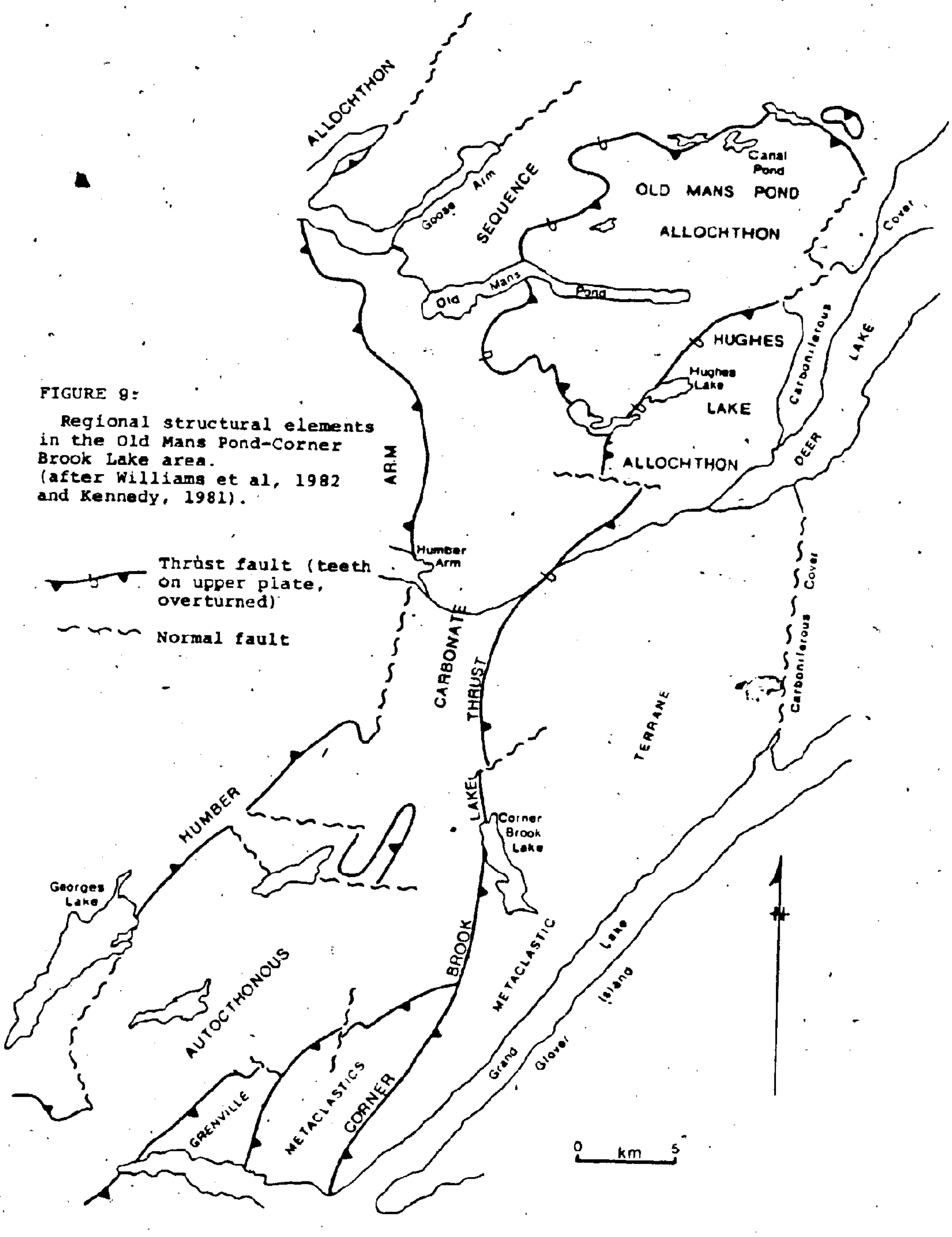


FIGURE 9: Regional structural elements in the Old Mans Pond-Corner Brook Lake area. (after Williams et al, 1982 and Kennedy, 1981).

the north both have been truncated by later faults while to the south their juncture lies somewhere beneath Long Pond. On purely geometric grounds it is suggested here that these faults are in fact linked and constitute a 'piggy back thrust stack' (Butler,1982). This concept will be discussed more fully in the next section.

6.8 ASSESSMENT AND STRUCTURAL SYNTHESIS

In the preceding sections the Old Mans Pond area has been subdivided into four structural domains, the boundaries of which coincide with well defined natural structural and/or stratigraphic breaks. Each of these domains demonstrates a recognizable sequence of structural elements which may be related to secular deformational events. The sequence of structural elements observed in each domain is summarized in Table 5.

Any structural synthesis of the area must necessarily integrate each of the recognized sequences into a single deformational sequence which may be applied to the area as a whole. To do this requires that individual elements from separate domains must somehow be correlated temporally. Consideration of the fact that once widely separated rock groups have been juxtaposed along major tectonic surfaces

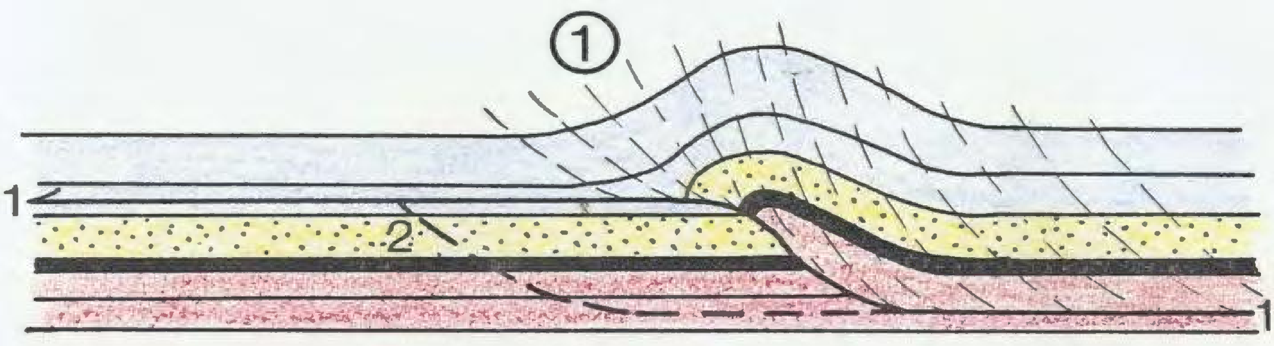
TABLE 5: Summary of sequence of events observed in structural domains of the Old Mans Pond area.

RANK	DOMAIN A (Carbonate sequence)	DOMAIN B (Old Mans Pond Allochthon)	DOMAIN C (Hughes Lake Allochthon)	DOMAIN D (Deer Lake Basin)
FOURTH GENERATION D4		Block faulting	Block faulting	
THIRD GENERATION D3	Block faulting	Moderate east-dipping fracture cleavage; minor kink folds.	Open folds with west-dipping axial planes.	
SECOND GENERATION D2	Possible folding; minor west-directed thrusting.	Isoclinal, SE-facing folds, strong axial plane cleavage ranging from slaty to micaceous.	Isoclinal folds; strong cleavage.	Block faulting
FIRST GENERATION D1	Upright, open folds in west, weak cleavage; isoclinal east-verging folds in east, strong axial plane cleavage.	Weak bedding-parallel foliation in east; soft sediment folds and bedding plane thrusts in remainder.	Weak, layer-parallel foliation	Folding and overturning of beds east of Deer Lake.

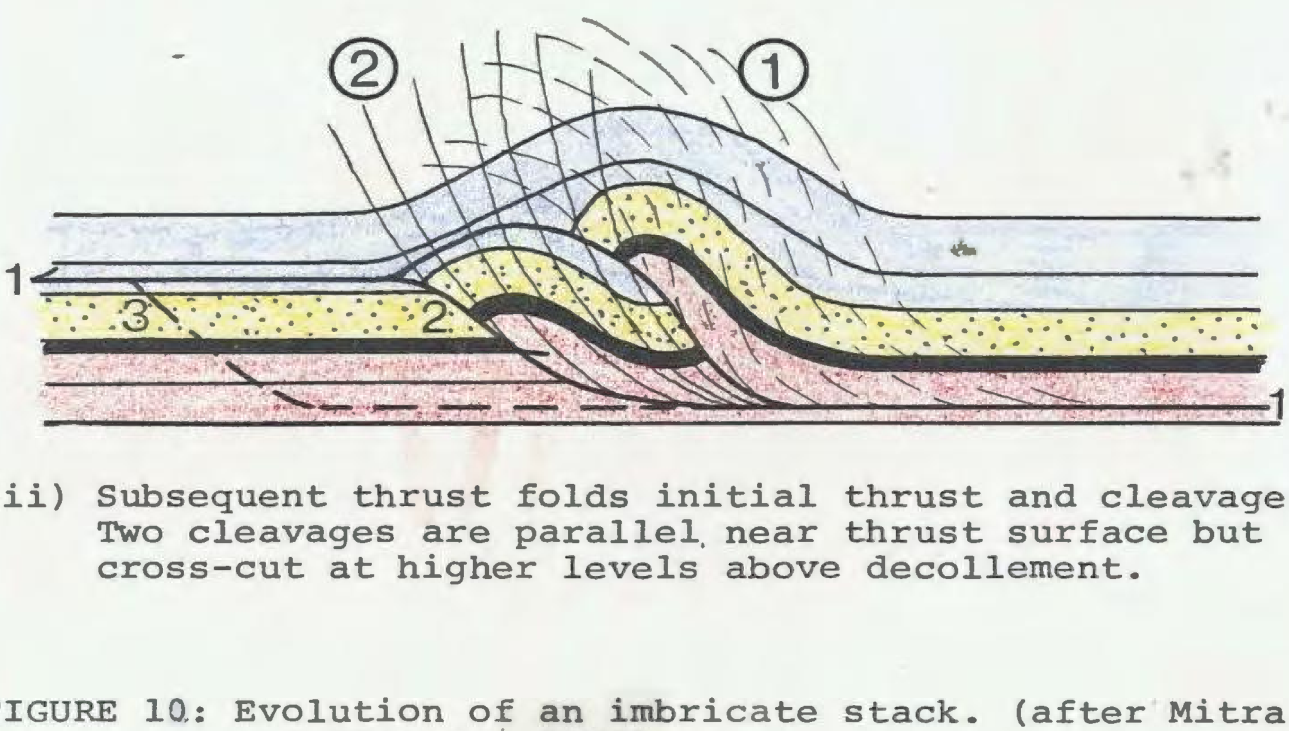
requires that due caution must be exercised in attempting such a correlation.

The most obvious link between Domains A,B and C are the dominant planar fabrics in each. These are invariably parallel to each other and impart to the area its overall structural grain. (Note: As the rocks of Domain D are essentially undeformed in the Old Mans Pond area they are neglected in the discussion to follow.) Stereoplots of data from each of the domains demonstrates well the correlation of these elements in space (see Figures 6B, 7, and 8). However,despite this strong spatial correlation, a temporal correlation of these elements is suspect since the dominant fabric in Domain A is a D1 element whereas in Domains B and C it is a D2 element.

A fundamental observation to be made here is that not only are the dominant fabrics in each of the domains parallel but, also, the major thrusts in the area are parallel to those fabrics on either side of them. Certain studies (eg. Mitra and Elliott, 1980) have demonstrated that cleavage formation and thrusting are commonly coeval and, when such is the case, the cleavage within a given thrust sheet is asymptotic to the thrust and the two are therefore parallel near the thrust plane. This is illustrated in Figure 10a. Should a second thrust and its



(i) Initial thrust and associated cleavage.



(ii) Subsequent thrust folds initial thrust and cleavage. Two cleavages are parallel near thrust surface but cross-cut at higher levels above decollement.

FIGURE 10: Evolution of an imbricate stack. (after Mitra and Elliott, 1980)

associated cleavage develop in front of the first, an imbricate stack of the type illustrated in Figure 10b is generated. At this stage structural complications involving cross-cutting cleavages and folding of the original thrust surface are evident at higher levels in the stack. However, at a lower level of erosion, such as we see in the Old Mans Pond area, the cleavages are parallel to their associated thrusts and what is observed is what appears to be a single deformation in a spatial field. In reality however, the deformation is time transgressive towards the foreland (ie. as we progress towards the west in the Old Mans Pond area) so that the cleavage and thrusts become slightly younger in this direction.

Application of this concept to the Old Mans Pond area sheds some light on the temporal correlation of structural elements between domains. Table 6 shows the deformational history of the area assuming correlation of thrusting and the formation of the dominant fabrics across the area as postulated above. If correct this correlation provides a structural datum upon which to hang the remainder of recognized deformational sequence. From this it is evident that an early D1 event preceded the main period of thrusting in the east but did not effect the more westerly terrane. This early event is well documented in similar rocks along strike to the northwest and southeast where it is generally

TABLE 6: Correlation of structural elements in the Old Mans Pond area.

RANK	DOMAIN A (Carbonate sequence)	DOMAIN B (Old Mans Pond Allochthon)	DOMAIN C (Hughes Lake Allochthon)	DOMAIN D (Deer Lake Basin)
FOURTH GENERATION D4	Block faulting	Block faulting	Block faulting	Block faulting; folding and thrusts east of Deer Lake.
THIRD GENERATION D3	Possible folding; minor west-directed thrusting.	Moderate east-dipping fracture cleavage; minor kink folds.	Open folds with west-dipping axial planes.	----
SECOND GENERATION D2	Upright, open folds in west, weak cleavage; isoclinal east-verging folds in east, strong axial plane cleavage.	Isoclinal, SE-facing folds, strong axial plane cleavage ranging from slaty to micaceous.	Isoclinal folds; strong cleavage.	----
FIRST GENERATION D1	-------	Weak bedding-parallel foliation in east; soft sediment folds and bedding plane thrusts in remainder.	Weak, layer-parallel foliation.	----

interpreted to represent an early phase of the Taconic Orogeny (Bursnall,1979; Kennedy, 1981). Its existence in the more easterly, transported sequences of the Old Mans Pond area is consistent with the westward-transgressive nature of the deformation discussed above.

The fact that this early fabric does not exist in the more westerly carbonate terrane is significant in that it indicates that this portion of the ancient margin was not affected by the earliest deformation. This contrasts with findings immediately to the south which show that easterly portions of the carbonate terrane demonstrate the complete range of deformational elements shown by the metaclastic terrane (Kennedy,1981).

This lack of involvement of the carbonate sequence in the earliest deformation may be due in part to the unique position of the Old Mans Pond area west of the northern end of a minor reentrant in the ancient continental margin as defined by the trace of the Baie Verte-Brompton Line which swings sharply westwards in this area (see Figure 11). This reentrant represents a relatively minor feature as compared to the larger reentrants and promontories described by previous authors (Thomas,1977; Williams and Doolan,1979), however, its effect on the geology of the Old Mans Pond area was significant.

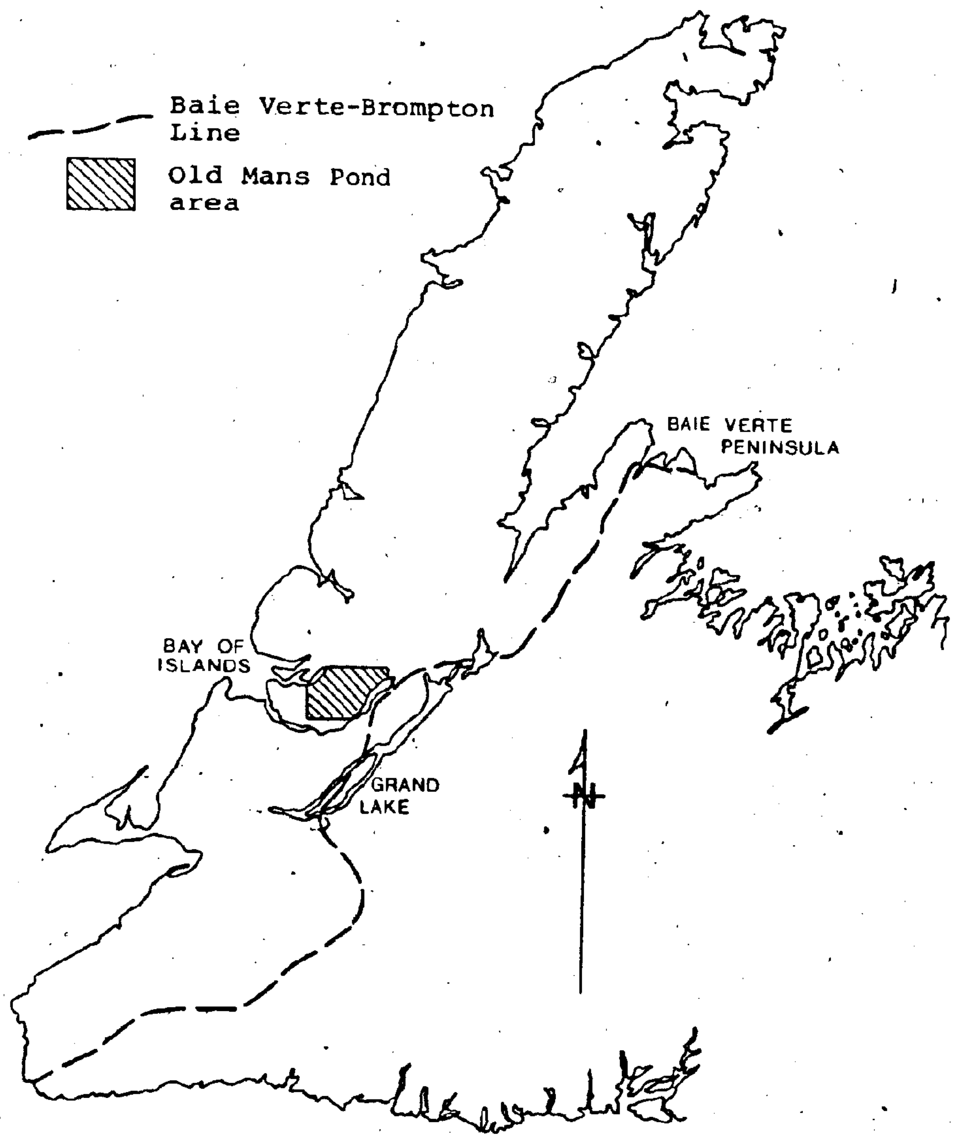


FIGURE 11: Location of Baie Verte-Brompton Line in Newfoundland.

As pointed out by Williams (1979), reentrants are marked by wide zones of thin-skinned deformation. This is evident in the Old Mans Pond area where thrusts were initially shallower than in adjacent areas, allowing for movement of structurally transported sequences farther horizontally and away from the main locus of deformation. Hence, the minor structural salient which characterizes the area. Rocks of the Old Mans Pond Allochthon were thus moved farther west than their counterparts to the north and south and, as a result, they are better preserved and less metamorphosed. Considering the apparently large horizontal component of motion it is not surprising that the autochthonous carbonate sequence fails to demonstrate the earliest effects of this westerly-transgressive deformational event.

Three other aspects of the geology of the Old Mans Pond area may also be related to the formation of an imbricate stack.

Firstly, within the context of the imbricate stack model proposed above, the rather nebulous weak cleavage which is nearly coplanar with the dominant cleavage in the Old Mans Pond Allochthon may best be interpreted as having formed in response to a slightly earlier or later thrust similar to the second cleavage in Figure 10b. It has thus been included as an integral phase of D2.

Secondly, as mentioned previously (Section 6.4), the concept of an imbricate stack may be used to explain the apparent regional antiform in the area. The process by which this is accomplished is best illustrated via a hanging-wall sequence diagram (see Figure 12a, adapted from Elliott and Johnson, 1980). In this diagram it is evident that at some point along strike imbricates may rejoin the main decollement. When this occurs the ends of the stack are characterized by antiformal folds involving both thrusts and cleavage (D.Elliott, pers comm, 1982) producing a characteristic 'eye-lid pattern' (see Figure 12b).

Thirdly, the reversal in structural polarity which characterizes the area may be partially explained as being an integral part of construction of the imbricate stack. Passive rotation of thrust related elements is accomplished in a fashion similar to that described by Mountjoy (1960) and Mitra and Elliot (1980) in which successive movement on several thrust surfaces, one beneath the other, may result in considerable cumulative rotation of the upper sheet. As successive wedges of material are added beneath the initial thrust this surface must be rotated into the vertical and possibly beyond due to space considerations.

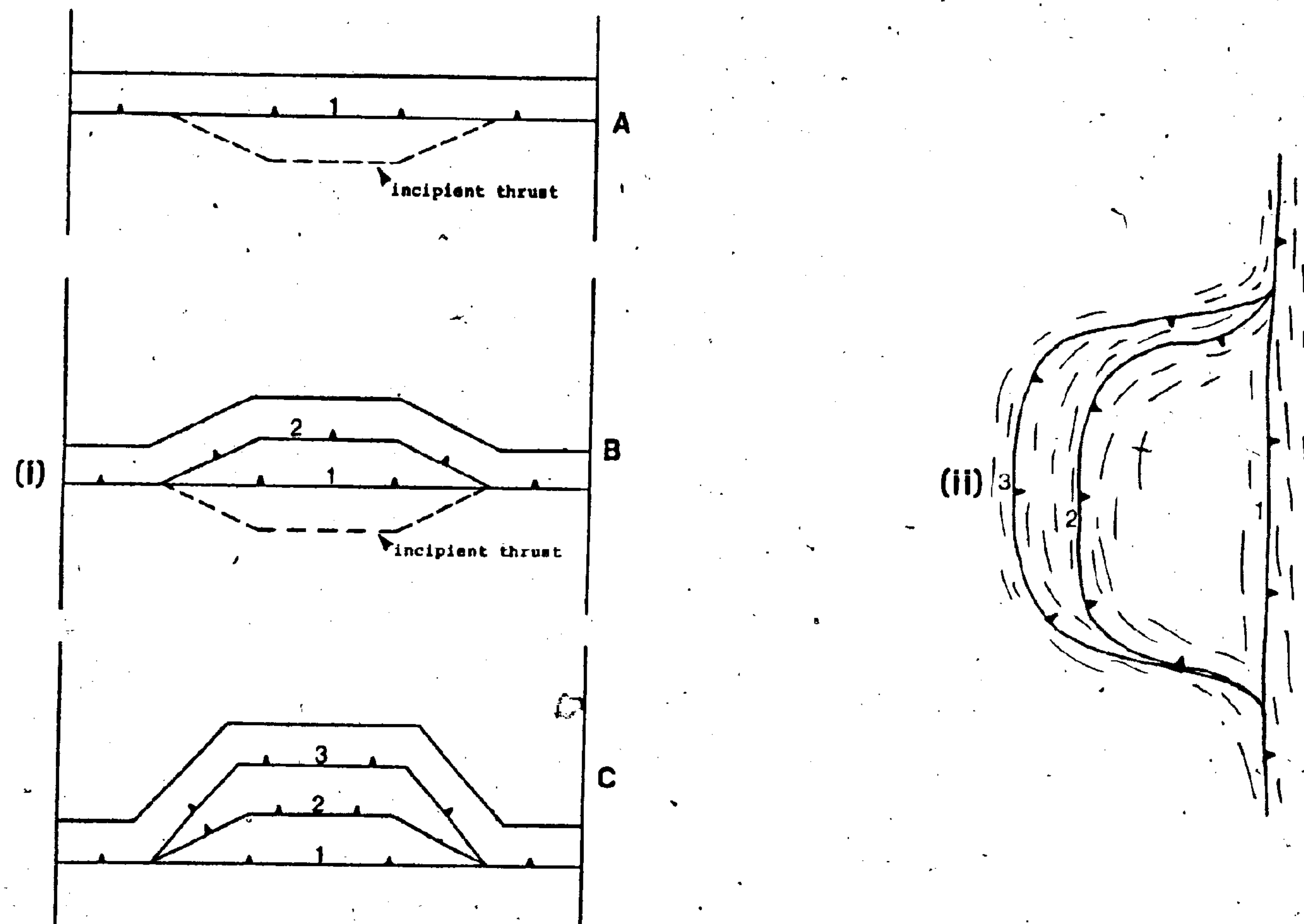


FIGURE 12: (i) Hanging-wall seqüence diagram illustrating growth of an imbricate stack. Thrust transport direction is out of the page. (after Elliott and Jóhnson, 1980)
(ii) Plan view of (i) showing characteristic 'eye-lid' pattern.

One implication of this suggestion has particular relevance to the Old Mans Pond area. In order to overturn the Old Mans Pond Allpehthon, it is required that at least one, and probably more, thrust slices be present to the west of it. Such thrusts may exist but remain unrecognized. The most likely candidate is the fault which truncates the eastern margin of the Humber Arm Allochthon along the eastern shore of Penguin Arm (Williams et al,1982,1983). This fault is presently interpreted as a high angle normal fault but the possibility that it represents an oversteepened thrust does exist (see cross-section in back pocket). Similar faults are common along the eastern margin of the Humber Arm Allochthon and it has been suggested by at least one other worker that these faults are actually thrusts which cut up the back of the allochthon (Walthier,1949, "Island Pond thrust"; see also Schillereff,1980 and Kennedy,1981).

A significant effect which the reentrant described earlier may have had is to have acted as a harbour during later deformation, buffering much of the area from penetrative effects. As a result, later (D3) elements are scarce and difficult to characterize. In the east (Hughes Lake Allochthon), open folds with northwest-dipping axial planes have been allocated as F3 since they fold the S2 fabric in this domain. However, Douglas (1950) and Mountjoy

(1960) have both described similar style folds which they interpret as having formed as upright or, in this case, westerly inclined folds which were subsequently rotated into a reversed sense of asymmetry through motion on an underlying thrust surface. This motion may represent reactivation of the thrust during later deformation (ie. during D3) or may represent a late-stage motion during imbrication of the stack (ie. late D2). If the latter were the case, then these folds in the Hughes Lake Allochthon may be late stage D2 features.

In the west, D3 is characterized by possible upright folding in the carbonate sequence (eg. angular folds in the Reluctant Head Formation) and a moderately east-dipping fracture cleavage evident in rocks of the Old Mans Pond Allochthon. The minor west-directed thrust fault present along the north shore of Old Mans Pond is also a D3 feature. These effects indicate continued compression from the east during D3.

Figure 13 illustrates a simplified model for the structural evolution of the Old Mans Pond area. The geometry is essentially that of a large duplex (Dahlstrom, 1970; Butler, 1982) the definition of which hinges on the recognition of a roof thrust, in this case the basal decollement of the Humber Arm Allochthon. Otherwise the

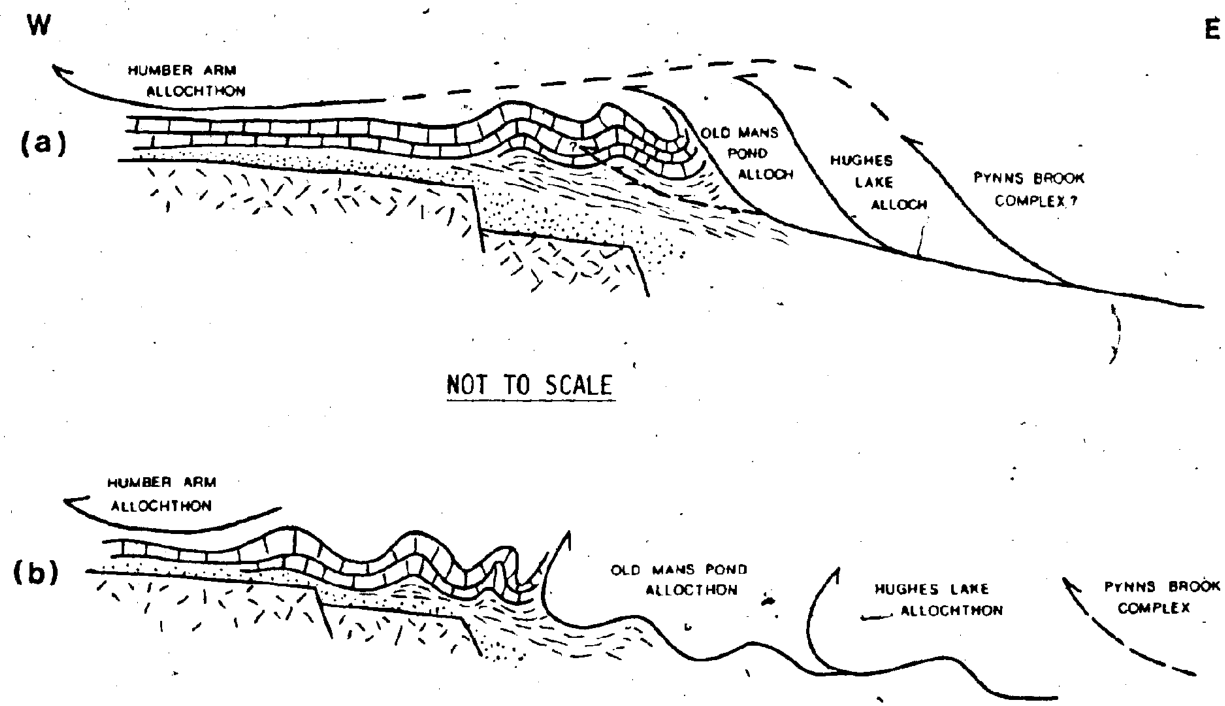


Figure 13: Duplex model for the structural evolution of the Old Mans Pond area.
(a) Thrusting and generation of duplex.
(b) Upright folding causing rotation and overturning of thrusts and related fabrics.

structure is termed an imbricate stack. Although the inferred link between the basal decollement of the Humber Arm Allochthon and some as yet undefined surface east of Deer Lake is highly speculative, it is an interpretation which solicits much suport and warrants serious consideration. It is reasonable to imagine that the ophiolitic Bay of Islands Complex must have at some stage been rooted to other rocks of ophiolitic affinity, the closest of which occur in the Pynns Brook Complex (Williams et al, 1982). The Pynns Brook Complex represents the continuation of the Baie Verte-Brompton Line which is a major linear feature in the Apalachians, generally viewed as the most westerly possible root for obducted ophiolitic complexes (Williams and St-Julien, 1982). Hence the link between the two in Figure 13a.

The scenario envisaged here then involved initial thrust imbrication of continental rise sediments in an eastward dipping subduction zone followed by obduction of this structural assemblage across an essentially undeformed continental shelf edge along a major decollement. At some time movement along this decollement ceased and subsidiary imbricate thrusts were generated to accomodate further shortening (for example see Elliott and Johnson, 1980; Rowley and Kidd, 1981). A large fold nappe was also formed beneath the Old Mans Pond Allochton at this time (see Figure

13a). This fold is required since the carbonate sequence now lying "above" this thrust is always right-way-up and northwest facing. The only way to arrive at this configuration within the proposed model is for the carbonate sequence to have been originally overturned beneath the thrust. The axis of the inferred synformal fold nappe presumably lies somewhere between 'Window Pond' and the most westerly exposure of the Reluctant Head Formation. It is this inferred synform which may be responsible for the unusually rapid transition in structural polarity which characterizes the area.

Subsequent to this thrust imbrication, a second deformational event was responsible for folding and overturning, at least in part, the initial thrusts and their related fabrics (Figure 13b). This is nicely demonstrated by the thrust exposed along the north shore of Old Mans Pond which is east-dipping along the shore of the pond but then rolls over to become moderately northwest-dipping further to the north.

In summary, the overall geometry and sequence of deformational events in the Old Mans Pond area would seem to fit well with a simple model involving thrust imbrication and coeval cleavage formation within a single, westwards time transgressive deformational event. Recognition of this geometry represents the crucial initial step towards unravelling the overall tectonic history of the area. According to Dahlstrom (1970), specific structural environments should contain a limited suite of structural elements and it is merely variations in size, form and combinations of these elements which tend to mask the underlying simplicities. Once a simple geometric solution to the observed structural and stratigraphic pattern has been developed, as has been done above, it may then be used as a basis for further study.

6.9 TIMING OF DEFORMATIONAL EVENTS:

A prime consideration which remains concerning the structural evolution of the Old Mans Pond area is 'when?'. To place an absolute age on a given deformational event three approaches are possible. The first is to date events in relation to the age of the rocks affected. In the Old Mans Pond area the rocks affected range in age from Helikian to middle or upper Ordovician (disregarding the Carboniferous strata of the Deer Lake Basin) thus making this approach relatively ineffectual. The second approach is to use isotopic data for minerals of known relative age. Since no such data exists in the Old Mans Pond area this approach may obviously not be applied here.

The third, and most applicable approach is to correlate the deformation with regional events of known age and style. In recent years much work has been done to firmly establish an accepted sequence of tectonic events and the style and timing of these events as they apply to the Humber Zone. This 'tectonic framework' places certain constraints on how the structural development of the Old Mans Pond area may best be interpreted. A brief review of this established framework is given below. This information has been compiled from Rodgers (1968,1970); Williams (1978b,1979,1982); Williams and Bursnall (1982); Williams and Hatcher (1982); and Colman-Sadd (1982) to which the reader is referred for further information.

Earliest recognized deformational elements in the rocks of the Humber Zone have been related to the Taconic Orogeny of lower to middle Ordovician age. Effects of this orogeny manifest themselves in the transported allochthonous sequences of west Newfoundland (eg. Humber Arm Allochthon) and in the rocks of the Fleur de Lys Belt, where Taconic polyphase deformation is evident. It is generally believed that the Taconic Orogeny resulted from the attempted subduction of the North American plate beneath an oceanic plate to the east, resulting in the destruction and imbrication of the ancient margin. This orogenic phase culminated in the emplacement of an allochthonous sequence of rise prism clastic sediments and oceanic crustal material onto the continental margin and, finally, continent-continent or continent-island arc collision. Taconic effects are highly restricted spatially, being most evident in areas of presumed plate overlap (eg. eastern Humber Zone and western fringe of the Dunnage Zone). More questionable Taconic effects have been recognized in parts of the Gander Zone while remaining portions of the orogen appear to have been undisturbed by this event. Invariably the Taconic event is characterized as having been polyphase in nature.

The next event to effect the Humber Zone was the Devonian aged Acadian Orogeny. This orogenic event was much more regional in its effect and Acadian structures may be recognized across the entire orogen in Newfoundland. Upright folds with locally strong penetrative axial planar cleavage tend to characterize the Acadian. West directed thrusting is evident locally in the west but east directed thrusting is common elsewhere (ie. Notre Dame Bay, Gander and Avalon Zones). Generally, however, the trend was towards more vertically driven rather than horizontally directed tectonism. Intrusion of large igneous bodies such as the Topsails Igneous Complex also occurred at this time.

The last major orogenic episode to effect the rocks of the Humber Zone was the Alleghanian Orogeny of Carboniferous age. Alleghanian effects in the northern Appalachians are poorly understood and range from non-existant to locally intense. Large transcurrent faults and associated cross-folds are prominent Alleghanian features in Newfoundland along with very localized thrusting. With regards to the Old Mans Pond area, Alleghanian effects may be safely disregarded since the Alleghanian deformational front has been documented to lie to the east of Deer Lake (Williams et al.,1982) and no penetrative deformation may be recognized in Carboniferous strata west of Deer Lake. Thus, all recognizable penetrative effects shown by the middle Ordovician and older rocks of the Old Mans Pond area must be related to either the Taconic or Acadian events or, more likely, a combination of both.

The ages of recognized deformational events in the Old Mans Pond area, based on local considerations and the regional tectonic framework outlined above, have been interpreted as follows:

(1) D1/D2: Both D1 and D2 have been interpreted as distinct phases of the Taconic Orogeny. D1 is evident only in the more easterly, transported assemblages and changes character from a relict/cleavage in the east (Hughes Lake Allochthon) to a less pervasive, soft sediment deformation

in the west (Old Mans Pond Allochthon). D2 is interpreted as the main phase of Taconic thrust imbrication and concommitant pervasive cleavage formation. This phase of tectonism was time transgressive towards the west and is itself polyphase in nature (ie. weak cleavage which is nearly coplanar with the dominant S2 fabric; possible late F2 folds in Hughes Lake Allochthon).

Support for this interpretation takes a number of forms. The style of deformation (ie. polyphase in nature, characterized by westerly transport of material) is consistent with present concepts of the Taconic (Rodgers,1970; Kennedy,1975; Williams,1979). The occurrence of small, deformed gabbroic bodies along one of the thrusts (Old Mans Pond Allochthon) compares favourably with the documented occurrence of similiar bodies along Taconic structural surfaces in the Fleur de Lys Supergroup (Williams and Talkington,1977; Bursnall,1979). These fragments may be ophiolitic in nature, and thus require an easterly source, or they may be related to basaltic flows (Lighthouse Cove, Deer Pond Volcanics) which lie conveniently along a natural decollement between basement and cover.

Kennedy (1981) has suggested a Taconic age for thrusting along strike to the south based on the style of deformation and limited isotopic data on metamorphic muscovite which yield a Silurian (c.f. 430 m.y.) cooling age (Wanless et al,1965,1973).

(2) D3: Based on the upright nature of D3 effects, and the fact that they overprint Taconic elements yet are constrained to being pre-Alleghanian, it is proposed here that D3 corresponds to the Acadian Orogeny. As mentioned previously, much of the area was most likely sheltered from Acadian effects due to the presence of a minor reentrant in the ancient margin. Some reactivation of earlier thrusts is entirely likely and it is also suggested here that some passive rotation of Taconic fabrics into their present northwest-dipping configuration may have occurred at this time.

(3) D4: All normal faults in the area are believed to be younger than Acadian and possibly younger than Alleghanian since many involve Carboniferous strata. As mentioned above, some of these faults, particularly the Goose Arm fault and the fault along the eastern margin of the Humber Arm Allochthon, may in fact be reactivated thrusts.

6.10 SUMMARY

The Old Mans Pond area is dominated by an imbricate stack of structural assemblages which involve a representative sampling of much of the ancient continental margin of North America including basement rocks (Round Pond Complex) and the overlying sedimentary prism (Old Mans Pond and Mount Musgrave Groups). Structural evidence and regional tectonic considerations indicate that the stack was assembled from the east and emplaced against the autochthonous carbonate sequence during the Taconic Orogeny. Early fabrics which are evident in the transported sequences are not present in the carbonate sequence implying that the carbonate bank was not involved in the earliest phase of destruction of the margin. However, the carbonate bank was involved in the main phase of the Taconic at which time it suffered considerable folding and disruption. This is evident in the omission of much of the carbonate sequence (Table Head etc.) beneath the Old Mans Pond Allochthon, which contrasts with the situation farther to the west where the Humber Arm Allochthon was emplaced onto an essentially undisturbed carbonate bank at the same time.

Subsequent orogenic activity during the Acadian is partly responsible for overturning thrusts and fabrics generated during the Taconic Orogeny, thus producing the marked reversal in structural polarity which characterizes the area. Aside from this the Acadian had little other effect on the area, possibly due to its sheltered position at the northwest end of a minor reentrant in the ancient margin.

Except for late-stage block faulting, the Alleghanian Orogeny is believed to have had little or no effect on the area since Carboniferous strata along the western margin of the Deer Lake Basin are undeformed. The Alleghanian structural front in this area lies to the east of Deer Lake (Williams et al, 1982,1983).

PART FOUR-SUMMARY

CHAPTER SEVEN

7.1 CONCLUSIONS

The major contributions of this study towards a better understanding of the geology of the Old Mans Pond area are as follows:

(1) A previously unrecognized allochthonous assemblage of rise prism sediments within the area (Old Mans Pond Allochthon) has been accurately delineated and characterized during this study. The Old Mans Pond Allochthon is divisible into three lithic units (Old Mans Pond Group) which have been correlated with the Curling Group of the Humber Arm Allochthon. Detailed paleontology and sedimentology remains to be done in order to confirm this correlation and establish paleogeographic relationships between the two.

The contact between the Old Mans Pond Allochthon and the carbonate sequence is a major, sinuous thrust fault which has sited along it at least two metagabbro bodies.

Movement on this thrust was originally from east to west but it has since been modified to dip moderately to the northwest.

(2) A second newly recognized structural slice (Hughes Lake Allochthon) has also been delineated during this study. This slice involves a complex series of crystalline metamorphic rocks at its base (Round Pond Complex). The Round Pond Complex includes granodioritic gneisses interpreted as Grenville basement, amphibolite units interpreted as mafic dikes and chloritic schists interpreted as a metasedimentary sequence of Hadrynian age. Also included in the Round Pond Complex is a possible felsic volcanic unit and a relatively undeformed alkaline granite which may be related to this silicic volcanism. This is the first report of silicic volcanism at this level in west Newfoundland even though silicic volcanic rocks and related granites of this age are common in the southern Appalachians (Catoctin, Mount Rodgers etc, see Rankin, 1975). Additional petrography, geochemistry and geochronology are necessary to establish this Grenville basement-felsic volcanic-plutonic relationship.

Overlying the Round Pond Complex to the southeast is a thick sequence of clastic sedimentary rocks and minor mafic volcanics designated as the Mount Musgrave Group. A well exposed, variably metamorphosed mafic volcanic sequence (Deer Pond Volcanics) directly overlies the Round Pond Complex forming the lowest member of the Mount Musgrave Group. The Deer Pond Volcanics are interpreted as rift facies basalts extruded during initiation of the Iapetus cycle correlative with the Lighthouse Cove Formation of the Labrador Group (see Williams and Stevens, 1969). It is highly possible that the Deer Pond Volcanics form a bimodal volcanic suite with the felsic volcanics presently included in the Round Pond Complex.

Overlying the Deer Pond Volcanics to the southeast is a homoclinal, southeast-facing sequence of massive arkosic sediments which is variably conglomeratic at its base (Little North Pond Formation). The Little North Pond Formation has been interpreted as a clastic cover sequence overlying Grenville basement and is thus correlative with the Bradore Formation of the Labrador Group.

A series of pelitic and psammitic schists lying to the southeast of the Little North Pond Formation constitute the upper member of the Mount Musgrave Group (South Brook Formation). The South Brook Formation is similar in lithology, metamorphic grade and structural style to the Fleur de Lys Supergroup and its interpretation as part of a sedimentary cover sequence overlying Grenville basement serves to strengthen correlations between the Fleur de Lys Supergroup and the Labrador Group.

(3) Structurally the Old Mans Pond area is dominated by a large-scale imbricate stack involving the structural assemblages described above. Local relationships indicate that this stack was assembled from the east and emplaced against the carbonate sequence during the Taconic Orogeny. Assembly of the stack, deformation and metamorphism all occurred diachronously from east to west as indicated by the lack of involvement of westerly portions of the carbonate sequence in the earliest stages of deformation. Much of the area was sheltered from later deformation and metamorphism due to its position northwest of a minor reentrant in the ancient margin.

7.2 DISCUSSION: TECTONIC EVOLUTION OF THE HUMBER ZONE, WEST NEWFOUNDLAND:

The regional geology of the Humber Zone of west Newfoundland has generally been incorporated into a plate tectonic model involving growth and subsequent destruction of an Atlantic-type continental margin. A model for this tectonic evolution is briefly described below. This model draws heavily on contributions made by Dewey and Bird

(1970); Williams (1979); Rowley and Kidd (1981) and Colman-Sadd (1982) towards a developmental model for the Appalachian Orogen and an attempt is made to incorporate the findings of this study into the framework laid out by these workers.

The late Precambrian through lower Ordovician development of the eastern margin of the North American continent now recorded in the Humber Zone involved growth of an Atlantic-type continental margin along which an eastward-thickening sedimentary apron, characterized by shallow water clastics and carbonates in the west and deep water greywackes and shales with minor carbonates in the east, was deposited upon a basement of Grenvillian gneissic rocks. Lowest parts of the cover sequence are characterized by tholeiitic mafic flows which were fed by mafic dikes intruded along fractures in Grenville basement during the earliest rifting phase (Strong and Williams, 1972).

The geology of the Old Mans Pond area demonstrates virtually all facets of this ancient margin. Grenvillian basement rocks presumably underlie the entire area at depth and are exposed in the Round Pond Complex of the Hughes Lake Allochthon. Relict mafic dikes are found associated with these crystalline metamorphic rocks and mafic porphyritic and amygdaloidal volcanics (Deer Pond Volcanics) locally overlie them. A thick clastic sequence (Mount Musgrave Group) unconformably overlies the Round Pond Complex and has been interpreted to represent a portion of the thicker, more easterly part of the sedimentary prism.

The allochthonous Old Mans Pond Group also represents a part of the sedimentary prism, albeit more proximal than the Mount Musgrave Group. These rocks show strong affinities to both autochthonous and allochthonous portions of the known Paleozoic sedimentary sequence in west Newfoundland and have for the time being been interpreted to have originally lay somewhere between those two (see Figure 14).

Completing the sedimentary section in the Old Mans Pond area are Cambro-Ordovician sediments of the ancient carbonate bank. Lower parts of this sequence are locally clastic in nature (Penguin Cove Formation), however, the bulk of the succession consists of shallow water carbonates correlative with the autochthonous carbonate bank sequence common throughout western Newfoundland and traceable over the length of the Appalachian-Caledonides system (Rodgers, 1968; Swett and Smit, 1972; Williams, 1978b).

In the vicinity of Old Mans Pond the lowest portion of the carbonate sequence is represented by the Reluctant Head Formation (Lilly, 1963). This unit consists of thinly interbedded limestones and muddy dolostones with local breccia units and is inferred to be upper middle Cambrian in age. While correlatives of this formation are known to the south (Grand Lake Brook Group), east (Bobbys Brook Formation) and west (Cooks Brook Formation) the exposures at Old Mans Pond represent the only location where the Reluctant Head remains essentially unmetamorphosed and the only place in west Newfoundland where a nearly complete section is preserved.

Figure 14 shows the palinspastic restoration and interpretation of the various lithic units prior to the initiation of the destruction of this passive continental margin.

The earliest evidence for the destruction of the ancient stable continental margin is a disconformity which marks the top of the St. George Group (lowest Llanvernian). This disconformity resulted from upwarping of the carbonate shelf as it passed through the outer arc swell or peripheral bulge to the west of the already active subduction zone (Chapple, 1973; Jacobi, 1981; Rowley and Kidd, 1981; Shanmugam and Lash, 1982). Normal, east-dipping listric faults were initiated on the shelf at this time (Rowley and Kidd, 1981) and erosion of the shelf, in places down to basement, occurred (Williams and Stevens, 1974). An early

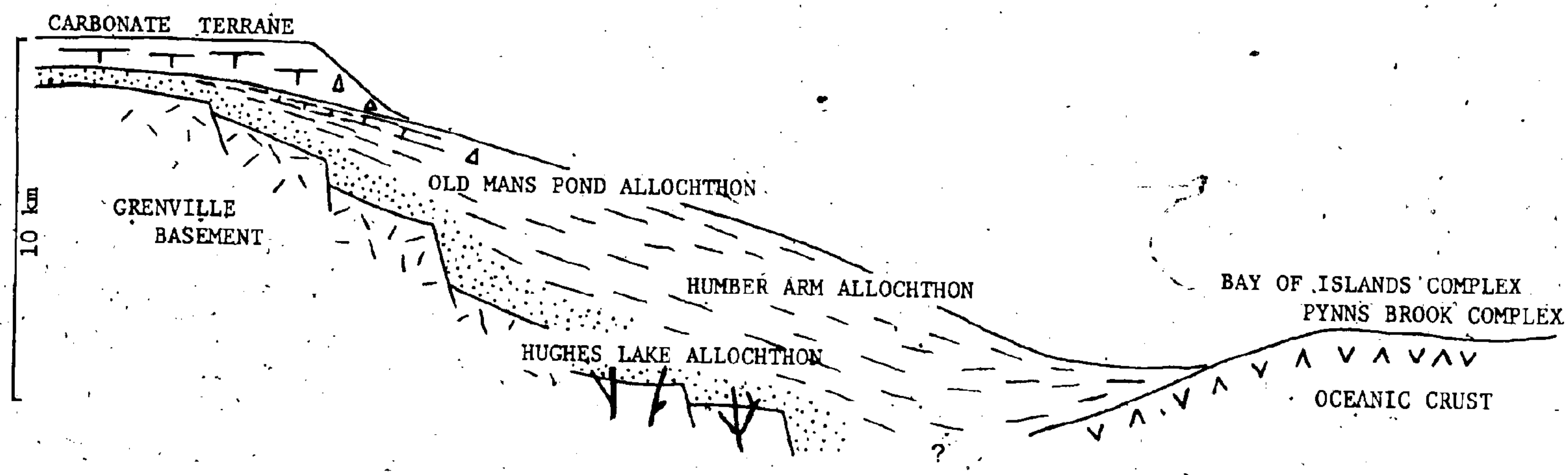


FIGURE 14: Restoration and interpretation of Early Paleozoic lithic assemblages of the Old Mans Pond and surrounding area according to the model of a passive continental margin.

Llanvernian age (469 Ma, Dallmeyer and Williams, 1975) from the metamorphic aureole at the base of the Bay of Islands ophiolite complex indicates that obduction of this sequence had begun by this time. Shunmagum and Lash (1982) cite jamming of the subduction zone as a cause for the peripheral bulge, implying that accretion of continental rise sediments had also begun.

Subsequent to being uplifted, the shelf subsided to abyssal depths progressively westwards due to downflexing into the subduction zone to the east (Williams, 1979; Rowley and Kidd, 1981). This subsidence is recorded by deeper water carbonates (Table Head Group, Klappa et al, 1980) which are succeeded by a flood of immature clastic sediments (flysch) derived from the east and containing ophiolite detritus and clasts of distinctive rise prism lithologies (Stevens, 1970; Rowley and Kidd, 1981). Youngest exposures of this flysch are early to medial Arenig in age (Stevens, 1976) and indicate that the accretionary wedge, complete with ophiolite complex, was being transported, uplifted and eroded by this time. The presence of rise prism lithologies indicates that continental rise sediments were also incorporated into the accretionary prism.

Rowley and Kidd (1981) suggest that deformation and metamorphism of the rise prism sediments began immediately after incorporation into the accretionary wedge and that stacking, deformation and metamorphism all occurred diachronously and progressively from east to west. Findings of this study concur with this view since the carbonate sequence in the Old Mans Pond area shows none of the effects of earliest deformation shown by the transported sequences.

As subduction continued, more continental rise material was being progressively thrust-accreted, deformed, uplifted and eroded, shedding flysch westward (Stevens, 1970; Hiscott, 1978). As this mass crossed the carbonate shelf edge it was moving on a single thrust surface or decollement to which fragments of the carbonate bank and, rarely, Grenville basement were attached (Elliott and Johnson, 1980; Rowley and Kidd, 1981). Eventually this major decollement locked, forcing more easterly portions of the thrust sheet to override more westerly parts. This late stage imbrication was responsible for final stacking and emplacement of the Humber Arm Allochthon and equivalents, and for generation of the thrust stack which dominates the Old Mans Pond area. Large fold nappes such as that beneath the Old Mans Pond Allochthon were also formed at this time (see Figure 13a). According to Rowley and Kidd (1981), carbonate slivers (eg. Penguin Hills Klippe, see Williams et al, 1982) found between separate slices of transported structural assemblages are signposts of this late, large-scale imbrication of a single initial thrust and argue against gravity sliding as a mechanism for assembly and emplacement of allochthonous sequences. As pointed out by these authors, such a mechanism does not preclude the existence of earlier or later thrusts affecting these rocks (see Casey and Kidd, 1981). A similar mechanism has been well documented for the celebrated Moine thrust system of northwest Scotland (Elliott and Johnson, 1980) where folding of thrusts, formation of imbricate stacks and longitudinal ramping of thrusts are all clearly illustrated to be a direct consequence of such a process. Such a mechanism has obvious merit in the Old Mans Pond area (see Chapter 6).

Because of the westerly transgressive nature of this entire process a strong deformational and metamorphic gradient was created across what is now the Humber Zone. In the west, both transported and autochthonous sequences are unmetamorphosed and only mildly deformed while to the east, laterally equivalent sequences have been polydeformed and highly metamorphosed (Fleur de Lys Supergroup). The Old Mans Pond area conveniently spans the intervening terrane and records the transition from one to the other.

Final emplacement of the Humber Arm Allochthon has been dated as medial Caradocian (D. multidens zone, Stevens, 1976) and essentially marks the end of the Taconic Orogeny in Newfoundland. Culmination of this orogenic event may have been due to collision of the North American plate with a second continental plate (Williams, 1979) or island arc (St. Julien and Hubert, 1978; Hiscott, 1978; Rowley and Kidd, 1981) or, alternatively, may have been caused by the positive bouyancy of the North American continental block which eventually counteracted the downward pull of the subducted slab (Colman-Sadd, 1982). In any event, subduction ceased and a widespread cover of Caradocian shale was deposited across what was previously an active volcanic terrane to the east (Dunnage Zone) while a Caradocian unconformity is evident in other parts of the system (Williams, 1979). This, combined with the fact that Late Ordovician and Silurian rocks record a change from deep-water marine to terrestrial conditions (Williams, 1967b), indicates that the Iapetus Ocean was destroyed at this time.

In Newfoundland, a brief period of relative quiescence was followed by a second orogenic event during the Devonian (Acadian Orogeny). The Acadian Orogeny is generally believed to have resulted from renewed subduction (Colman-Sadd, 1982) and its effects are evident across the entire orogen (Williams, 1979). This orogenic event is characterized by generally upright folding rather than the more recumbent structures characteristic of the Taconic

Orogeny (Williams, 1982). In the Humber Zone, upright to slightly westerly inclined folding of allochthonous and autochthonous sequences along with minor thrust faulting and penetrative cleavage formation have all been suggested as Acadian features (Williams, 1979, Williams and Godfrey, 1981). In addition, regional metamorphism related to the intrusion of large plutonic batholiths (eg. Topsails Igneous Complex) also occurred during the Acadian.

Remarkably, the Old Mans Pond area is relatively free from any deformational or metamorphic effects which may be readily attributed to the Acadian Orogeny. The most significant effect of this event was to passively rotate earlier Taconic features into their present reversed sense of polarity. The reason for this lack of Acadian overprinting has been attributed here to the position of the Old Mans Pond area to the northwest of a minor reentrant in the ancient margin as defined by the Baie Verte-Brompton Line. This reentrant allowed for more thin-skinned deformation during the Taconic resulting in structural assemblages being moved further horizontally and away from the orogenic front, thus resulting in the strucural salient evident in the area. The reentrant also acted as a harbour during the Acadian, sheltering the area from pervasive effects.

A third orogenic event to effect the northern Appalachians (Alleghanian Orogeny) had little or no effect on the Old Mans Pond area other than localized block faulting. The Alleghanian deformational front lies to the east of Deer Lake in this region (Williams et al, 1982, 1983).

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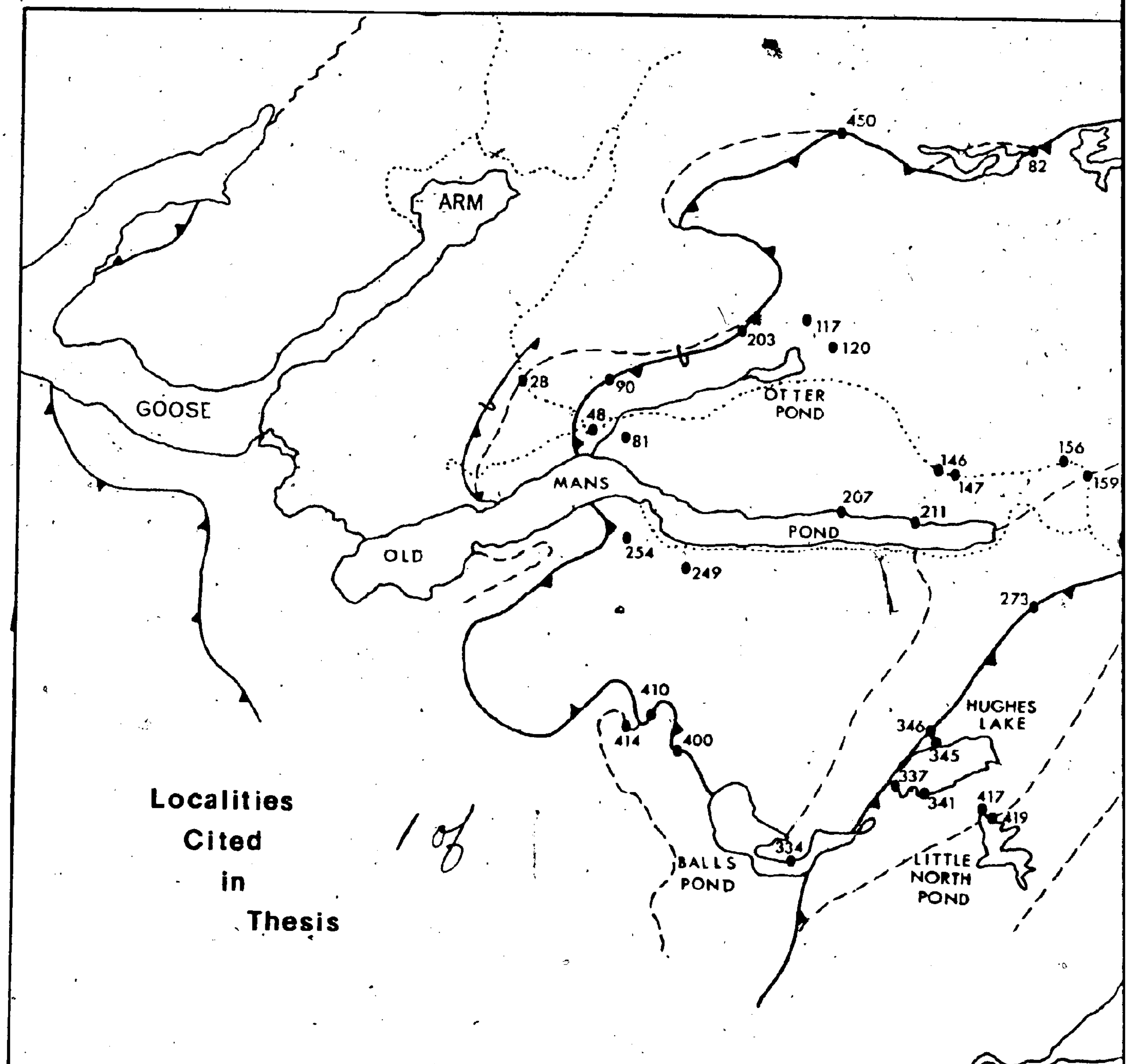

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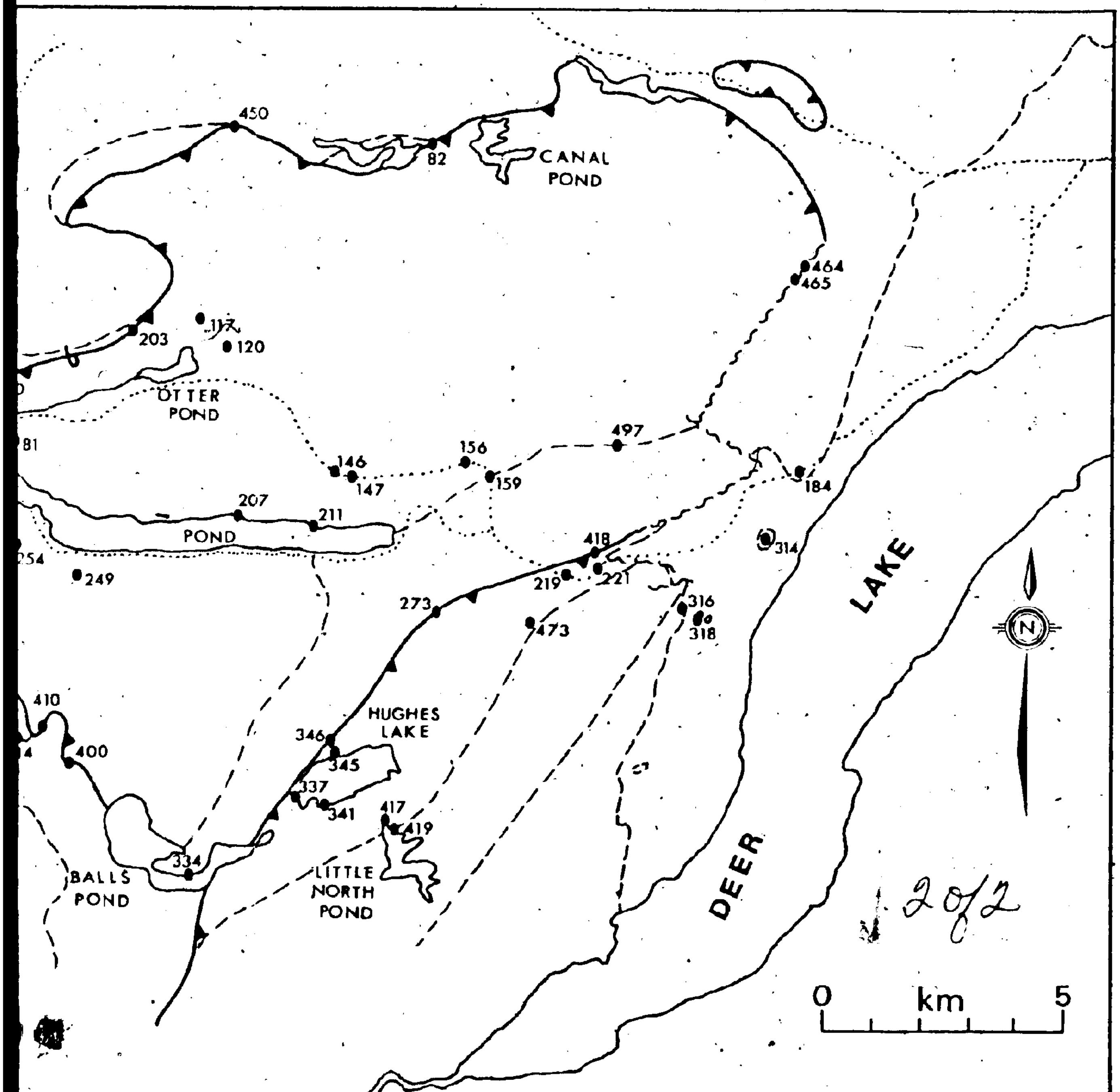
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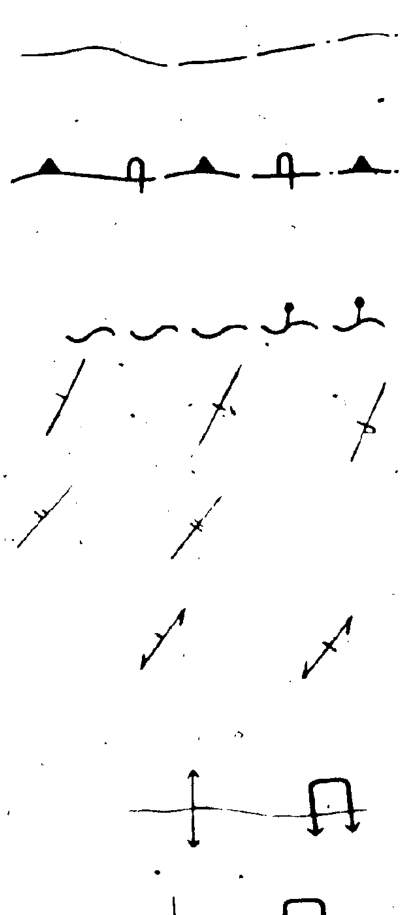
EXPLANATION OF SYMBOLS



Geologic contact
(defined, approximate, inferred)

Thrust fault (teeth on upper plate with direction of dip where overturned
(defined, approximate, inferred)

High angle fault (solid dot indicates downthrow side)

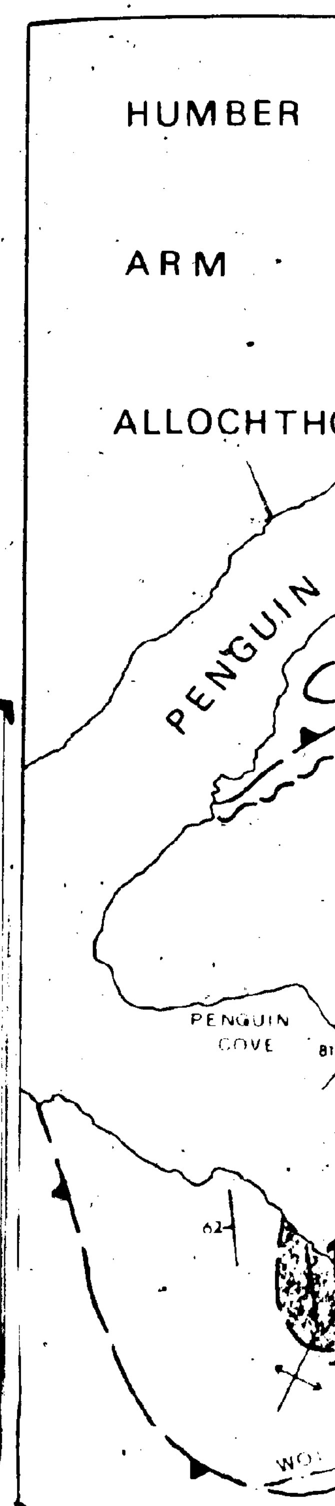
Bedding, tops known
(inclined, vertical, overturned)

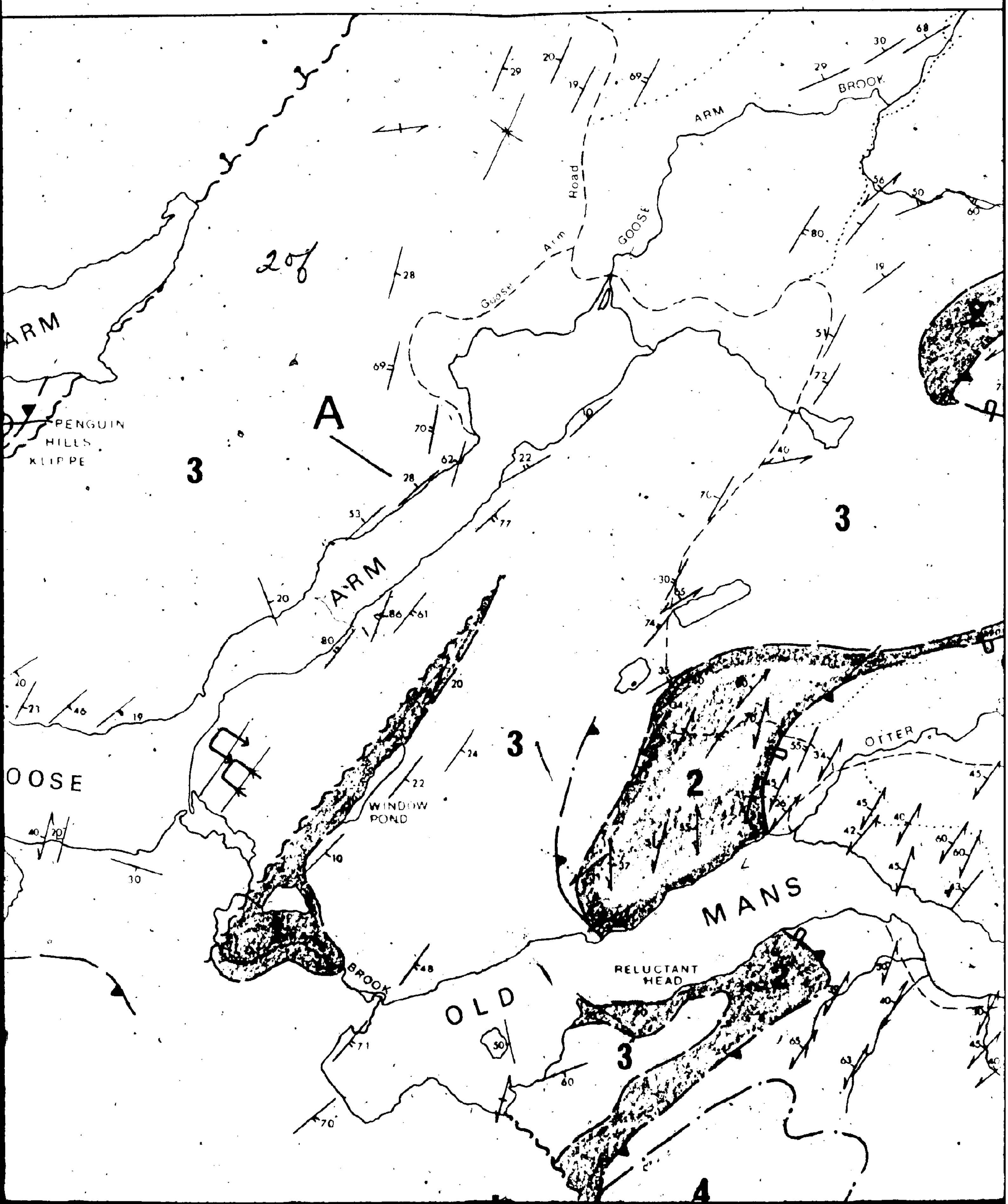
Bedding, tops unknown
(inclined, vertical)

Main schistosity or foliation in metamorphic rocks, dominant cleavage in sedimentary rocks
(inclined, vertical)

Axis of anticline
(upright, overturned)

Axis of syncline





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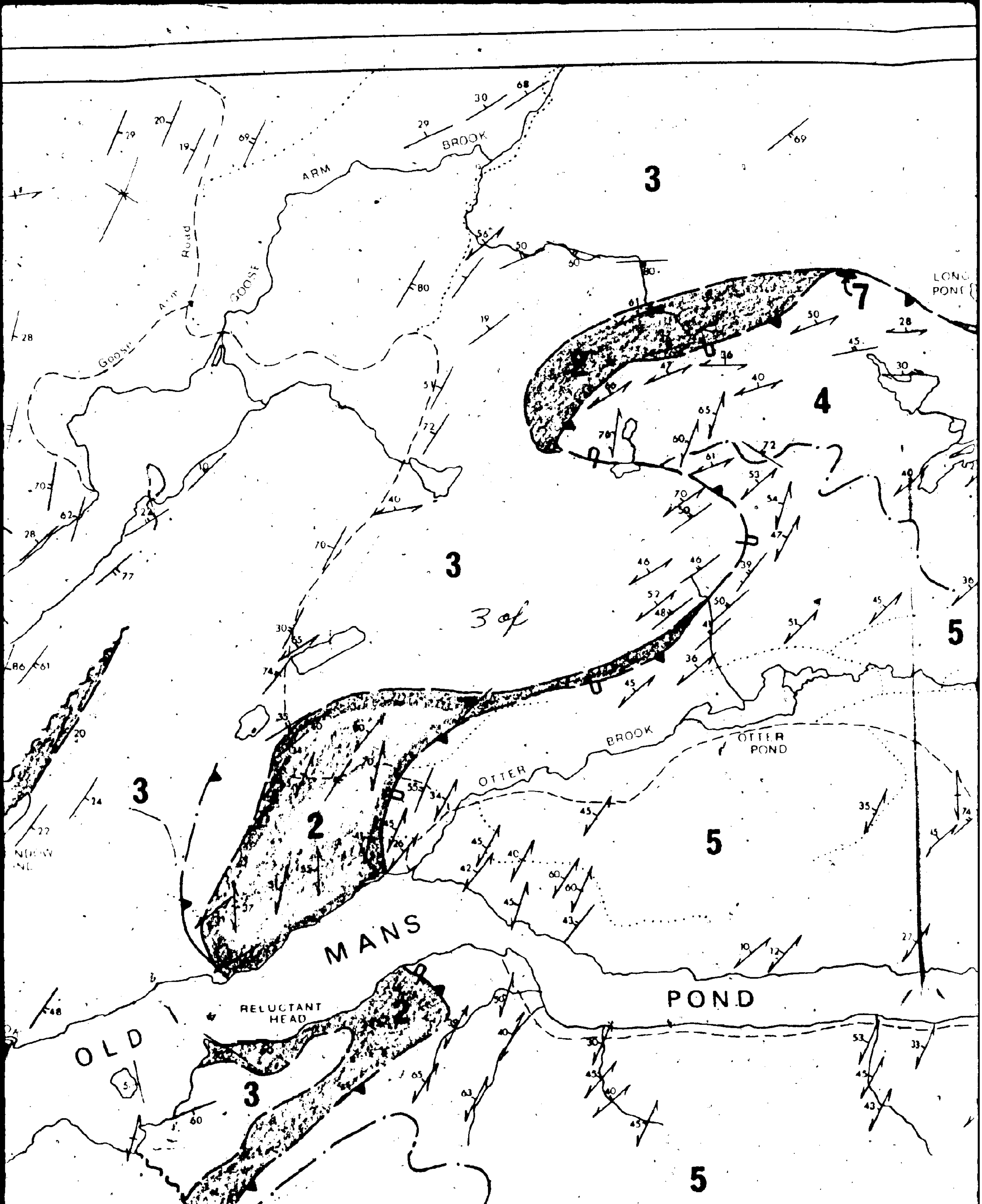

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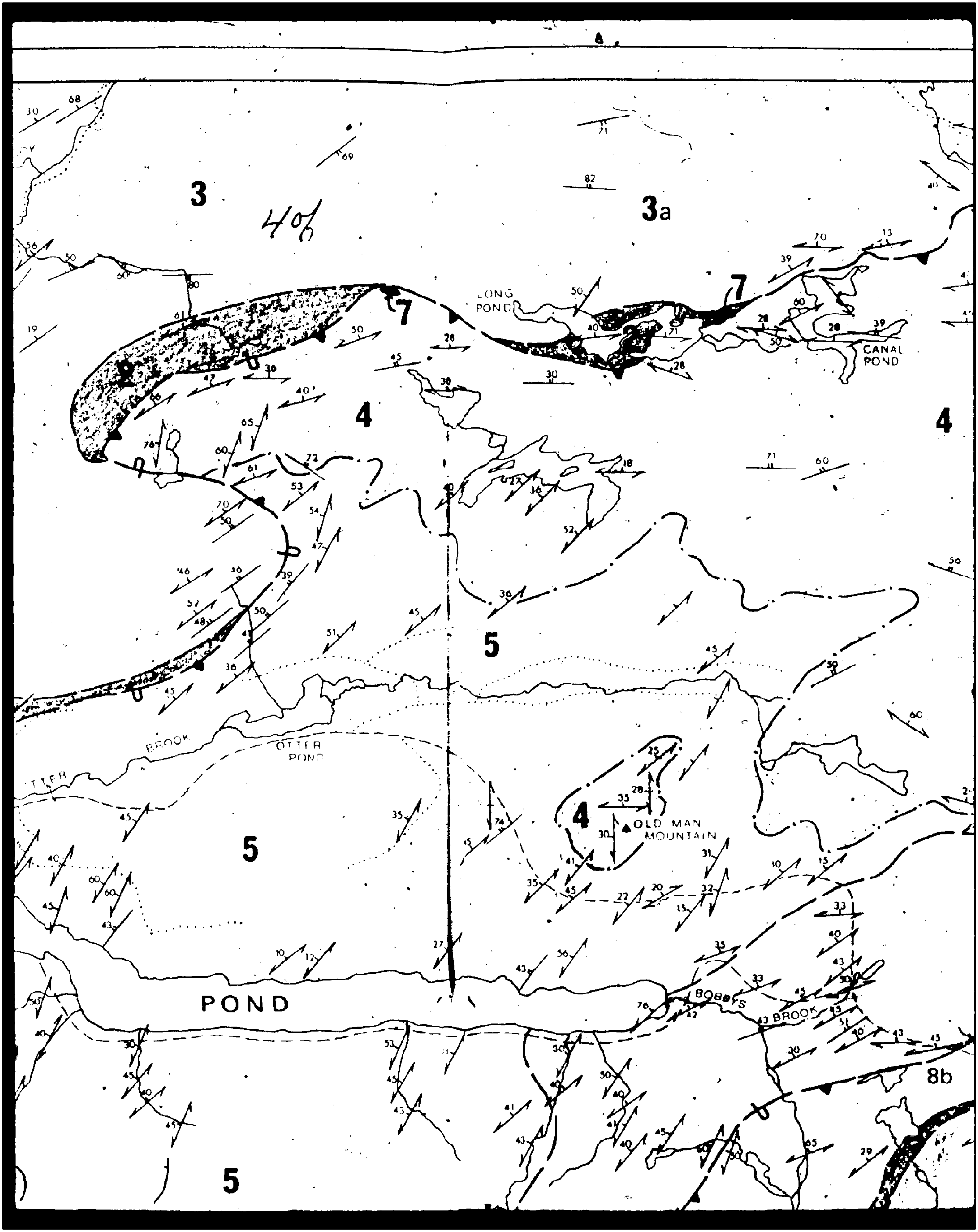

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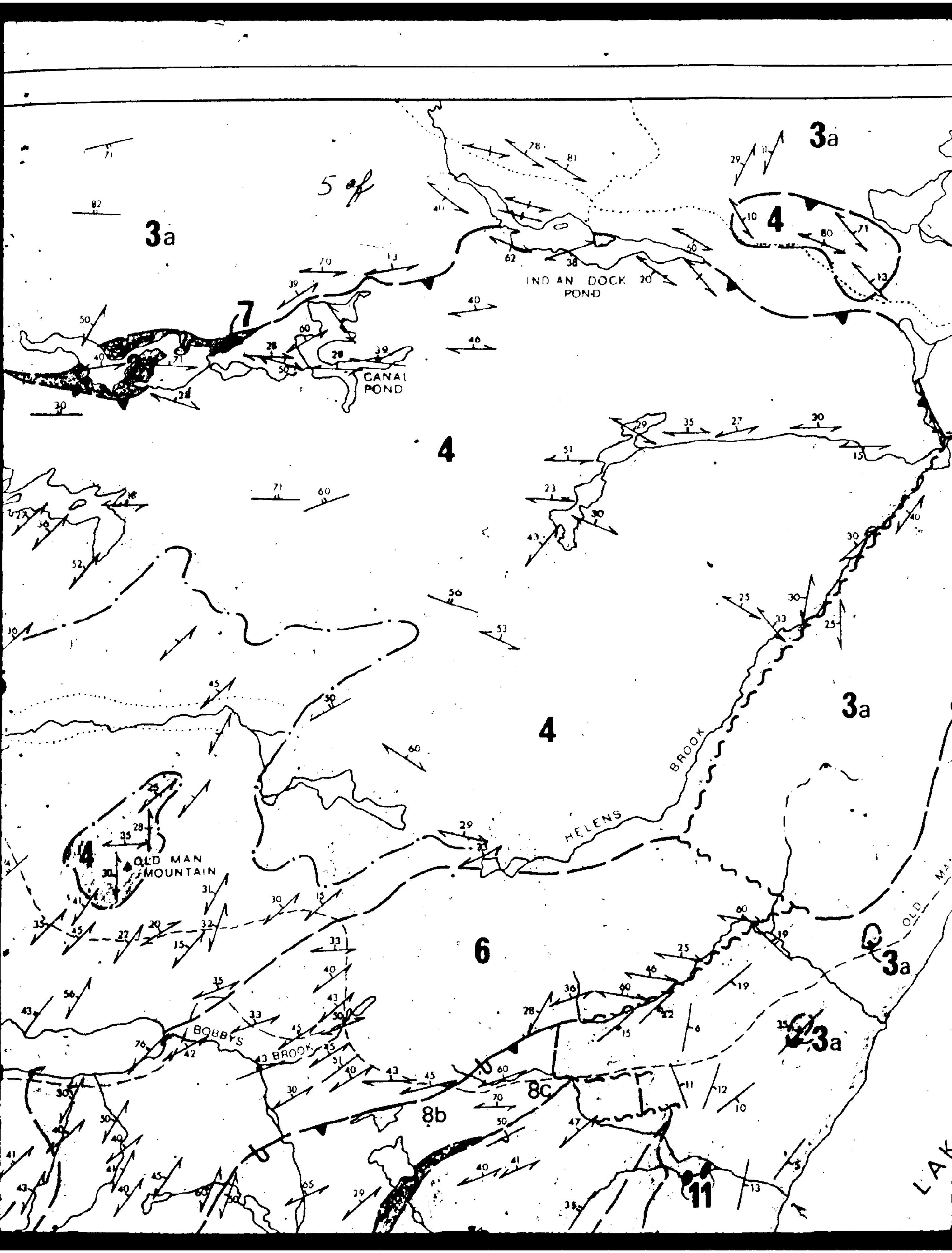

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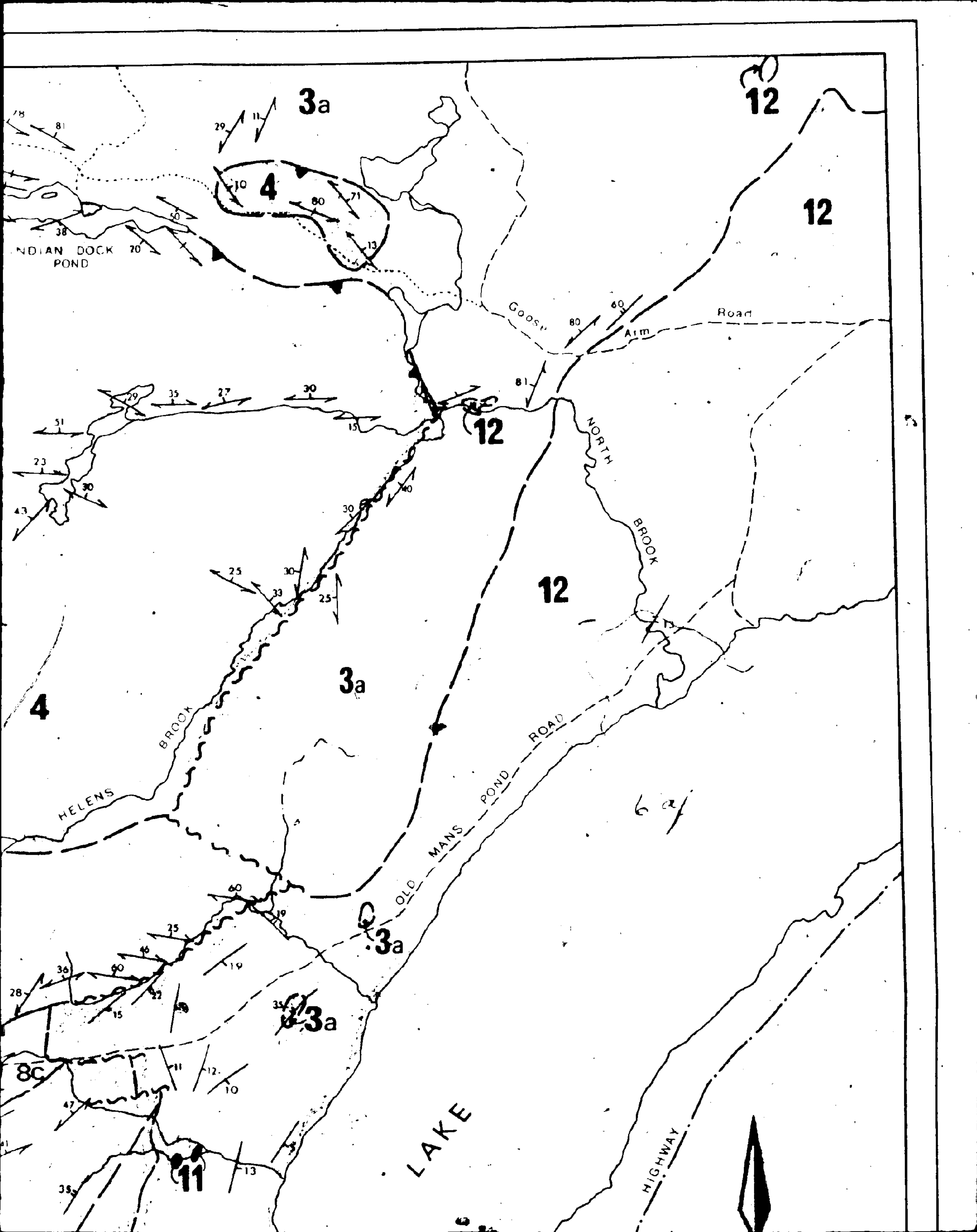
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LAKE
HIGHWAY

Axis of Syncline
(upright, overturned)

Gravel road, fair weather only

Logging trail, passible on foot only

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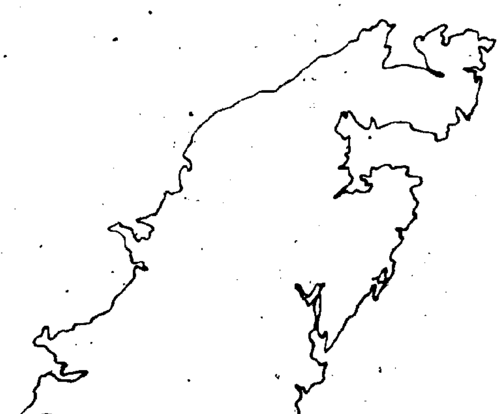

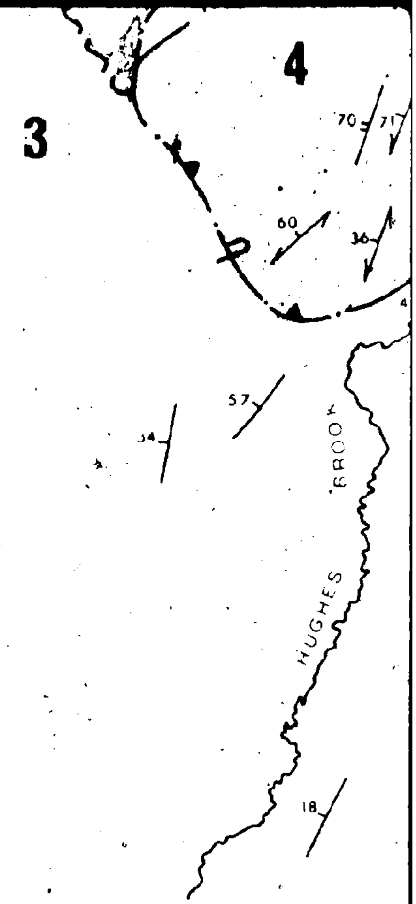

GEOLOGY

OF

OLD MANS POND

AREA

WEST NEWFOUNDLAND

by: R T Gillespie, 1981

With additions by: H. Williams and D. Knapp, 1981

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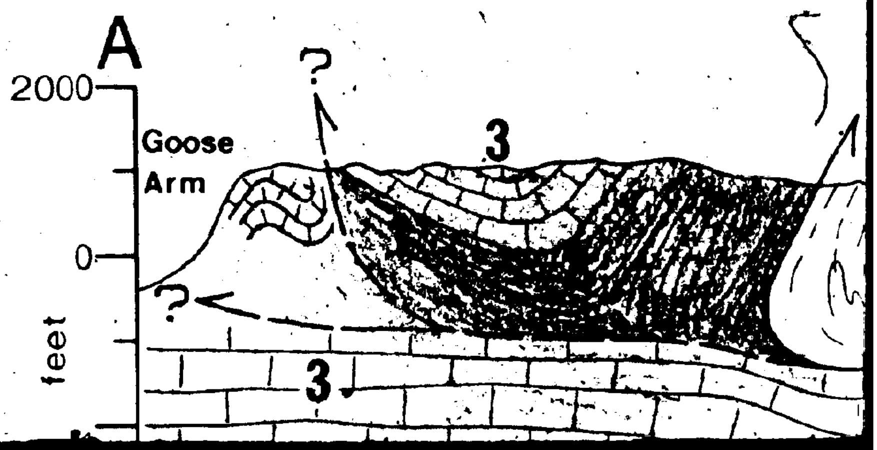

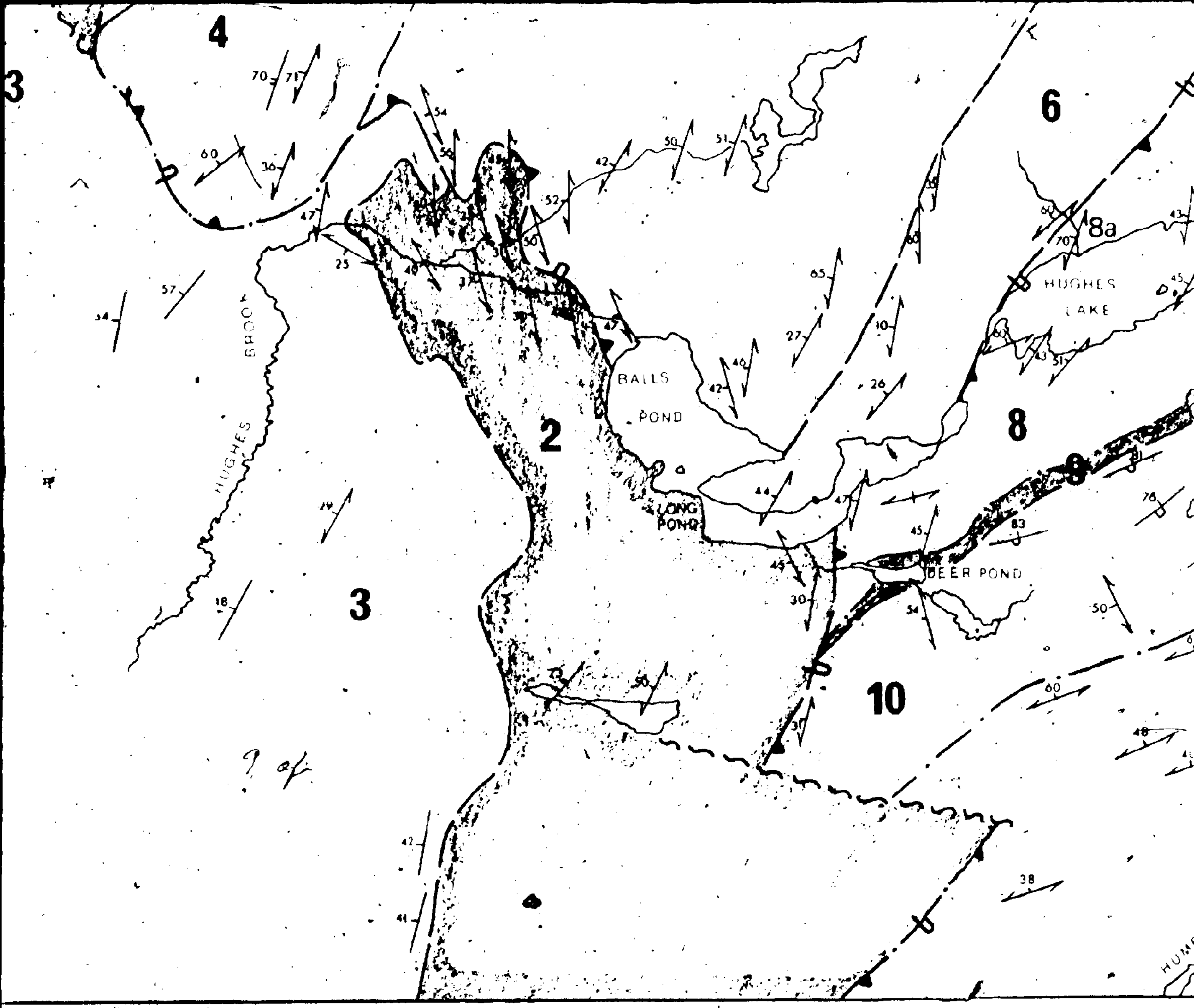

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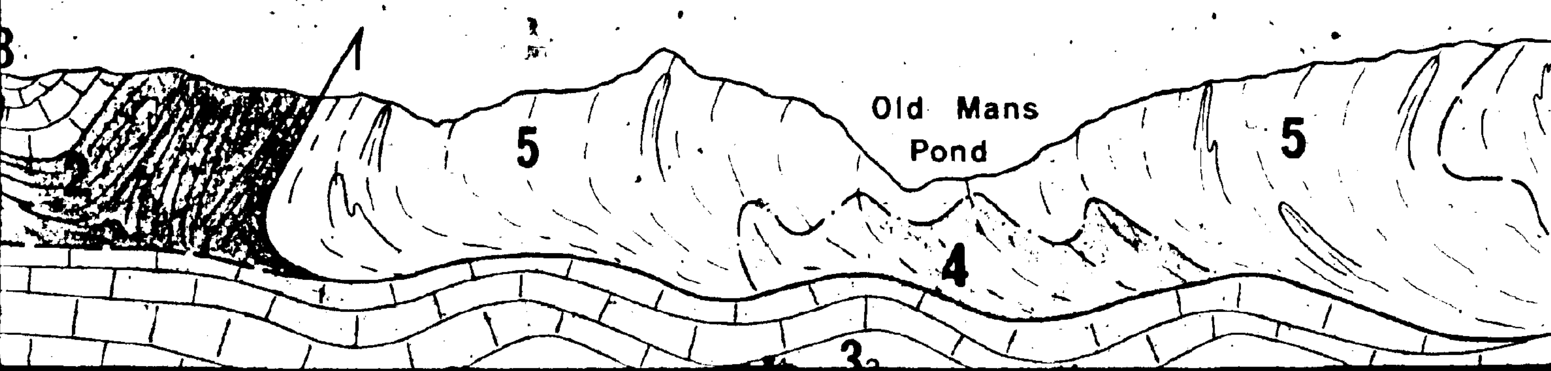

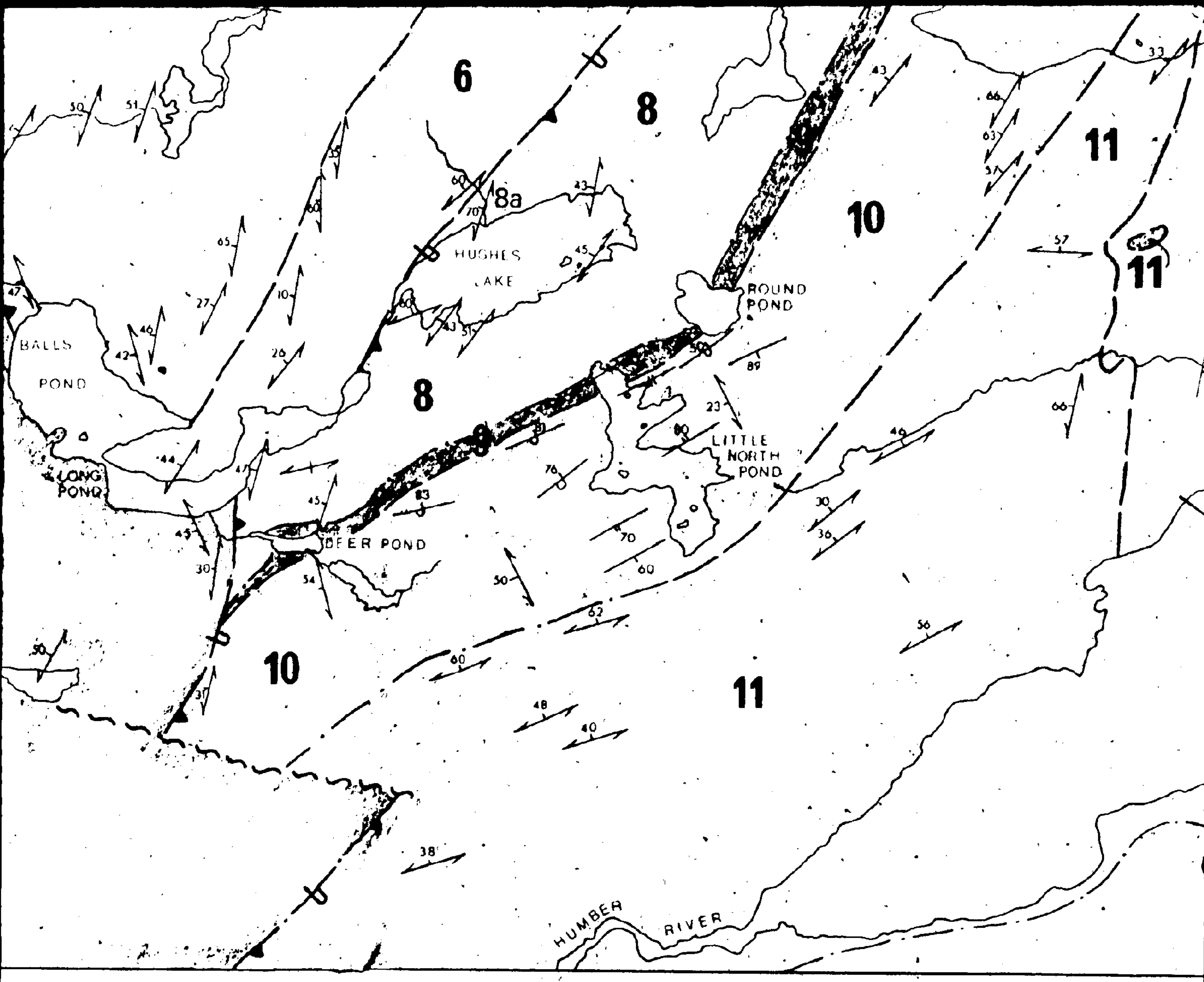

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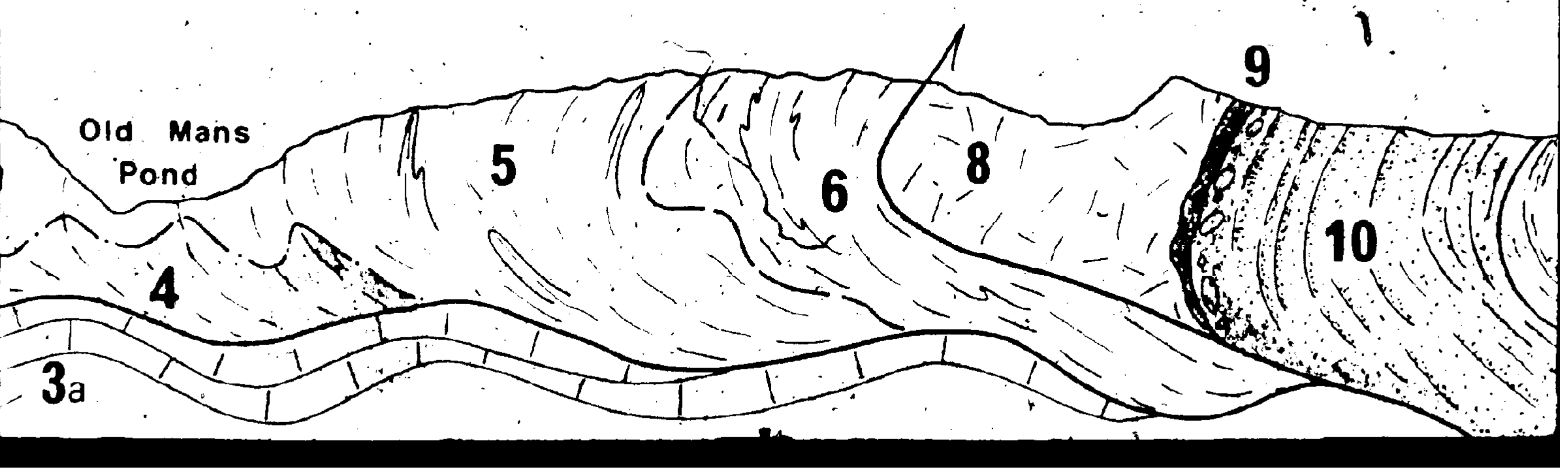

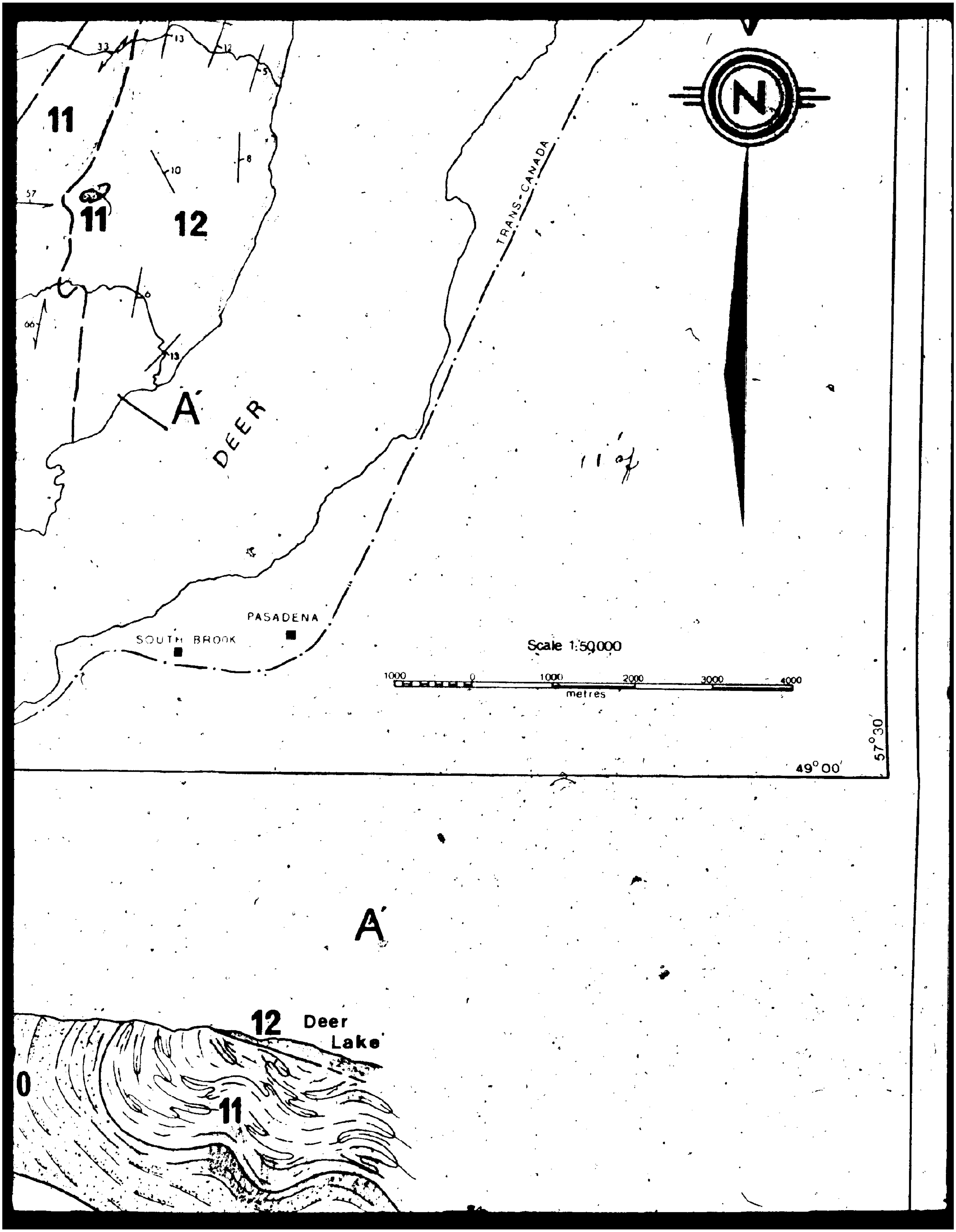

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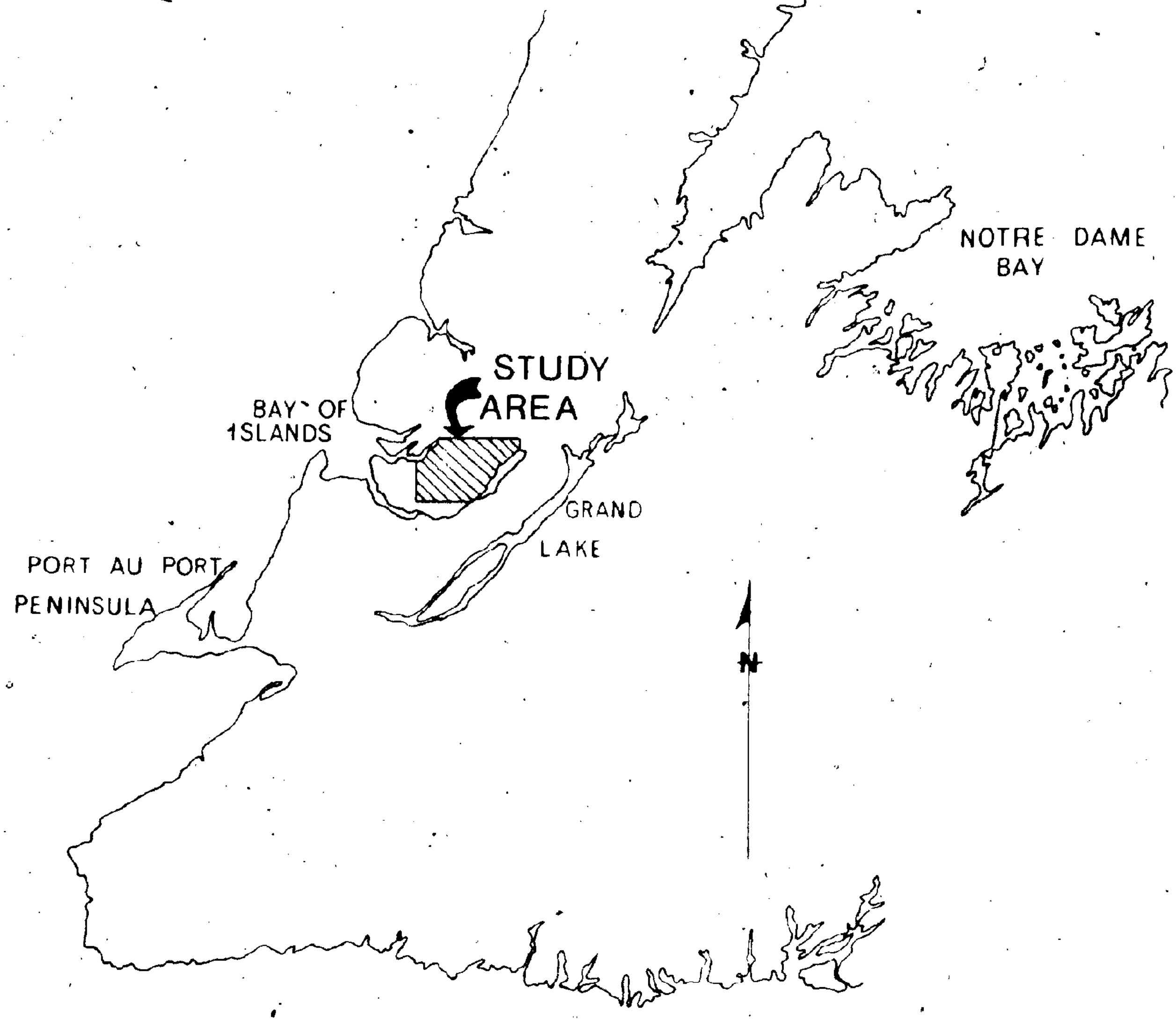

Location of Old Mans Pond area, west Newfoundland.

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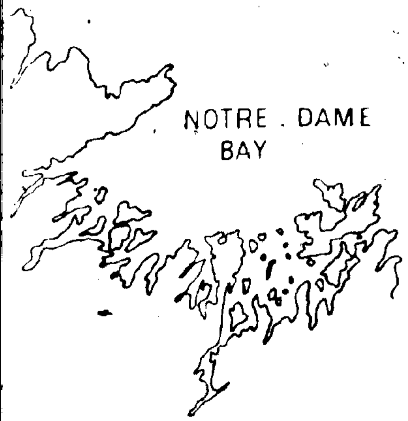

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t Newfoundland.

CARBONATE SEQUE

UPPER CAMBRIAN TO LOWER ORDOVICIAN

3 ST GEORGE GROUP: MAINLY MEDIUM TO THICK
AND BUFF DOLOSTONE, MAY INCLUDE SOME ROC
AGE; 3A EASTERN CARBONATE TERRANE: MASSI
MARBLE, MINOR SILICICLASTIC CARBONATE AN

LOWER TO MIDDLE CAMBRIAN

2 RELUCTANT HEAD FORMATION: THINLY INTERBE
AND BUFF TO ORANGE DOLOSTONE, OOLITIC IN
LENSOID UNITS OF CARBONATE BRECCIA COMMO
VARIABLY OOLITIC

1 PENGUIN COVE FORMATION: BUFF TO PINKISH
SILTSTONE AND SHALE IN LOWER PART; INTER
DOLOSTONE IN UPPER PART, COMMONLY OOLITI

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12 DEER LAKE GROUP: RED AND GREEN
SANDSTONE AND SHALE

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E, MAY INCLUDE SOME ROCKS OF UPPER CAMBRIAN
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CICLASTIC CARBONATE AND COARSE BRECCIA UNITS

N

RMATION: THINLY INTERBEDDED GREY LIMESTONE
E DOLOSTONE, OOLITIC IN UPPER PORTIONS;
CARBONATE BRECCIA COMMON, BLOCKS AND MATRIX

ATION: BUFF TO PINKISH SANDSTONE, MINOR GREY
LE IN LOWER PART; INTERBEDDED LIMESTONE AND
R PART, COMMONLY OOLITIC AND ONCOLITIC

OLD MANS POND

UPPER CAMBRIAN OR LOWER ORDOVICIAN

METAGABBROIC ROCKS

LOWER CAMBRIAN TO LOWER ORDOVICIAN

OLD MANS POND GROUP:

6 BOBBYS BROOK FORMATION: THINLY
SILVER-GREY PHYLLITE; MARBLE BR
PHYLLITE

5 OTTER BROOK FORMATION: SLATY TO
SILTSTONE; SUBORDINATE WHITE TO
QUARTZ PEBBLE CONGLOMERATE UNIT

4 CANAL POND FORMATION: GREENISH
QUARTZ PEBBLE CONGLOMERATE, GRE

14 of

LEGEND

COVER ROCKS

ARBONIFEROUS

12 DEER LAKE GROUP: RED AND GREEN BOULDER CONGLOMERATE, SANDSTONE AND SHALE

OLD MANS POND ALLOCHTHON

PPER CAMBRIAN OR LOWER ORDOVICIAN

METAGABBROIC ROCKS

15 %

LOWER CAMBRIAN TO LOWER ORDOVICIAN

OLD MANS POND GROUP:

6 BOBBYS BROOK FORMATION: THINLY BEDDED GREY MARBLE AND SILVER-GREY PHYLLITE; MARBLE BRECCIA; MINOR DARK SHALE AND PHYLLITE

5 OTTER BROOK FORMATION: SLATY TO PHYLLITIC GREY SHALE AND SILTSTONE; SUBORDINATE WHITE TO GREENISH SANDSTONE AND QUARTZ PEBBLE CONGLOMERATE UNITS; MINOR CARBONATE BRECCIA

4 CANAL POND FORMATION: GREENISH GREYWACKE, WHITE SANDSTONE, QUARTZ PEBBLE CONGLOMERATE, GREENISH AND PURPLE ARGILLITE

HUGHE

LATE HADRYNIAN TO

MOUNT MUSGRAVE

11 SOUTH BROOK
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10 LITTLE NORT
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LATE HADRYNIAN TO CAMBRIAN

MOUNT MUSGRAVE GROUP:

11 SOUTH BROOK FORMATION: PELITIC TO PSAMMITIC QUARTZ-FELDSPAR-MUSCOVITE-CHLORITE SCHISTS

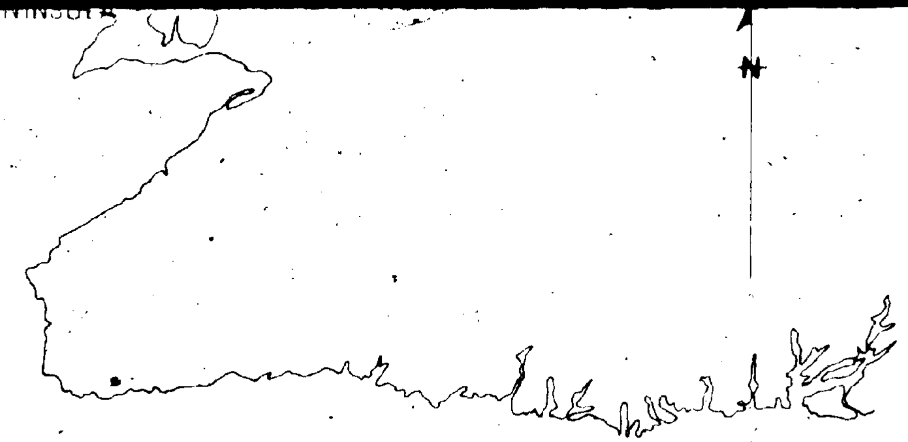
10 LITTLE NORTH POND FORMATION: COARSE ARKOSIC GREYWACKE, QUARTZ PEBBLE CONGLOMERATE AT BASE; MINOR SCHISTOSE GREYWACKE AND PHYLLITIC SCHIST

HADRYNIAN (?)

DEER POND VOLCANICS: METAMORPHOSED MAFIC VOLCANIC FLOWS, LOCALLY PORPHYRITIC AND AMYGDALOIDAL; MINOR ARKOSIC INTERBEDS

HELIKIAN

8 ROUND POND COMPLEX: GRANODIORITIC GNEISS AND FOLIATED



Location of Old Mans Pond area, west Newfoundland.

170F

CARBONATE SEQUENCE

UPPER CAMBRIAN TO LOWER ORDOVICIAN

3 ST GEORGE GROUP: MAINLY MEDIUM TO THICK BEDDED GREY LIMESTONE AND BUFF DOLOSTONE, MAY INCLUDE SOME ROCKS OF UPPER CAMBRIAN AGE; 3A EASTERN CARBONATE TERRANE: MASSIVE GREY AND BUFF MARBLE, MINOR SILICICLASTIC CARBONATE AND COARSE BRECCIA UNITS

LOWER TO MIDDLE CAMBRIAN

2 RELUCTANT HEAD FORMATION: THINLY INTERBEDDED GREY LIMESTONE AND BUFF TO ORANGE DOLOSTONE, OOLITIC IN UPPER PORTIONS; LENSOID UNITS OF CARBONATE BRECCIA COMMON, BLOCKS AND MATRIX VARIABLY OOLITIC

1 PENGUIN COVE FORMATION: BUFF TO PINKISH SANDSTONE, MINOR GREY SILTSTONE AND SHALE IN LOWER PART; INTERBEDDED LIMESTONE AND DOLOSTONE IN UPPER PART; COMMONLY OOLITIC AND ONCOLITIC

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OLD MANS POND ALLOCHTHON

UPPER CAMBRIAN OR LOWER ORDOVICIAN

METAGABBROIC ROCKS

LOWER CAMBRIAN TO LOWER ORDOVICIAN

OLD MANS POND GROUP:

6 BOBBYS BROOK FORMATION: THINLY BEDDED GREY MARBLE AND SILVER-GREY PHYLLITE; MARBLE BRECCIA; MINOR DARK SHALE AND PHYLLITE

5 OTTER BROOK FORMATION: SLATY TO PHYLLITIC GREY SHALE AND SILTSTONE; SUBORDINATE WHITE TO GREENISH SANDSTONE AND QUARTZ PEBBLE CONGLOMERATE UNITS; MINOR CARBONATE BRECCIA

4 CANAL POND FORMATION: GREENISH GREYWACKE, WHITE SANDSTONE, QUARTZ PEBBLE CONGLOMERATE, GREENISH AND PURPLE ARGILLITE

190f

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LATE HADRYN

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11 SOUTH
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HUGHES LAKE ALLOCHTHON

LATE HADRYNIAN TO CAMBRIAN

MOUNT MUSGRAVE GROUP:

11 SOUTH BROOK FORMATION: PELITIC TO PSAMMITIC QUARTZ-FELDSPAR-MUSCOVITE-CHLORITE SCHISTS

10 LITTLE NORTH POND FORMATION: COARSE ARKOSIC GREYWACKE, QUARTZ PEBBLE CONGLOMERATE AT BASE; MINOR SCHISTOSE GREYWACKE AND PHYLLITIC SCHIST

20.68

HADRYNIAN (?)

DEER POND VOLCANICS: METAMORPHOSED MAFIC VOLCANIC FLOWS, LOCALLY PORPHYRITIC AND AMYGDALOIDAL; MINOR ARKOSIC INTERBEDS

HELIKIAN

8 ROUND POND COMPLEX: GRANODIORITIC GNEISS AND FOLIATED GRANODIORITE; 8A FOLIATED TO MASSIVE GRANITE; 8B ALBITE-CHLORITE SCHIST; 8C PINK FELSITE, AGGLOMERATE; MINOR THIN AMPHIBOLITIC UNITS