THE ORIGIN OF THE LION'S HEAD PENINSULA BEACH

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ABSTRACT

The beach deposits at the head of the Lion's Head Peninsula are described and categorized according to the type, size and morphology of the rocks making up the deposit and their origins. This categorization emerges as a pattern of four zones along the length of the beach.

The points at each end of the beach, which used to be in a much more defined bay, have been glacially eroded by re-entrants and undercut by postglacial lakes. Shales and dolomite from the escarpment make up this zone's deposits.

Zone two is a dolomite cobble beach supplied by the escarpment's erosion from a blockaded late-glacial ice margin and the undercutting of postglacial lakes.

Zone three is a mixture of the dolomite from the escarpment, lacustrine sand deposits, and glacial erratics.

Zone four is made up of a distinct band of erratics deposited by the ice of the Georgian Bay lobe of the Late Wisconsin Glaciation. The Lion's Head promontory stood resistant to the flow of ice and caused it to deposit these large erratics which are still visible today.

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Dr. D. C. Ford for suggesting the topic and for his helpful advice and reference material. Thanks should also go out to Mary Lou Byrne of the Geography Department for her advice on the laboratory analysis of the samples. I would also like to thank Wiarton Willy for his excellent accommodations during the field work portion of this thesis. Finally, thanks to my family for their support and encouragement.

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1. Introduction

The Lion's Head Peninsula, situated at the approximate mid-point of the Bruce Peninsula on the Georgian Bay side, represents one of the many interesting geomorphological features found in this area of southwestern Ontario. As with every other landform in the Bruce area, its present form is a result of glacial and glacio-lacustrine processes in the past and karst and fluvial processes at the present time. The study of these processes and the resulting landforms has been well established through work carried out from the turn of the century but not all has been fully accounted for. One such area, deserved of closer study, is the beach found on the shores of Georgian Bay at the head of the promontory known as the Lion's Head Peninsula. This thesis represents a study of the characteristics of the beach deposits and will aim to offer suggestions as to their origins.

On reaching the beach at the head of the peninsula, via the well known Bruce Trail, and initially surveying its one kilometre length, it becomes evident that a pattern exists in the beach deposits. The beach, running in a northwest to southeast direction, displays a relatively concave form which is bounded at both ends by shale undergoing erosion. The northwest end is named Lion's Head Point and the southeast end of the beach is named Gun Point. From these points, moving successively inward to the centre, there is a zone in which a uniform dolomite cobble beach dominates, followed by a transition zone of coarse sands and limestone and dolomite medium sized rocks. At the approximate

centre of the beach there is a zone of erratics which consists of carbonate and non-carbonate rocks varying over a wide spectrum of shapes and sizes. Just northwest of this centre band of erratics is a small inlet named McKay's Harbour.

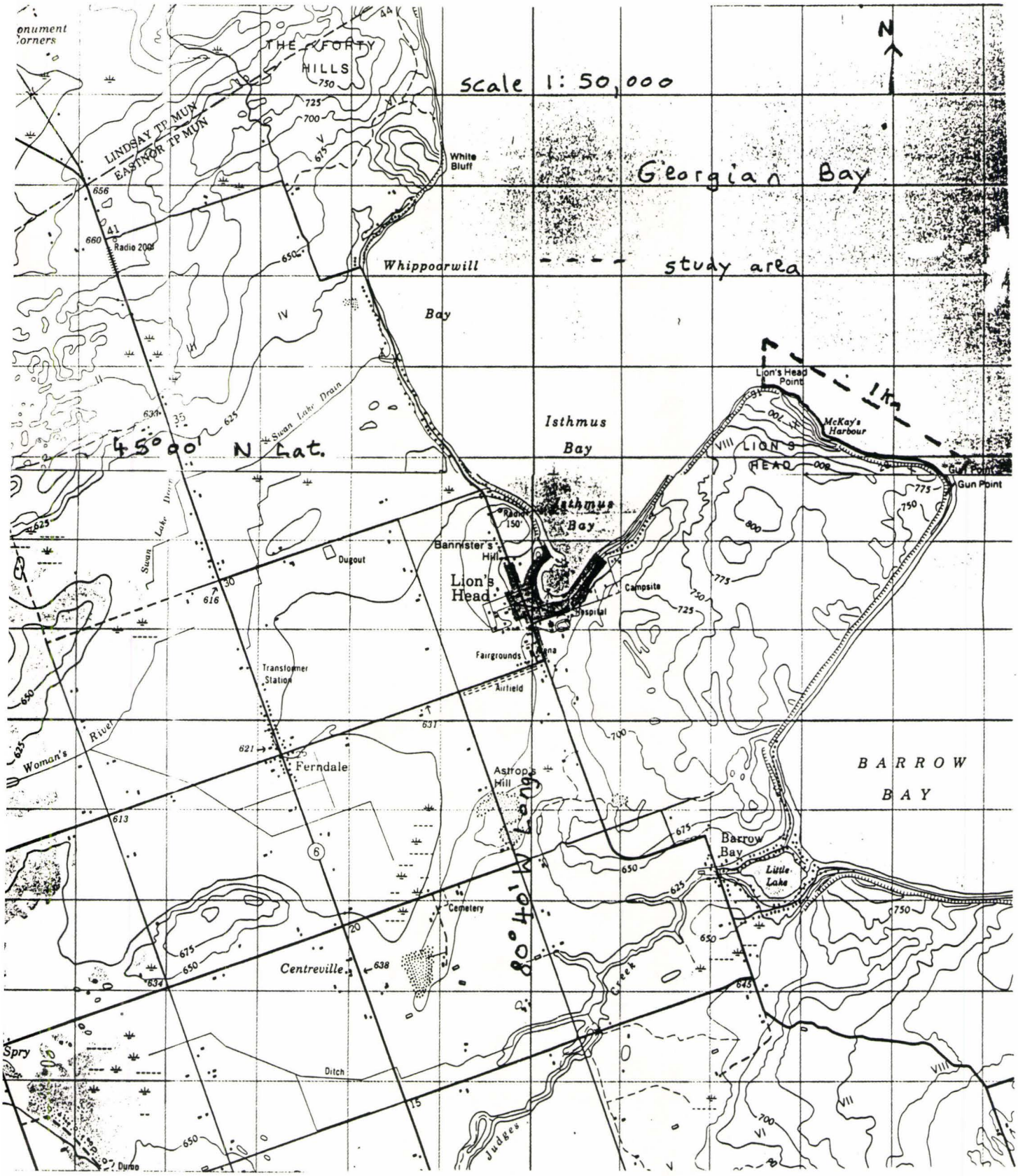
McKay's Harbour provides a well used campsite for hikers on the Bruce Trail and for rock climbers who are challenged by the 100 metre cliffs found at Lion's Head Point. These features, coupled with the view of Georgian Bay, make the setting of this northeasterly facing beach a truly spectacular environment. This fact made the field work done during the investigation quite enjoyable.

Measurements to determine the approximate sizes and shapes of the beach deposits were performed in the field and a number of sand samples were taken at sites where enough sand existed for sampling. A grain size analysis was performed on the sand samples in the laboratory. The lab and field work have allowed for a relatively accurate description of the beach deposits. In investigating the origin of these deposits many references were consulted in order to piece together the events leading to the beach's present form. The nature of the references indicates that the late glacial and postglacial history of the Niagara Escarpment (of which the cliffs at Lion's Head are part) and its surrounding features has been thoroughly studied but not fully agreed upon.

The field work and the interpretation of many previous studies has allowed for the conclusions made in this thesis. The

Niagara Escarpment, including the Bruce Peninsula, represents an area where the action of glacial ice is preserved in the fossil landforms of today. This is because the escarpment posed as a unique landform for ice to flow over as it advanced, readvanced, and retreated (not necessarily in that order) on its northeast to southwest axis of flow during the Wisconsin glaciation. One such fossil landform is very possibly the beach at the head of the Lion's Head Peninsula. This study shows that the specific form and deposits of the beach are closely related to the interaction between the landform of the Niagara Peninsula and the last glacier to influence the area. The subsequent actions of the waters of Georgian Bay, the atmosphere, and the Bruce Peninsula, are recognized, but their influence on the actual beach deposits being where they are today is secondary with respect to this study.

Figure 1. The Lion's Head Peninsula, Ontario
(Source: Dept. of Energy Mines, and Resources, 1979)



2. Literature Review

The majority of studies done involving specific landforms on the Bruce Peninsula have been carried out within larger studies of the Niagara Peninsula area or of the Great Lakes. These works have attempted to reconstruct ice margin positions during the last glaciation of the Great Lakes region, glacial lake levels, and the location of drainage channels for these glacial lakes. The information provided by these studies and some specific karst studies is important with respect to the goals of this thesis as well.

Cowell (1976) points out that the Georgian Bay Lobe of the 'Classical' Wisconsin glacier, moving from the northeast, was the last glacier to pass over the Bruce Peninsula. This in itself is not a novel observation, but he goes on to note that this ice movement was "almost parallel to a major joint set direction and resulted in extensive scouring" (p.27). The influence of this on the Lion's Head Peninsula form is immense. The glacial action led to the removal of weaker inter-reefal strata and left many more resistant bioherms standing in relief. The Lion's Head Peninsula represents one such bioherm. It is a large dolomite promontory which remained relatively resistant to the glacial ice action.

Straw's (1968) study of glacial erosion along the Niagara Escarpment points out that the glacial erosion of less resistant material adjacent to the promontories has resulted in the development of bays and re-entrants at, among other places on the Georgian Bay side of the Bruce, Isthmus Bay and Barrow Bay.

Isthmus Bay, to the north and Barrow Bay, to the south of the Lion's Head Peninsula represent glacial re-entrants during the last readvance of ice in the Wisconsin glaciation. This indicates that the ice was probably stopped at the head of the promontory, at least for a short time, while ice readvanced in the re-entrant areas. An ice front stopped at the head of the Lion's Head Peninsula would obviously be of great importance in determining what was deposited in the area. The observations made in Straw's study are useful in accounting for the beach deposit and are further discussed later in the paper.

Stadelmann (1973) provides an in depth study of the late-glacial and postglacial history of the Bruce Peninsula and in doing so offers some important clues as to the origin of the beach deposit of study. He indicates that a kame moraine was formed by the Isthmus Bay re-entrant in the vicinity of the village of Lion's Head and that till squeezed between layers of gravel in this re-entrant indicates that an ice standstill or minor readvance interval within a general ice retreat took place. If this is the case then it could have been at this time that deposits were made at the ice margin at the head of the Lion's Head Peninsula. The maps in Stadelmann's paper also depict the Lion's Head promontory as an island during some of the post-glacial lake stages. This fact would again have an influence on deposition and sediment reworking and possibly on the present beach form. This influence will be evaluated further on in the paper.

Many other studies that indicate important factors in the development of the Lion's Head Peninsula beach deposit have been carried out. These studies do not literally describe the deposits and account for their form and composition on the beach being studied, but they do indicate factors which would be important in their determination. Poole et al. (1976) describes the overall geology of the southwestern Ontario area and Bolton (1957) is more specifically concerned with the stratigraphy of the Niagara Escarpment. These works describe the lithology of the rocks which make up the area in question and thus provide information about the origin of the deposits found on the beach. The history of the water levels in the Lion's Head area must also be considered in this investigation. The glacial lakes which have occupied the Huron (including Georgian Bay) Basin and thus influenced the deposits at Lion's Head are described in detail in several articles in the work edited by Karrow and Calkin (1984). The works described in this review represent the references most valuable in the study of the Lion's Head Peninsula beach.

3. Description of the Study Area

3.1 General

The information in this section of the chapter is taken from Cowell (1976) and also consists of the author's personal knowledge.

The Lion's Head Peninsula displays the characteristic rugged topography of the Georgian Bay side of the Bruce Peninsula. The cliffs at the Lion's Head Point are approximately 100 metres above the water - these being among the highest on the peninsula whose highest cliffs have a relief of 122 metres.

The vegetation on the peninsula consists of a transition zone from the species of the northern Boreal Forests and the Eastern Deciduous Forests of southern Ontario. Since the near shore forest is protected by the Bruce Trail Association, and the land is so rugged, much of the original growth still lines the beach at the head of the peninsula. The original growth in this area consists of white and black spruce, white cedar, and some beech, oak, maple, pine, and birch. The secondary growth which is also present in the area is mainly white cedar, birch, and aspen.

No agriculture actually exists on the Lion's Head Peninsula but much of the land of Eastnor Township, in which the peninsula and beach is found, is suitable and used for cultivation. This is due to the fact that the Eastnor Clayplain represents the largest farmable area on the Bruce Peninsula. This is a lacustrine deposit laid down during the Nipissing stage of the postglacial

Great Lakes which is now artificially drained for the purpose of cultivation.

The promontory and the beach of study are very popular recreation areas. The village of Lion's Head, situated on Isthmus Bay on the northwest corner of the Lion's Head Peninsula, has a small permanent population of 250 but vacationers add to this in the summer months. There is a large number of yachts moored at Lion's Head and cottages line both sides of the peninsula right up to the point where the cliffs become too rugged for buildings to be supported and the shoreline too thin. The Bruce Trail, which skirts the entire Lion's Head Peninsula, is a very popular route among hikers and the rocks at Lion's Head Point are equally popular among the more daring rock climbers. In winter the trails become excellent for cross country skiing. Interestingly, the shoals off of the beach at the head of the peninsula are still fished commercially from Lion's Head and Wiarton.

The climate of the Bruce Peninsula is classified as cool temperate according to the Koppen-Geiger climatic classification. The mean annual temperature at both Wiarton and Tobermory is 6.5 degrees celsius, mean annual rainfall is 63.4 centimeters at Wiarton and mean annual snowfall is 291.2 centimeters. The snow cover lasts from mid-November to early April and a build-up of thick ice along the Georgian Bay shore is the norm. This would presumably affect the form of the beach being studied. Ice pressure would lead to the formation of ice push ridges running parallel to the waterline but none were observed in this study

which was carried out in the fall.

Because of its submergence under postglacial lakes for extended periods of time, most of the till, outwash and lacustrine deposits associated with glacial processes elsewhere in southern Ontario are absent on the Bruce Peninsula. The resulting exposed bedrock, composed of dolomite and limestone, has undergone considerable karstification and has led to the development of karren formations on most areas of bedrock on the Bruce. The climate being cool temperate and quite humid throughout the postglacial history of the Bruce Peninsula has resulted in many formations characteristic of solution weathering. These include rills, pitted and grooved surfaces, widened joints, and karren. Solution features on the beach deposits were not abundant but were observed on some of the limestone blocks near the northwestern end of the beach (Plate 1). Stadelmann (1973) notes that caves existing on the south shore of Barrow Bay, the re-entrant to the south of the Lion's Head Peninsula, indicate a mature stage of karstification.

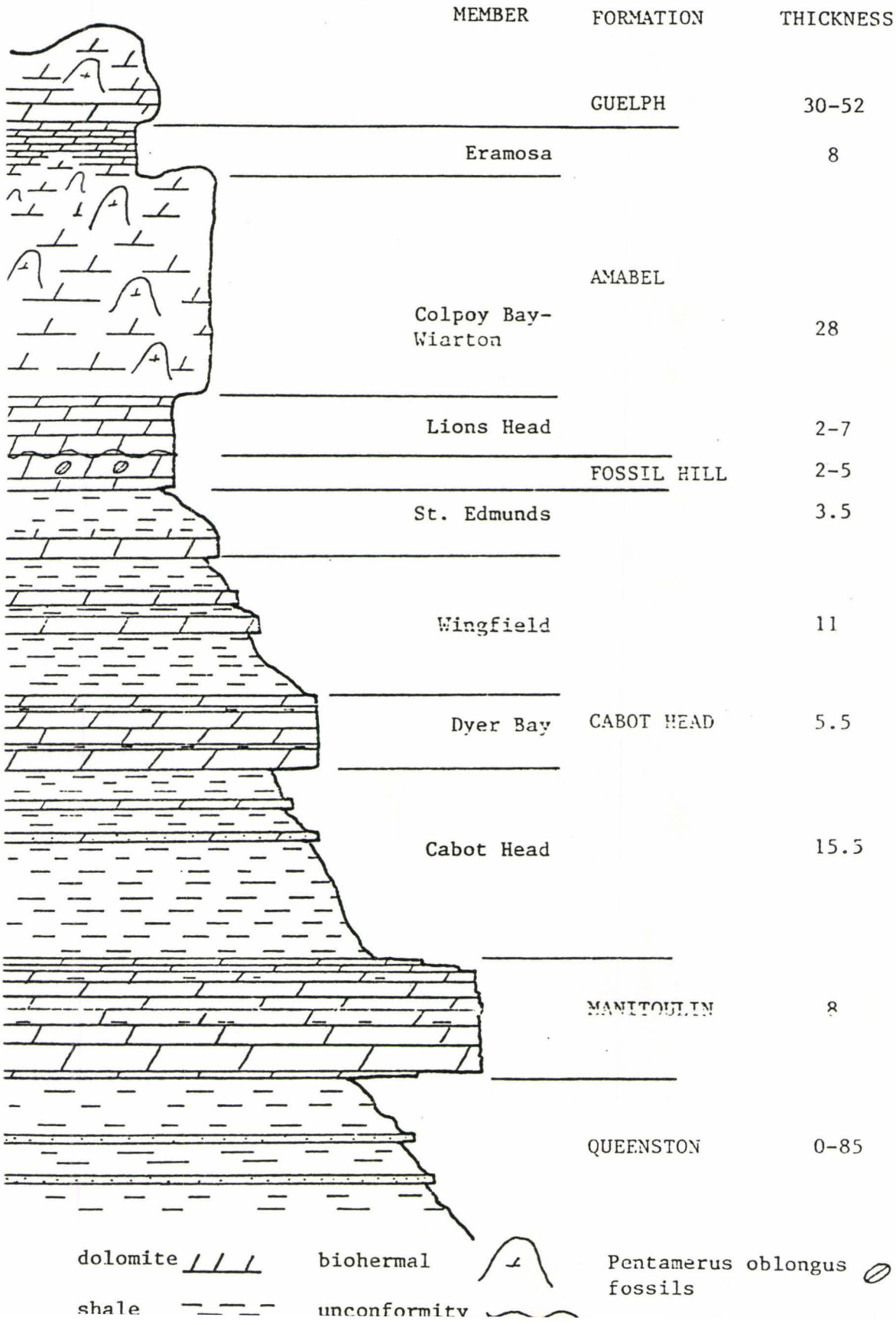
3.2 Geology

The Bruce Peninsula lies in the geologic zone known as the St. Lawrence Platform - a zone bounded by the Canadian Shield to the north and west and the Appalachian Orogen to the south and east. This platform consists of various undeformed Paleozoic formations of relatively thin orthoquartzite, carbonate, and shale which lie unconformably on the crystalline rocks of the Precambrian Canadian Shield. During the Paleozoic a series of

sedimentary domes and basins developed on this Precambrian basement. This occurred as sediment supplied from the Canadian Shield uplands to the north and the Appalachian Mountains to the east and southeast was deposited from inland seas transgressing from the west during the Cambrian to Cenozoic times. The Bruce Peninsula makes up a section of the northeast boundary of one such sedimentary basin known as the Michigan Basin. The strata of the peninsula dip southwest towards the centre of the Michigan Basin and are thickest (1500 metres) beneath Lake Erie. During the Middle Silurian period (approx. 420 million B.P.) large crinoid banks and complex biostromal or barrier reefs formed at the outer rim of a rapidly subsiding Michigan Basin. The Guelph and Amabel Formations, which outcrop at the Lion's Head Peninsula, display reef complexes which are of extreme importance when considering the influence of quaternary erosion on the area's present form.

The path of the present day Niagara Escarpment is the result of the differential weathering of more and less resistant sedimentary rocks laid down during the Upper Ordovician and Lower and Middle Silurian times. This escarpment, forming the eastern boundary of a cuesta, reflects the resistance of Middle Silurian rocks to denudation. The dip of these rocks is to the south and southwest at about 25 to 30 feet per mile. The section of the Niagara Escarpment which runs up the Bruce Peninsula displays a stratigraphy (Fig. 2) bounded by the Ordovician Queenston red

Figure 2. Stratigraphy of the Bruce Peninsula, after Liberty and Bolton (1971). (Source: Cowell, 1976)



shales at the bottom and the Guelph dolomite at the top. In the area of study the formations of interest are, in ascending order, the Manitoulin, Cabot Head, Fossil Hill, Amabel, and the Guelph, which are further divided into members of the formations. Straw (1968) points out that the members of the Clinton and Cataract groups occupy the face of the escarpment and that these are overlain by the members of the Albemarle group. Each of these formations could conceivably have supplied the beach with deposit material. The descriptions and the origins of the important deposits are taken from works by Bolton (1957), Liberty (1966) and Cowell (1976).

The Lower Silurian deposits are members of the Cataract Group and are comprised of the Manitoulin and Cabot Head member of the Cabot Head Formation. Cowell (1976) describes the Manitoulin Formation as, "a grey to bluish-grey argillaceous dolomite with shale partings which weathers into thin, flaggy beds, brown to dark grey in colour" (p.17). The Cabot Head member of the Cabot Head Formation is described by Liberty (1966) as a soft, red and green shale with thin limestone beds and gypsum. The Manitoulin dolomite was deposited in a stable marine environment. The close of this phase is marked by an increase in clastic sediments and the extension of Cabot Head shales over the area. It marks the beginning of regressive marine conditions. The contact between the two formations is gradational and the upper contact of the Cabot Head Formation is placed at a sharp lithological change.

The Cataract Group is overlain by the Middle Silurian Clinton Group of deposits. This is composed of a great variety of sedimentary rocks with rapidly changing lithologies. The Cabot Head Formation contains the Dyer Bay, Wingfield, and St. Edmunds members (in ascending order) and is overlain by the Fossil Hill Formation. Bolton (1957) describes the Dyer Bay Member as a thin bedded, brownish grey to blue-grey, finely crystalline dolomite, with numerous green to grey shale partings. Its lower and upper contacts are sharp. Green to greenish grey shales and interbedded green to brown, dense, argillaceous dolomites is Bolton's (1957) description of the Wingfield Member. Another sharp contact leads to the St. Edmunds Member which is a massive, mottled brown and greyish brown, medium crystalline dolomite. This member weathers white and has a gradational contact with the overlying Fossil Hill Formation. The Fossil Hill Formation is a thin and unevenly bedded, crystalline, fossiliferous dolomite which is characterized by biostromes in its basal part and coral biostromes in its upper beds. It has a sharp contact with the overlying member of the Amabel Formation.

The Middle Silurian Amabel Formation of the Albemarle Group is, according to Liberty (1966), a reefal complex presenting biostromal, biohermal and interbiohermal facies. Bell (1985) notes that "the Amabel Formation is the massive equivalent of the Lockport Formation which forms the caprock at Niagara Falls"(p.10). Liberty (1966) describes the lower member (Lion's Head) as a dense, thinly bedded, white dolomite which weathers to

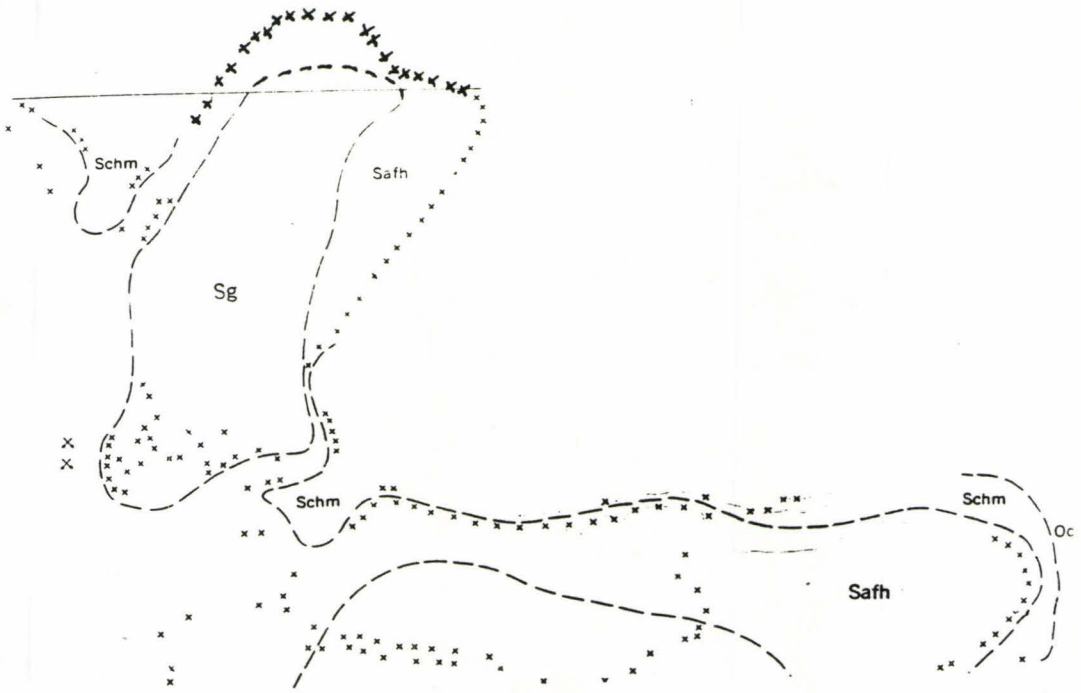
a grey to dark brown colour. It is characteristically well bedded and jointed and therefore has a blocky nature. The middle member is the Colpoy Bay-Wiarton Member and is described by Cowell (1976) as a massive biohermal member with locally thin bedded interreefal strata. It represents a fine to coarse grained, very pure dolomite which, because of its resistance to erosion, often forms the top of the escarpment. It is light grey with purple mottling and it displays the best examples of solutional weathering. The upper member of the Amabel is the Eramosa - a thin bedded, grey to light brown dolomite believed to be time transgressive between its over and underlying biohermal facies. It is a bituminous dolomite often having a petroliferous odour.

At the top of the Albemarle Group is the Guelph Formation. It and the Amabel Formation are a product of continuous sedimentation. The Guelph Formation is a reefal complex of tan to brown, evenly textured, fine and medium crystalline dolomite.

All of the above mentioned strata are found in the vicinity of the study area (Fig.3). The Manitoulin and Cabot Head Formations are found at the glacial re-entrant sites on both sides of the promontory. The Amabel and Fossil Hill Formations form the cap rock along the top of the escarpment skirting the Georgian Bay shoreline at Lion's Head (Plate 2). The Guelph Formation overlies much of the Lion's Head Peninsula in a roughly rectangular band which runs along the centre of the promontory (Plate 3). The formations which are interreefal, because of their large number of beds and joints, have been highly susceptible to

erosion whereas the mentioned bioherms have remained less altered. This is seen in the pattern of rocks at the Lion's Head Peninsula.

Figure 3. Rock Distribution on the Lion's Head Peninsula (Source: Liberty, 1966)



LEGEND

PALAEOZOIC

MIDDLE AND LOWER SILURIAN

Sg GUELPH FORMATION

Safh AMABEL AND FOSSIL HILL FORMATIONS: (Lockport)

Schm CABOT HEAD AND MANITOULIN FORMATIONS

UPPER ORDOVICIAN

Oq QUEENSTON FORMATION

Ogb GEORGIAN BAY FORMATION

Rock outcrop

Geological boundary (defined, approximate or assumed)

Quarry

Dry well

Show of gas

Glacial striae

Sand or gravel

Zinc occurrence ×Zn

Zinc prospect ×Zn

3.3 Glacial and Postglacial History

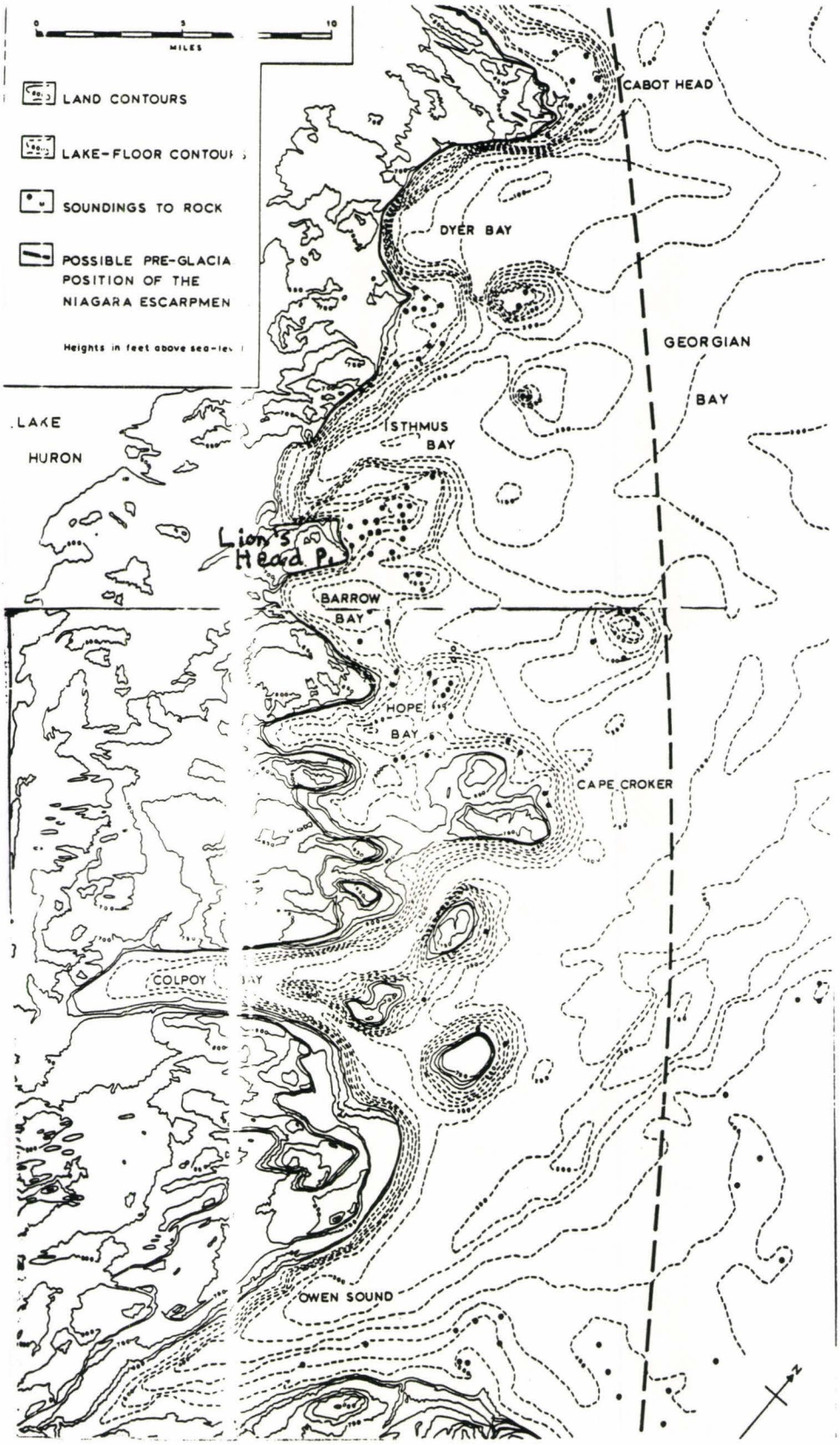
The glacial and postglacial deposits normally found in extensive areas of southwestern Ontario are generally not found on the Bruce Peninsula. This is a result of the long periods during which the peninsula was submerged under a series of postglacial lakes. The result is that the peninsula consists mostly of a glacially abraded dolomite pavement which has been altered by wave and karst action since the retreat of the last ice to influence the area.

The area of study was last glaciated by the Georgian Bay Lobe of the 'Classical' Wisconsin glacier moving from the northeast (Cowell, 1976). Straw's (1966) study of glacial re-entrants along the Niagara Escarpment offers much information about how glaciers might have affected the present form of the Lion's Head Peninsula and its beach. The re-entrants can be described as major indentations in the escarpment which are separated by bold promontories and both show a southwest, northeast orientation. The glacial erosion of the escarpment at the sites of these re-entrants was initiated by the existence of gaps and major joints in the Amabel dolomite. Indeed, the direction of ice flow was practically parallel to a major joint set in the dolomite. Once this caprock was eroded, the less resistant Clinton and Cataract groups were easily eroded by ice. Re-entrants occur at Isthmus Bay and Barrow Bay on either side of the Lion's Head Peninsula. Up to 300 feet of glacial drift lies within these re-entrants beneath the lake floor and although

penetrated by postglacial lakes, the shape of the re-entrants has been only minorly influenced by wave action (Straw, 1968). The promontories of Amabel dolomite, such as Lion's Head, point and taper toward the northeast. These forms represent large bioherms whose less resistant material was removed by ice. The fragmentation of the Niagara Escarpment along the Bruce Peninsula is seen as large capes (Cape Croker) or shoals at Lion's Head or islands at the mouth of Colpoy's Bay near Wiarton (Fig.4).

During the last general advance and small readvances of the Georgian Bay Lobe of the Laurentide Ice Sheet the escarpment northwest of Owen Sound was covered by powerful streams of ice which overran the re-entrants in a southwesterly direction. The relatively fast moving ice repeatedly occupying the re-entrants caused erosion of the bedrock. This is confirmed on the Bruce by the fact that the escarpment practically disappears at many re-entrants (eg. Isthmus Bay). Straw (1968) concludes that features, including Isthmus and Barrow Bay, functioned as routes for ice from Georgian Bay in all three major stages of the Late Wisconsin glaciation. He also points out that the development of re-entrants northwest of Blue Mountain comprised the major part of a complete remodelling of the escarpment. It is probable that prior to intensive glacial erosion a linear cuesta running from Cabot Head to Blue Mountain existed. The previously mentioned scarp outliers, shoals, and islands in Georgian Bay are believed to be the residual forms left by large scale glacial degradation of broad ridges separating the major ice ways. The Lion's Head

Figure 4. Bathymetry of the Western Shores of Georgian Bay (Source: Straw, 1968)



Peninsula could be one such ridge in its eroded form. The ice ways extend beneath the lake and the deepest parts of the troughs are found where ice flow would have been constricted laterally by the resistant shoals and islands (Fig.4).

The retreat of ice from the Bruce Peninsula was followed by a series of proglacial lakes developed in front of the melting ice sheet. The land relieved of ice was inundated with water at varying levels according to the position of drainage channels for the meltwater and isostatic rebound of the deglaciated land (Fig. 5).

The first stage of the large postglacial Lake Algonquin is the Early Lake Algonquin (12000 B.P.). This lake was drained through the Port Huron outlet and its shores were at a present day elevation of 185 metres above sea level. At this point the margins of ice were close to the Bruce Peninsula and had their greatest influence on its form. Further ice retreat led to the Kirkfield phase, named after the Kirkfield outlet which flowed to Lake Iroquois in the Lake Ontario basin. This lake's elevation was approximately 175 metres and at this point Lion's Head would have been exposed.

During the following Main Lake Algonquin phase the water level returned to 185 metres. From approximately 11000 B.P. to 9000 B.P. a transitional series of dropping water levels took place as drainage outlets to the Ottawa River valley to the northeast opened up. The waters of Georgian Bay and Lake Huron became separated at this low stage. The water in Georgian Bay

Figure 5. Lake Phases in the Lake Huron Basin
(Source: Eschman and Karrow in Karrow and Calkin, 1984)

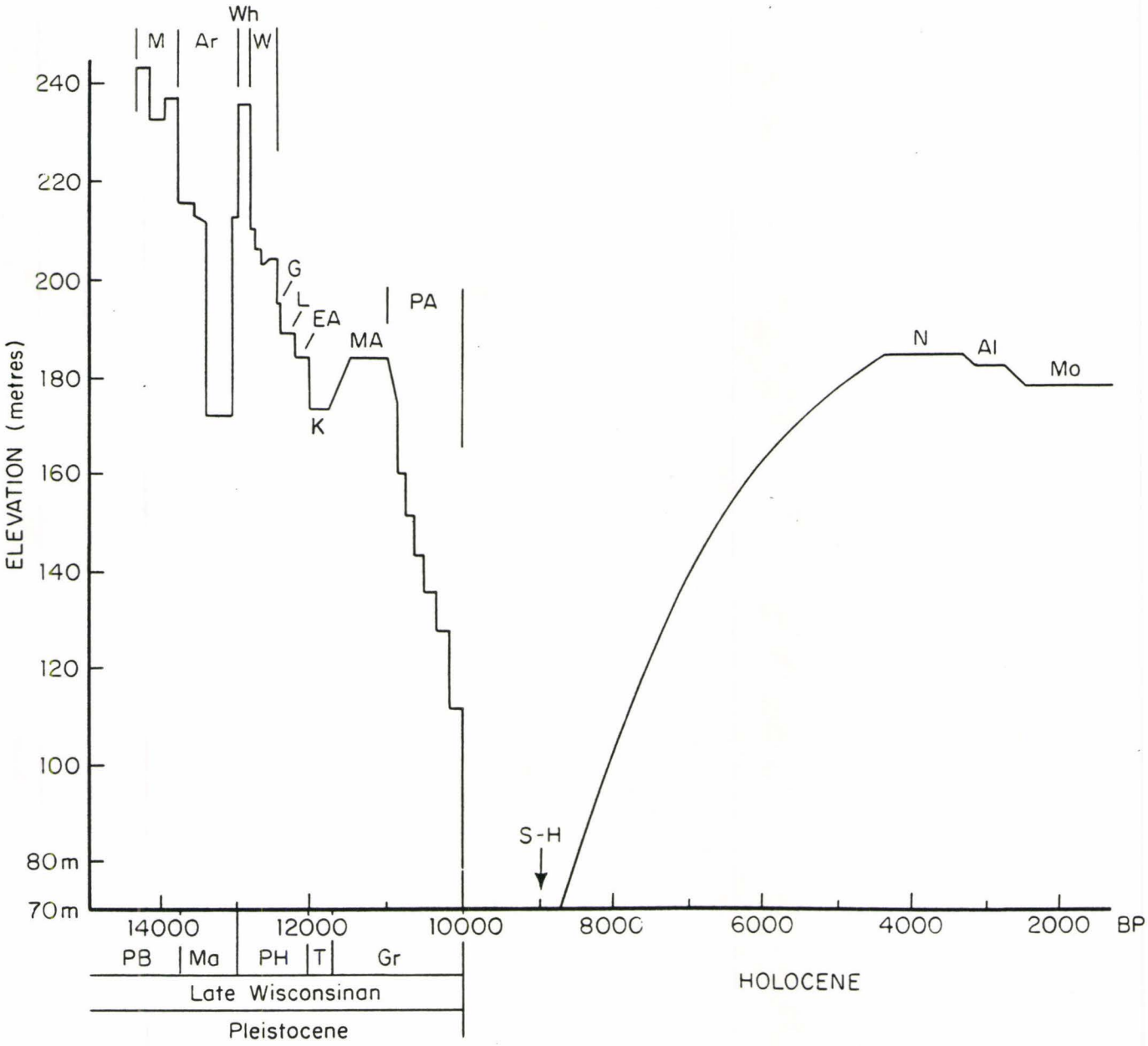


Figure 3. Lake phases in Lake Huron basin. Letter symbols: M – Maumee, Ar – Arkona, Wh – Whittlesey, W – Warren and Wayne, G – Grassmere, L – Lundy, EA – Early Algonquin, K – Kirkfield, MA – Main Algonquin, PA – Post-Algonquin, S-H – Stanley and Hough, N – Nipissing Great Lakes, Al – Algoma, Mo – Modern. Other letter symbols: Gr – Greatlakean Stade, Ma – Mackinaw Interstade, PB – Port Bruce Stade, PH – Port Huron Stade, T – Twocreekan Interstade.

during this low stage is known as Lake Stanley and that in Lake Huron is known as Lake Hough. The next 5000 years following this low water stage is known as the Stanley-Nipissing transition.

During this transition isostatic uplift of the North Bay outlet raised the water levels in the Huron basin above the present levels. The present shoreline of Georgian Bay was submerged but the Lion's Head, among others, was not. The water level reached a maximum at the end of this Nipissing stage at 4000 B.P. when the Port Huron outlet was reached. The water level over the present beach at the head of the Lion's Head Peninsula would have been 30 metres.

Following this maximum, drainage at Port Huron was accompanied by downcutting and isostatic uplift. A pause in the downcutting at Port Huron at approximately 3000 B.P. stabilized water levels for a short time. This is termed the Lake Algoma stage. The resumption of downcutting at Port Huron has lead to the present level of Georgian Bay and Lake Huron.

The possibility of a standstill phase and even a slight readvance of the Georgian Bay Lobe of the Laurentide Ice Sheet during the Early Lake Algonquin phase would explain much about the form of the beach area. Eschman and Karrow (1984) recognize a proglacial Lake Schomberg which extended from near the Niagara Escarpment in the west to beyond Lindsay, Ontario in the east. It existed while at least two tongues of fine grained till and varved sediments were deposited by the fluctuating Georgian Bay ice lobe north of the Oak Ridges Moraine. The fine texture of

this till (Kettleby Till) results from the reworking of lake sediments during ice readvances, as older tills are sandier. Lake Schomberg is the same age as the Early Lake Algonquin in the Huron Basin. Both were formed as the ice margin retreated off the Bruce Peninsula and allowed water to gather in the Huron and Georgian Bay basins prior to the opening of the Kirkfield outlet to the east.

The standstill and readvance theory accounts for much that is seen in the Lion's Head area. Stadelmann's (1973) accounts of the fluvioglacial deposit southwest of Lion's Head and the Eastnor Clay Plain shed much light on the position of the ice front and the beach deposits at the head of the peninsula.

The partially reworked kame moraine at Lion's Head was formed when the ice front was in the immediate vicinity and it represents one of the rare glacial deposits on the Bruce. It developed at the time when ice melted back across the peninsula towards the northeast and Lake Algonquin ponded against this ice front. Water melting off the glacier flowed directly into the lake carrying assorted sizes of debris and a kame type of landform developed. During the ice standstill period of Lake Schomberg, debris was transported by supraglacial and englacial streams and by active ice to the east of the escarpment. Therefore, the erosion and redeposition of materials would involve rock types found east of the escarpment. It makes sense then, that high proportions of non-carbonates, shales and limestones are found in the kame deposit as opposed to dolomites,

which are dominant west of the escarpment. Some deposits at the beach are dominantly non-carbonates, shales and limestones and could have their origins in areas east of the escarpment as well.

Stadelmann (1973) indicates that the poorly sorted and slightly rounded material composed of a relatively high proportion of friable shales signifies that most of the material in the deposit was transported over a short distance and was only briefly influenced by water before being redeposited. This supports the hypothesis that the material was deposited in deep water but in close proximity to the ice front. The fluvioglacial landform runs parallel to the southwest, northeast trending Lion's Head escarpment and is believed to have been formed from a glacial re-entrant lobe during a very slight readvance in the Early Lake Algonquin. The ice front would have been stopped in front of the Lion's Head promontory depositing material at this time. Some of this material is possibly still seen on the present beach at the head of the promontory.

4. The Lion's Head Peninsula Beach

4.1 Description of the Deposits

As has been mentioned, the beach displays a distinct sequence of deposits (Fig. 6). The description of the beach deposits can be categorized into four distinct zones and in this study the four zones are further stretched to encompass the different origins of the deposits.

For the purpose of describing the beach deposits, size and morphology measurements were taken (Fig. 7) of random samples at 20 sites from Gun Point to Lion's Head Point - a one kilometre distance. This constituted sampling areas with approximately three metre radii every 50 metres. Sample site one was at Gun Point and sample site twenty was at Lion's Head Point. The configuration and geometry of the zones described have been schematized for the purpose of simplifying the description. It should be noted that the zones' measurements are approximate and that this fact does not significantly alter the accuracy of the explanation of the deposits' origins.

Zone 1, as it is denoted in Figure 6, runs for approximately the first 100 metres from Gun Point. The larger deposits here could be described as being very angular to subangular in shape (based on Powers, 1953) and analysis of the sand deposited yielded it to be relatively coarse grained. Statistical analysis of the grain size data on sampled sands showed large standard deviations, indicating poor sorting, and negative skews, indicating coarse grained textures (Table 1). In this zone, large

Figure 6. Zones of the Lion's Head Peninsula Beach

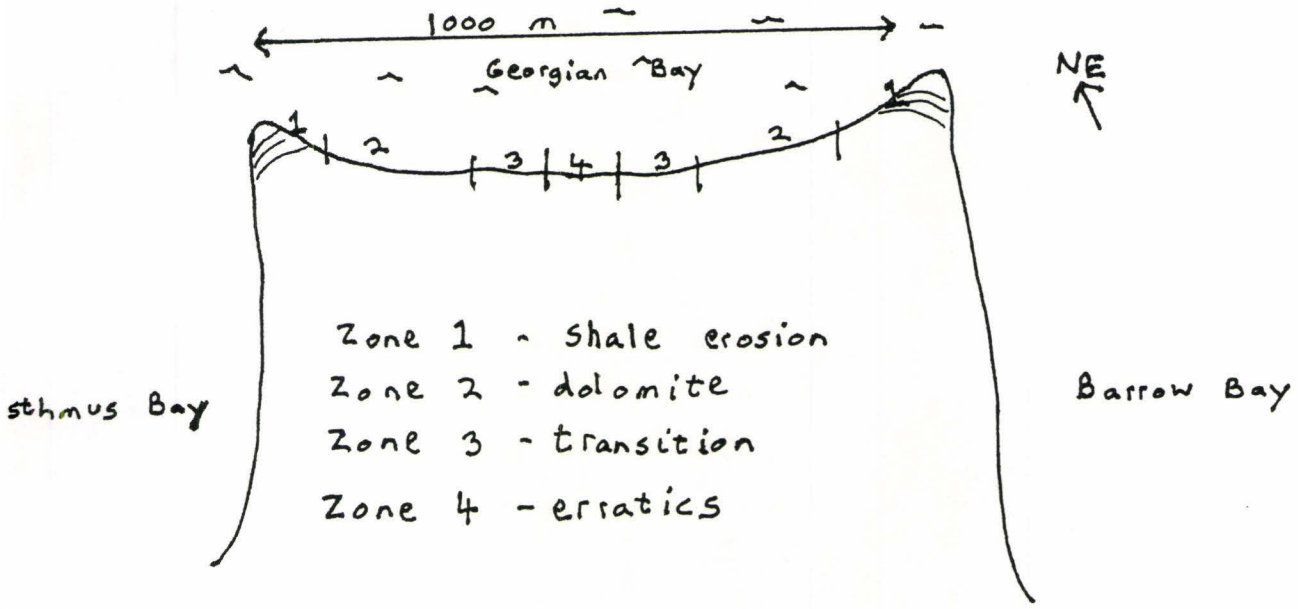
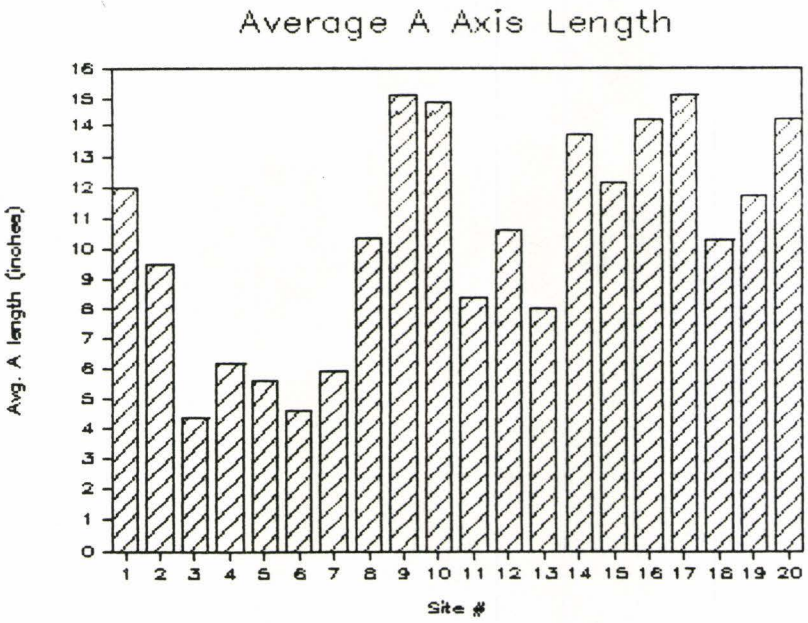


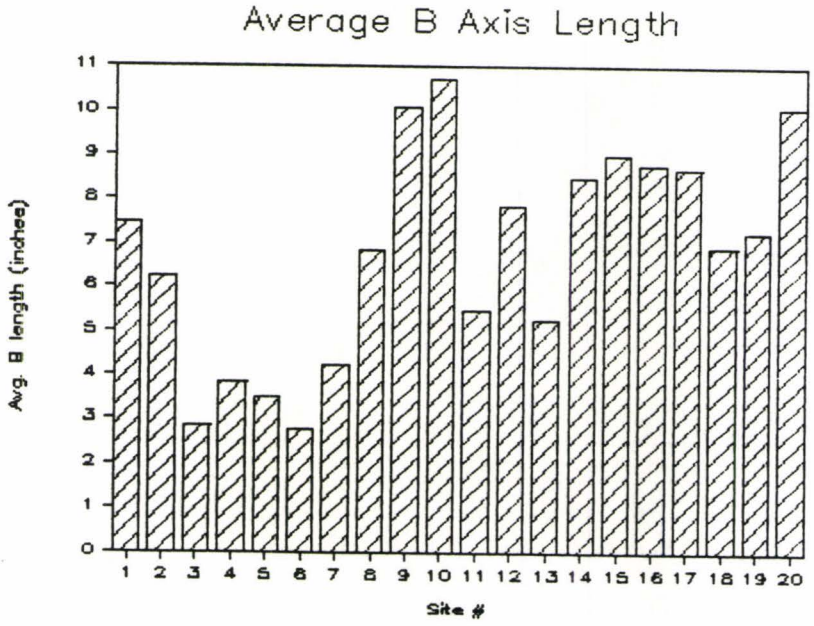
Figure 7. Deposit Morphology and Size

Figure 7a.



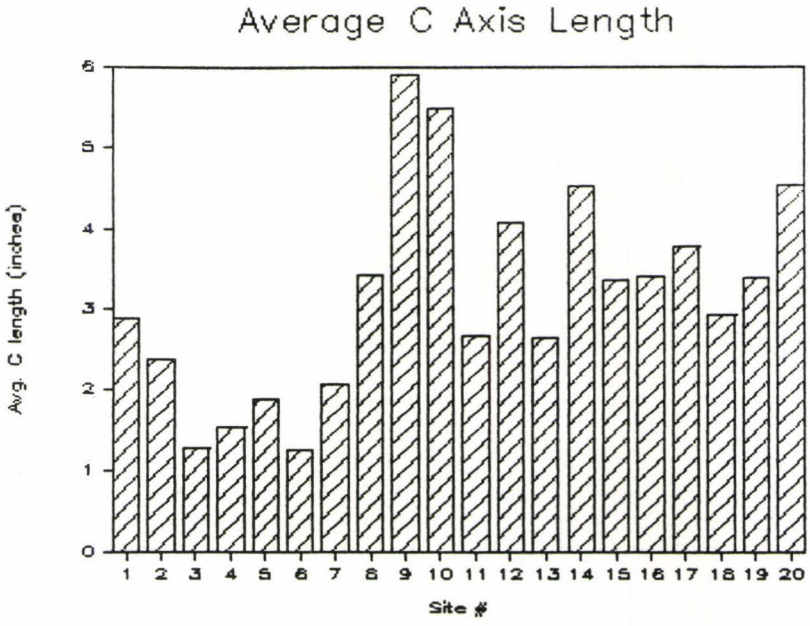
Note: Axis A is the long axis of the sample.

Figure 7b.



Note: Axis B is the intermediate axis of the sample.

Figure 7c.



Note: Axis C is the short axis of the sample.

Figure 7d.

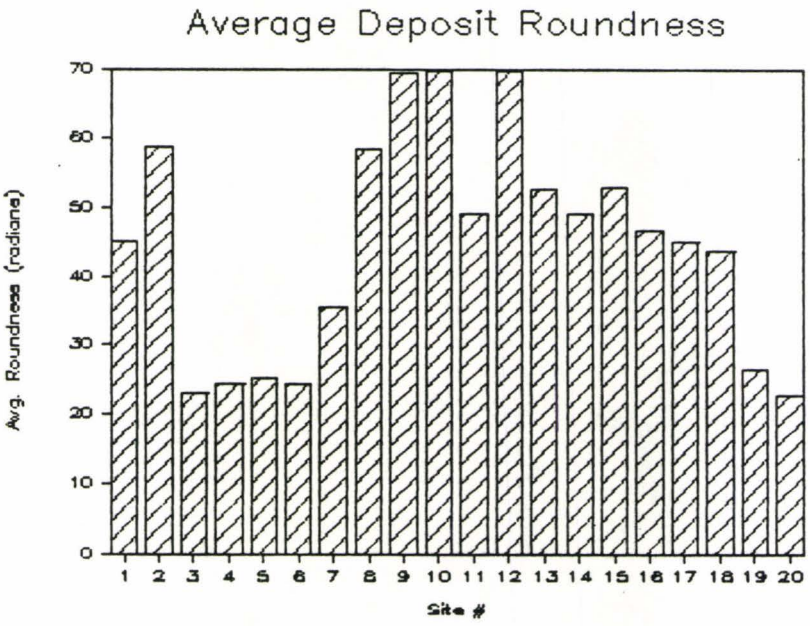


Figure 7e.

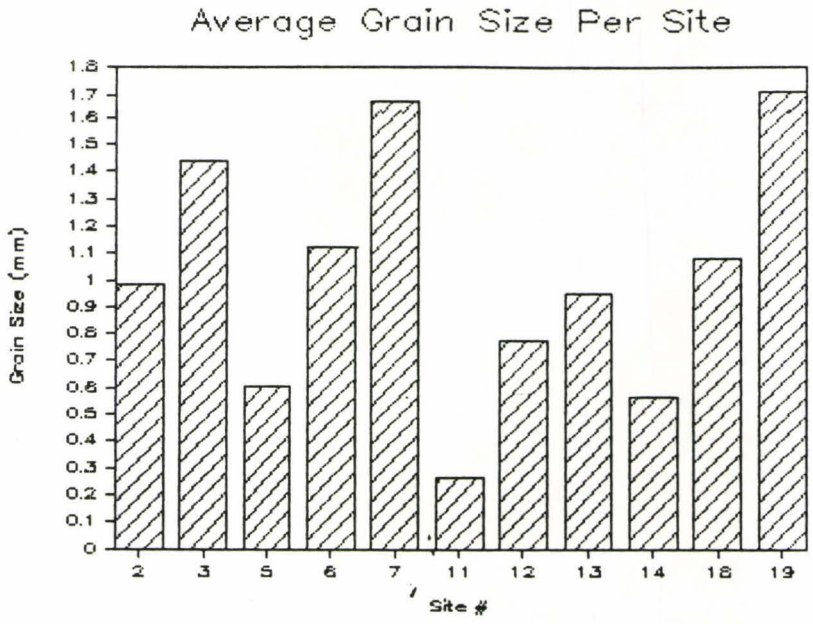


Table 1. Statistics from the Grain Size Analysis.

Site #	Avg. Size (mm)	Variance (mm)	Std. (mm)	Skewness	Kurtosis
2	0.91	0.27	0.48	0.12	1.62
3	1.21	0.22	0.47	-1.12	2.57
5	0.65	0.13	0.37	1.18	3.76
6	1.02	0.22	0.47	-0.13	1.37
7	1.39	0.08	0.29	-2.30	6.91
11	0.30	0.06	0.24	3.05	14.54
12	0.76	0.21	0.46	0.52	2.16
13	0.82	0.34	0.59	0.15	1.27
14	0.58	0.15	0.39	1.54	4.25
18	1.01	0.21	0.46	-0.03	1.36
19	1.41	0.06	0.25	-2.39	6.99

Large standard deviations signify poor sorting and vice-versa.

Positive skewness signifies an excess of fine grains and vice-versa.

(after Pethick, 1984)

slabs of overlying dolomite and shale beds had obviously fallen onto the beach as underlying dolomite and limestone beds of the escarpment were eroded (Plate 4). The subsequent erosion of these slabs by the waters of Georgian Bay has lead to their present form.

The area past sample site three is represented by a change in the shapes and sizes of the beach deposits. Zone 2, as this area will be labelled, is characterized by sub-rounded to well rounded pebbles and cobbles with very little sand in the area. This zone is a good example of a dolomite cobble beach (Plate 5) and it is approximately 200 metres in length. The skewness and the standard deviations from the sand samples which were able to be taken from this zone indicate that finer grained, better sorted sand deposits are the norm in zone 2.

Zone 3 (Plate 6) can only be described as a transition zone where coarse grained sands are mixed with dolomite and limestone rocks varying from pebble to boulder size and the odd erratic boulder. The large average grain size of the sand sample from site seven in this zone indicates that coarse grained sands are characteristic of the transition. Its negative skewness and small standard deviation further indicate that this area of the beach is made up of well sorted, coarse grained deposits. Zone 3 is approximately 100 metres in length with quite a distinct boundary as it changes to the type of deposits found in what has been labelled Zone 4 of the beach.

Zone 4 lies at the approximate centre of the beach and can

be defined as a band of erratics of boulder size (Plate 7). Sampling at sites nine and ten revealed that the deposits found in the zone are the largest size of any on the beach. The majority of the erratics, which stretch for a distance of approximately 100 metres, are well rounded from wave action. Numerous larger limestone and dolomite sub-angular and sub-rounded slabs, also showing signs of the erosive action of waves and water, are interspersed throughout this band.

The sequence of deposits from the centre band of erratics to Lion's Head Point is an approximate mirror image of the sequence from Gun Point to the centre. One distinct feature on this side of the beach is McKay's Harbour (Plate 8) - a small inlet situated in between sites eleven and fourteen. This area is characterized by the same limestone deposits which are found in its counterpart (Zone 2) but there is a much increased amount of fine sand deposited in the inlet (Fig. 7e). The positive skewness denotes the excess of fine grains and the higher standard deviations indicate the wide spectrum (fine sand to large cobbles) of deposits in this zone of the beach (Table 1). Apart from the inlet, and a slightly less linear shoreline, the beach is the same.

4.2 Suggested Origins of the Deposits

The geology and the glacial and postglacial history of the study area, as described in Chapter 3, may fully account for the deposits found on the Lion's Head Peninsula Beach. It is the purpose of this section to pinpoint the sources of the deposits

in Zones 1 through 4 with additional evidence and with reference to the previously described processes and lake levels.

Aerial photographs of the study area reveal that Lion's Head Point and Gun Point have receded and been rounded off considerably by the ongoing process of wave action. The shelf position shows that the head of the promontory was once characterized by a much more distinct bay. Judging by the glacial and postglacial history of the area it is concluded that the ice action from re-entrants eroded the corners of the promontory making them susceptible to further erosive action (e.g. wave undercutting) from the varying lake levels during the postglacial period. The overlying Guelph, Amabel and Fossil Hill Formations on the escarpment have been eroded and at the moment the dolomite and shale being eroded is that of the St. Edmunds and Wingfield members of the Cabot Head Formation. The characteristic dolomite with interbedded green shale of the Wingfield and the massive brown dolomite of the St. Edmund are exactly what is seen being toppled onto, and eroded on the beach at Zone 1.

The Zone 2 and 3 deposits are composed of limestones, and sands which most likely originated from the rocks of the Niagara Escarpment behind the beach. This is evidenced by the fact that the escarpment has been eroded well back from the present shoreline and the eroded Guelph and Amabel dolomites correspond with those deposits found on the beach. Evidence of wave undercutting during postglacial lake levels (most likely the Nipissing high) is seen at many sites (Plate 3) of the present

day escarpment. This undercutting, coupled with the previous pressures of an ice front pressing against the escarpment, would have supplied the Guelph and Amabel Formations to the beach and their further erosion by the lake waters would have lead to their present form. The factors leading to the formation of McKay's Harbour are not certain. It is relatively certain that the still, ponded water found at this inlet has lead to the settling out of the fine sands found in the samples taken. It could be that the later meltout of a residual ice block left by the last glaciation lead to the indentation seen as McKay's Harbour but this would require further study.

The band of large erratic deposits at Zone 4 are most likely linked to the action of the Georgian Bay lobe of the last Wisconsin Glaciation. Studies of the late glacial history of the Bruce Peninsula show that it would have come under the influence of a definite ice standstill and possible readvance of the Georgian Bay Ice Lobe just prior to the last full northeastern retreat of the Laurentide Ice Sheet. It has also been shown that the Lion's Head Peninsula stood out as a promontory resistant to erosion from the glacial ice. This was manifested in the ice erosion of the less resistant Clinton and Cataract Groups of rocks and the non-erosion of the more resistant Albemarle Group of rocks. The re-entrants are today named Isthmus Bay and Barrow Bay and the promontory left standing is the Lion's Head Peninsula.

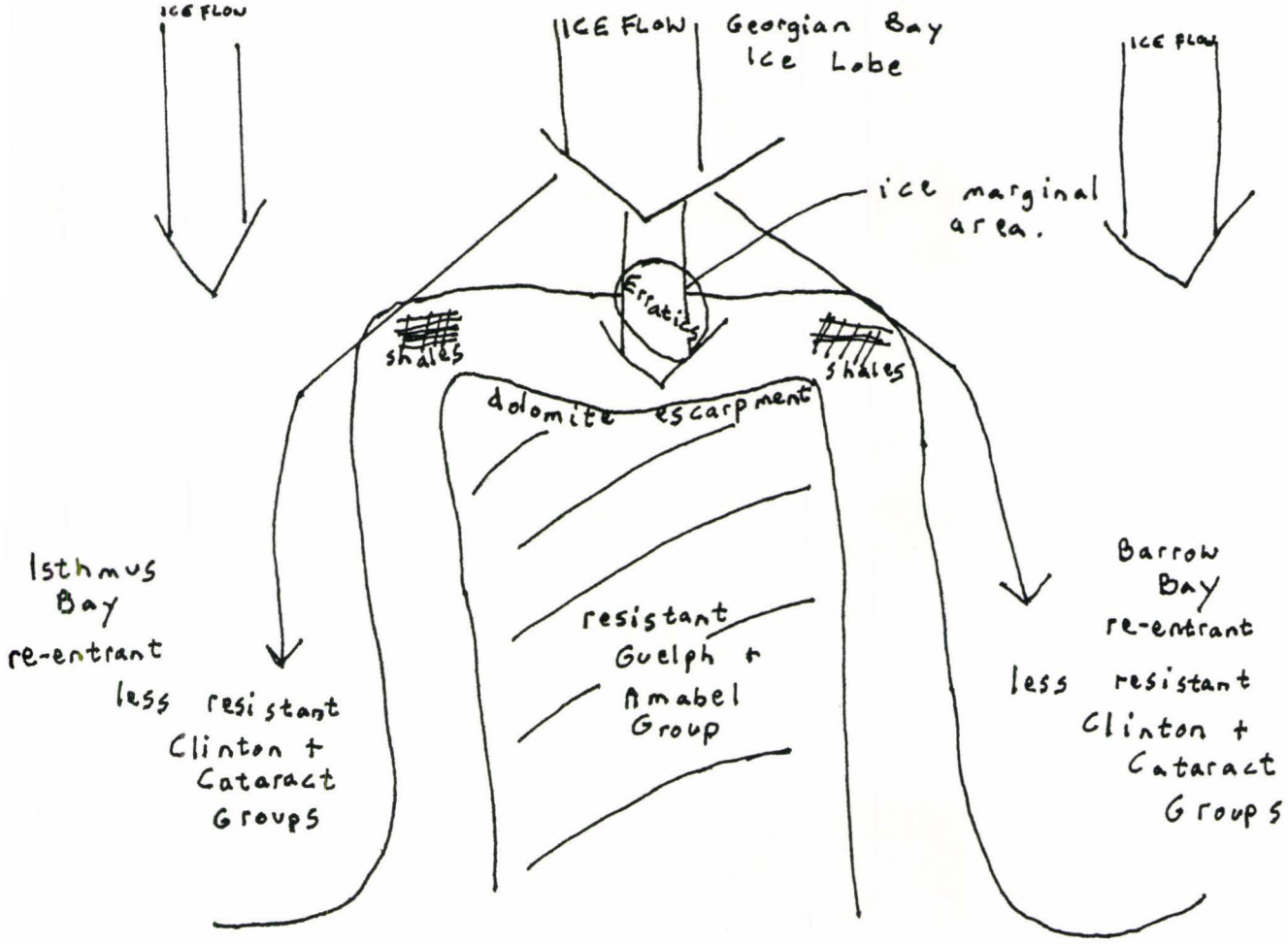
The strong pressures exerted by the ice moving into the re-

entrants in a southeasterly advance could have resulted in the erosion of the corners or margins of the promontory but its heart, or centre would have created an obstacle, or barrier to ice flow. This would have placed the ice margins right at the head of the promontory. It is therefore proposed that the band of erratics in Zone 4 of the beach were deposited at the margins of the Georgian Bay Ice Lobe during its final standstill, or slight readvance of the Late Wisconsin Glaciation (Fig. 8).

It can only be concluded by this study that the erratics represent blocks of bedrock picked up by the moving ice at points east of the deposition site. Due to their large size it can be said that the boulders were not carried great distances by the ice before it was stopped by the resistant promontory at Lion's Head. Some of the erratics could also be from the escarpment which would have experienced great pressures as the ice margin was pressed up against it. Some of the erratics do match the Guelph and Amabel Formations description as far as can be told. These boulders have, however, undergone considerable weathering since their deposition and many of the surfaces appear to be altered by chemical and physical weathering (Plate 9). The erratics transported by the ice and deposited at its front are shield rocks (e.g. non-carbonates) and they differ in appearance from the sedimentary rocks which would have been supplied by the escarpment. Finding the exact geographic source of the erratics would involve an enormous study not possible in this frame of thesis.

The origins of the deposits described at Zones 1 through 4 are backed up by historical and field evidence of the present beach form. It should be noted that this study serves to describe the deposits and account for their origins. As a consequence, the further erosion of the actual sediments by lake action is not detailed here. It is the categorizing of the deposits according to type and origin which has been achieved in this study.

Figure 8. The Late Wisconsin Georgian Bay Ice Lobe and The Lion's Head Peninsula



5. Conclusions

The Lion's Head Peninsula Beach can be divided into four distinct zones according to the types of deposits found therein. These deposits are found in this sequence as a result of the late glacial and postglacial history of the area. These zones, according to deposit type and source, are:

Zone 1: type - St. Edmunds and Wingfield shales and dolomites of the Cabot Head Formation.

origin - Initial erosion of the overlying Guelph, Amabel, and Fossil Hill Formations at the margins of the promontory as ice moves into the adjacent re-entrants during last readvance. Wave undercutting by different lake levels causing collapse of the formations. Subsequent erosion by water has lead to the present form.

Zone 2: type - Relatively uniform dolomite cobble beach. Deposits are from Guelph and Amabel Formations on the Niagara Escarpment.

origin - Erosion of the layers of caprock at the head of the peninsula by late-glacial ice and postglacial lakes has supplied this section of the beach with its deposits.

Zone 3: type - Transition zone from uniform cobble beach to centre zone of erratics. Made up of variable sizes of Guelph and Amabel dolomites, coarse grained sands, and a small number of erratics.

origin - Dolomite origin is the same as in Zone 2. Sands were most likely deposited in Nipissing Stage lake and the erratics were deposited by the last glacier to influence the area.

Zone 4: type - Shield rocks carried from sites east of Lion's Head by ice of last Georgian Bay lobe of ice. These rocks, which are mostly granitic, dominate but there are some dolomites from the escarpment as well.

origin - Ice held up against the promontory deposited some of its load immediately in front of it - the band of erratics included. They have been reduced in size and rounded by weathering but are still a prominent feature of the beach.

Further study of the Lion's Head Peninsula Beach could reveal the exact processes which formed McKay's Harbour and the exact sources of the erratics deposited in the beach's centre. It is almost a certainty that glacial related processes have caused the basic form of McKay's Harbour.

Appendix

Plate 1: Solution weathering on a carbonate slab (dolomite) at site 20.

Plate 2: Amabel and Fossil Hill Dolomite caprock of the Lion's Head Peninsula.

Plate 3: Undercut tongue of Guelph Dolomite about 0.5 km back and 30 m up from the beach. Possibly initiated during high level Lake Nipissing Phase.

Plate 4: Dolomite and shale beds fallen to the beach level as undercutting caused collapse. Site 20.

Plate 5: Dolomite cobble beach. Zone 2.

Plate 6: Transition zone of various deposits. Zone 6.

Plate 7: Section of erratic beach deposits in Zone 4.

Plate 8: McKay's Harbour

Plate 9: Deposits altered from weathering and wave action in the zone of erratics.

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