GEOLOGY OF MARYSTOWN MAP SHEET (E/2), BURIN PENINSULA, SOUTHEASTERN NEWFOUNDLAND

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NL-339 (3/77)

GEOLOGY OF MARYSTOWN MAP SHEET (E/2), BURIN PENINSULA, SOUTHEASTERN NEWFOUNDLAND

by

S.W. TAYLOR

A Thesis
Submitted in partial fulfillment of the
requirements for the degree of
MASTER OF SCIENCE

Memorial University of Newfoundland

August, 1976

St. John's Newfoundland

ABSTRACT

The geology of southeastern Newfoundland is poorly understood in many respects. Marystown map-sheet (E/2) is a small part of this region but it contains many of the characteristic geological features which have been problematic. Detailed geological mapping, petrography and geochemistry were employed in the study of the map area.

Marystown map-sheet (E/2) is divided into three segments by two northeasterly trending faults, each characterized by different rock sequences. The northwest segment is underlain by Late Precambrian rocks very similar to the volcanic rocks found elsewhere in southeast Newfoundland, being a subaerial, bimodal, slightly alkali, basalt-rhyolite suite. The rocks of this segment are interpreted to have formed as a result of high angle, block faulting. The central segment consists of a Late Precambrian (?) to Middle Cambrian sequence beginning with red and green sandstones and siltstones overlain by a red shale - pink limestone - grey siltstone - black shale unit. This sequence, fossiliferous in part and lithologically similar to rocks of equivalent age found elsewhere in the region, is interpreted to have formed firstly by erosion of a land mass and deposition of clastic sediments in an intertidal environment and secondly, by deposition of non-clastic and minor clastics in a restricted marine environment. The southeast segment is underlain by a conformable, Late Precambrian sequence beginning with the oldest rocks of the map area, grey, laminated, siliceous siltstones and polymictic conglomerates, which were derived from a subaerial acid volcanic - submarine sedimentary terrain and deposited in an environment with both deep- and shallow-

water characteristics. These sedimentary rocks are overlain by a thick pillow basalt - tuffaceous sedimentary sequence intruded by a comagmatic, layered sill: These volcanic and intrusive rocks are chemically and petrographically similar to ocean ridge tholeiites.

The area was subjected to a period of northwest-southeast compression in post Middle Cambrian times. Metamorphism varies from greenschist facies in the older rocks to unmetamorphosed in the youngest rocks.

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CHAPTER 1

INTRODUCTION

1.1 General

During the summer of 1975, the author was involved in mapping topographic sheets 1M/3 and 1L/14, as part of a planned three year program of mapping and petrochemical-geochemical study of the southern part of the Burin Peninsula (map sheets 1M/3, 1M/4, 1L/13, 1L/14). The program is under contract to Dr. D.F. Strong of Memorial University of Newfoundland for the Newfoundland Department of Mines and Energy.

The area is of geological interest because of its relatively unmapped nature, its importance in interpreting the geology of the easternmost Appalachians, its economic importance and the number of conflicting reports on the geology of the Avalon area of eastern Newfoundland. The author was responsible for the east-half of sheet 1M/3 and this thesis deals specifically with that area (Fig. 1).

1.2 Location and Size

The thesis area is located between latitudes 47°15 and 47°00 north and longitudes 55°00 and 55°15 west (Fig. 1). This is an area of approximately 486 sq. km (18 x 27 km) but about 1/3 of this area is covered by water.

1.3 Access

The two largest towns of the map-area are Marystown and Burin and these are connected to each other and to the Trans-Canada Highway

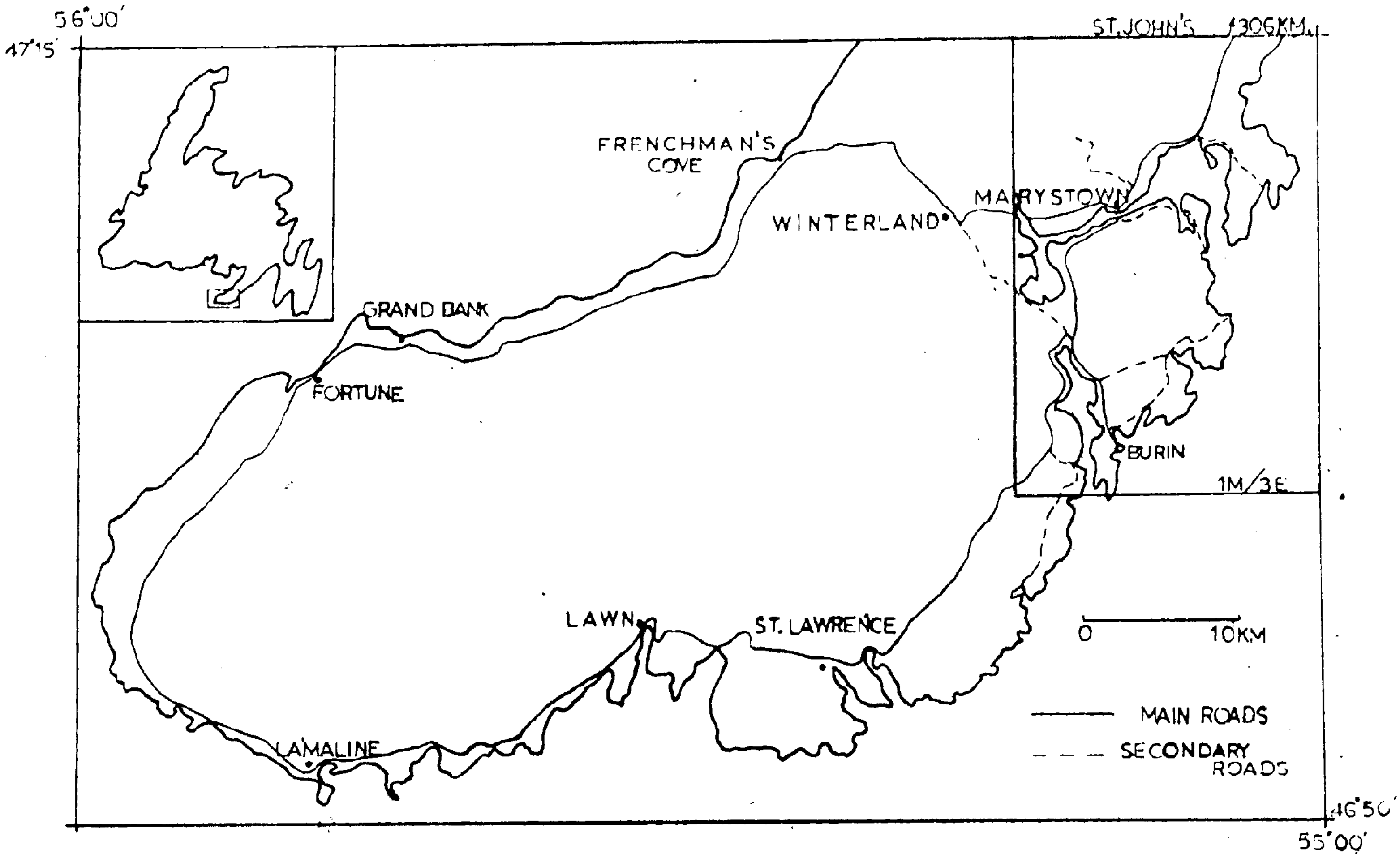

Figure 1: Location map of the thesis area.

(Route 1) by Route 11, a paved road which bisects the map area. The total distance via highway, from the northern part of the area to St. John's, the provincial capital, is approximately 306 kilometers (Fig. 1).

Within the map area, most parts are accessible by road and/or boat with the northwest corner presenting the only problem, being densely forested with no roads and few streams.

Canadian National coastal boats service Marystown and Burin. There are two small airstrips in the vicinity, near Frenchman's Cove and near Winterland (Fig. 1).

1.4 Physiography and Climate

Exposure within the map area varies from excellent to poor with bedrock geology generally controlling the topography. The volcanic rocks, where not schistose, form hills while the sedimentary rocks form lowlands and are poorly exposed. Glacial features were described by Van Alstine (1948) for part of the area and these are believed to be applicable to the entire area. Ice movement was largely from the north during the most recent ice advance.

Arable soil is found only over the Cambrian sedimentary rocks while elsewhere, where rock is not outcropping, there is a cover of till and/or waterlogged peat. The area is generally poorly drained, with the numerous ponds of the uplands being surrounded by bogs. Streams are generally youthfull and follow the less resistant formations. The climate of the area varies from year to year but is generally wet, with warm winters and cool summers (relatively!).

1.5 Previous Work

Geological investigation in the region has been concentrated on areas to the west and south of the map, due to the occurrence of fluorite there.

The only published maps of the area under consideration are those by Van Alstine (1948), covering the southern portion on a scale of 1 inch to 1 mile, Anderson's (1965) reconnaissance map on a scale of 1 inch to 4 miles, and Greene's (1974b) preliminary map on a scale of 1 inch to 2 miles. Unpublished maps dealing with all or a portion of 1M/3 east half include those of Jooste (1964) and Serem Corp. (1972) on scales of 1 inch to 1 mile.

Work on other areas of the Burin Peninsula includes that of Dale (1927), Walthier (1948), Willars (1953), Williamson (1956), Bradley (1962), Bartlett (1967), CERA (1973), CERA (1974) and Teng (1974).

Earlier work relative to the map area that has been carried out on the Avalon Peninsula includes that of Jukes (1843), Murray and Howley (1881), Buddington (1919), Hays (1948) and Rose (1948). The G.S.C. has published several memoirs on Avalon geology, including those of Rose (1952), Hutchinson (1953), Jenness (1963) and McCartney (1967). Memorial University faculty and graduate students have produced more specific results in the last few years. Among these, Papezik (1970), Hughes (1970), Hughes and Brückner (1971), Anderson (1972), Malpas (1972), and Strong and Minatides (1975) are the most relevant.

1.6 Purpose and Scope

As stated above, the only published map of any detail on the area under consideration is the preliminary map (scale 1 inch = 2 miles) of Greene (1974b). The objectives were that further work would lead to a subdivision of the existing groups, a refinement of the present geological boundaries and a better understanding of the stratigraphic and structural relationships between groups. To assist in this work geochemical analyses were done on approximately 100 specimens. It was hoped that more definite correlations could be made with rocks to the north and east of the area and thus, possibly assist in the interpretation of Avalon geology.

1.7 Methods of Field Investigation

Mapping was carried out on air photos (scale 1:15,840) and transferred to Forest Inventory maps (scale 1:15.840) and finalized on topographic maps (scale 1:50,000).

All exposures in read-cuts were examined, as well as as many of those inland and along the coast which time permitted. A helicopter was used in several areas but particularly in the northwest.

Approximately 800 rock samples were collected from approximately 500 localities, unevenly distributed over the area. The occurrence of extensive bog in the north and west presented the main obstacle to obtaining the desired coverage.

1.8 Acknowledgements

I am grateful to Dr. D.F. Strong for suggesting the topic and supervision throughout the study.

I would also like to thank S.J. O'Brien, P.G. Strong and D.M. Wilton for invaluable discussion and assistance in mapping my area. I am especially grateful to M. Killam and N. Gagnon for the excellent meals and field assistance they provided.

I would like to acknowledge the assistance given in the field by G. Kirby, J.B. Whalen, B.A. Greene and M.M. Anderson, and in the lab by J. Vahtra and D. Press. G. Andrews is thanked for major element analyses. W. Marsh assisted in photography and G. Ford, F. Thornhill and L. Warford prepared thin sections.

Special thanks go to Mrs. F.L. Taylor, my mother, who typed the first draft and to L. Murphy, who typed the final copy of this thesis. D. Baker is thanked for his assistance in preparing the CMAS projections.

I benefited from discussions with faculty and fellow students of the geology department of Memorial University of Newfoundland.

Financial support, while not in the field, was provided by a Memorial University of Newfoundland fellowship.

CHAPTER II

REGIONAL GEOLOGY

2.1 Introduction

The Canadian Appalachian structural province has been subdivided into nine zones based on different "Ordovician and earlier depositional and/or structural histories" (Williams et al., 1974). The map area lies in the southwest portion of the Avalon zone, zone "H", of southeastern Newfoundland (Fig. 2). Because of its importance in later discussions, the geology of the Avalon zone, as exposed in Newfoundland, will be discussed in some detail in the following section.

2.2.1 Stratigraphy of the Avalon Zone

Table 1 shows various authors' interpretations of stratigraphic relations in various areas across the Avalon zone. The locations of the columns are shown in Fig. 3 (in pocket). In general, the stratigraphy of the Avalon zone can be described as a sequence of Hadrynian flows, pyroclastics and volcanogenic sediments, overlain locally by Cambrian to Upper Devonian sedimentary rocks (Williams, 1967; McCartney, 1969; Brückner, 1969; Williams et al., 1974). The one obvious exception, even to this broad generalization, is the stratigraphic column for the Northern Burin Peninsula, column "b" of Table 1 (Bradley, 1962). Bradley's evidence for a Ordovician-Silurian age for some of his volcanics and sediments appears weak and he relied heavily upon correlation with a very similar stratigraphy found by White (1939) for rocks to the west of his area, around Fortune Bay. However, Williams (1971) reinterpreted the geology of this region to produce the stratigraphy shown in the Fortune

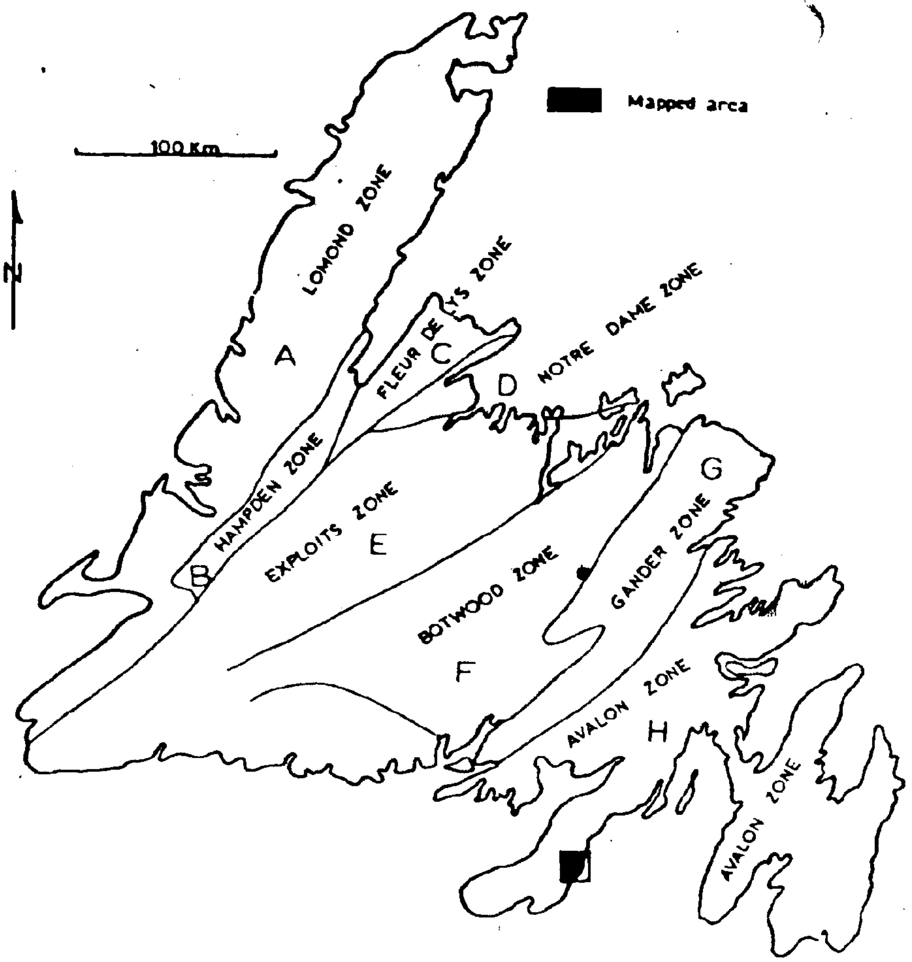

Figure 2: Tectonostratigraphic zones of Newfoundland (after Williams et al., 1974).

TABLE 1: Various Interpretations of Stratigraphic Relations across the Avalon Zone of Newfoundland

	A	B	C	D	E	F	G	H	I	J	K
	FORTUNE BAY	NORTHERN BURIN PEN.	SOUTHWESTERN BURIN PEN.	1973 (East half) SOUTHEASTERN BURIN PEN.	PLACENTIA BAY	WESTERN TRINITY BAY	WESTERN AVALON PENINSULA	CAPE ST. MARY'S	EASTERN TRINITY BAY	CONCEPTION BAY	EASTERN AVALON
Devonian	Late Great Bay de l'Eau Form. 300 + rd. gy. & gn. conglomerate w rd. & pu. sandstone, ls. & granitic rocks as pebbles. (?) or earlier Pools Cove Formation 1,500 rd. granite cobble cg., pk. to buff arkosic cg., buff, coarse boulder cg. (?) or earlier Cinq Isle Formation 650 rd. micaceous sandstone, qtz. pebble cg., rd. sh. & micritic ls.	Late Terrenceville Form. 300 + Brown & Grey cong. & sandstone, grey-green shale, and red mudstone.									
Silurian		(?) Rencontre Formation 60-1,200 Basal rd. & pu. volcanic cg., rd. st., sn., & minor rd. sh., one felsite flow.									
Ordovician		Middle and/or Late (?) Andersons Cove Form. 750-1,650 Greywacke cg. w acidic vol. pebbles; gn. tuff, varved slates; meta-cg.; minor bl. & pillows. Mid. and/or Late (?) Belle Bay Formation 1,200 Felsite, rhy. porph. andesite porph. flows, minor bl. flows, rd. agglomerate & tuff, minor felsite, rd., gn. & pu. bedded sn. Early (?) Grand Le Pierre Form. 320 Dense, br., a-lithic tuff, minor felsite, greywacke, chert, & bl.				Early Clarenville Group (?) Gray sh., bl. sh & sn.				Early Bell Island and Wabana Groups 1,500 Shale, sandstone and oölitic hematite.	
[illegible]	[illegible] [illegible] Cove Form. [illegible] [illegible] gn. micaceous st., [illegible] minor red. & pu. sh. Middle to Lower Random Formation White quartzite and gy. sh. & sn. & st. Lower Cambrian to Latest Precambrian Chapel Island Form. (?) Green-gray sn. & st. [illegible]	Upper Nine Mile Hill Form. 1,100 Hornfelse, quartzite, bl., & greywacke cg.	Lower Youngs Cove Form. 13 rd. & bl. sh. w minor ls. nodules Lower (?) Random Formation 200 Wh. quartzite w minor sh. lenses Lower Cambrian to Latest Precambrian Chapel Island Form. (?) Rd. & gn. st. w minor sh.	Middle 33 Manuels River Form. (?) Bl. & gy. shales Middle Chamberlains Brook Formation (?) Olive shales Manganiferous sh. and ls. "Hanfordian" beds. Lower Brigus Formation Rd. & gn. sh. w ls. nod.; ls., st. & conglomerate	Middle Manuels River Formation Middle Chamberlain's Brook Form. Lower Brigus Formation Rd. & gn sh w pk. ls. Lower Smith Point Formation Massive pk. ls. Lower Bonavista Formation Rd. & gn. sh. w pk ls. Lower Random - Quartzite & gy. sn.	[illegible]er [illegible]ott Cove Group [illegible] & bl. sh. & [illegible] Middle 30 Manuels River Form. Bl. & gy. shales Middle 90 Chamberlain's Brook Form. Rd. & gn manganiferous rd. Lower 110 Brigus Formation Rd. & gn sn. w pk ls. Lower 10 Smith Pt. Form. - pk. ls. Lower 140 Bonavista Formation Rd. & gn. sh. w [illegible] ls.	Middle Chamberlain's Brook Manganiferous beds. Lower Brigus Form. 20-120 Rd. & gn. slate w pink ls. Lower 16 Smith Point Formation Pink algal ls., rd. [illegible] argillite [illegible] Lower Bonavista Formation 0 - 30 Red & gn. st. w ls. & basal cg.	Upper Gull Cove Form. Bl. gn & sh. Beckford Head Form. Gy. gn. sn. w minor vol. Middle Manuels River Form. Bl. & gy. shales Middle 150 Chamberlain's Brook Form. Rd. & gn. mudstones w minor basic vol. Lower 125 Brigus Form Rd. & gn. sh. w pk. ls. Lower 10 Smith Pt. Form - pk. ls. Lower 60 Bonavista Formation Rd. & gn. sh. w pk. ls.	Elliott Cove Formation 93 + sh & st. Manuels River Formation 120 Bk. gy. & bl. sh. & sl. w ls. & minor pillow bl. Chamberlain's Brook Formation 110+ Gy. gn. sl. & sh., w ls. & manganese at bottom Brigus Formation Rd. & gn. sl. w ls. nodules 23 - 130+ Smith Point Formation Pk, algal ls. 15 Bonavista Formation 0 - 30 Rd. & gn sl., thin ls. & basal cg.		
Precambrian	Latest Precambrian Rencontre Formation 900-920 Pu. crossbedded st., rd. micaceous st., pu. & rd. pebble & cobble cg., gy. st. & argillite. Latest Precambrian 300-750 Mooring Cove Formation Gn. & bl. agglomerate, mafic flows; mo. rd. & gy. sed. rocks. Late Precambrian Andersons Cove Formation 300-450 Gy. argillite, sn., st., minor pu. tuff, sl. & tuff. [illegible] rocks. Late Precambrian (915 ± ?) (?) 3,000-6,000 Belle Bay Formation Felsic & mafic vol. rocks, minor pu. to gy. st.	Deer Park Pond Formation 0-1,500 Schistose, porph. yellow & gn. felsite & tuff. Interbedded in the lower part w meta. bl. & in the upper part w minor meta-greywacke. Southern Hills Formation 3,000 Greywacke conglomerate in lower part; rd. & pu. felsite in middle part; main basalt in upper part.	Late Precambrian Rencontre Formation (?) Rd. st., argillite & sh. Burin Volcanic Complex (?) undivided vol., breccia, sediments & porphyry	Late Precambrian (?) Burin Group (?) Pillowed, dk. gy. to pu. basic flows. Minor basic pyroclastic & tuffaceous sed. Late (?) Rock Harbour Group Wh. weathering, gy. sn., fine st. & coarse cg. Harbour Main Group Purple, yellow & red acidic pyroclastics. Minor flow banded rhy., amygdaloidal, pu. & gn. & gy. basic flows, and pk. qtz. feldspar porphyry	Lower Cambrian and Upper Precambrian Unnamed gy. sh. & st. Upper Precambrian Unnamed red beds. Precambrian Burin volcanic complex - acid pyroclastics & flows w some basic volcanics and sediments	Latest Random Formation 30 - 110 White, gn. gy. & pk. quartzite, cross bedd., st. & sn. Crown Hill Formation 800 + Rd. pebble cg, st., [illegible] red sn.; gn. [illegible] MUSGRAVETOWN GROUP Rocky Harbour Formation 300 + Yellowish gn crossbedded st. Undifferentiated 300+ Gy., gn., and rd. st. & sn., gy to br. pebble cg. Bull Arm Formation 850 (450 30?) Acid & basic vol. and [illegible] gn. sh. & [illegible] minor pyroclastic rock Cannings Co Formation 30 Rd. & gn. st. w rd. sn. & st. Connecting Pt Group 2,400 Gn. to bl. gy. [illegible] st., some st. & [illegible] vol., red quartzite Love Cove Group 4,500 Acid to basic [illegible], some sl.,	Latest Random Formation 0 - 183 wh. quartzite, qtz.-pebble cg., arkose interbeds. Crown Hill Formation 0 - 300 Red pebble cg., minor gn. cg. & rd. siltstone. Undivided Units 350 + Rd. conglomerate & arkose, gn. sn., gy. sn., slate, argillite. MUSGRAVETOWN GROUP Trinny Cove Formation 600 gn. & rd. arkose, grit, sn., gy., many sn. Maturin Ponds Formation 300-400 Massive & bedded rd. arkose & siltstone Big Head Formation 1,500 - 2,200 Rhy., pink, st., gn. & gy. sn & sl., rd. st., sn. & cg. Bull Arm Formation 2400 Mafic vol. flows & pyroclastics. Rhy. tuffs & flows w minor sed. Connecting Point Group 2,600 Gn. & gy., well-bedded sn.,	Random Formation 125 + wh., gn. gy. & pk. quartzite, cross bedded, st. & sh. Cross Point Formation 60 Bk. rd. current-bedded grits & thin cg. Northern Head Formation 500 Bk. rd. st., sn. & sl. w gn. gt. sn. & gn. quart. cg. MUSGRAVETOWN GROUP 1,300 Lears Cove Formation 720 Rd. sn., sl. & grits w some gy. gn. sn. & sh. Belerly Cove Formation 230 Rd. quart. cg. w rd. felsite pebbles w dk. rd. current bedded & ripple marked sn., st. & grits w some sh. - weathering, gy. gn. st. sn. & br. st. Bull Arm Formation 60 - 2,450 Rd. lavas, breccia, tuffs w minor st. & interbedded gy. gn. st., sn. & sl.	Random Formation 0 - 150 Wh. quartzite, cg. Snows Pond Formation 939 - 2,100 Rd. st. & sn., gy. gn. st. & sn. HODGEWATER GROUP Whiteway Formation 150 Rd. sn. & st. w minor gn. beds Hutts Town Formation 630 - 1,900 Massive gy. st. & sn. Carbonear Formation 1,000 - 1,200 Gy. sl. & sn.	Conception Group 1,800 - 2,500 Gy. gn. sn., sl. & greywacke & cg. w minor rd. sn. and basic flows. Harbour Main Group 1,400 + Andesite, basalt, rhyolite, and related pyroclastics. Some red sed. and minor grey gn. sed. (560 ± 20 m.y.)	[illegible] Formation 1,600 + Rd. & gy. gy. arkosic st., minor sl., cg. & sn. CABOT GROUP 4,000 Signal Hill Formation 2,300 ± Rd. [illegible], rd., gn. & gn. gy. arkosic st., minor sl., cg. & sn. St. John's Formation 300 ± Dk. gy. to bl. sl., ag. & grit, w a few cg. lenses & st. at top. [illegible] ? Torbay Slate 900 ± Cherty gy. sl., gn., rd., & [illegible] CONCEPTION GR. [illegible] Conception Slate 900 ± Cherty gy. & gn. [illegible] Early Proterozoic (?) Harbour Main Group 1,000 Chl. schists, amygdaloidal rd., fl., felsite, & sl. w vol. breccias, rhy., tuff, & interbedded cherty, gn. & rd. sn., sl. & coarse cg. (560 ± 20 m.y.)

SOURCES OF INFORMATION

Column "a" = Williams (1971)
Column "b" = Bradley (1962)
Column "c" = Bartlett (1967)
Column "d" = Van Alstine ([illegible]) & Williamson (1974)
Column "e" = Greene ([illegible])
Column "f" = Jenness (1963)
Column "g" = McCartney (1967)
Column "h" = Fletcher (1972)
Column "i" = McCartney (1967)
Column "j" = McCartney (1967)
Column "k" = Rose (1952)

Bay column ("a") of Table 1. Therefore, on the basis of the strong correlation between the Ordovician-Silurian stratigraphy of Bradley (1962) and the stratigraphy of nearby areas in particular and the whole Avalon zone in general, it is believed that a re-examination of the Cambrian and its contacts on the northern Burin Peninsula will lead to a reinterpretation similar to that presented by Williams (1971) for the Fortune Bay area, i.e. the transfer of the unfossiliferous, "Ordovician-Silurian" strata to the Late Precambrian.

On a finer scale there are many inconsistencies, something to be expected over an area so large (approx. 175 km. X 275 km) and so little studied. Therefore, in order to discuss the stratigraphy of the Avalon zone in a comprehensible way the framework provided by King <u>et al</u>. (1974) is used. They divided the Precambrian-Ordovician stratigraphy of the Avalon zone into three "assemblages", based upon differences in "palaeogeographical setting" or environment of deposition. They applied their division only to the "Avalon Region" (areas 1 and 2 of Fig. 3) and this is the first attempt to extend their work to the entire Avalon Zone. Fig. 3 shows the distribution of the three "assemblages" as inferred from the most recent geological map of Newfoundland (Williams, 1967). This sketch map is an over-simplification of the complicated geology of the Avalon zone, however, it is sufficient for the purpose of the following discussion.

2.2.2 Lower Assemblage

"The 'Lower Assemblage' comprises", according to King <u>et al</u>. (1974), "terrestrial and marine, basic to acidic, volcanic rocks, closely related volcanic sedimentary rocks, and acid plutonic rocks consanguineous with the acid volcanics". The plutonic rocks are not regarded as essential to this discussion of stratigraphy and they are treated in a later section.

In Area 1 (Fig. 3), rocks which fall within the definition of the "Lower Assemblage" belong to the Harbour Main Group (mostly volcanic rocks and associated terrestrial sediments) and the Conception Group (mostly marine volcanic sediments). Stratigraphic relations within the Harbour Main Group are obscured by faulting (Papezik, 1970; Brückner, 1969) and it is only possible to speak in general terms. The mafic elements make up approximately two-thirds of the group's volcanics, which consist primarily of rhyolite flows, ignimbrites and basalt flows. Sedimentary rocks of this group include both marine and terrestrial volcanic sediments, with McCartney (1967) interpreting the former as deposits of a lacustrine environment or possibly marine embayments (a view supported by Hughes and Brückner, 1971), and the latter as being the result of deposition by rivers in a volcanic terrain. The base of the Harbour Main Group is not exposed but McCartney (1967) estimated its thickness to be greater than 1,800 m. The Conception Group is a sequence with a basal conglomerate passing upward through sub-greywackes into siltstones (McCartney, 1967 and 1969). The sediments are generally greenish grey or black but locally red. They are made up of (dominantly acid) volcanic debris (King et al., 1974). The presence of numerous tuff horizons and minor pillow lava units is noteworthy. Other special features worth mentioning are the occurrences of Late Precambrian soft bodied Metazoan forms below a tuff bed at Cape Race (Anderson and Misra

1968) and tillites within the Conception Group sequence (Brückner and Anderson, 1971).

As indicated in columns "i", "j" and "k" of Table 1, there is some ambiguity regarding the relationship between these two major rock units. McCartney (1967) and Rose (1952) recognized the existence of a local angular unconformity and an extensive erosional unconformity beneath the Conception Group. This led these two authors to assume that the two rock units formed at different times, although Rose (1952) believed that the occurrence of "Conception like" rocks within the Harbour Main Group indicated a relatively short hiatus for the unconformity. Hughes and Brückner (1971) suggested that this similarity, combined with the occurrence of tuff beds and lavas within the Conception Group indicated a penecontemporaneous development of these two groups. This view was supported by the detailed mapping of Maher (1973) and O'Brien (1972), who concluded that the unconformity resulted from the encroachment of the marine sediments over the erosional surface of the subaerial volcanics and sediments, with very little loss of the depositional record. Recent work by Williams and King (1976) has suggested that "the bulk of the Conception Group must overlie the Harbour Main", at least in the southern Avalon Peninsula. They subdivided the Conception Group of the southern Avalon into four formations, however, extension into the northern Avalon is made impossible by facies changes.

Area 2 (Fig. 3) is underlain by volcanics and terrestrial sediments of the Bull Arm Formation and the marine volcanic sediments of the Connecting Point Group and the Big Head Formation (as well as its probable equivalents in columns "f" and "h"), columns "f", "g" and "h"

(Table 1).

The Connecting Point Group (columns "f" and "g" of Table 1), represents a vast accumulation of "greenish grey slaty shales and siltstones, both in part siliceous, and greywacke beds", reaching a thickness of 7,300 m (Jenness, 1963).

The Bull Arm Formation consists of "mafic and felsic flows, pyroclastics and brecciae, and volcanogenic conglomerates, tuffaceous arkoses and siltstones" (Malpas, 1972). The mafic element comprises about one half, the acidic element about one quarter and the tuffs and sedimentary rocks about one quarter of the formation. King et al. (1974) believed the Bull Arm to be dominantly subaerial, because of such things as red beds and ignimbrites, but with interbedded marine sediments, indicating the proximity of water. The Big Head Formation (and equivalents) is dominantly "grey-green and grey siltstones, slates, green cherty argillites, and arkoses" (McCartney, 1967).

The Bull Arm Formation may be as thick as 2,400 m and the Big Head Formation ranges from 450 to 2,100 m (McCartney, 1967).

The relationship between the Connecting Point Group and the Bull Arm Formation, like the Harbour Main-Conception relationship, is apparently variable. Jenness (1963) recognized an angular unconformity above the Connecting Point Group, whereas McCartney (1967) puts the Bull Arm conformably and gradationally overlying the Connecting Point, although much of the contact is obscured by faulting (Malpas (1972).

The Big Head Formation (and its equivalents)conformably overlies the Bull Arm Formation with the boundary being marked by intercalation of volcanogenic sediments and volcanic rocks (King et al., 1974).

Area 3 (Fig. 3) has been separated from other areas because it is a region of controversy and is poorly understood. Rocks correlative with the "Lower Assemblage" are found within the Love Cove Group (column "f" of Table 1). This group consists of schistose acidic to intermediate volcanics with minor interbedded chert, greywacke and sandstone (Jenness, 1963). The Love Cove Group is largely undivided as yet (Fig. 3).

Jenness (1963) believed that the greater amount of deformation within the "Love Cove rocks" indicated an older age for them than for the Connecting Point Group. He considered the Love Cove Group to be in fault contact with all other groups. Younce (1970), however, regarded the Love Cove Group to be deformed equivalents of the Bull Arm and suggested that a gradational relationship exists between these two units in some areas (see also section on the structure of the Avalon zone).

In Area 4 (Fig. 3) the "Lower Assemblage" includes the Belle Bay Formation, the Anderson's Cove Formation and the Mooring Cove Formation of column "a" (Table 1) and the Anderson's Cove, Belle Bay, Grande Le Pierre, Deer Park Pond and Southern Hills Formations of column "b". As discussed above, it is believed that the latter formations, mapped by Bradley (1962) as formed during two widely separated periods of volcanism, are all Late Precambrian in age and if not correlative with each other, they are not far separated in time.

In the Fortune Bay area, Williams (1971), placed a sequence of greenish grey argillites and sandstones with minor tuffs and tuffaceous sediments (the Anderson's Cove Formation, thickness 500 m, representative of the marine volcanic sediments) conformably above a dominantly subaerial, silicic and mafic volcanic unit containing minor grey sediments (the Belle Bay Formation, similar to the volcanic rocks of the "Lower Assemblage", thickness of 6000 m +) and conformably below more volcanic rocks with a larger proportion of mafic flows and both red and green sediments (the Mooring Cove Formation, thickness 750 m, similar again to the subaerial volcanics and related sediments). The dominantly subaerial volcanics and the dominantly submarine sediments are not divided in Fig. 3.

In the northern Burin Peninsula area (column "b"), the Anderson's Cove Formation (thickness 1,200 m), with its greywacke conglomerate, green tuffaceous slates and minor pillowed ~~basa~~lts, and the lower part of the Southern Hills Formation, greywacke conglomerate and green schists, are comparable to the marine volcanic sediments of the "Lower Assemblage". Only the Anderson's Cove Formation is separated from the volcanics in Fig. 3. The following are all correlated with the dominantly subaerial volcanics and sediments of the "Lower Assemblage"; the Belle Bay Formation, 1,800 m, rhyolite and andesite flows with minor basaltic flows, pyroclastics and red, green and purple siltstones, the Grand Le Pierre Formation, 300 m, brown crystal-lithic tuffs with minor felsite, chert, greywacke and basalt, the Deer Park Pond Formation, 1,500 m, schistose yellow and green felsite and tuff with metabasalt and greywacke, and the upper part of the Southern Hills Formation, red and purple felsite interbedded with greywacke, schist, phyllite and metabasalt.

Little is known about the "Burin Volcanic Complex" found on the islands of Placentia Bay, column "e", other than that it contains rocks comparable to "Lower Assemblage" strata (Williams, 1967; Greene, 1974a).

Rocks of the southern Burin Peninsula (columns "c" and "d") are discussed in detail in later sections but it can be seen from Table 1 that rocks of the "Burin Volcanic Complex", (Bartlett, 1967) and the Harbour Main Group, Rock Harbour Group and the Burin Group (Van Alstine, 1948; Jooste, 1954) as described by previous workers can be classified as "Lower Assemblage".

As seen on Fig. 3, most of the Burin Peninsula has been classed as volcanic rocks of the "Lower Assemblage" after Williams (1967). It is realized, however, that the poorly mapped nature of this area makes this generalization highly tentative.

2.2.3 Middle Assemblage

The "Middle Assemblage", "a thick detrital sequence, dominantly composed of debris derived from rocks of the 'Lower Assemblage'" (King et al., 1974), is found in a number of "belts" as well as a few isolated "strips" (Williams, 1967). King et al. (1974) described three "belts" which crop out in Areas 1 and 2 (Fig. 3). Their "eastern and central belts", although not in contact, are thought to be correlative, but they retain the different names proposed by earlier workers; the Cabot Group, column "k", Table 1 (Rose, 1952) and the Hodgewater Group, column "i" (McCartney, 1967). Both groups consist of a conformable and gradational sequence starting with grey to black shales, the St. John's Formation (tentatively elevated to Group status by Williams and King, 1976), with a thickness of 300 m in the east, and the Carbonear Formation in the central blet, 1,200 m. overlain by grey to greenish sandstone, lower

Signal Hill Formation, in column "k" and the Halls Town Formation, 1,500 m, in column "i". These are overlain by red sandstone and conglomerate in the east (upper Signal Hill and Blackhead Formations) and thinner, finer grained greenish-grey strata with subordinate red beds in the "central belt" (Whiteway Formation, 100 m, and Snows Pond Formation, 2,100 m).

The "western belt" of Areas 1 and 2, although in contact with the "central belt" of "Middle Assemblage" strata, is given a different name because of facies changes and poor exposure. This comprises the upper parts of the Musgravetown Group of columns "f", "g" and "h" of Table 1. Broadly speaking (facies changes are numerous), it starts off with red and green siltstones and sandstones (the Rocky Harbour, Trinny Cove, Maturin and Lears Cove formations) overlain by red sandstones, siltstones and conglomerates with some green beds (the Crown Hill, Northern Head and Cross Point Formations and the undivided unit of column "g").

In Area 3 (Fig. 3), Jenness (1963) has correlated rocks of this assemblage with rocks in the east (upper Musgravetown of column "f"). In Area 4, rocks similar to the Musgravetown Group have been noted by Williams (1971), column "a" (the Rencontre Formation, 1,500 m of red and purple sandstone and conglomerate with some grey sandstone), by Greene (1974a), column "a" (the Chapel Island Formation, grey-green siltstones and sandstones) and by Bradley (1962), column "b" (the Rencontre Formation, 1,200 m of red and purple conglomerate, sandstone and siltstone).

Bartlett (1967) reports red sandstone and shale (the Rencontre Formation) overlain by red and green sandstone and shale (the Chapel Island Formation), column "c". Greene (1974a) notes the presence of red beds and overlying grey sandstone and shale on the islands of Placentia Bay (column "e"). Column "d" is discussed in detail below.

2.2.4 Upper Assemblage

The "Upper Assemblage" is described as comprising "a sequence of orthoquartzites, ..., and a fossiliferous mudstone - limestone - shale - sandstone sequence...." (King et al., 1974). These rocks are found in a number of down-folded and faulted patches throughout the Avalon Zone, (Fig. 3). The various units of this "assemblage", where found, are very consistent over a large area and it is only in the southwest, Area 4, columns "a", "b", "c" and "d", that lithologies vary. The reader is referred to excellent discussions of this "assemblage" by Hutchinson (1962) and Fletcher (1972).

In Areas 1, 2 and 3 (Fig. 3) the sequence consists of a white, pink and grey quartzite, shale, quartz pebble conglomerate (locally) unit (the Random Formation, 0-200 m), overlain by a red and green shale unit with thin pink limestone beds and nodular horizons and locally with a thin basal conglomerate (the Bonavista Formation, 150 m) overlain by a massive pink, algal limestone (the Smith Point Formation, 15 m), overlain by more red and green shale with limestone beds and nodules (the Brigus Formation, 220 m) overlain by red and green manganiferous mudstones and minor limestones and basic volcanics (the Chamberlains Brook Formation, 170 m) overlain by a black shale and siltstone unit (the Manuels River Formation, 30 m) overlain by grey-green and black shale and siltstone with minor basic volcanics (the Elliot Cove Group, 200 m) overlain by grey and black shale, siltstone and sandstone with oolitic hematite (the Belle Island and Wabana Groups, 1,500 m and the Clarenville Group).

Contacts within this "assemblage" appear to be mostly gradational, with the "probable disconformities" (Hutchinson, 1962) above the Brigus and the Manuels River Formations and the Elliot Cove Group being based upon fossil evidence (Fletcher, 1972, however records an angular unconformity above the Brigus Formation). The one, fairly continuous break appears to be above the Random Formation (Fletcher, 1972, records it as an angular unconformity and Greene and Williams, 1974, record a conformable contact at some localities).

In Area 4, the rocks of this assemblage are much less studied, however it is possible to recognize the following sequence in the areas around Fortune Bay: white quartzite, grey shale and sandstone unit (the Random Formation, columns "a" and "c" and possibly the quartzite of the Nine Mile Hill Formation, column "b"), overlain by siltstones and sandstones (Young's Cove Formation, 60 m, column "a"), hornfels and greywacke conglomerate (Nine Mile Hill Formation, column "b) and red and black shale with minor limestone nodules (Young's Cove Formation, 15 m, column "c"). Column "d" is discussed below.

2.2.5. Other Rocks

Rocks which don't correspond to the above discussed "assemblages" are the red, brown, and grey conglomerates, sandstones, shales and mudstones with minor limestone, found in the west (columns "a" and "b"). These are contained in the Great Bay de l'Eau (300 m), the Pools Cove (1,500 m) and the Cinq Isles (430 m) Formations in the Fortune Bay area and the Terrenceville Formation (300 m) of column "b".

2.2.6 Summary of Stratigraphic Relations across the Avalon Zone

Figures 3 and 4 are meant to show the advantages of using "the environment of deposition" approach (King et al., 1974) in deciphering the complicated geology of the Avalon zone. Only maximum thicknesses are used in Fig. 4.

One reason that this approach is attractive is, of course, the fact that it doesn't rely heavily upon absolute or relative ages. Ages inferred from both approaches are highly controversial (see Anderson, 1972; Greene and Williams, 1974; Hughes and Brückner, 1971) and a detailed discussion is not attempted at this time. However, it is possible to set some approximate age limits on the "assemblages" as well as within them.

As shown in Table 1, radiometric age dating has given anomalously young ages, presumably because of the metasomatized nature of the volcanics sampled (Malpas, 1972; Hughes and Malpas, 1971). Cormier (1969), working with rocks of similar character to those discussed here, proposed that the young ages were due to the "updating" effect of the Acadian Orogeny. Anderson (1972) used stratigraphic methods to show that the "Lower Assemblage" strata of Area 1 represents an age span of 800-600 m.y. This, combined with the fact that all "Lower Assemblage" strata appear to be separated from Lower Cambrian fossils by a thick section of "Middle Assemblage" rocks, appears to limit the "Lower Assemblage" to the Hadrynian. If one puts an absolute age of 570 m.y. on the base of the Cambrian, it would be very difficult to define such a base within the

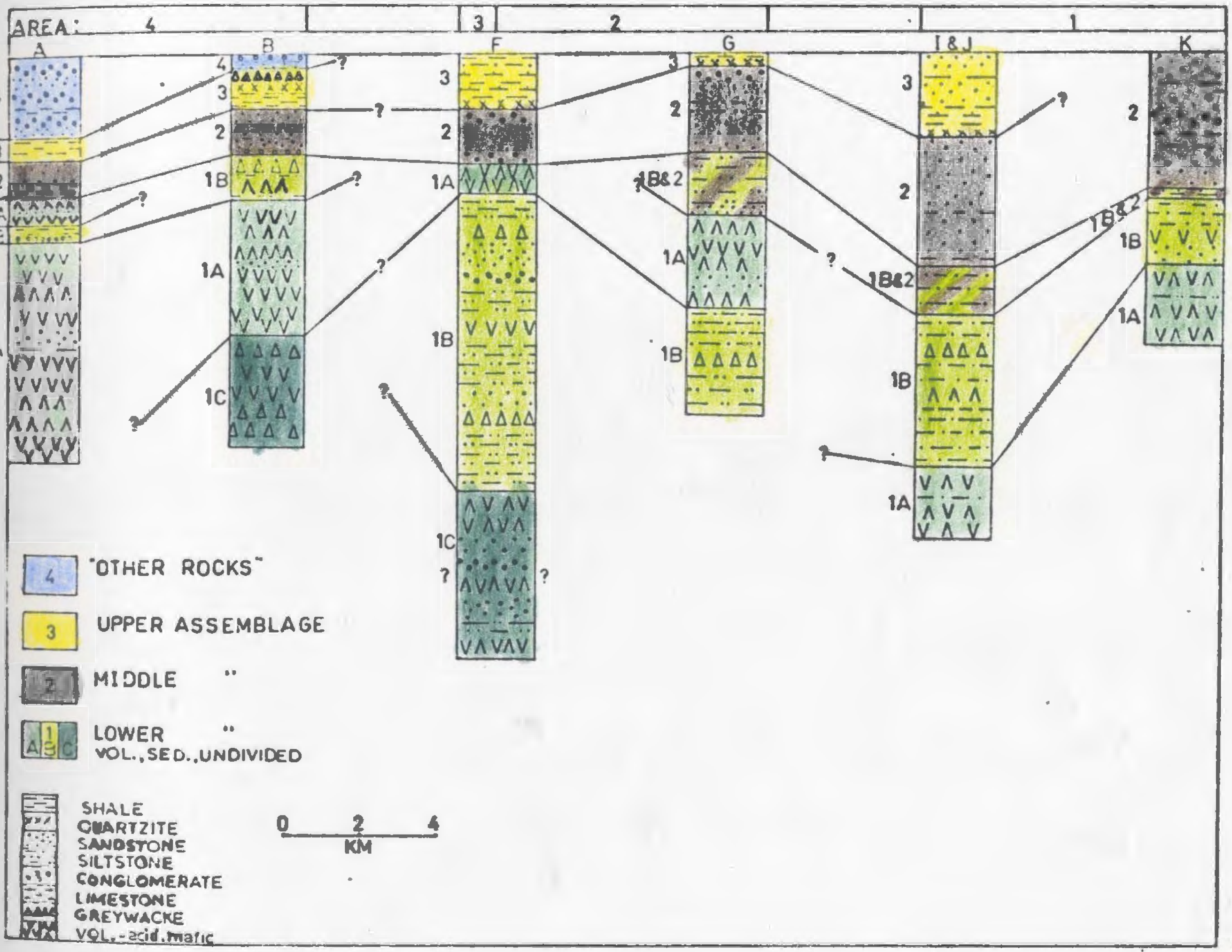

Figure 4: Schematic cross-section across the Avalon zone. Maximum thicknesses are used. Location of columns, sources of data and colour code are given in Fig. 3 (in back).

Avalon Zone (Greene and Williams, 1974). Fletcher (1972) believed the base of the Cambrian to be represented in southeast Newfoundland by "the unconformity next below the earliest shelly fossils". Greene and Williams, 1974, have shown that the unconformity referred to (that above the Random Formation) does not occur everywhere within the Avalon Zone. Furthermore, they have suggested that the Random Formation is strongly diachronous and propose that the base of the Cambrian be "defined paleontologically". In some cases (such as in the Fortune Bay area) this would put the base of the Cambrian within the "Middle Assemblage".

At this time it is not possible to draw time lines in most regions of the Avalon zone and the correlation lines drawn on Fig. 4 do not indicate time equivalence. The available evidence indicates that there was probably a significant time overlap between "assemblages" as well as among units within the "assemblages" in various regions across the Avalon zone (see also conclusions of this chapter).

2.3 Intrusive Rocks of the Avalon Zone

It is not the intention of the author to present a detailed treatment of the intrusives of the Avalon zone and the reader is referred to the papers by Strong et al. (1974) and Williams et al. (1974) from which this brief description is taken.

Plutonic rocks of the Avalon zone range in age from Late Precambrian (the Holyrood Pluton, dated at 574 ± 11 m.y. by McCartney et al., 1966) to Middle Carboniferous (the St. Lawrence Granite, dated at 315 ± 5 m.y. by Bell and Blenkinsop, 1974). Compositions range from gabbroic to granitic but the latter are much more common (Williams, 1967; Strong et al., 1974)

Diabase dykes of probable Precambrian age cut rocks of the Avalon zone (Williams et al., 1974). There are also dykes of Cambrian (Fletcher, 1972), Devonian and Triassic ages (Papezik et al., 1975).

2.4 Structure of the Avalon Zone

The structural history of the Avalon zone is poorly understood and the following brief discussion is very simplified. There is a general concensus among workers on the Avalon zone that there are two main periods of deformation represented in various places across the region.

The youngest of these, the one representing the major compressive event, has been ascribed to the Acadian Orogeny of Devonian age, (Williams et al., 1974; Anderson et al., 1975). It is represented by open-style folding with axial planar cleavage forming in the less competent beds in the eastern parts of the Avalon zone but increasing in intensity westward to tight upright folds with a strong penetrative cleavage near the margin of the zone (Williams et al., 1974). Compression was from the west-northwest and east-southeast directions, and resulted in some thrusting. "Tear faults" were particularly well developed in the Isthmus of Avalon region (McCartney, 1969) and the older Precambrian faults (discussed below) were reactivated at this time (Malpas, 1972).

The character of the older deformation appears to argue against the use of the term "orogeny" to describe it (cf. Hughes, 1970; Brückner, 1969), at least away from the western margin of the zone. In the area around Bonavista Bay (column "f", Fig. 3), Jenness (1963) described the occurrence of schistose fragments of Love Cove Group within non-schistose

Musgravetown conglomerate. This led Blackwood and Kennedy (1975) to propose a Precambrian period of deformation in this region. However, Younce (1970) and Williams et al. (1972) didn't regard these schistose fragments as sufficient evidence to alter their view that the deformation was post-Ordovician (Acadian), based upon the fact that the Cambro-Ordovician rocks of the region contain the same, single, penetrative foliation as the older rocks.

Late Proterozoic deformation of the Avalon Peninsula has been described by a number of authors (Rose, 1952; McCartney, 1967; Hughes and Brückner, 1971; Fletcher, 1972; Anderson et al., 1975) and it has been ascribed to an "Avalonian" orogeny (Lilly, 1966; Rodgers, 1972). However, the evidence at present suggests that the compressional events, regarded by the author to be essential when using the term "orogeny", during late Precambrian time occurred over a wide time interval in different places at different times. The main features of this older deformation are a number of high angle faults with associated gravity sliding and transgressive-regressive events (King et al., 1974; Papezik, 1970; McCartney, 1969).

2.5 Conclusions on the Development of the Avalon Zone

There have been a number of papers proposing possible developments of the Avalon zone, particularly dealing with the Late Precambrian development (Papezik, 1970; Hughes and Brückner, 1971; Malpas, 1972; Strong et al., 1974; Strong and Minatidis, 1975), however, to date, there has been no single hypothesis proposed which adequately explains all observed features. It is not my intention to propose a theory to exp[illegible] the development of the Avalon zone, however, the preceeding discussion of these features requires a general summary of the events which may have taken place.

Sometime in the early Hadrynian volcanism began within the Avalon zone. The type of crust this volcanism occurred on is not known to outcrop in southeast Newfoundland, and it has been interpreted both as continental (Papezik, 1970, 1973a, 1974; Strong, 1974a,b; Strong et al., 1974a,b) and as oceanic (Hughes and Brückner, 1971; Rodgers, 1972). Volcanism occurred at different times, in different places with a younger age (average?) for some of the western volcanics (the Bull Arm and possibly the Love Cove) than for the Harbour Main in the east. Volcanism was generally followed by, and in some cases accompanied by, the deposition of marine, sedimentary strata. The occurrence of volcanic rocks, within the sedimentary sequence of some of the older groups (e.g. the Conception) which mostly overly a volcanic assemblage (e.g. the Harbour Main) is further evidence of "older" and "younger" periods of volcanism. The fact that the volcanism appears to be dominantly subaerial may be an indication that the body(ies) of water in which the sediments were deposited was(were) shallow and/or restricted to areas away from the main volcanic "centers".

Shortly after the end of most of the volcanism, the body(ies) of water began to disappear and the accumulation of sediments took place in a continental environment. The sources of the detritus were the already formed volcanics and sediments which were uplifted along major faults which may have been active during volcanism (McCartney, 1969; Papezik, 1970; Hughes and Brückner, 1971). The transition from dominantly marine sedimentation to dominantly terrestrial sedimentation probably occurred at different times in different areas.

In latest Precambrian to middle Early Cambrian time (depending on location), a body of water transgressed from east to west and then apparently regressed from part of the area, allowing another transgressive event to be recorded in the east and west but not in the central area (Greene and Williams, 1974). Shallow marine sediments with very local volcanics accumulated until the early Ordovician with only very minor breaks and with minor plutonic activity (the Holyrood Pluton, 574 ± 11, and the Swift Current Granite, 510 ± 20, Bell and Blenkinsop, 1975). In Silurian to Devonian time, the Avalon zone was subjected to compressive stresses and, primarily, post-tectonic, granitic plutonism. In the west, sedimentary rocks of this period, possibly "represent alluvial fan deposits .....which accumulated between periods of granite intrusion ....." (Williams, 1971). Granitic plutonism took place as late as Middle Carboniferous (St. Lawrence Granite). Since that time erosion has been the only recorded event except possibly for intrusion of some Mesozoic dykes (Papezik <u>et al</u>., 1975).

CHAPTER III

GENERAL GEOLOGY

3.1 General Statement

The map-area is divided into three segments, each characterized by rocks of contrasting modes of origin, by two north-east trending faults, the Lewins Cove thrust fault and the Little Bay vertical fault; an eastern segment, south-east of the Little Bay Fault and bordered on the east by Placentia Bay; a central segment, a "whale shaped" area, bounded by the Little Bay Fault toward the south-east and the Lewins Cove Fault toward the north-west; and a western segment, north-west of the Lewins Cove Fault, that constitutes more than one-half of the total map area (Map 1, in back).

The eastern segment is underlain by a Late Precambrian conformable sequence beginning with a succession of shallow to deep water (lateral sense) sedimentary rocks (Rock Harbour Group) overlain by a thick, pillow lava unit with minor pyroclastic and sedimentary rocks (Burin Group). All rocks show evidence of northwest-southeast to east-west compression, with the pillow lavas being intensely deformed in places. The two groups are cut by gabbroic to granodioritic bodies and their associated dykes.

The central segment is underlain by Late Precambrian to Middle Cambrian sedimentary rocks (Inlet Group), showing abundant evidence of shallow water to intertidal environments of deposition. These rocks are asymmetrically folded, axial planes dipping moderately to the north-west, and the more incompetent units are intensely deformed in places. Compression was in a northwest-southeast direction.

The western segment consists of Late Precambrian subaerial acidic to mafic volcanics and associated terrestrial sediments (Marystown and Mortier Bay Groups) very similar to rocks found throughout the Avalon Zone. These rocks also show evidence of northwest-southeast compression with the differential movement occurring mostly parallel to bedding and resulting in well defined shear zones.

3.2 Stratigraphy

3.2.1 Rock Harbour Group

3.2.1.1 Definition, Distribution and Thickness

The term Rock Harbour Series was first used by Jooste (1954) to describe a siliceous sedimentary sequence he mapped on the Rock Harbour Peninsula and on islands to the north of the map-area. Greene (1973) changed its status to that of group and extended its outcrop area to the peninsula east of Fox Cove (MAP 1).

Within the map-area, the Rock Harbour Group extends for a distance of 15 km outcropping on two peninsulas along the eastern edge of the Burin Peninsula. It is best exposed and reaches a maximum outcrop width (3 km) on the Rock Harbour Peninsula. The base of the Group is not exposed within the map area. A thickness of 1,900 m was estimated on the peninsula east of Fox Cove. The Rock Harbour Group is here divided into two formations, the Wild Cove and the Tides Cove.

3.2.1.2 The Wild Cove Formation

The Wild Cove Formation consists, mainly, of a polymictic,

TABLE 2. TABLE OF FORMATIONS

NONINTRUSIVE ROCKS						INTRUSIVE ROCKS	
ERA	PERIOD	EPOCH	GROUP	FORMATION	LITHOLOGY	INTRUSIVES	LITHOLOGY
				Thickness in meters			
CENOZOIC		Recent		Post Glacial Sediment (0-10)	Peat, stratified sand and gravel		
				angular unconformity			
		Pleistocene		Glacial Drift (0-15)	Glacial till, boulder clay, sand and gravel		
				angular unconformity			
PALEOZOIC	Carboniferous (?)	Middle (?)				Basic Dykes	Diabase
	Cambrian	Middle (?)	Inlet Group (1,150) +	Pleasant View Farm Formation (100 m)	Grey siltstone and black shale overlying green mudstone with minor red mudstone and grey and pink limestone		
		Lower		Salt Pond Formation (450 m) +	Red and green shale, red and green mottled shale, red shale with limestone lenses and pink algal limestone.		
PALEOZOIC or PROTEROZOIC	Cambrian or Precambrian	Lower Cambrian and/or Latest Precambrian		Bay View Formation (600 m) +	Grey-green siltstones, red and grey micaceous silty sandstone; rippled marked and cross-bedded		
				Fault Contact			
			Mortier Bay Group (~ 1000)	Creston Formation (~ 500)	Dominantly mafic flows with minor acidic and intermediate pyroclastics.		
				Cashel Lookout Formation (~ 500)	Rhyolitic flows and pyroclastics with minor red and grey volcanogenic sediments.		
				(?) unconformity			
	Hadrynian		Marystown Group (1000)	Undivided within map area	Acidic flows and pyroclastics with minor red, volcanogenic sediments.	Anchor Drogue Pluton and related dykes	Granite to granodiorite with mostly diabase dykes
				Fault contact			
PROTEROZOIC			Burin Group (4000 +)	Beaver Pond Formation (900 +)	Black, chlorite schist, reddish pillow basalt and minor blue grey limestone.	Wandsworth sill and related dykes	Mainly gabbro with some diorite and granodiorite Diabase dykes.
				Path End Formation (1200)	Light grey pillow andesite with minor mafic tuffs and agglomerates.		
				Port Au Bras Formation (900)	Grey, massive tuff Sandstone, siltstones and mudstone with minor greywackes, black argillite and algal limestone		
				Pardy Island Formation (1000)	Black to red pillow basalt with minor red to grey siltstone and red limestone		
			Fork Harbour Group (1,900) +	Wild Cove Formation (500)	Grey-green cobble conglomerate with minor grey cross bedded sandstone.		
				Tides Cove Formation (1,400)	Grey to greenish-grey finely laminated siltstone, well bedded sandstone and greywacke with minor conglomerate and algal limestone.		

poorly sorted, rounded to subrounded, medium to coarse grained, grey-green conglomerate (Plate 1). In some cases, grey sandstone showing cross-bedding forms lenses within the conglomerate. The formation is best exposed along the coast, however, excellent, typical exposures are to be found in the vicinity of Rock Harbour, where it forms a continuous band approximately 500 meters thick. On the peninsula east of Fox Cove, the Wild Cove Formation consists of large lenses forming prominent hills inland and cliffs along the coast.

The more common rock types found as clasts, include in order of abundance; red rhyolite (both porphyritic and massive), siliceous siltstone, greywacke, quartzite and granite. Greene (1973) reported the occurrence of 1 meter boulders within this conglomerate, however the maximum size encountered in the present study was 15 cm clasts.

In good exposures it is possible to see the large scale lensoid nature of the conglomerate, with large "pockets" of conglomerate making up any given surface. The pebbles and cobbles of the conglomerate show excellent imbrication.

3.2.1.3 The Tides Cove Formation

The Tides Cove Formation is dominantly a sequence of finely laminated siltstones and well bedded grey sandstones and greywackes (Plate 2) which show many excellent examples of graded bedding. Thin beds and lenses of polymictic conglomerate are relatively common. A sequence of stromatolitic limestone and conglomerate was found east of Breakheart Point (Plate 3), near the contact with the Burin Group, however elsewhere within the map area limestone is limited to its

Plate 1: Polymictic conglomerate in the Wild Cove Formation. Near Rock Harbour.

Plate 2: Siltstones, sandstones and greywackes in the Tides Cove Formation. Just south of map area along coast, looking north. Cliff face is approx, 10 m high.

Plate 3: Limestone (stromatolitic) within Rock Harbour Group near its upper contact. Near Breakheart Point, looking south.

Plate 4: Limestone conglomerate in Tides Cove Formation. South of map area.

occurrence as clasts within thin conglomerate beds (Plate 4) (e.g. east of Dock Point). East of Breakheart Point there are two limestone beds, one 10 m and the other 20 m thick, separated by a conglomeratic horizon. The limestone is a distinctive blue grey colour and although recrystallized, the stromatolites are usually easily recognizable.

The detrital sequences of this formation are very siliceous and in some cases the rock is better named a quartzite. Near Tides Cove Point, a quartz pebble conglomerate is found interbedded with the fine grained sedimentary rocks. There is a small amount of black, rusty weathering argillite.

3.2.1.4 Relationship with Overlying Rocks

The base of the Rock Harbour Group is not exposed and it is conformably overlain by mafic pillow lava and pyroclastics of the Burin Group (discussed below). Jooste (1954) interpreted the Rock Harbour Group to overlie the volcanics, however, as Greene (1973) pointed out, the Rock Harbour Group is seen to dip under the volcanics at all observed contacts and there is abundant evidence in pillows and graded bedding that indicate the sequence is upright (Map 1).

The nature of the contact is best observed along the coast. At Duricles Cove, the Rock Harbour Group is in fault contact with a pyroclastic unit, and deformed limestone occurs along the fault zone. East of Breakheart Point, siltstones and sandstones are overlain by a stromatolitic limestone-conglomerate sequence (disucssed above) which is overlain by some siltstone beneath pillow lava. The sequence is conformable and the top of the Rock Harbour Group is placed at the base of the pillows. At Jigging Cove and east of Dock Point, the transitions into the Burin Group are very similar, with steeply dipping siltstones, greywackes and argillites conformably overlain by pillow lavas. The two localities differ in that there is more conglomerate present near the contact east of Dock Point.

3.2.1.5 Origin, Age and Correlation

The character of the Wild Cove Formation would indicate a near-shore or possibly a beach deposit, with the siltstones, sandstones and greywackes of the Tides Cove Formation forming in deeper water. The limestone would form in local, protected environments with limestone conglomerate possibly resulting from mechanical destruction of these beds by wave action.

Greene (1973) suggested "that some of the conglomerate of the group may represent tillites and that the isolated granite boulders in the siltstones may be attributed to ice-rafting . However, the lack of striated pebbles and the fact that the conglomerate shows imbrication indicates that these are not tillites. The "isolated boulders" were only encountered near conglomerate beds and are considered to result from local slumping. The occurrence of acid volcanics and intrusives as clasts within the conglomerate with no source for these in the vicinity, indicates that these pebbles and cobbles have been transported from some distance and not simply eroded from a "shoreline" of these rocks.

The age of the Rock Harbour Group cannot be readily ascertained because (1) its base is not exposed, and (2) it is overlain by a "unique" assemblage of rocks (discussed below) which are in fault contact with all other rocks in the area. Correlations are also difficult because of the isolated nature of these rocks. However, lithological similarities between the Tides Cove Formation and other Late Precambrian marine sedimentary rocks of the Avalon Zone, (e.g. the Big Head Formation, the Andersons Cove Formation, the Connecting Point Group and the Conception Group) indicates a possible correlation with such units. This suggestion finds support in the fact that the Connecting Point Group outcrops along strike to the north-east (Jenness, 1963: Williams, 1967). The Wild Cove Formation finds no correlatives within the Avalon zone, although it resembles basal conglomerates of the Conception Group and some of the conglomerates of the Musgravetown Group (McCartney, 1967) and the fact that the Wild Cove Formation contains pebbles of acid volcanics reinforces the suggestion that the Rock Harbour Group represents a similar sequence to that found elsewhere in the Avalon zone (see Chapter 2).

3.2.2 Burin Group

3.2.2.1 Definition, Distribution and Thickness

Van Alstine (1948) used the name Burin Series for a sequence of massive and pillowed lavas and pyroclastic rocks with minor amounts of tuffaceous sediments and limestone occurring on the southern Burin Peninsula. Greene (1973) changed the name to Burin Group and delineated its distribution on the southern Burin Peninsula. The group conformably overlies the Rock Harbour Group and is in fault contact with other rocks of the map area.

The group extends from Jean de Baie in the north to the southwest corner of the map area, a distance of 27 km, and attains a maximum outcrop width of 6 km (Map 1). It is best exposed along the coast and on the islands in Placentia Bay, but good exposures of most of the rock types of this Group can be observed along road cuts.

The Group may be as thick as 4 km but it is believed that unrecognized folding and faulting has resulted in an overestimate. Van Alstine placed the thickness between 1,500 m and 2,800 m.

The Burin Group has been divided into four formations, the Pardy Island, the Port au Bras, the Path End and the Beaver Pond.

3.2.2.2 The Pardy Island Formation

The name Pardy Island Formation is here used for the predominantly pillow lava sequence which lies conformably above the Rock Harbour Group and conformably beneath the overlying Port au Bras Formation. It outcrops on islands and along the Placentia Bay coast in the south and in a band on the Rock Harbour Peninsula in the north (Map 1). It is faulted out to the north of Fox Cove. The formation has an estimated thickness of 1 km although it may be thicker in the south.

The Pardy Island Formation consists mainly of black, aphyric pillow basalts (Plate 5), with minor red to grey, finely laminated argillaceous sedimentary rocks on Burin Island and lenses of red limestone which have been reported on the northeast side of Pardy Island (Van Alstine, 1948).

The pillows are generally small and spherical but reach up to a meter in length (Plate 6). Hematite staining is common and in large

Plate 5: Typical pillow basalts of the Pardy Island Formation. South of map area.

Plate 6: Hematized, relatively large pillow basalt in the Pardy Island Formation. Northeast of Port au Bras.

outcrops, the hematite staining can be seen following fractures. The formation has been sheared along well defined zones, leaving the rest relatively unaffected. The basalts are locally vesicular (usually filled with calcite) and show scoriaceous, chilled margins. Pillow breccia is developed on the Rock Harbour Peninsula where greywacke horizons also occur near its contact with the Rock Harbour Group.

3.2.2.3 The Port au Bras Formation

The Port au Bras Formation consists of pyroclastics, tuffaceous sediments, both clastic and non-clastic and minor pillow lava. It is continuous over the length of the Burin Group exposure, however it shows a large variation in thickness, partially owing to its intertonguing with the overlying and underlying formations. The formation, which is believed to reach a thickness of 900 m, is best observed along road cuts in the vicinity of Port au Bras and Mortier.

The Port au Bras Formation has been divided into three members (Strong et al., 1976), based mainly on work to the south of the map area and it has not been possible to extend these divisions to the north. Pyroclastics include grey-green tuffs and greenish agglomerates with fragments of mafic material up to 5 cm in diameter. However, the dominant rock type of this formation within the map area is a greyish, massive tuffaceous sandstone. It is composed of altered feldspar and pyroxenes. Grey sandstones, siltstones and mudstones are common in the vicinity of Port au Bras and greywackes were noted in the vicinity of Mortier. On the Rock Harbour Peninsula, the formation consists mainly of grey-green tuffaceous siltstones which are finely laminated and include some red bands west of Dock Point. Black argillite, in small amounts, is present near Beau Bois. Pillow basalts are rare and are similar to those of the Pardy Island Formation.

Perhaps the most distinctive, but atypical unit of the Port au Bras Formation is a blue-grey stromatolitic limestone which attains a maximum thickness of 15 m in the vicinity of Burin. The limestone is recrystallized, and recognition of stromatolites is difficult. Limestone conglomerates, apparently derived from this unit have been reported in the vicinity of Whales Cove and Gripe Cove (Greene, 1973).

3.2.2.4 The Path End Formation

The Path End Formation transitionally and conformably overlies the Port au Bras Formation. It is intruded by the Wandsworth sill to the west and occurs as xenoliths within the sill. Near its contact with the intrusion the formation is altered to the extent where it is difficult to identify lithologies.

The formation occurs in the southern part of the map area over a distance of 17 km, attaining a maximum thickness of 1,200 m. Excellent exposures of this formation may be viewed in the vicinity of Burin (Map 1).

The Path End Formation is dominantly pillow lavas with minor tuffs and agglomerates. The composition of the pillow lavas appears to be different from the Pardy Island pillows in that they are light green to grey in colour (Plate 7). However, this color change may be in part due to the increase in grain size exhibited by the Path End pillows, which are commonly porphyritic. There is very little interpillow material, but minor amounts of cherty sediment were noted and some red sandstone

Plate 7: Typical pillow basalt in the Path End Formation. Near Burin. Sledge is 1 m long.

and siltstone occurs near Burin. The chilled margins of the pillows which are generally elliptical, with the long axis being up to 1 m in length, are vesicular. Tuffs and agglomerates, particularly abundant in the south, are indistinguishable from the pyroclastics of the Port au Bras Formation.

3.2.2.5 The Beaver Pond Formation

The Beaver Pond Formation occurs to the west of the Wandsworth sill and extends for a distance of 18 km in the southern part of the map area (Map 1). This dominantly pillow lava unit is faulted against rocks to the west. The Beaver Pond Formation is thought to be as thick as 900 m although its schistose character indicates repetition by faulting.

Within the map area the formation generally consists of a black, chlorite schist. This is believed to be due to the "sandwiching" of the formation between the Little Bay Fault and the Wandsworth sill. This chlorite schist is best viewed along the main road just south of the Epworth turn-off. Pillows were recognized in a few places and in its type area to the southwest of the map area the formation consists of pillows up to 3 meters in length which are generally aphyric, only slightly vesicular and weather to a distinctive reddish color (Strong et al., 1976).

A blue-grey limestone bed (5 m thick) occurs near the Little Bay Fault. It is similar to the limestone which occurs within the Port au Bras Formation, although it is recrystallized to the extent that recognition of stromatolites, if present, was not possible. A small amount of red sandstone is interbedded with the basaltic lava near Burin.

3.2.2.6 Origin, Age and Correlation

The occurrence of pillows throughout the Burin Group and the colour and bedded character of the pyroclastics and sediments indicates deposition in a submarine environment. The presence of red sandstones, although not abundant, may indicate a shallow water environment, which is supported by the occurrence of the stromatolitic limestone at two horizons.

Some of the sedimentary rocks found within the Port au Bras Formation and interbedded with the pillow lava units resemble the Rock Harbour Group. They differ, however, in that they are less siliceous and apparently more tuffaceous. One gets the impression that the Rock Harbour Group was derived from the erosion of an acidic volcanic pile, whereas the Burin Group sediments came from mafic volcanics with a significant contribution of pyroclastic material. The presence of stromatolitic limestone near the top of the Rock Harbour Group and within the Burin Group may indicate that a similar environment existed at these times.

There is nothing like the Burin Group reported elsewhere within the Avalon Zone. Its age is not known for certain, however, although it is in fault contact with other rocks to the west within the map area, it unconformably underlies latest Precambrian-Cambrian sediments of the Inlet Group in the vicinity of Beaver Pond, to the south (Strong et al., 1976). It is therefore taken to be Precambrian in age. Van Alstine (1948) believed the Burin Group to be Ordovician, although Williamson (1956) showed that the rocks which Van Alstine assigned to the Cambrian and thought to underlie the Burin Group were in fact interbedded with the volcanics and probably weren't Cambrian in age.

The fact that the Burin Group conformably overlies the Rock Harbour Group supports the idea that it is Precambrian, and it is further suggested that this relationship with "Connecting Point like" rocks indicates a possible correlation with part of the Bull Arm although the possibility that the Burin Group is also equivalent to part of the Connecting Point Group is not ruled out. It should be noted that although pillow lavas are rare within the Precambrian sequences of the Avalon zone, they occur within the Conception-Harbour Main rocks (Maher, 1972) and within the western exposures of the Bull Arm (Papezik, personal communication). Younce (1970) reports a pillow lava unit within Bull Arm equivalents.

3.2.3 The Marystown Group

3.2.3.1 Definition, Distribution and Thickness

The term Marystown Group is here used for the dominantly acidic, subaerial volcanic rocks that are faulted against the Inlet Group (discussed below). These had been correlated with the Harbour Main Group by Van Alstine (1948) and by Greene (1973), although the latter believed that another name should be used because of the uncertainty of such a correlation. The group has been subdivided into eight formations by Strong et al. (1976), however, only one or possibly two of these formations are present within the map area and because of facies changes, the lithologies will be discussed under the heading of the group.

The Marystown Group extends from Little Bay to the southwest corner of the map area and beyond, a distance of well over 20 km, and it attains a maximum outcrop width of 4 km (Map 1). A very rough estimate of the thickness would be 1 km.

3.2.3.2 Lithology of the Marystown Group

The Marystown Group is here subdivided into three members which are shown on the geological map in the back pocket; a volcanogenic sedimentary member, a dominantly acidic pyroclastic member, and a dominantly acidic flow member.

The sedimentary rocks are found mainly along the fault separating the Marystown Group from rocks to the east, occurring discontinuously from Little Bay to about half-way up Big Salmonier Brook. Small pockets are also found interbedded with the volcanics. The most common rock type is a red, well sorted sandstone, exhibiting peculiar orange alteration patches, with good small-scale crossbedding. Conglomerates occur along with the sandstone and range from poorly sorted, angular to subrounded, well sorted varieties. The clasts are generally less than 3 cm in size and are entirely derived from acidic volcanics and volcanogenic sediments of local origin. Red siltstones and shales are less abundant.

The dominantly acidic pyroclastic member generally underlies the lower topographic features of the area underlain by the Marystown Group. It is intimately interfingered with the acidic flows and in many cases the division is arbitrary. The member consists mainly of red, rhyolitic tuffs, lithic lapilli tuffs and agglomerates. The fragments are dominantly rhyolitic in composition and reach a maximum of 15 cm in diameter. The matrix of the pyroclastics often contains crystal fragments of albite. Also found within this member, in minor amounts, are lenses of red sandstone, red porphyritic and often flow-banded rhyolite and water-lain grey tuffs. The latter are believed to result from deposition in lakes because they are rare and local in extent. A small amount of more andesitic lithic lapilli tuff was observed.

The acidic flow member is dominantly composed of a red porphyritic (albite) rhyolite, often delicately flow banded. In many cases the flow banding is highly contorted, due to the high proportion of crystals. In the southern part of the map area, spherulites (up to 1 cm in diameter) are developed within this member. Lithic lapilli tuffs with a matrix varying from rhyolitic to andesitic are common. The fragments (up to 3 cm) are generally of rhyolite although some mafic fragments were observed. Some "bombs" of rhyolite were found within the flow banded rhyolite, indicating the continuance of explosive activity. A small amount of dark red to black amygdaloidal basalt was found.

This group is poorly exposed, with the most accessible outcrops found in the vicinity of the Tolt (Map 1).

3.2.3.3 Origin, Age and Correlation

The red colour, the generally poorly bedded character of the pyroclastics, the cross bedded character of the sedimentary rocks and the abundance of delicately flow banded rhyolite make it apparent that the Marystown Group was deposited under subaerial conditions. All three units would form at approximately the same time with the sediments accumulating as a result of erosion and varying degrees of transport by streams transecting the volcanic pile.

Within the map area, the Marystown Group is in fault contact with rocks to the east and is unconformably overlain by volcanics to the northwest. This latter contact was not observed in the field, but it is taken to be an unconformity because, (1) when viewed on the regional map (Strong et al., 1976), the northeast strike of the Marystown Group is truncated, (2) both the gravity and magnetic maps for the area show a sharp break along the contact and (3) there are lithological differences. The unconformity is not taken to represent an important time break and it may be due to the over-lap of volcanic series from different sources.

To the west of the map area rocks similar to the Marystown Group are conformably overlain by a thick sedimentary sequence which contains Middle Cambrian fossils near its top (Walthier, 1948). This suggests a Late Precambrian age and its relationship with overlying rocks would then be similar to those of the Bull Arm Formation (McCartney, 1967) and the Belle Bay Formation (Williams, 1971), to which the Marystown Group bears many lithological similarities.

The evidence for placing the Marystown Group above the Burin Group is found in the occurrence of a distinctive dyke rock (discussed later) as an intrusive within the Burin Group and as fragments within pyroclastics of the Marystown Group.

3.2.4 The Mortier Bay Group

3.2.4.1 Definition, Distribution and Thickness

The term Mortier Bay Group is introduced here in reference to the mafic to acidic volcanic rocks which crop out in the northwestern third of the map area. It underlies an area of approximately 150 sq. km and thus forms the most extensive group of the map area. However, it is poorly exposed and its locally schistose character makes it the least understood of the groups. A very rough estimate of its thickness would be in the order of 1 km.

The group was included within the Harbour Main Group, along with the Marystown Group, by Greene (1973). However, because of the above discussed unconformity, the Mortier Bay and the Marystown Groups are distinguished. The Mortier Bay Group is divided into two formations; the Cashel Lookout and the Creston.

3.2.4.2 The Cashel Lookout Formation

The Cashel Lookout Formation, which can best be observed along Route 11 north of Marystown, is dominantly acidic and can be divided into three intimately related members; volcanogenic sedimentary, rhyolite flow and acid pyroclastic.

The sedimentary member consists of red to grey sandstones and conglomerates and although it occurs throughout the formation it appears to be concentrated near the top of the formation and apparently represents a break in the volcanic activity.

The rhyolite flows range from massive to delicately flow banded varieties (Plate 8). Excellent examples of autobrecciation can be seen along Route 11 near the Rock Harbour turnoff (Plate 9). The flows are generally red and commonly contain albite phenocrysts.

The pyroclastic member consists mainly of a very distinctive red

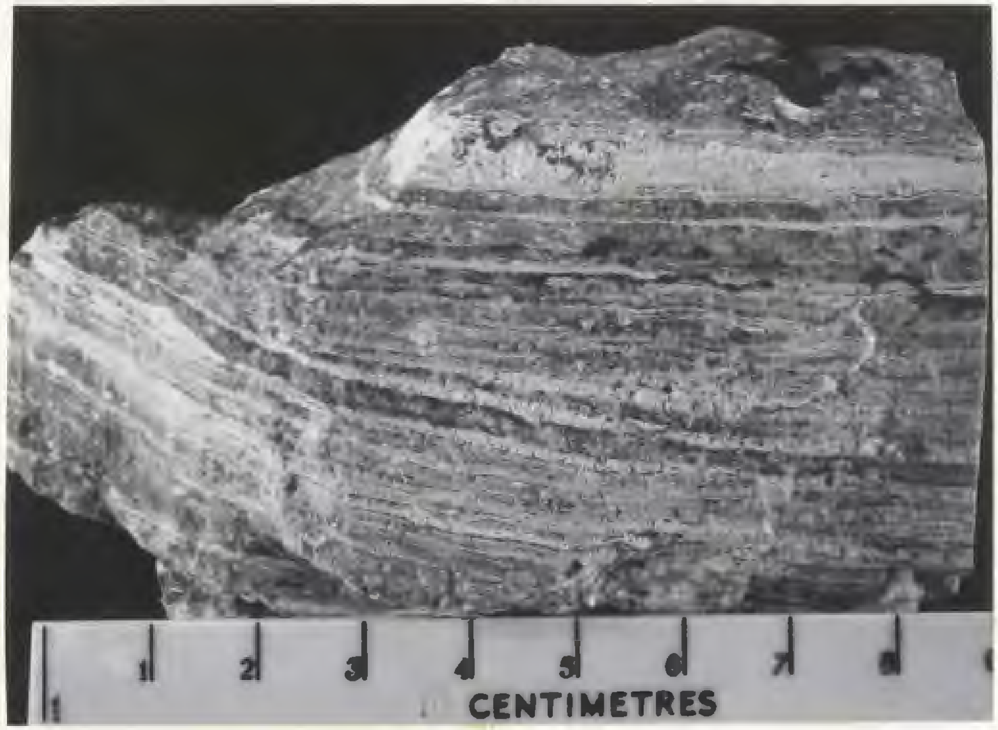

Plate 8: Delicately flow banded rhyolite in the Cashel Lookout Formation. Near turn-off to Rock Harbour on Route 11.

Plate 9: Autobrecciated rhyolite in the Cashel Lookout Formation. Location is the same as Plate 8.

to grey crystal lithic tuff. The crystals are usually of quartz and/or feldspar and are commonly well rounded. Minor amounts of amygdaloidal basalt were observed interbedded with the tuffs.

The Cashel Lookout Formation and the Creston Formation (discussed below) are intimately related, but the latter appears to overlie the former as it "truncates" the stratigraphy of the Cashel Lookout in some localities (Map 1).

3.2.4.3 The Creston Formation

The Creston Formation consists of as much as 500 m of mafic flows with minor amounts of acidic and intermediate pyroclastics in the west and intermediate pyroclastics with minor amounts of acidic tuffs and basaltic flows in the east. The following have been shown as members on Map 1.

The basalt member is best exposed along Route 11 near Creston North and along the coast in the vicinity of Mooring Cove. The flows are massive to highly amygdaloidal, dark green to purple, aphyric rocks. The amygdules are most commonly filled with chlorite and calcite, but zeolites occur. In some areas the basalt is a bright red, due to hematization, especially along numerous shear zones. The amygdules are concentrated in bands and along with some flow top breccia give some indication of bedding.

The intermediate pyroclastic member consists of a variety of tuffs and agglomerates, with the most common rock type being a greenish lithic tuff. The fragments are both mafic and acidic and are up to 5 cm in length.

The acidic pyroclastic member is found as lenses, intimately intertonguing with the other rocks of the Creston Formation. It can be described as a lithic lapilli to agglomeratic tuff with fragments usually of rhyolite, ranging up to 5 cm.

Small pockets of volcanogenic conglomerates, containing well rounded pebbles of basalt and rhyolite, and rhyolite flows are uncommon occurrences (not shown on Map 1).

3.2.4.4 Origin, Age and Correlation

The Mortier Bay Group originated under similar conditions as the Marystown Group, although the preponderance of mafic and intermediate rocks within the former and the assumed unconformity between the two may indicate another, or at least a changed magma source. As mentioned above, this unconformity is not thought to be significant and the age of the Mortier Bay Group is taken to be Late Precambrian and it is correlated with part of the Bull Arm and the Belle Bay Formations.

3.2.5. The Inlet Group

3.2.5.1 Definition, Distribution and Thickness

The Inlet Group is defined here as the sequences of fine grained sedimentary rocks which exist in the "whale-shaped" trough stretching from the southwest corner of the map area to Jean de Baie in the northwest. This is a distance of 25 km and the group attains a maximum outcrop width of 4 km. The Inlet Group is best exposed along the west side of Burin Inlet, north of Big Salmonier Brook. Fig. 5 shows a

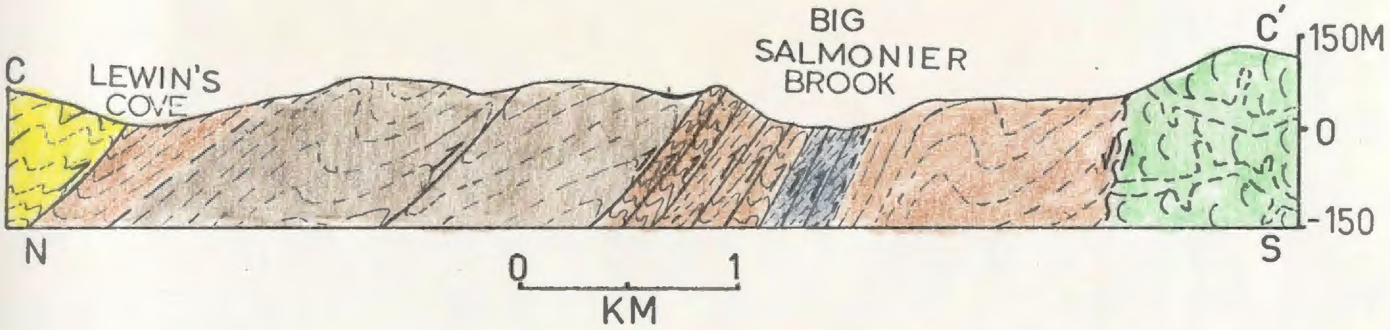

Figure 5: Cross-section of Inlet Group. Location of C - C' and colour-code are shown on Map 1 (in back). Vertical exaggeration, 3X.

section through the group along line C - C' shown on Map 1.

As can be seen from this cross section, any estimate of the thickness of the Inlet Group is approximate and the figure 1150 m should be taken as a maximum. The group is divided into three formations, the Bay View, the Salt Pond and the Pleasant View Farm.

3.2.5.2 The Bay View Formation

The Bay View Formation consists mainly of grey-green siltstones and red micaceous silty sandstone. Its base is not seen within the map area, however, 600 m of this formation are believed to occur in the Burin Inlet section. Along this section, the oldest rocks exposed are red, purple and grey micaceous siltstones and sandstones. These show good small scale crossbedding, ripple marks, mud cracks and worm burrows (Plate 10). The latter are small and no other fossils were found.

These rocks are overlain by a ripple marked, grey siltstone unit which contains several grey quartzitic beds which are highly variable in thickness. This unit is overlain by a thick sequence of grey-green siltstone with minor red and purple micaceous siltstone. Large "disc-shaped" grey limestone concretions occur within the grey-green siltstone. Ripple marks are relatively common and are of the interference type ranging up to 3 cm in amplitude.

3.2.5.3 The Salt Pond Formation

The Salt Pond Formation occurs in two separate areas (Map 1, Fig. 5) and can best be observed along the shoreline of Burin

Plate 10: Worm burrows in the Bay View Formation. South of map area.

Plate 11: Nodular limestone in Salt Pond Formation. View of bedding surface south of Big Salmonier Brook along Burin Inlet.

Inlet. The formation is generally poorly exposed and the thickness of 450 m must be considered a maximum. In its more northwesterly exposure, the Salt Pond Formation usually exhibits a strong cleavage, possibly reflecting its proximity to the major thrust fault (Map 1) which thrusts the Marystown Group over the formation in the vicinity of Salt Pond. Its contact with the Bay View Formation is not exposed, but it is believed to be gradational.

In the southeasterly exposures of the Salt Pond Formation, there is a much greater degree of "tectonic shuffling" of units (Fig. 5). Near the thrust fault which places the Bay View Formation above it, the Salt Pond Formation consists of a tectonic breccia and the rock generally exhibits a strong cleavage. The formation is faulted against the Burin Group to the east.

The Salt Pond Formation is mainly a fine grained clastic sequence with abundant limestone nodules and several massive, algal limestone beds. The oldest rocks of the formation are dark red shale with pink limestone nodules, grey and purple shale and red, green and purple mottled shale. The limestone nodules are fossiliferous (Coleoloides) and their lensoid nature is due to diagenetic processes (Plates 11 and 12). Limestone generally increases in abundance upwards and massive pink limestone beds (up to 1 m thick) with manganese-stained algae situated on bedding planes occur near the top of the formation. These beds contain abundant fragments of Hyolithes and Coleoloides.

The Salt Pond Formation differs from the underlying Bay View Formation in that it is finer grained, contains no visible mica, does not exhibit shallow water features (ripple marks, mud cracks, etc.),

Plate 12: Same locality as Plate 11.

Plate 13: Trilobite in Pleasant View Farm Formation. Distance between bars is 1 cm. Near Pleasant View Farm. Braintreella - Lower Middle Cambrian.

contains shelly fossils and abundant pink limestone nodules. Where not in thrust contact with the overlying formation the contact is considered gradational.

3.2.5.4 The Pleasant View Farm Formation

The Pleasant View Farm Formation constitutes the youngest rocks in the map area (excluding intrusives). Because of its susceptibility to erosion, this formation is poorly exposed, with the best outcrops occurring along Big Salmonier Brook where it enters Burin Inlet and in a gravel pit along the main road in Little Salmonier. The 100 m given for the thickness of the formation is a maximum. This formation crops out in several bands where they have been preserved with older rocks thrust upon them (Map 1 and Fig. 5), and because of their lithologies, these rocks have taken up a lot of movement during this thrusting. Hence, they are generally very schistose.

Nevertheless, it is possible to recognize two distinct units within the Pleasant View Farm Formation. The uppermost unit consists of black, rusty weathering, highly fissile shale and dark grey siltstone. The shale contains light grey limestone nodules up to 8 cm in diameter. Both the siltstone and shale are highly fossiliferous (trilobites) and good specimens can be obtained where the bedding cleavage relationships are favourable (Plate 13).

This unit is conformably and gradationally underlain by a sequence of light green mudstone with minor red mudstone and shale, grey limestone and dark grey siltstone which passes gradationally into the Salt Pond Formation. One bed of manganiferous, pink weathering limestone

(60 cm) was found to be highly fossiliferous (trilobites). Fossils (trilobites) were also found within the greenish mudstone, but because of its blocky nature, good specimens could not be obtained.

3.2.5.5 Undifferentiated Inlet Group

As shown on the geological map (Map 1), there are two areas where the Inlet Group has been left undivided; in the vicinity of Little Bay and near Little Salmonier. In these structurally complex areas it was not possible to delineate the various formations. All three formations occur in Little Bay but only two, the Pleasant View Farm and the Salt Pond, were identified in the Little Salmonier area.

3.2.5.6 Origin, Age and Correlation

The rocks of the Inlet Group represent two environments of deposition. The Bay View Formation with its sandstone and siltstone, frequently red and containing abundant ripple marks, mud cracks and cross-bedding indicates deposition by streams and/or in a shallow marine, in part intertidal area. The source of the mica within these rocks is unknown. The well sorted quartzitic sandstones may represent some kind of a beach or bar deposit. There appears to be a general decrease in grain size and the amount of red material as one approaches the transition into a second environment of deposition, represented by the Salt Pond and Pleasant View Farm Formation. The fine grained nature, the common occurrence of limestone, and the lack of ripple marks and mud cracks within these rocks suggests deposition in a quiet, shallow, possibly restricted marine environment where there was either little erosion of land masses or where the addition of coarse clastics was restricted. The black shales of the Pleasant View Farm Formation may represent a lagoonal environment or at least a further restriction of the body of water.

Van Alstine (1948) correlated rocks here referred to as the Inlet Group with Lower and Middle Cambrian formations known to occur elsewhere within the Avalon zone. Since then, the terminology and stratigraphy of the type localities elsewhere have been altered and Greene (1974) recognized the occurrence of Eocambrian beds within the map area. Although correlations could be made with confidence, the author feels that a detailed paleontological study is necessary before the formation names used elsewhere in the Avalon zone are used within the map area, in particular, and in other areas of the southern Burin Peninsula in general.

The Pleasant View Farm Formation, because of its fossil content and distinctive lithologies is the most easily correlated. The upper unit, black shales and grey siltstones, containing, according to Van Alstine (1948) and Fletcher (written communication to D.F. Strong, 1975), trilobites of the _Paradoxides davidis_ and _Hydrocephalus hicksii_ zones, is therefore lithologically and paleontologically similar to the Manuels River Formation. The lower unit, green mudstones, red shale and limestone, all manganiferous, containing trilobites of the _Paradoxides bennetti_ zone (Van Alstine, 1948), is correlative with the Chamberlains Brook Formation, Van Alstine (1948) recorded the occurrence of manganiferous beds which he correlated with the "Hanfordian" beds containing fossils of the _Protolenus_ zone of upper Lower Cambrian age. The author was unable to recognize these beds as a mappable unit.

The Salt Pond Formation is lithologically similar to the Lower Cambrian units of the Avalon Peninsula, i.e. the Brigus, the Smith Point and the Bonavista Formations. Structural complexity and the lack of fossil control, prevent any definite correlations at this time but, the estimated thickness of the Salt Pond Formation (Table 2) is comparable to the thickness of the Lower Cambrian in other areas.

The base of the Cambrian will have to be defined paleontologically within the map area, as suggested by Greene and Williams (1974), because there is no obvious break in the stratigraphic record and the transition into the Precambrian rocks appears to be gradational (if in fact the lower units of the Bay View Formation are Precambrian). The quartzite-grey siltstone unit of the Bay View Formation may be correlated with the Random Formation. The unit above this is then best correlated with part of the Youngs Cove Formation and the unit below is correlated with the Chapel Island and possibly part of the Rencontre Formation.

In conclusion, the Inlet Group appears to represent a conformable sequence which spans the time interval from latest Precambrian or possibly earliest Cambrian to Middle Cambrian.

3.3 Intrusive Rocks

Intrusive rocks of the map area range in age from Late Precambrian to Middle Carboniferous (?) and in composition from granite through gabbro to anorthosite and pyroxenites (Table 2).

3.3.1 The Wandsworth Sill

The oldest intrusives of the map area appear to be the Wandsworth

Sill and its related dykes, which are considered to be co-magmatic with the Burin Group, i.e. Late Precambrian in age. This is opposed to the views of Van Alstine (1948), who considered the "metagabbro", as earlier workers in the area called the sill, to be Ordovician, probably based upon his belief that the Burin Group was Ordovician, of Williamson (1954), who considered the sill to be Post-Cambrian but Pre-Devonian, based upon petrographic similarities to a gabbro he found to be that age outside the map area, and of Greene (1974), who considered it to be Devonian, presumably based upon the fact that the majority of intrusives of the Appalachian Province are believed to be of that age (Williams _et al._, 1974).

Field evidence indicating that the Wandsworth Sill is related to the Burin Group includes the lithological similarities, the lack of evidence for any intrusive relations with the Inlet Group, and the fact that the sill is restricted to the Burin Group over a distance of 25 km. The latter two features can be readily discerned on the geological map (Map 1). The sill is faulted against the Inlet Group in the vicinity of Little Bay.

Although the sill is regionally concordant, there is abundant evidence for local crosscutting relations as pointed out by Van Alstine (1948). The sill is displaced by a large dextral fault in the vicinity of Burin Inlet.

Within the map area, the Wandsworth Sill crops out over a distance of 20 km and attains a maximum outcrop width of 2.5 km. Within its boundaries there are abundant and sometimes large (up to 100 m thick) xenoliths. These sheet-like xenoliths occur throughout the sill but are most common near its margin. It is probable that these sheets have added significantly, perhaps as much as one third, to the estimated thickness of 2 km for the sill.

There is no single dominant rock type within this sill, however, over most of its exposure, the rock is gabbroic and variations are limited to grain sizes and plagioclase-ferromagnesian ratios. Usually the variations show no regular distribution or the weathered and lichen covered surface doesn't allow recognition of any primary features. On both sides of Burin Inlet, however, it is possible to study some characteristics of the Wandsworth Sill in detail. On the west side of the inlet, it consists of a number of bands ranging from 1 to 20 cm in thickness, some ferromagnesian-rich, some plagioclase-rich (Plate 14). In places these bands are disrupted by magmatic flow and slumping (Plate 15). On the east side of the inlet, the cumulus banding is developed to its greatest observed extent with bands of pyroxenite and anorthosite attaining thicknesses of 10 m.

In other places such as along the new, Little Salmonier-Mortier road, there are coarse irregular patches (up to 1 m in diameter) of hornblende (crystals up to 5 cm) rich rock, indicating that in some cases variations are caused by local concentrations of water. In still other places, the rock appears to be made up almost entirely of fine grained diabasic material, suggesting a number of pulses as opposed to a single intrusion.

At its northern extremity, in the vicinity of Little Bay, the sill consists of a granodiorite. The transition is fairly rapid, but it is believed that the granodiorite represents a more differentiated

Plate 14: Cumulus banding in the Wandsworth Sill. West side of Burin Inlet.

Plate 15: Magmatically disrupted cumulus banding in the Wandsworth Sill. Same locality as Plate 14.

pulse of the sill because the contact is marked by a zone of successive intrusions ranging from fine felsites to coarse gabbros which show two chilled margins.

In hand specimen, the most common rock of the sill consists of approximately equal amounts of plagioclase and fibrous actinolite (after pyroxene). A foliation, parallel to the regional schistosity, is developed near the margin of the sill. Along some fractures within the sill, the rock has been sheared so that it now weathers to a aqua colour whereas the gabbro is usually white weathering.

On the Rock Harbour peninsula, a number of gabbroic intrusives cut the Rock Harbour Group and during the field work (see chapters 4 and 5) these were regarded as being related to the Wandsworth Sill. It is not known whether these bodies are concordant or not because no contacts were observed.

The Wandsworth Sill, the Burin Group and the Rock Harbour Group are cut by a number of diabasic dykes, ranging up to 5 m in thickness. The vast majority of these are believed to be related to the Wandsworth Sill, although some may be later. The dykes are fine-to medium-grained and commonly vesicular. Along the coast, south of Beau Bois, a number of dioritic dykes were observed, and along the west coast of the Rock Harbour Peninsula felsic dykes are present. These more acid varieties probably reflect the more differentiated nature of the Wandsworth Sill in that area.

The Wandsworth Sill is also cut by porphyritic dacite and trachyte bodies which may be related to the sill or may be later.

3.3.2 Plagioclase Porphyries

One other volumetrically insignificant group of dykes which cut the Wandsworth Sill and the Burin Group are plagioclase porphyry dykes. Because of their importance with respect to the relative ages of the Marystown and Burin groups (discussed above) they are separated from other dykes.

These dykes, never thicker than 1 m, contain plagioclase phenocrysts up to 2 cm in length, giving them a very distinctive appearance. These crystals are set in a grey-green diabasic matrix.

3.3.3 The Anchor Drogue Pluton

This predominantly granodioritic body, formerly known as the Fresh Pond granodiorite (Van Alstine, 1948), and the Freshwater Pond granodiorite (Greene, 1973, 1974), crops out in the most westerly portions of the map area south of Freshwater Pond.* The rock can best be described as a pink, medium grained, granodiorite to quartz monzonite.

As with the Wandsworth Sill, the boundaries of the Anchor Drogue Pluton shown on Map 1 represent the outer limits of observed intrusives. Within these boundaries, there are many blocks and sheets of volcanic rock of the Marystown Group, into which the granodiorite is intruded. The nature and abundance of these blocks suggests that they are roof pendants and the Anchor Drogue may be regarded as a high level intrusion.

Greene (1974) considered the pluton to be Devonian in age based upon Williamson's (1956) contention that the occurrence of fluorite within it and the petrological similarity between the pluton and the St. Lawrence pluton indicates equivalence. However, the fact that the

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* The name Anchor Drogue Pluton was introduced by Strong _et al_., 1976.

Anchor Drogue Pluton is truncated by the thrust fault, Map 1, thought to be pre-St. Lawrence granite in age, indicates that the Anchor Drogue Pluton is older.

A definite age is not known, but, a congenetic relationship with the Marystown Group cannot be ruled out. This hypothesis was first put forward by Van Alstine (1948).

The Anchor Drogue Pluton is cut be diabase dykes and may be related to these and other dykes cutting the Marystown and Burin Group.

3.3.4 Younger Dykes

One diabase dyke was found cutting the Inlet Group within the map area and it is probable that some of the dykes cutting the older groups are related to this late igneous event. It can be said that these dykes are post-lower Cambrian and may be related to the St. Lawrence granite.

The dyke, cropping out along the west side of Burin Inlet, is approximately 3 m wide and is one of the least altered dykes found in the map area. It is a black, fine grained rock consisting of pyroxene and plagioclase .

3.4 Structural Geology

There is no direct evidence of more than one deformation to be found within the map area. Only one schistosity was observed and the differences exhibited in the styles of deformation are believed to be explainable by relative position in the rock pile at the time of deformation and by lithological differences.

The Inlet Group provides the most definite indications of the style of deformation which affected the area. Fig. 5 shows some of the structures observed along the Burin Inlet section. The deformation can be described as asymmetric folding with one limb dipping at approximately 20° and the other approaching a vertical orientation (Plates 16 and 17). An axial planar cleavage is developed in some cases and it generally has a strike of between 20° to 40° azimuth and dipping to the northwest at between 40° to 50° (Fig. 6).

In some cases these asymmetric folds are disrupted along thrust faults (Plate 18), which parallel the cleavage, i.e. the folding and faulting are closely related. Along one of the faults the Bay View Formation is thrust upon the Salt Pond Formation representing a vertical component of movement in the order of 800 m. In this case a tectonic breccia has been developed (10-20 m thick) whereas most of the other thrust faults don't have associated breccia. Near-vertical schistose zones have been developed in the more incompetent rock units, e.g. the Pleasant View Farm Formation, which have somewhat localized zones of movement.

The most geologically and topographically obvious thrust fault (Map 1) is the one which places the Marystown and Mortier Bay Groups over the Inlet Group and has been named the Lewins Cove Fault because, in the vicinity of Lewins Cove it is best exposed in a quarry (Plate 19).

Because of the scarcity of measurable attitudes within other groups, with the exception of the Rock Harbour Group, and because of the confusion caused by the interfingering and lensing of rock units, especially within the Marystown and Mortier Bay Groups, it is necessary

Plate 16: Asymetric anticline in Inlet Group showing axial planar cleavage dipping to the NW. Along Route 12, north of Little Salmonier.

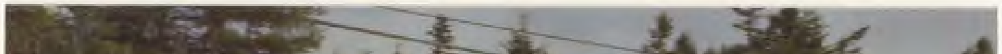


Plate 17: Asymetric syncline at same locality as Plate 16.

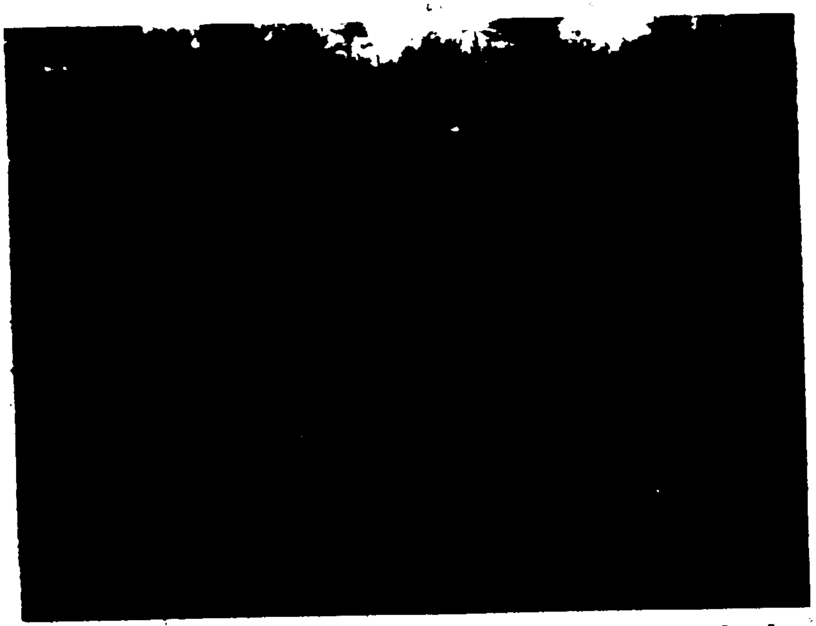


Plate 16: Asymetric anticline in Inlet Group showing axial planar cleavage dipping to the NW. Along Route 12, north of Little Salmonier.

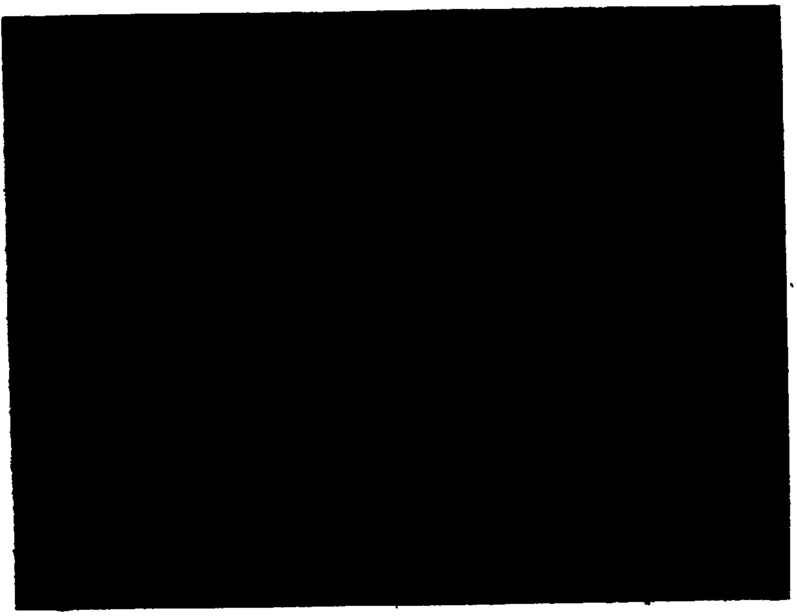


Plate 17: Asymetric syncline at same locality as Plate 16.

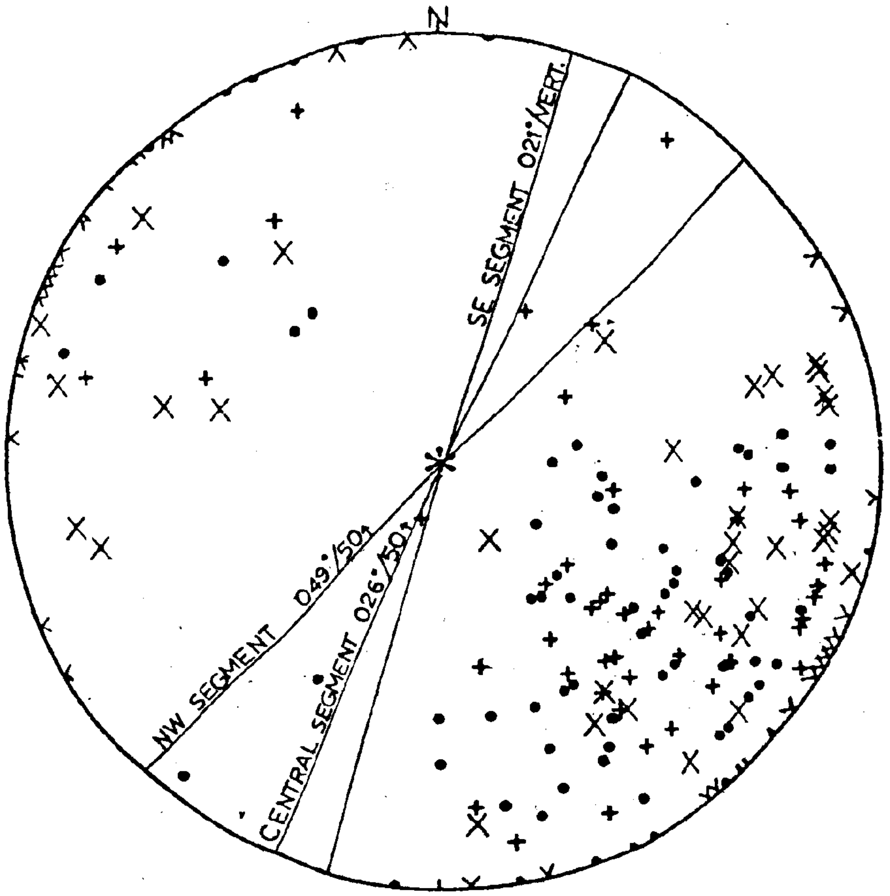


Figure 6. Cleavages. Lines indicate position of planes best fitting the highest concentrations of poles. N-W segment - northwest of Lewin's Cove Fault. S-E segment - southeast of Little Bay Fault. Central segment - between the two faults. ● - poles to cleavages in NW segment. x - poles to celavages in SE segment. + - poles to cleavages in central segment. Note dominant NE strike and NW dip of cleavages in all segments.

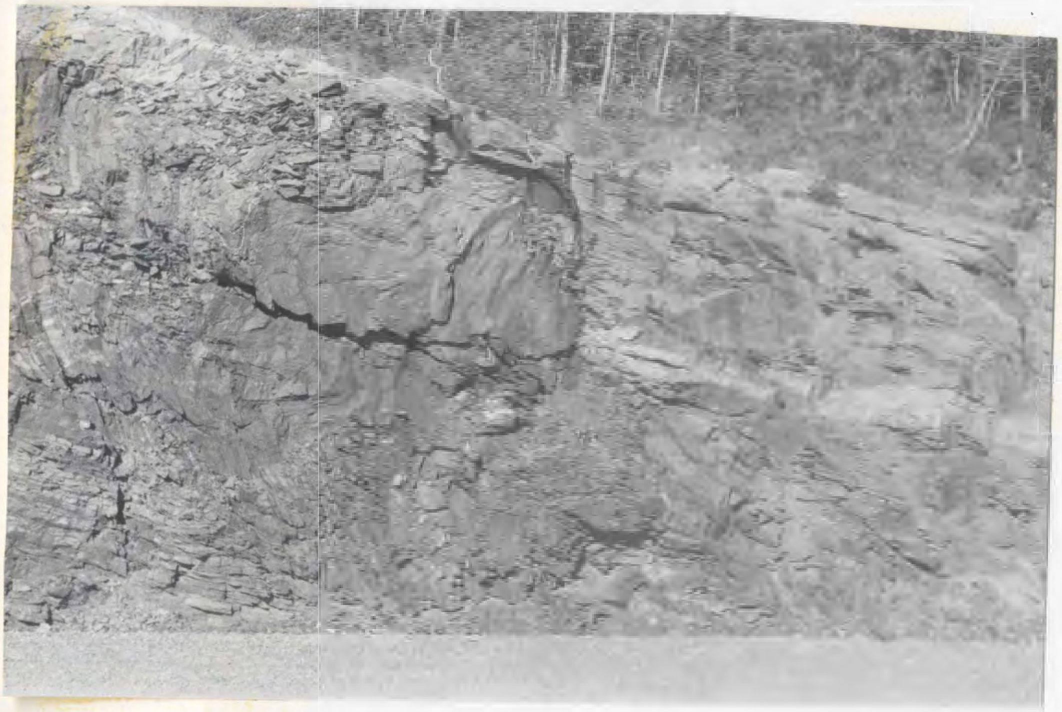
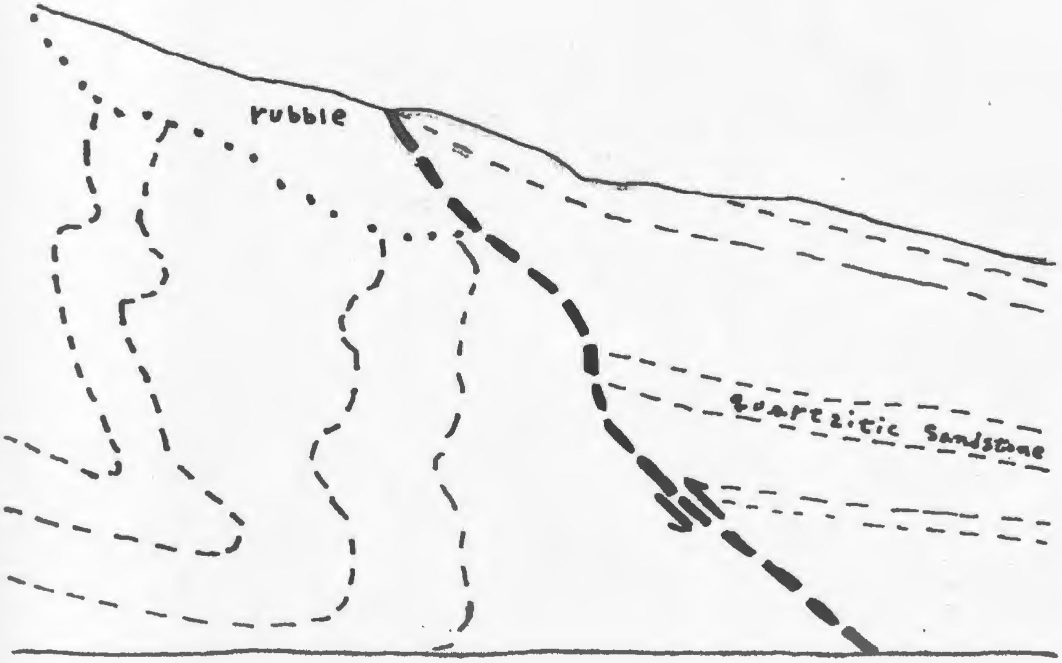


Plate 18: Thrust fault within the Inlet Group.



Drawing of Plate 18

Plate 19: Lewin's Cove Fault. Upper 3 m of quarry face is Marystown Group and the bottom is Salt Pond Formation. Near Lewin's Cove.

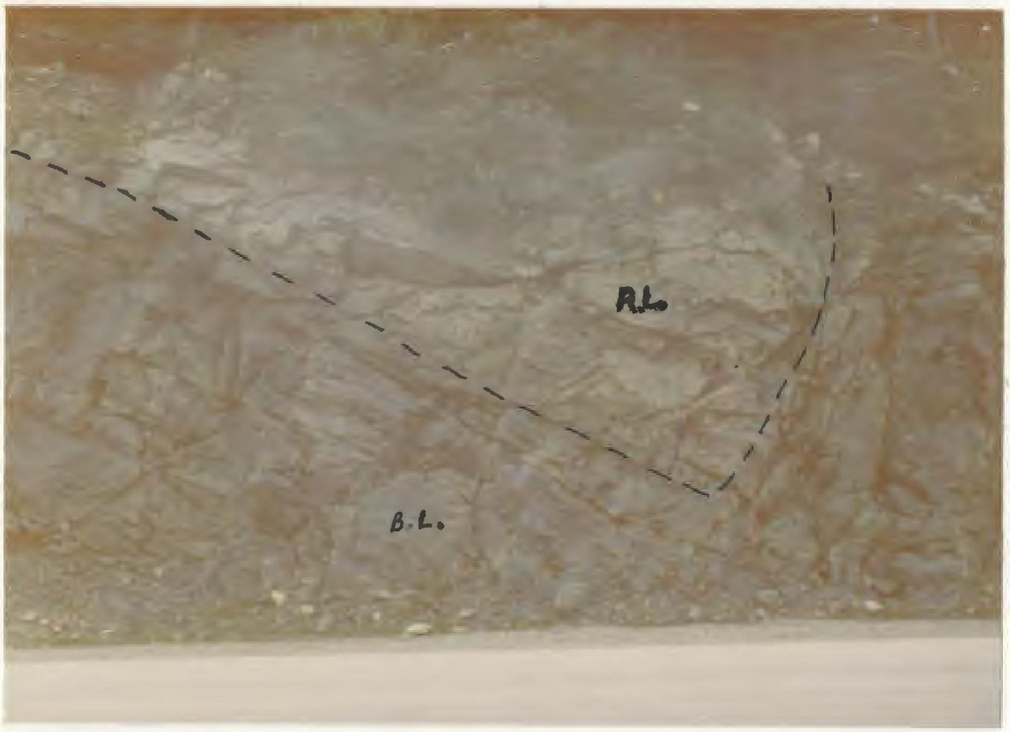


Plate 20: Asymetric foldinq in the Marystown Group. R.L. - rhyolitic lapilli tuff; B.L. basic lapilli tuff. Near Salt Pond.

to rely heavily upon the structural style worked out for the Inlet Group.

The Marystown Group shows the development of schistose zones paralleling the Lewins Cove Fault and the cleavage and faults of the Inlet Group (Fig. 6), although they are more variable and appear to be localized within certain lithologies, usually crystal and/or lithic lapilli tuffs, presumably because these rocks are less resistant than the other units. Folding is difficult to recognize and although most of the measured attitudes indicate a variably dipping, westward facing sequence there is some evidence of a similar style of folding to that found in the Inlet Group (Plate 20).

The Mortier Bay Group has apparently taken up an unequal amount of deformation as evidenced by the frequency and intensity of the shear zones. It is also apparent that the amount of deformation increases from west to east, forming a wide zone of intense brecciation in the vicinity of Creephole Point (Plate 21). The amount and style of deformation appears to have been dependent upon the original orientation of the bedding. In the north-west, the bedding strikes at right angles to the schistosity and is essentially oriented as it was originally, in the east, where the rocks may have been oriented differently, the less resistant units (e.g. the Creston Formation) have undergone intense shearing and have been thrust over by the more massive units which are still essentially flat lying. Folding of the strata accompanies this thrusting much in the same fashion that occurred in the Inlet Group.

The Burin Group exhibits a slightly different pattern of deformation, in that the strike of the formations and the schistosity are slightly more northerly than in other groups and the beds dip more

Plate 21: Intense brecciation in the Creston Formation. Near Creephole Point.

steeply (Map 1, Fig. 6). This is thought to be due to the presence of the large, relatively massive body, the Wandsworth Sill, within the rock sequence. This body would tend to act as a "buttress" during compression, thus causing deformation by shearing and tilting rather than folding of the rocks closely associated with the sill. It should be mentioned here that there is evidence of a decrease in deformation within the Burin Group as you get away from the sill to be found to the south of the map area, where flat lying strata are reported in several places (Strong *et al.*, 1976).

The Rock Harbour Group is locally folded into southwest plunging structures with steeply dipping axial planes (Greene, 1974), but the conformable nature of the contact between the Rock Harbour and the Burin Groups, the "linearity" of this contact and the parallelism of the axial planes with structures in other groups argues against a different period of deformation for these structures. It appears more likely that the differences are due to the position of the Rock Harbour Group within the sequence at the time of deformation.

Other than the series of northeasterly striking northwesterly dipping thrust faults discussed above, there are three other important faults recognized in the map area. Two of these, the one on the Rock Harbour Peninsula and the one running from Duricle Cove southwestwards to Burin Inlet have large dextral, slip components and probably a "thrust" component. The former fault is inferred from a study of air photos and has a horizontal displacement in the order of 500 meters. The latter one can be recognized in the field by a zone of intense shearing and has an apparent displacement of approximately 1600 m. This fault has also resulted in rotation of formation contacts (Map 1).

Probably the most important and the least understood fault of the map area is that which separates the Burin and Rock Harbour Groups from the other rocks in the area, the Little Bay Fault (Map 1). The relative ages of the Burin and Inlet Groups and the orientation of minor folds near the fault would indicate the Little Bay Fault is one of the high angle normal type. This style of faulting indicates a change in stress orientation from the thrusting and related faulting and folding and it may be much later or earlier. However, the situation may have been similar to that described by Williamson (1956) for the area to the south, where he concluded that similarly oriented normal faults were "produced in response to uplift and relief of pressure following an earlier period of compression".

3.4.1 Discussion

The deformation observed in the map area can thus be related to a single period of compression (principal stress axis oriented at approximately 305°). Previous workers in the area recognized the importance of this event (Greene, 1974; Van Alstine, 1948; Williamson, 1956). Van Alstine (1948) believed that the area was subjected to two periods of deformation, however, this was based upon a stratigraphy that is believed to be erroneous (see above and Williamson, 1956; Strong et al., 1976). Williamson (1956) interpreted the deformation in the area to the south in terms of one orogeny.

The time of the deformation can be dated only as post-Middle Cambrian and pre-Middle Carboniferous because it deforms the Pleasant

View Farm Formation but doesn't affect the St. Lawrence granite, dated at 315 ± 5 m.y. by Bell and Blenkinsop (1975). Deformations of this age within the Avalon Zone have been ascribed to the Devonian, Acadian Orogeny (see discussion in Chapter 2).

The situation which Fletcher (1972) envisaged for his area directly to the east of the map area fits the above observations. At the time of compression, there existed a "positive" area to the east, thus causing the formation of asymmetric folds with the steep limbs on the east side and thrusts and axial planar cleavage dipping at moderate angles to the northwest.

3.5 Summary of Geological History

Figure 7 and Figure 8 are schematic corss-sections of the area. The geological history of the map area began in the Late Precambrian with the deposition of the siliceous siltstones, sandstones and conglomerates of the Rock Harbour Group. The source of the sediments appears to have been a acidic, subaerial volcanic and marine sedimentary terrain. A continental shelf and slope environment is envisaged for this period, with stromatolitic limestones forming in protected, relatively shallow water areas and limestone conglomerates forming from the mechanical breakup of these "reefs". The submarine, mafic lava flows, pyroclastics and tuffaceous sediments of the Burin Group were then formed and intruded by a cogenetic sill (the Wandsworth Sill) and its associated dykes. The intermittent occurrence of stromatolitic limestone throughout this period of volcanism suggests a relatively shallow water environment.

There is no record of a gradual transition from submarine to

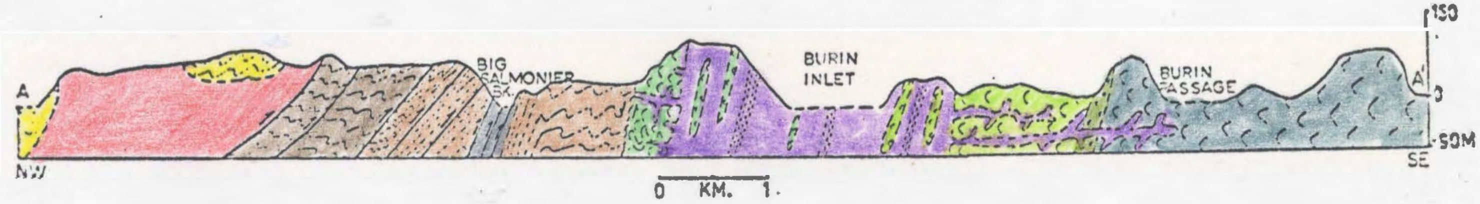


Figure 7: Cross-section of southern part of map area. Location of A-A' and colours* used are shown on Map 1.

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*Colours for units 3 and 5 as shown on Map 1 are reversed in this figure.

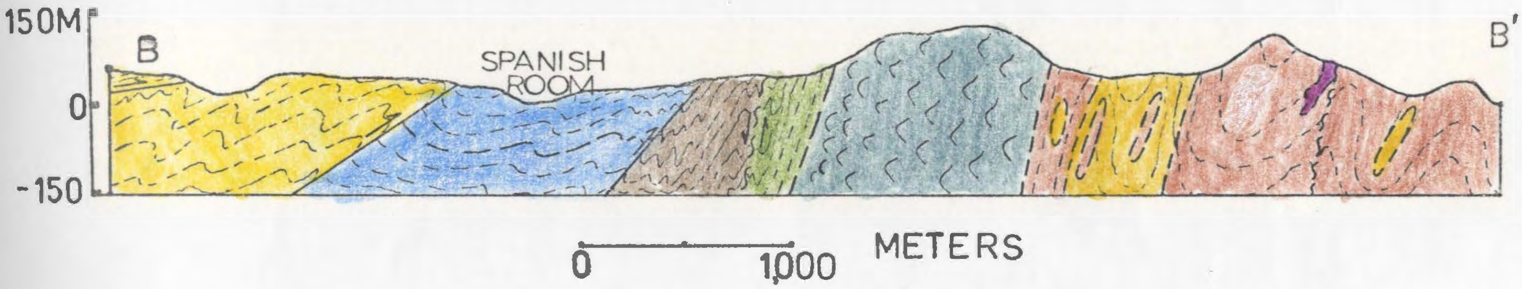

Figure 8: Cross-section of northern part of map area. Location of B-B' and colours*used are shown on Map 1.

*Colours for units 3 and 5 as shown on Map 1 are reversed in this figure.

subaerial volcanism and it must be assumed that there is a significant break in the record because when volcanism resumed, it was predominantly bimodal and subaerial represented by the Marystown and Mortier Bay Groups. The environment was one of overlapping volcanic sequences which were affected by erosion and where volcanogenic sediment formed in fluviatile settings. The Anchor Drogue Pluton was emplaced into its cogenetic volcanics as a high level intrusion.

As volcanism ceased, subaerial clastic sediments (lower Bay View Formation), then intertidal to neritic sediments (upper Bay View) and finally, with continued transgression, shallow marine clastics and non-clastics formed (Salt Pond and lower Pleasant View Farm Formations). The body of water became restricted, as evidenced by the youngest sedimentary rocks of the area, the black and grey, pyritic shales and siltstones (upper Pleasant View Farm).

Deformation, during the deposition of these rocks, was of the non-compressive type, being limited to the high angle faulting which likely accompanied the volcanic episodes. However, following the deposition of the Middle Cambrian sediments, the area was subjected to a compressive event, followed by uplift and erosion. Post-orogenic diabase dykes represent the youngest rocks of the map area.

CHAPTER IV

PETROGRAPHY

The following discussion concentrates on the petrography of those rocks which were analyzed, but thin sections were studied for most rock types and general observations are also given for these. Descriptions of representative specimens of analyzed rock units are given in Appendix 1.

4.1 The Rock Harbour Group

The most common rock type of the Tides Cove Formation, the well-bedded siltstone, consists of angular fragments of quartz, plagioclase (unaltered to slightly sericitized) and orthoclase in a fine matrix of the same material. There are a few rounded lithic fragments, similar to the siltstones that may represent reworking of partially lithified strata. The rock is cut by calcite veinlets and its fragments range from unaltered to moderately altered.

Cobbles of the Wild Cove Formation were sectioned in an attempt to determine whether or not they had correlatives within the map area, especially the acid, igneous cobbles of the Marystown and Mortier Bay Groups. One granitic cobble turned out to be a very distinctive rock composed of approximately 20 per cent plagioclase ($(An_{10})^*$), 40 per cent quartz and 40 per cent perthite, with minor muscovite, chlorite and opaques. The rock is slightly porphyritic and relatively unaltered. It is not correlative with any rock units studied within the map area. The other cobbles are not as distinctive and could have been derived from any acid volcanic terrain combined with a submarine, sedimentary terrain. However,

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*Plagioclase determinations were made using routine extinction methods on a flat stage.

the occurrence of fragments representative of both terrains in one volcanic breccia clast indicates that they were closely related in the source area at the time of eruption of the breccia and this is not the case within the map area (Chapter 3 and Map 1).

4.2 The Burin Group

4.2.1 The Pardy Island Formation

The pillow basalts of the Pardy Island Formation range from porphyritic to non-porphyritic varieties, with the former being more common. The porphyritic rocks generally consist of up to 20 per cent clinopyroxene phenocrysts (Plate 22) and smaller plagioclase phenocrysts (up to 20 per cent). Serpentinized pseudomorphs of olivine phenocrysts were recognized in some of the thin sections (Plate 23). The clinopyroxenes (augite) infrequently have an altered orthopyroxene core (Plate 24). The clinopyroxene is commonly twinned, shows a reaction rim with the matrix (Plate 25) and is variably altered to actinolite (Plate 26). Some of the pyroxene phenocrysts are up to .5 cm in length, but microphenocrysts are also common (Plate 27).

The plagioclase phenocrysts are in the oligoclase range (An_{20}), are generally unzoned, show albite twinning and are variably altered to sericite. The very fine-grained matrix is composed of plagioclase, magnetite and actinolite (after pyroxene). Hematite is commonly associated with the magnetite. The rock is generally cut by calcite veins with some epidote and quartz. Although not common, vesicles do occur, usually within the chilled margins of pillows, and are filled with calcite,

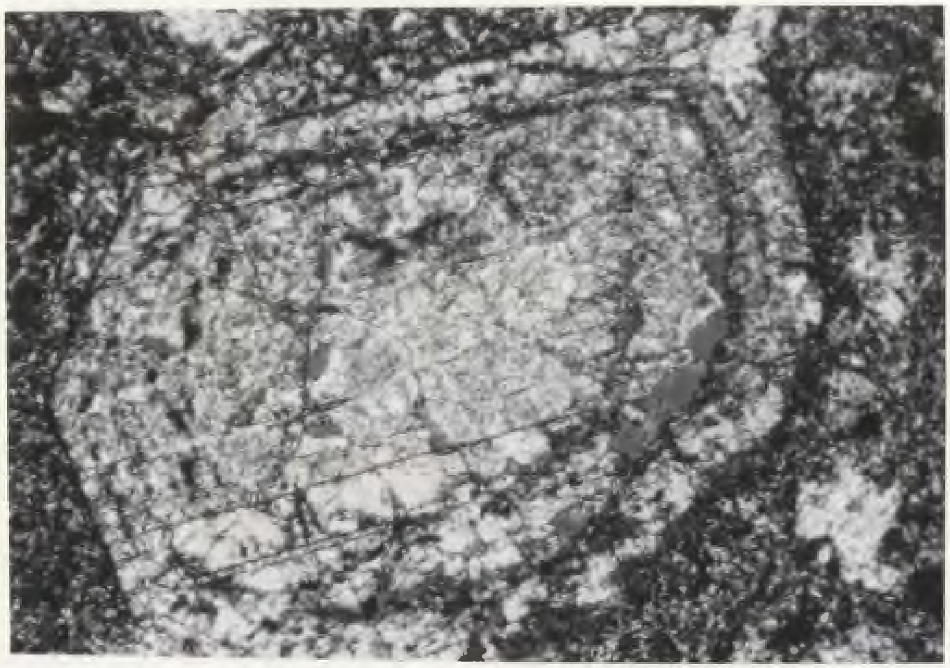

Plate 22: Clinopyroxene phenocrysts in the Pardy Island Formation (plane light, X 40).

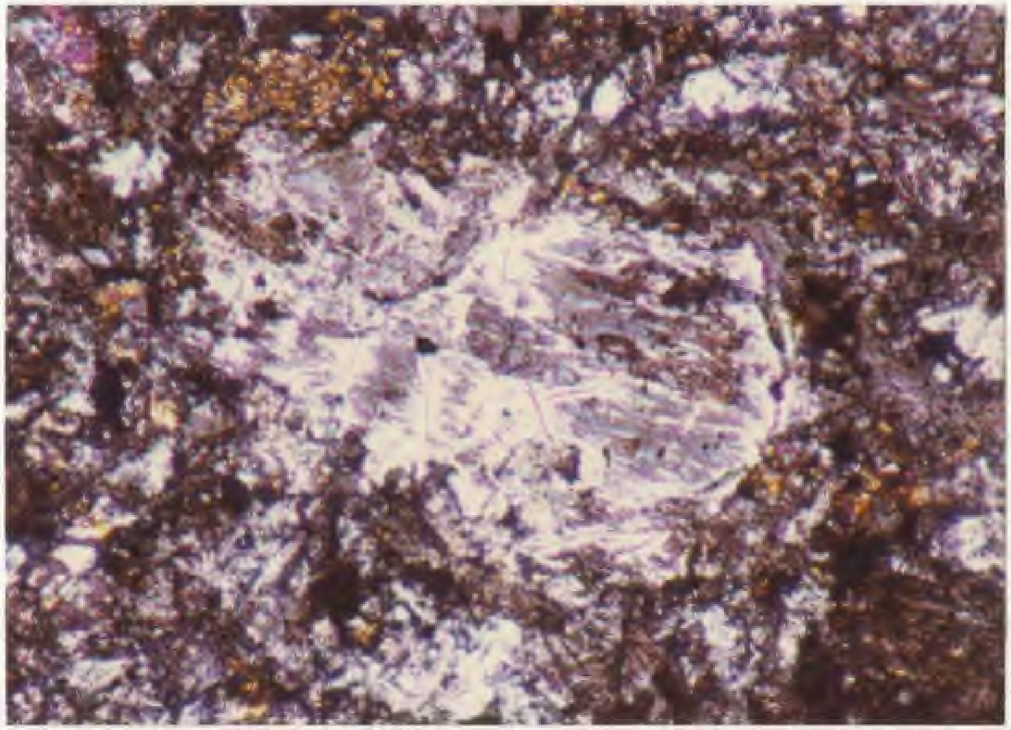

Plate 23: Serpentinized olivine phenocryst in Pardy Island Formation (X-Nicols, X 64).

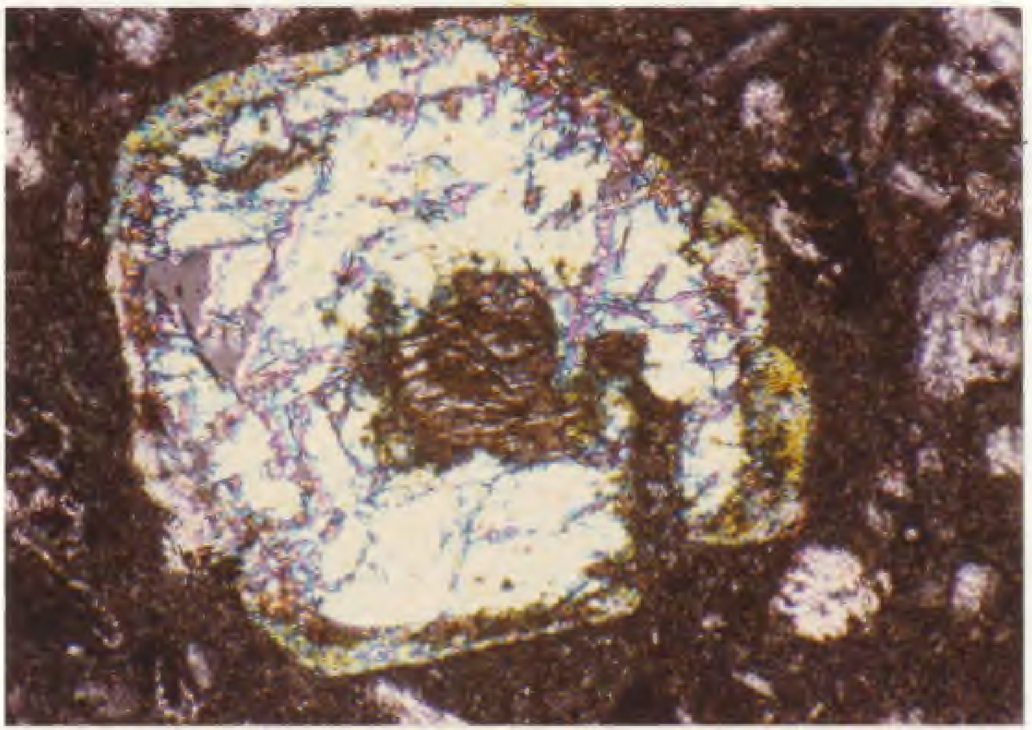

Plate 24: Clinopyroxene with an altered orthopyroxene core. Pardy Island Formation (X-nicols, X 40).

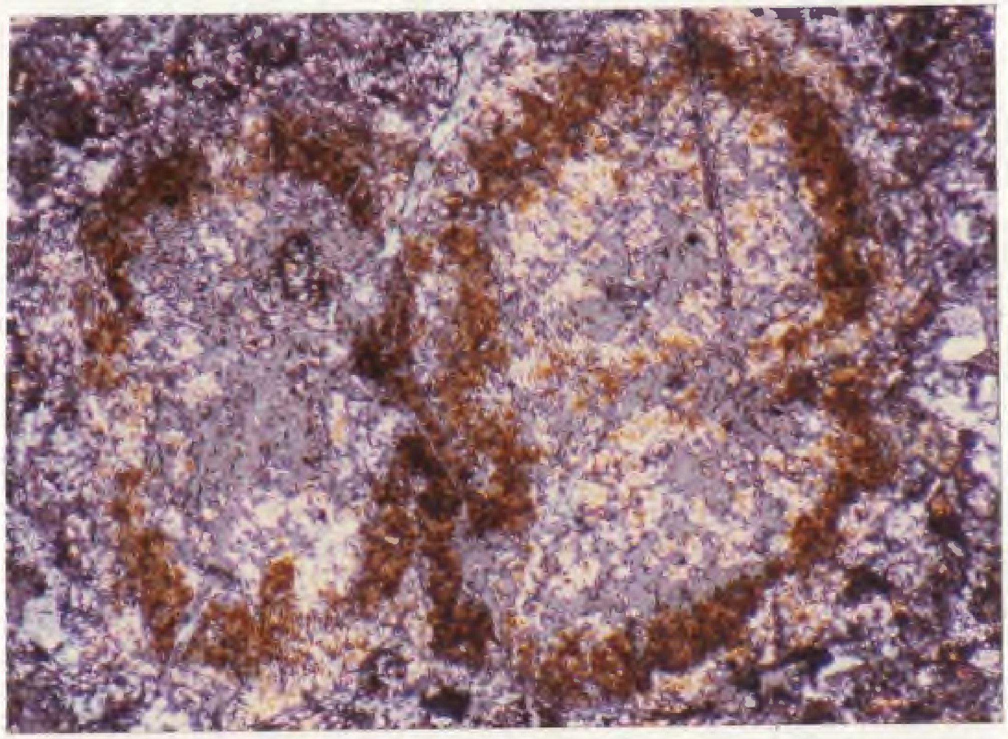

Plate 25: Altered clinopyroxene showing a reaction rim. Pardy Island Formation (X-nicols, X 40).

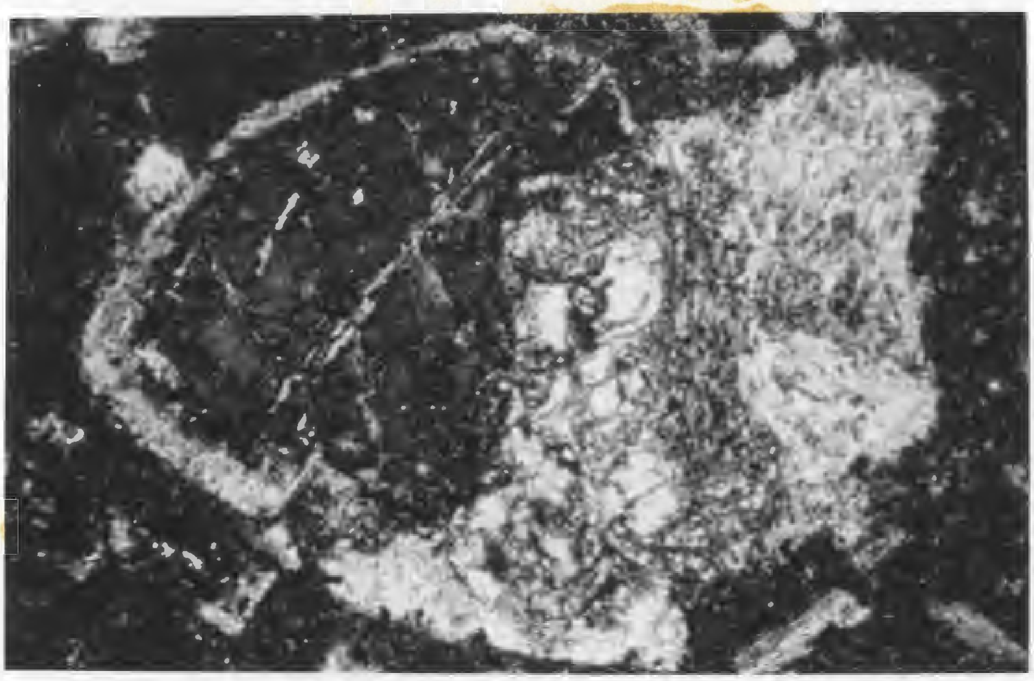

Plate 26: Clinopyroxene altered to actinolite. Pardy Island Formation (X - Nicols, X 40).

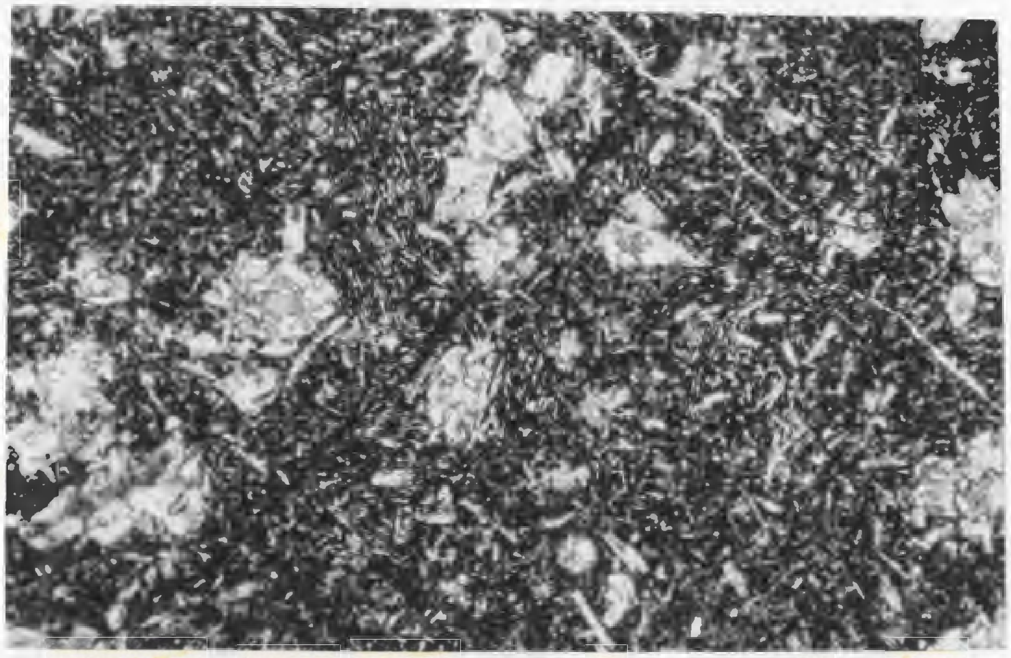

Plate 27: Microphenocrysts of pyroxene within the Pardy Island Formation (plane light, X 40).

chlorite, albite and quartz.

The interpillow material, although not plentiful, consists of poorly sorted, angular fragments of basalt and a few plagioclase phenocrysts set in a very fine-grained matrix.

4.2.2 The Port au Bras Formation

The most common rock type of the Port au Bras Formation, the tuffaceous sandstone, consists mainly of angular fragments of plagioclase crystals with lesser amounts of opaques in a matrix of calcite and chlorite. Epidote is a common alteration product. Some of the altered, angular fragments are probably of mafic volcanic origin. The limestone which is found within this formation, and those elsewhere within the Burin and Rock Harbour Groups, are totally recrystallized so that recognition of any primary structures was not possible in thin section.

4.2.3 The Path End Formation

The pillow lavas of the Path End Formation are commonly porphyritic but to a lesser degree than the Pardy Island Formation. The dominant type of phenocryst is plagioclase and is often the only one (Plate 28). Clinopyroxene where present as a phenocryst phase is altered to actinolite. No olivine was recognized. The plagioclase is altered to epidote and sericite and is now of a composition close to An_{10}. The matrix consists of an epidotized mat of plagioclase laths and chlorite. The scarcity of opaques is noteworthy. Epidote, calcite and quartz veins are common and some samples show evidence of silicific-

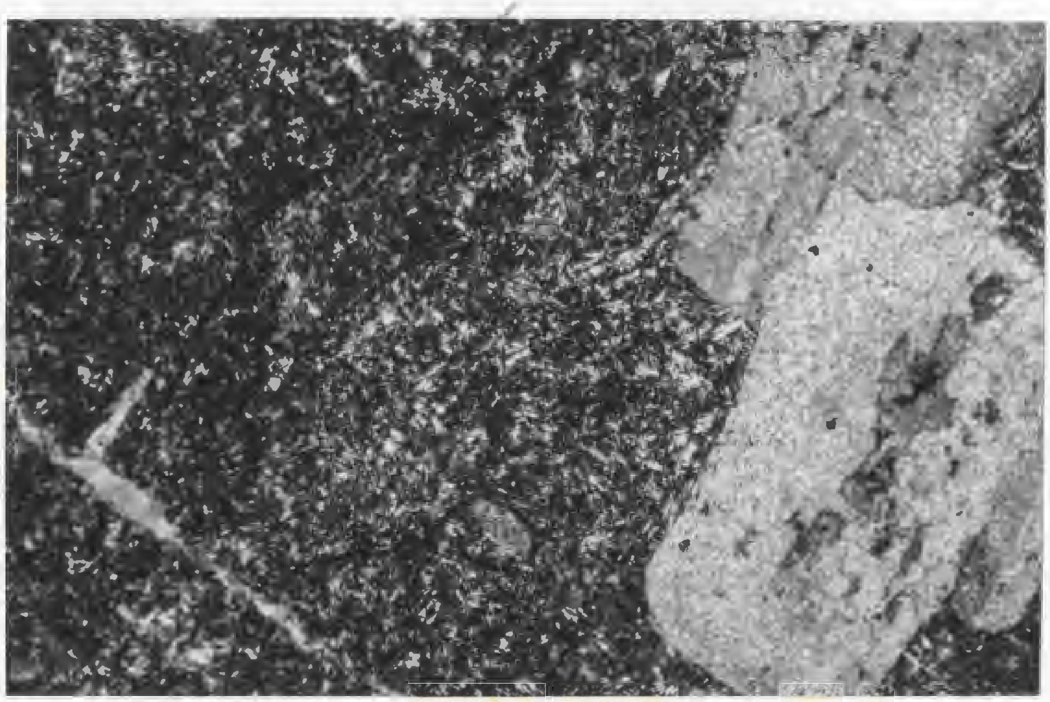

Plate 28: Plagioclase phenocrysts in the Path End Formation (X - Nicols, X 40).

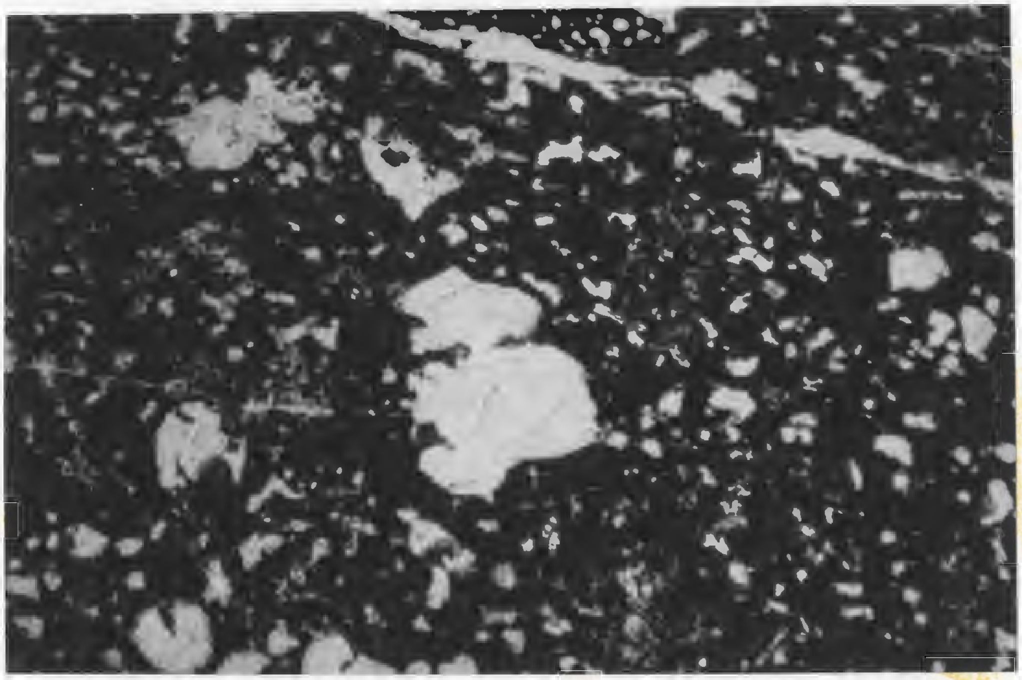

Plate 29: Chilled margin of Path End pillow (plane light, X 40).

ation. Chilled margins of pillows are highly vesicular (Plate 29), with quartz, epidote and calcite filling the vesicles.

4.2.4 The Beaver Pond Formation

Within the map area the Beaver Pond Formation is the most highly altered of the pillow lavas of the Burin Group. They generally consist of actinolite, epidote and albite, with some quartz and hematite. The original rock was non-porphyritic and non-vesicular, although a few stretched vesicles were recognized. Plate 30 shows a typical hematized variety of the Beaver Pond pillow lavas.

4.2.5 The Wandsworth Sill

The Wandsworth sill is discussed here because it is considered to be closely associated with the Burin Group (Chapter 3). In their most common variety, the gabbroic rocks of the main sill consist of approximately 50 per cent actinolite and 50 per cent plagioclase exhibiting ophitic intergrowth (Plate 31). The habit of the actinolite varies from aggregates of crystals of rubble-like replacements to prismatic, twinned crystals. In most cases the original ferromagnesian minerals have been completely replaced by the actinolite, although some sections contain remnants of large augite phenocrysts (Plate 31). The plagioclases are highly altered to sericite and albite, but more commonly to a high relief, isotropic mineral believed to be hydrogrossular. Rosettes of epidote were found in a number of cases and the rock is cut by epidote and quartz veins. One or 2 per cent of opaques are present and are altered to leucoxene. The actinolite is colorless to pleochroic green,

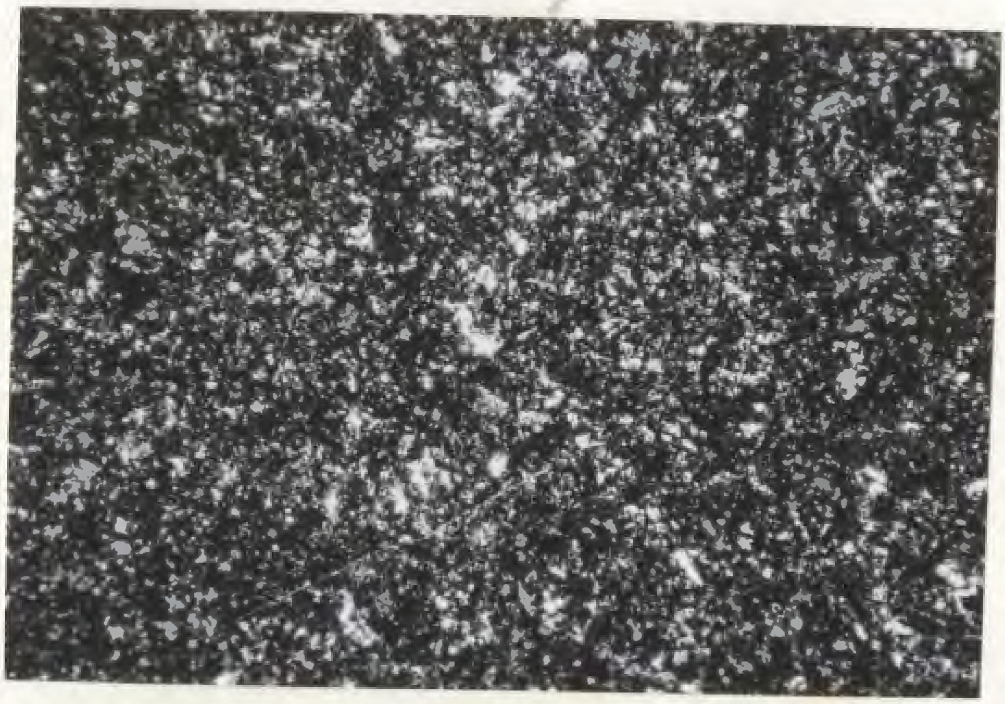

Plate 30: Hematized Beaver Pond pillow (plane light, X 40).

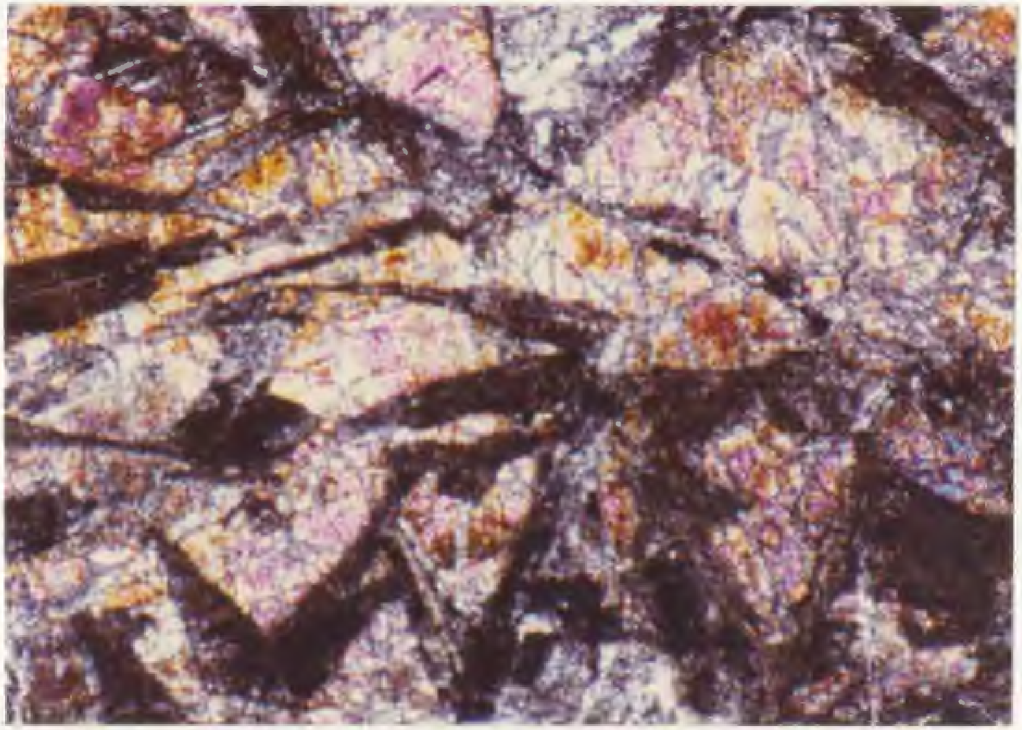

Plate 31: Ophitic texture in the Wandsworth sill. Plagioclase is altered to hydrogrossular (?). Clinopyroxene is relatively fresh. (crossed nicols, X 40).

indicating a low Fe/Mg ratio (Heinrich, 1968). The fine grained phases of the gabbro and the dykes associated with it have a similar mineralogy but are generally less altered.

The granodiorite is commonly composed of 30 per cent quartz, 60 per cent feldspar (mostly plagioclase) and 10 per cent ferromagnesians. The rock is generally sheared near the Little Bay Fault (Map 1) and the quartz shows undulatory extinction and a calaclastic texture. The plagioclase is altered to sericite, calcite and epidote. The ferromagnesians are believed to have been amphiboles because of their prismatic habit but they are now altered to chlorite, calcite and epidote.

The gabbroic dykes intruding the Rock Harbour Group on the Rock Harbour Peninsula, and previously thought to be related to the Wandsworth sill (Chapter 3 and Map 1), consist of brown hornblende (partially altered to chlorite and biotite) and plagioclase (An_{10-20}) partially altered to sericite and hydrogrossular (?). There is usually 1 or 2 per cent quartz and magnetite present. One section shows augite phenocrysts rimmed by brown hornblende, which is in turn, altered to chlorite (Plate 32). The lack of alteration of these rocks may imply a younger age for these intrusions than for the Wandsworth sill.

4.3 The Marystown Group

The Marystown Group is made up of many rock types (Chapter 3) and the petrography of the major types is discussed here. One of these, the porphyritic rhyolite, consists of phenocrysts (up to 30 per cent) of K-feldspar, albite and quartz of variable size. The K-feldspar often contains smaller albite crystals (Plate 33). Epidote is the most common

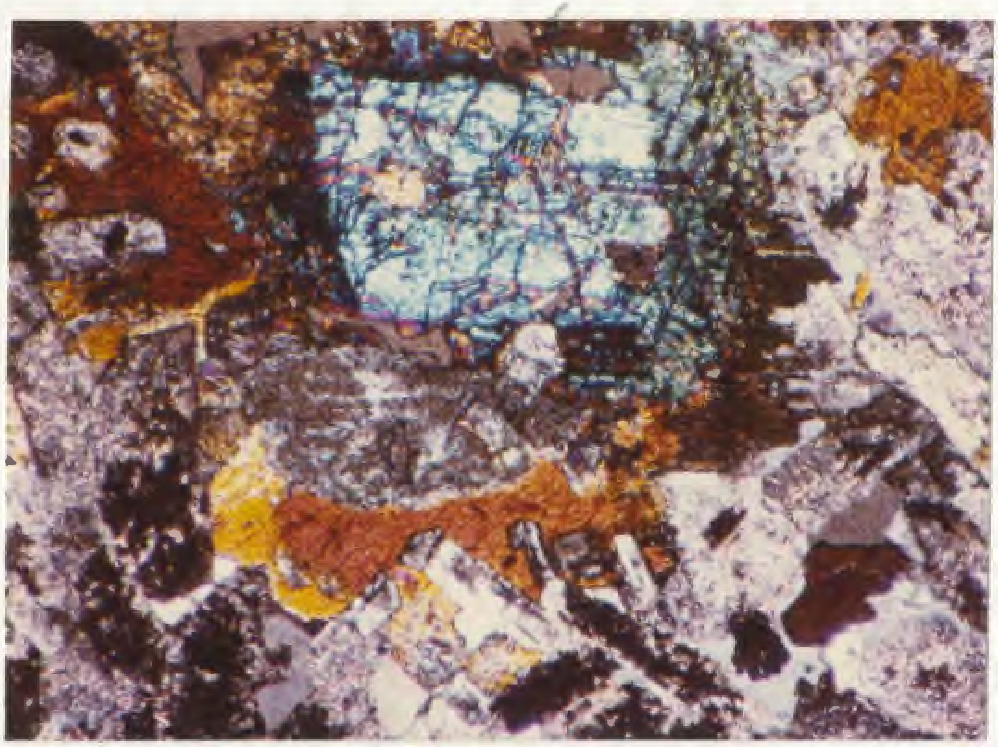

Plate 32: Clinopyroxene with an amphibole rim (in part altered to chlorite). Gabbro cutting Rock Harbour Group (crossed nicols, X 40).

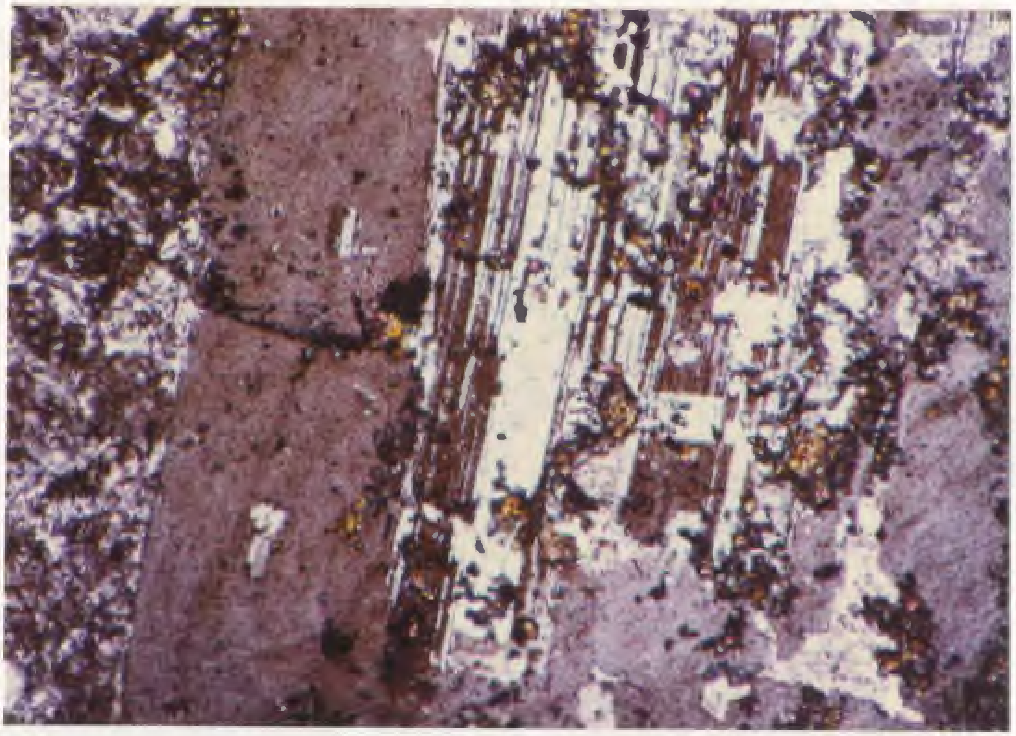

Plate 33: Albite phenocryst enclosed in an orthoclase phenocryst. (X-nicols, X 40).

alteration product, and mafic minerals (when present) are altered to chlorite and opaques, with the latter occurring in the groundmass (less than 1 per cent). The matrix is composed of a sugary intergrowth of feldspar and quartz. The phenocrysts are usually embayed due to reaction with the melt.

The pyroclastic rocks of the Marystown Group are dominantly acidic, containing fragments of broken crystals (quartz, plagioclase and orthoclase*) and rhyolite in a generally sericitized matrix of the same material. However, mafic clasts are much more abundant than would be expected from their present exposure as part of the Marystown Group within the map area. Thus it may be that these fragments were derived from another, more mafic area and/or level of the volcanic sequence. Trachybasalt is the most common mafic fragment, often being vesicular and epidotized. Only one exposure of this rock type was found within the map area. The volcanogenic sediments of the group consist of angular to subrounded grains and pebbles of quartz, orthoclase, albite and lithic fragments (usually rhyolite), with a hematite-bearing cement. Detrital muscovite, of unknown origin, occurs in most sections (up to 2 per cent) and the flakes help to define the small scale sedimentary features. Sericite occurs as an alteration product.

4.3.1 The Anchor Drogue Pluton

The Anchor Drogue Pluton is discussed here because of its believed association with the Marystown Group (Chapter 3). Thin sections show that the rock is a quartz monzonite, consisting of about 24 per cent quartz, 35 per cent plagioclase (An_{10}), 30 per cent orthoclase and 10

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*Some Carlsbad twinning was observed but the determination is not definite.

per cent mafics (now altered to chlorite and epidote). Magnetite occurs in amounts less than 1 per cent and epidote is a common alteration product of the feldspars. The rock shows excellent granophyric texture (Plate 34) and coarse granite with finer granitic xenoliths was noted, indicating successive intrusions.

The pyroclastics and flows of the Marystown Group are hornfelsed near their contact with the Anchor Drogue Pluton.

4.4. The Mortier Bay Group

The Cashel Lookout Formation of the Mortier Bay Group is similar to the Marystown Group, except its pyroclastics are generally more schistose. Flow banding is well developed within the rhyolites, and albite phenocrysts are commonly rotated by the movement (Plate 35). Hematization is common.

The mafic flows of the Creston Formation, interpreted as the youngest volcanics of the map area (Chapter 3), generally consist of a matrix of fluidal plagioclase (variably altered to calcite and/or epidote), hematite, chlorite and ilmenite (often altered to leucoxene) with variable amounts of olivine (altered to serpentine and hematite) (Plate 36) and plagioclase (An_{10}) phenocrysts. The rock generally contains amygdules, which are often flattened and frequently show features indicating formation of segregation vesicles, i.e. partial filling with residual liquid, then total solidification. The more common minerals found within these amygdules are; calcite, chlorite, epidote, quartz, albite and in a number of sections, prehnite and zeolite (laumontite?) (Plate 37).

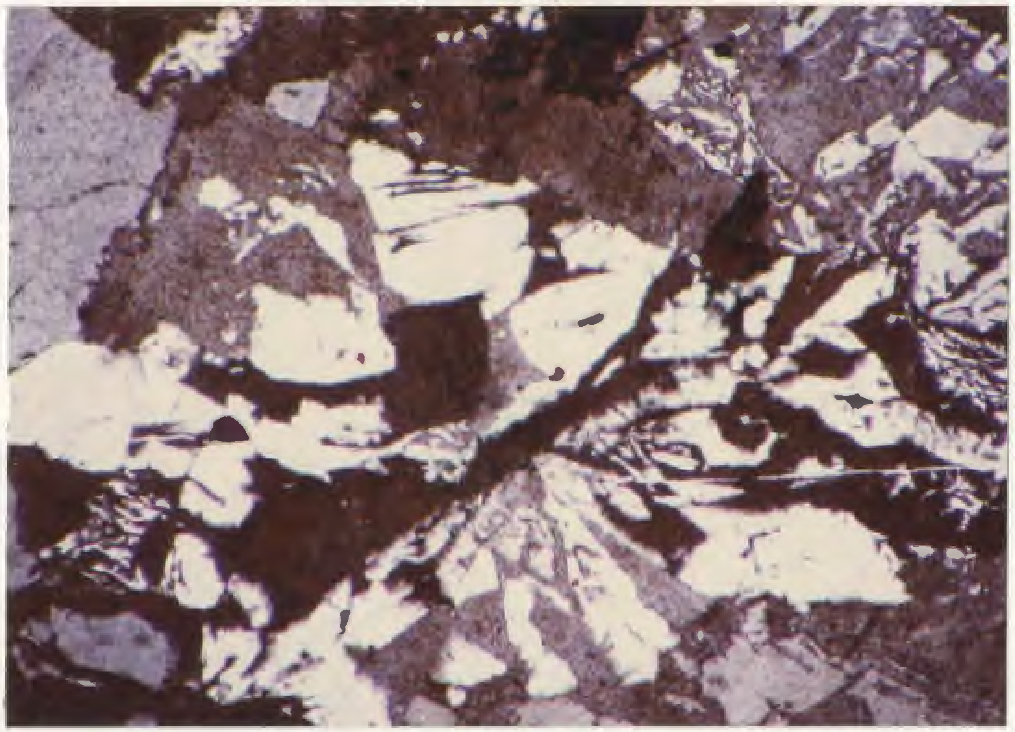

Plate 34: Granophyric texture in the Anchor Drogue (X-nicols, X 40).

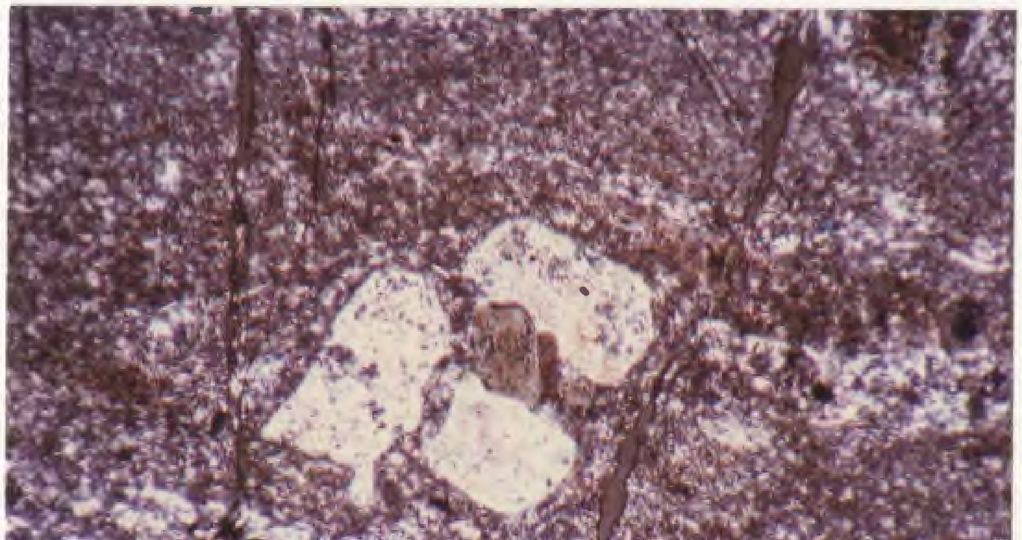

Plate 35: Albite phenocryst in rhyolite of the Cashel Lookout Formation (X-nicols, X 40).

Plate 36: Olivine phenocrysts altered to hematite and serpentine (X-nicols, X 40).

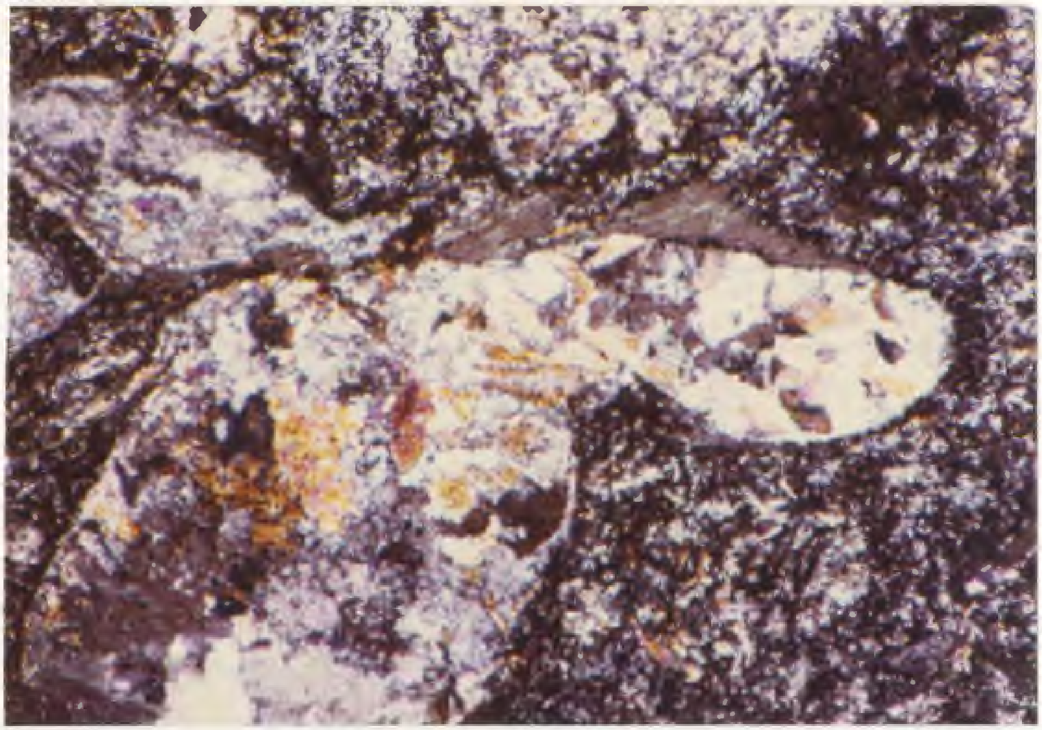

Plate 37: Amygdule in the Creston Formation filled with prehnite and a zeolite. (X-nicols, X 40).

The sediments and pyroclastics of the Creston Formation differ from those of the Cashel Lookout Formation and the Marystown Group only in having a higher proportion of mafic fragments and clasts.

4.5 The Inlet Group

Only a few rocks of the Inlet Group were sectioned, primarily to see if fossils could be identified. Both hyolithides and trilobites (Plate 38) were noted but a detailed study was not undertaken. The limestone of the Salt Pond Formation consists of 90 per cent grains of calcite with abundant hematite cement and 10 per cent clastic grains (angular to subrounded) represented by varying amounts of quartz and muscovite.

4.6 Other Intrusive Rocks

Intrusive rocks not discussed above include the important plagioclase porphyry dykes (Chapter 3). These rocks consist of approximately 10 per cent plagioclase phenocrysts (up to 0.5 cm in length) in a matrix of 50 per cent fluidal plagioclase (altered to epidote and calcite), 5 per cent leucoxene and 20 per cent chlorite. The phenocrysts show zoning of alteration products with the core being altered to calcite and the margins being altered to hydrogrossular (?).

The dyke cutting the Inlet Group, as expected, is one of the least altered rocks of the map area (Plate 39 and 40). It consists of unaltered plagioclase laths showing ophitic intergrowth with titan-augite. The pyroxene is altered to chlorite, and magnetite makes up 2 per cent of the rock. One large plagioclase phenocryst was noted.

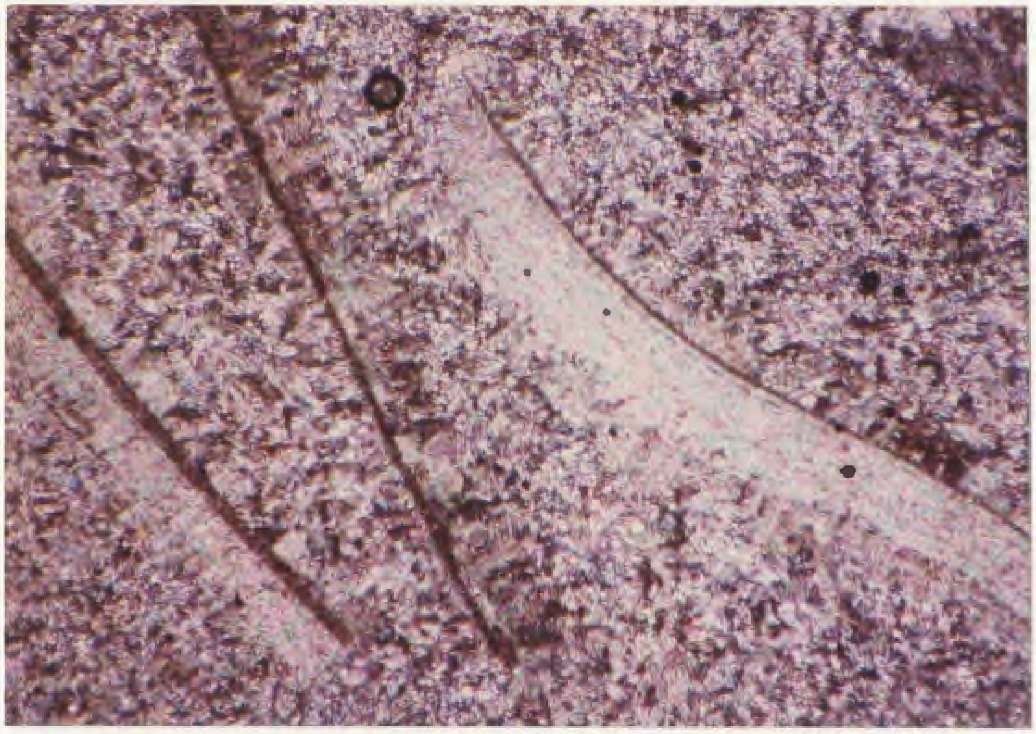

Plate 38: Fragments of trilobites in the Salt Pond Formation. (X-nicols, X 40).

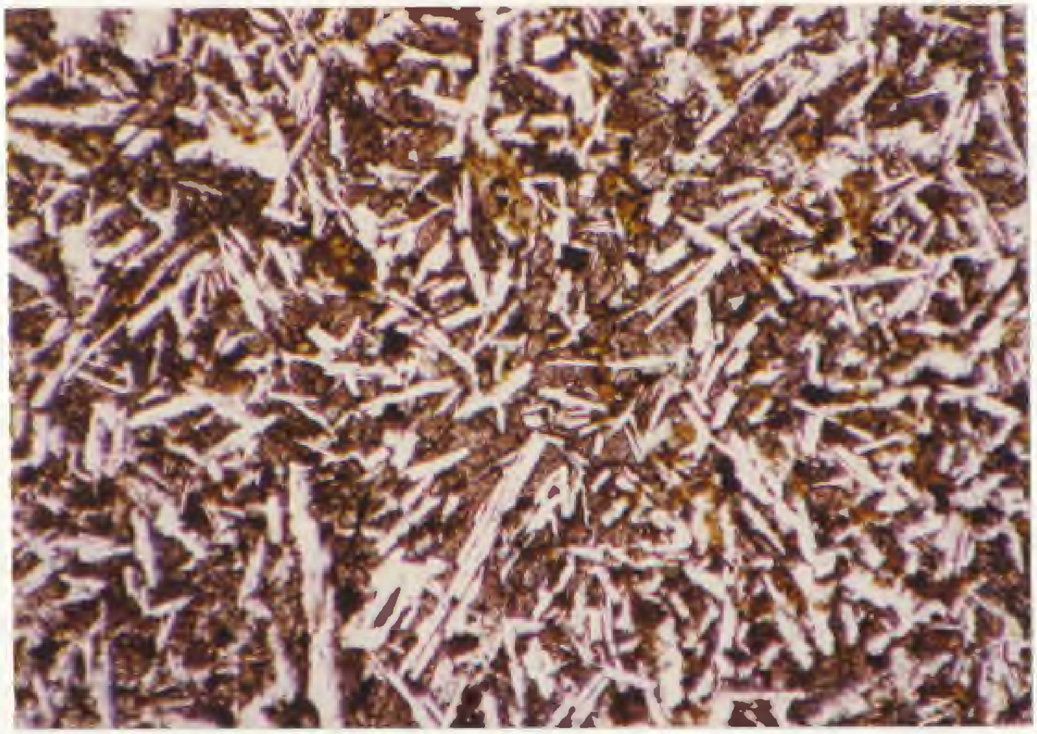

Plate 39: Ophitic intergrowth of titan-augite and plagioclase in dyke cutting the Inlet Group. (Plane light, X 40).

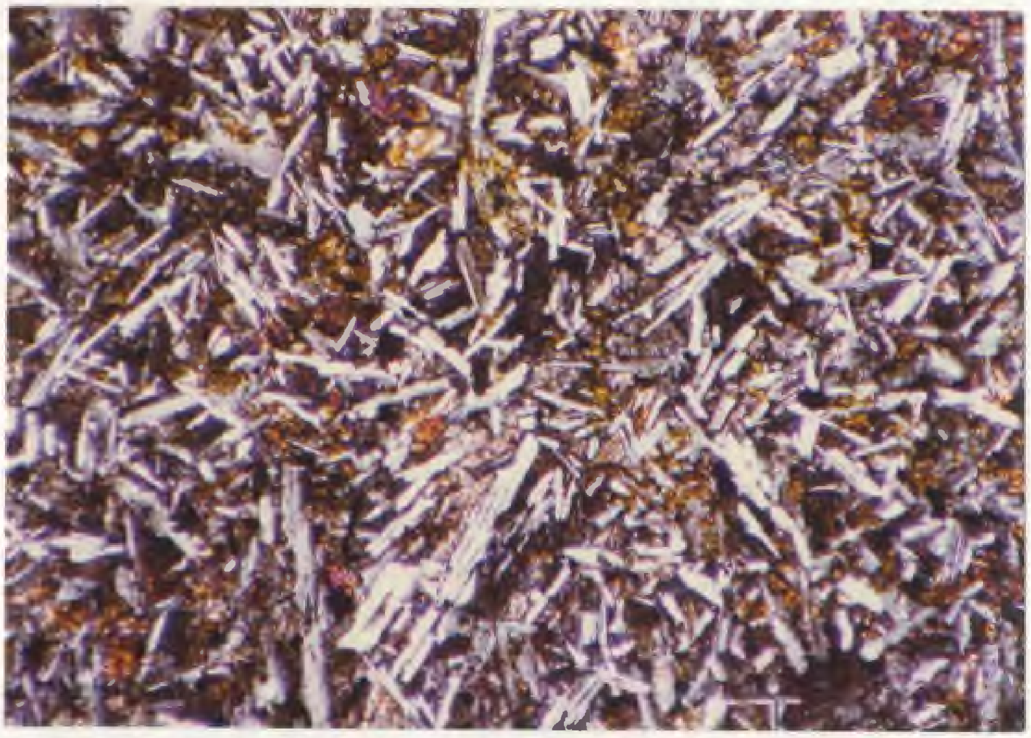

Plate 40: Same as Plate 39 with X-nicols.

4.7 Summary

The mafic flows of the map area show the following phenocryst assemblages:

	ORTHOPYROXENE	AUGITE	PLAGIOCLASE	OLIVINE
PARDY ISLAND	Present only in reacted cores	Dominant	Secondary in importance	Present
PATH END	----------	Secondary in importance	Dominant	----------
BEAVER POND	----------	----------	----------	----------
CRESTON	----------	----------	Dominant	Secondary in importance

The Wandsworth sill is dominantly a clinopyroxene-plagioclase rock.

The intrusives of the Rock Harbour Peninsula are less altered than the Wandsworth sill and other petrographic differences imply that they are unrelated.

Metamorphism varies from greenschist facies within the Burin Group and Wandsworth sill, to zeolite and prehnite facies within the Mortier Bay Group, to unmetamorphosed rocks of the Inlet Group and late intrusions.

CHAPTER V

GEOCHEMISTRY

5.1 Introduction

Chemical analyses were carried out on 102 samples for both major and trace elements. Six of these were collected by B.A. Greene.

Procedures used in preparation and analysis of samples and the accuracy of the determinations are given in Appendix 2. The analyses, along with the C.I.P.W. norms, are given in Appendix 3.

The average composition of the different volcanic formations are given in Table 3 (3 obviously altered samples were omitted from the averaging). Following a discussion of the effects of alteration, the chemistry will be dealt with under 2 headings: (1) the Burin Group, and (2) the Marystown and Mortier Bay Groups.

5.2 Alteration*

Fig. 9 is a diagram used by Hughes (1973) to show the mobility of alkalis during metamorphism. The diagram was constructed by plotting a number of analyses of unaltered rocks of a variety of types (those falling within the "Igneous Spectrum") and those of a "spilitic" nature (those falling outside the "Igneous Spectrum"). The value of such a diagram is limited, since unaltered rocks falling outside the "Igneous Spectrum" may occur and are classed as "altered" because they were not included in the above compilation (c.f. Stauffer _et al._, 1975).

With this in mind, it is apparent from Fig. 9 that although there has been some alkali mobility within all rock units, only the Pardy

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*See Appendix 4 for method used to treat some of the effects of alteration, i.e. high "loss on ignition" and oxidation.

Table 3: Average analysis of major rock units (Note: T277, T115 and 209 were not included because of alteration.)

	BURIN GROUP					MORTIER BAY GROUP		MARYSTOWN GROUP
N	13	9	9	24	6	17	6	8
UNIT	Pardy Is.	Path End	Beaver Pond	Wan. Gab+	Wan.G.D.	Creston	Cashel Lookout	
SiO_2	49.06	49.99	50.33	48.20	66.33	45.72	75.48	71.58
TiO_2	1.34	.56	.82	.29	.36	1.42	.24	.54
Al_2O_3	14.78	15.43	14.11	16.90	16.00	16.63	13.17	14.08
Fe_2O_3	3.83	3.08	3.40	1.89	1.98	5.89	.88	1.85
FeO	6.91	6.27	6.30	4.69	1.80	5.15	.45	.62
MnO	.18	.18	.18	.14	.07	.20	.05	.09
MgO	7.18	8.52	6.70	9.48	1.78	7.03	.15	.46
CaO	7.01	10.28	10.83	13.01	4.12	7.79	.64	.74
Na_2O	3.79	1.87	2.32	1.79	3.93	2.95	5.19	5.58
K_2O	.63	.39	.21	.17	1.85	.96	1.96	2.97
P_2O_5	.09	.02	.03	.03	.05	.33	.05	.09
H_2O^T	5.10	4.22	4.49	3.54	2.70	6.02	1.06	.74
Quartz	---	1.37	3.04	---	24.39	---	36.98	26.10
Orthocl.	3.94	2.39	1.31	1.04	11.13	6.06	11.79	17.80
Albite	33.91	16.41	20.66	15.69	33.86	26.66	44.69	47.89
Anorth.	22.69	33.74	28.90	38.92	20.48	31.30	2.09	3.13
Nephel.	---	---	---	---	---	---	---	---
Corundum	---	---	---	---	.16	---	1.49	.56
Diopside	11.04	15.47	22.48	22.22	---	6.32	---	---
Hyperst.	11.01	27.21	19.62	12.50	6.95	6.31	.38	1.16
Olivine	12.21	---	---	6.74	---	17.33	---	---
Magnet.	2.30	2.26	2.29	2.25	2.21	2.32	.93	.74
Ilmen.	2.69	1.10	1.64	.57	.70	2.88	.46	1.04
Hemat.	---	---	---	---	---	---	.25	1.37
Apatite	.22	.05	.07	.07	.12	.82	.12	.21
Sr	272	265	221	185	461	459	123	124
Rb	23	9	6	4	52	22	46	61
$\frac{FeO^*}{MgO}$	1.44	1.06	1.40	.67	2.01	1.49	8.27	4.96

+ T192A and T190B were not included in average because their effect is not proportional to their abundance.

* Total Iron calculated as FeO

N Number of samples used for averages

Table 4: Compositions of some basaltic rocks of known type.

	1	2	3	4	5	6	7
SiO_2	48.56	49.16	49.15	46.57	45.4	46.48	47.1
TiO_2	.24	2.29	1.52	1.85	3.00	3.10	2.2
Al_2O_3	18.69	13.33	17.73	8.20	14.7	16.68	15.7
Fe_2O_3	2.27	1.31	2.76	1.20	4.1	4.12	3.4
F_2O	4.30	9.71	7.20	9.75	9.2	7.30	7.8
MnO	.11	.16	.14	.14	.20	.18	.16
MgO	9.26	10.41	6.91	19.65	7.8	4.65	7.1
CaO	12.67	10.93	9.91	9.43	10.5	9.40	10.1
Na_2O	1.88	2.15	2.88	1.56	3.0	3.80	3.3
K_2O	.07	.51	.72	1.18	1.0	3.10	1.5
P_2O_5	.02	.16	.26	.26	.4	.90	.47
H_2O^+	1.16	---	---	---	---	---	1.1
Sr	---	350	---	---	---	---	566
Rb	---	11	---	---	---	---	23
$\frac{FeO^*}{MgO}$	.68	1.06	1.40	.55	1.65	2.60	1.53

1 Laminated gabbro from Mid-Atlantic Ridge (Melson and Thompson, 1970)
2 Olivine Tholeiite (Irving and Baragar, 1971)
3 High Alumina Basalt (Irving and Baragar, 1971)
4 Alkalic Picrite Basalt (Irving and Baragar, 1971)
5 "K-poor" alkalii olivine basalt (Irving and Baragar, 1971)
6 Trachybasalt (Irving and Baragar, 1971)
7 Average continental alkali basalt (Manson, 1967)

Rb and Sr values taken from Prinz (1967)

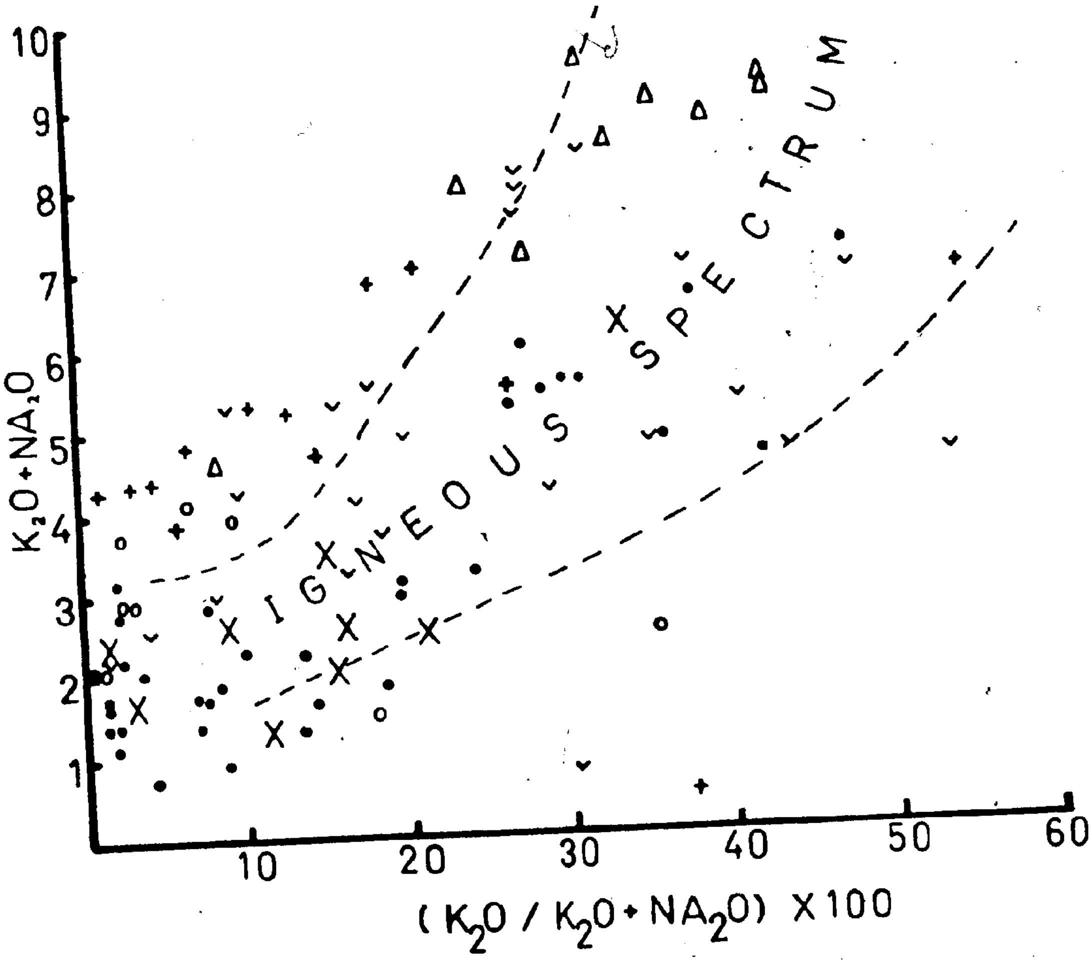

Figure 9: "Igneous Spectrum" of Hughes (1973). + - Pardy Island Formation; X - Path End Formation; ● - Wandsworth sill; o - Beaver Pond Formation; v - Mortier Bay Group; Δ - Marystown Group.

Island Formation is consistently outside Hughes' "Igneous Spectrum". However, the relatively less altered nature of these rocks compared to the others (see Chapter 4), and the other differences exhibited by the Pardy Island Formation, both petrographic and chemical (see below), suggest that its separation from the other rocks on Fig. 9 is at least in part due to primary differences.

5.3 The Burin Group

5.3.1 General Characteristics

Fig. 10 and Table 3 show that except for the cumulus ultramafic layers and the granodiorite associated with the Wandsworth sill, the Burin Group can be classified as basaltic, after Manson (1967), (note, the one analysis plotting in the silica range 55-60, is a silicified basalt).

Fig. 11 indicates the subalkaline nature of the Wandsworth sill, the Beaver Pond and Path End Formations. Twenty-three of the 30 analyses of the Wandsworth sill plot within the tholeiite field of Kuno (1968), with the other 7 plotting within the field of high alumina basalts. All 30 plot in the subalkaline field of Irvine and Baragar (1971), and all except 1 plot in the tholeiite field of MacDonald and Katsura (1968). All analyses of the Path End and the Beaver Pond basalts plot within the subalkaline field and the tholeiite field of Irvine and Baragar (1971) and MacDonald and Katsura (1964), respectively. 2 analyses of each of these formations plot within the high alumina basalt field and the rest plot within the tholeiite field of Kuno (1968).

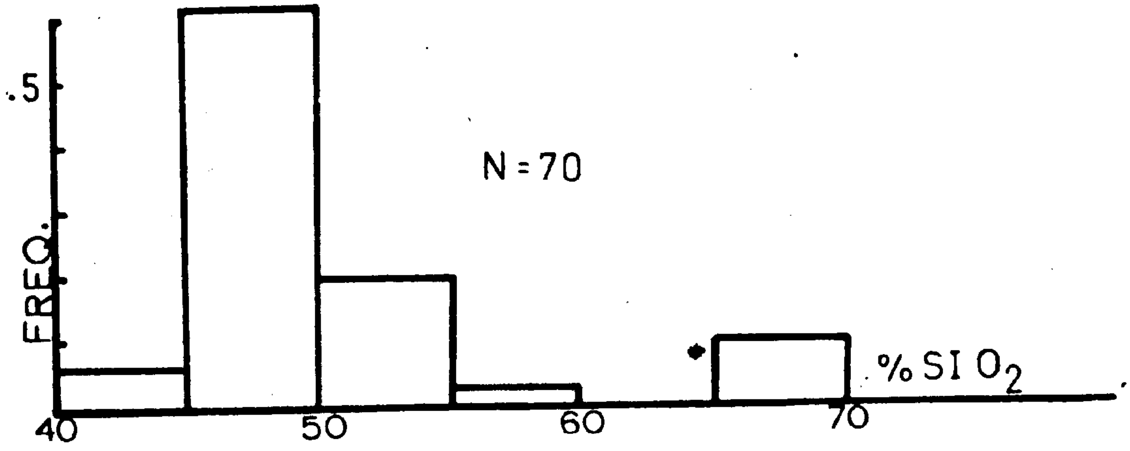

Figure 10: SiO_2 - histogram for the Burin Group.

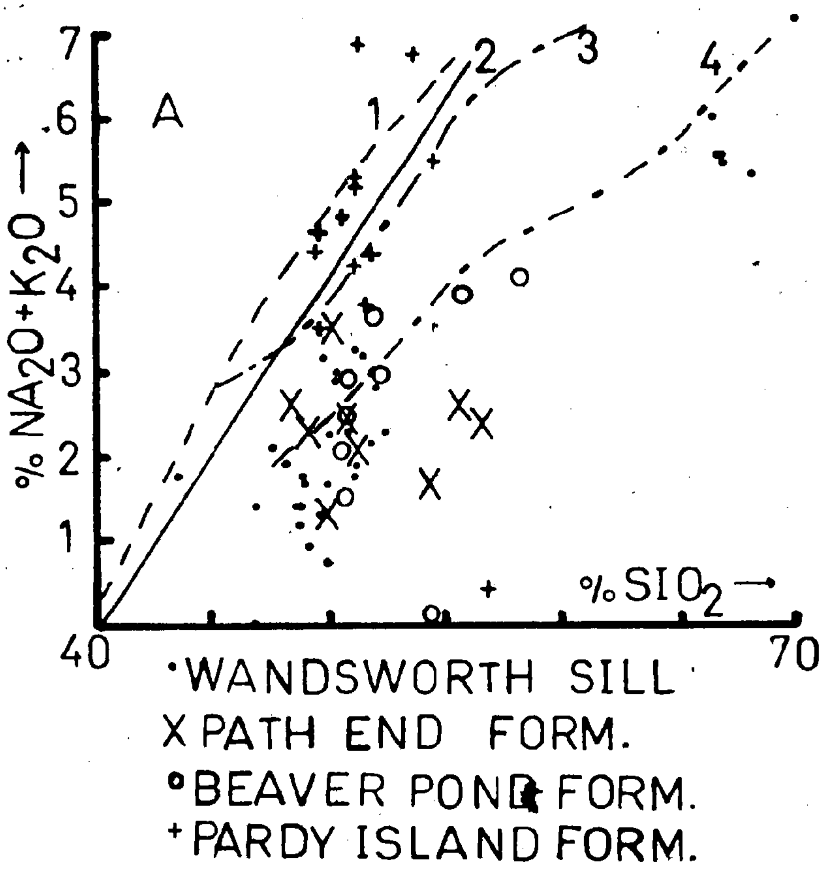

Figure 11: Alkali-silica diagram. Line 1 is Irvine and Baragar's (1971) separating alkaline (above) and sub-alkaline (below). Line 2 is MacDonald and Katsura's (1964), alkaline above and tholeiitic below. Line 3 separates alkaline (above) and high-alumina basalts and line 4 separates the latter from tholeiitic basalts (below) according to Kuno (1968).

The Pardy Island Formation exhibits a transitional nature with 2 of the 13 analyses plotting in the alkaline field of Irvine and Baragar (1971), and 7 of the 13 plotting in the alkaline field of MacDonald and Katsura (1968) and Kuno (1968). This may partially be due to metamorphic effects but other differences (higher TiO_2, K_2O and P_2O_5 in particular) are not explainable as post-depositional changes and the Pardy Island basalts are thus classed as transitional between alkali and tholeiitic basalt.

Normative classification of the Burin Group results in a range from quartz tholeiites to alkali olivine basalts, however, olivine tholeiites are by far the most common (Appendix 3). The appearance of quartz in the norms of the average Beaver Pond and Path End basalts (Table 3) is believed to be the result of silicification.

Fig. 12 suggests an oceanic affinity for the basaltic rocks of the Burin Group. Pearce et al. (1975) contend that alteration and metamorphism "tend to move oceanic rocks into the non-oceanic field". Therefore the occurrence of 42 of the 70 analyses of the Burin Group within the oceanic field is taken as evidence that these are oceanic tholeiites.

In Fig. 13 the field occupied by a composite of present day ocean-ridge samples (after Bailey and Blake, 1974) is plotted along with the Burin Group. The heavy lines show possible differentiation trends of the ridge rocks. The correspondence is striking and leaves little doubt that the Burin Group represents a suite of rocks very similar in chemistry to those forming at ocean ridges today. The scatter exhibited by the basalts may be due to alkali mobility as suggested by Bailey and Blake (1974).

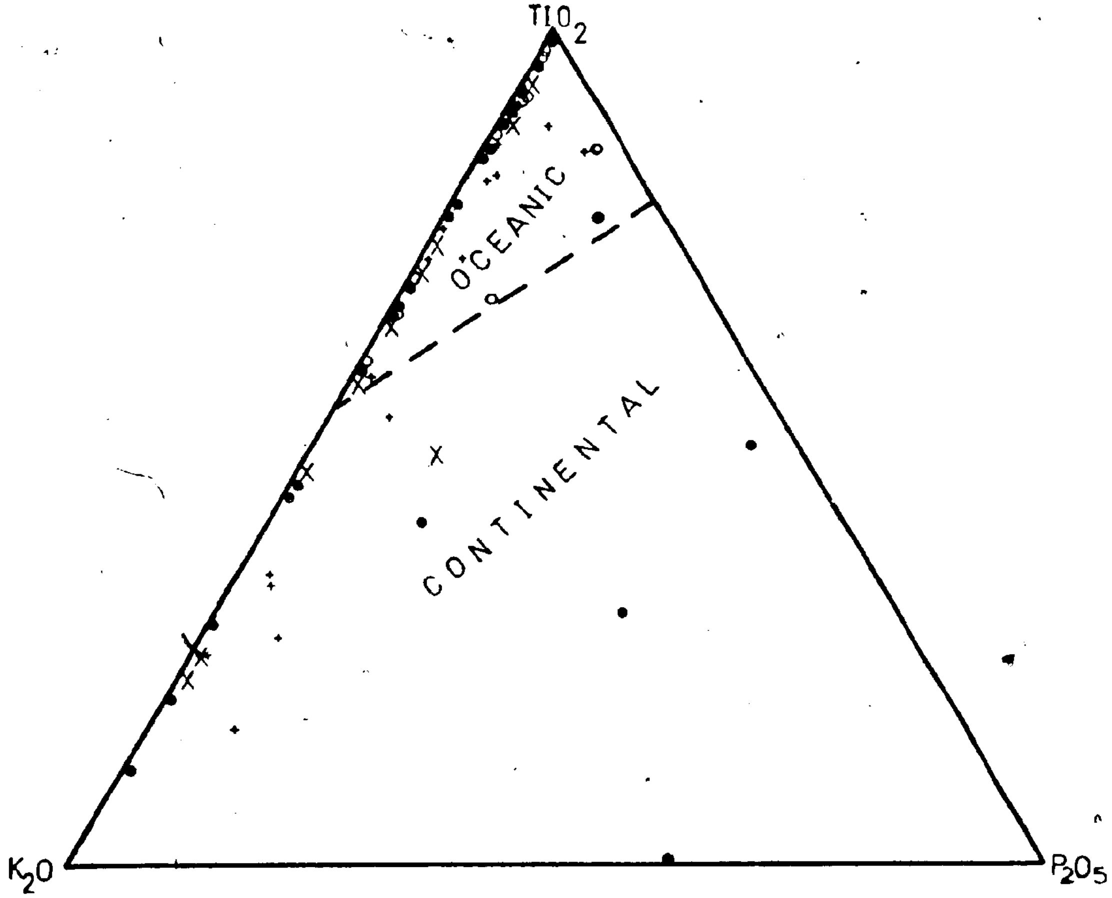

Figure 12: TiO_2 - K_2O-P_2O_5 diagram (after Pearce et al., 1975).

● Wandsworth sill
X Path End Formation
o Beaver Pond Formation
+ Pardy Island Formation

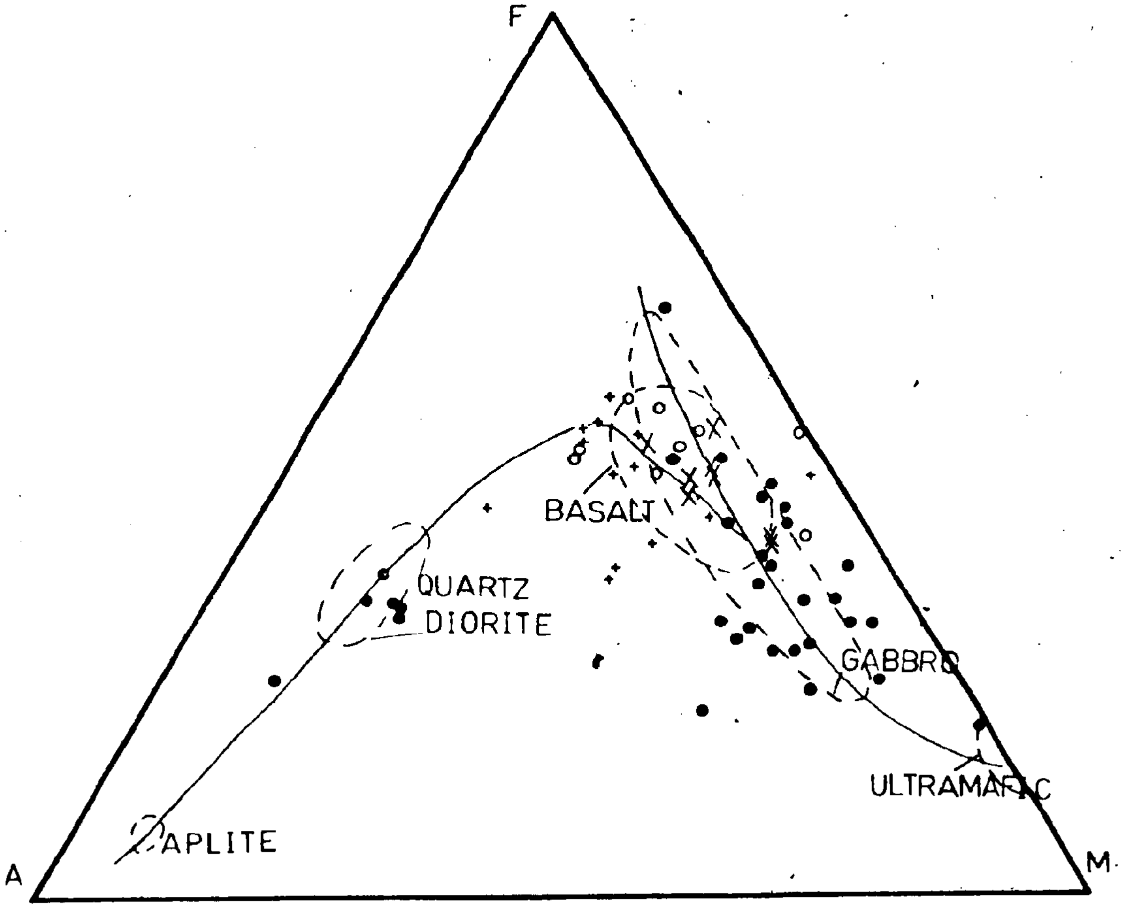

Figure 13: $A(Na_2O + K_2O)$ -F($FeO + .899Fe_2O_3$) - M(MgO) diagram. Dashed lines outline fields occupied by rocks from the mid-ocean ridges (Bailey and Blake, 1974).

- ● Wadsworth sill
- X Path End Formation
- o Beaver Pond Formation
- \+ Pardy Island Formation

It is interesting to note that although the Burin Group shows similar trends to most of the "onland" ophiolites (the Troodos and the California Coast Range in particular), it is most closely comparable to present day ocean ridge samples. This is also evident from a comparison of the average composition of the Wandsworth sill (Table 3) and a gabbro from the mid-Atlantic Ridge (Column 1, Table 4). A comparison of the basalts of the Burin Group with the olivine tholeiites of Hawaii (Column 2, Table 4) shows that the former are lower in TiO_2, P_2O_5 and MgO. They are also lower in FeO and higher in Fe_2O_3, reflecting post-crystallization oxidation effects. The Burin Group basalts are higher in Al_2O_3 but not as high as high alumina basalts nor the laminated oceanic gabbro (Table 4). The Pardy Island Formation has higher Na_2O and lower CaO, possibly in part a result of alteration although, the higher K_2O, TiO_2 and P_2O_5 also indicates a more alkalic nature for these rocks than others of the Burin Group.

5.3.2 Variation Diagrams

Fig. 14 shows the variation of major and trace elements with FeO*: MgO ratios, where FeO* = $(.899Fe_2O_3 + FeO)$. The behavior of TiO_2 suggests a different magma source for the Pardy Island Formation than for the rest of the Burin Group since the two trends cannot be explained by any normal low-pressure processes.

With this in mind, the trends of the Path End and Beaver Pond Formations and the Wandsworth sill are treated separately. They can be explained in terms of three stages of the cooling history which are shown as arrows on Fig. 14. During the first stage, Al_2O_3, CaO and Sr decrease

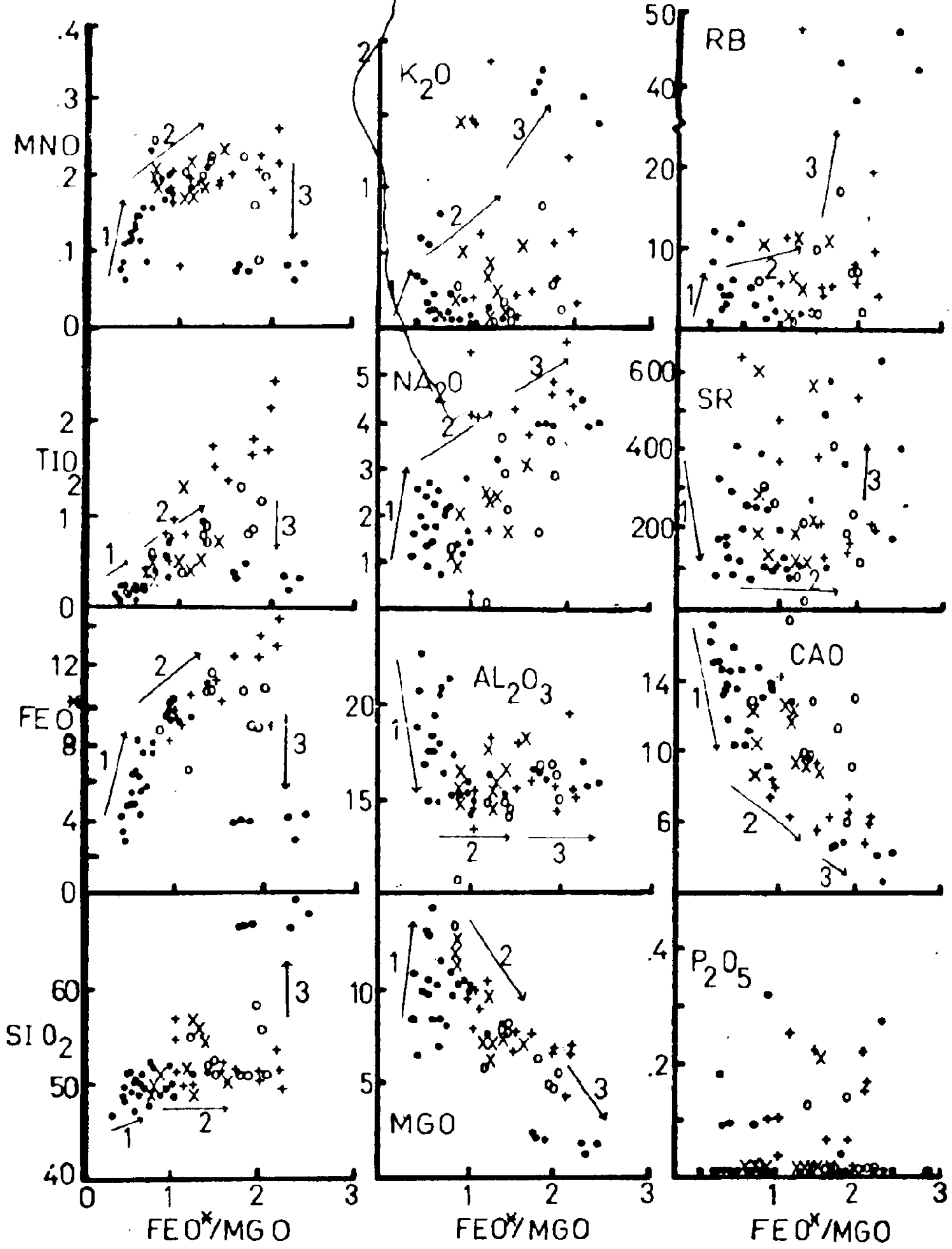

Figure 14: Variation diagrams of some major and trace elements showing the 3 stages of fractionation (arrows). FeO* (FeO + .899Fe_2O_3).

- ● Wandsworth sill
- X Path End Formation
- o Beaver Pond Formation
- + Pardy Island Formation

at an almost constant FeO*/MgO value (.4 to .6) while MgO, FeO*, MnO, Na_2O, K_2O, Rb and TiO_2 increase. SiO_2 also shows a slight increase. In the second stage Al_2O_3 and SiO_2 remain almost constant as the FeO*, MgO ratio increases (.6 to 2), TiO_2 continues to increase at the same rate, FeO, K_2O, Na_2O, Rb and MnO continue to increase but at a decreasing rate, MgO begins to decrease, Sr begins to increase and CaO continues to decrease (the high calcium in the Beaver Pond Formation may be due to alteration or it may be due to plagioclase enrichment). In the final stage TiO_2, FeO* and MnO show a sharp decrease, SiO_2, Rb, Sr and K_2O show a sharp increase, Al_2O_3 remains constant and MgO and CaO continue to decrease.

This type of behavior is most simply explained by the fractionation of plagioclase during stage 1 (with the formation of plagioclase cumulates), both plagioclase and clinopyroxene during stage 2 and plagioclase, clinopyroxene and opaques (titaniferous magnetite) during stage 3.

The high concentration of Sr in the late differentiates may be the result of the high proportion of plagioclase in these rocks. The behavior of P_2O_5 at this stage is not known but it was usually below the limits of detection.

The fractionation trend of the Pardy Island Formation, with its constant Al_2O_3 and SiO_2, increasing FeO, MnO and TiO_2 and decreasing MgO and CaO can most simply be explained by the fractionation of clinopyroxene and plagioclase in constant proportions.

It should be noted that fractionation of small amounts of other minerals, such as orthopyroxene and olivine, is not ruled out by the trends shown, but since these were observed only in the Pardy Island basalts (and orthopyroxene was metastable) (Chapter 4) they are not believed to have been important phases in the rest of the Burin Group.

5.3.3 Normative Basalt Tetrahedron

Figures 15, 16 and 17 show the relationships within the Burin Group when plotted on projections within the basalt tetrahedron (Yoder and Tilley, 1962). The solid lines indicate phase boundaries within the synthetic system and the dashed lines are for the natural system (at 1 atm.) as determined by the experimental work of Tilley et al. (1963, 1964, 1965, 1967) and Greene and Ringwood (1967).

The projection from quartz onto the OL.-CPX.-PLAG. plane, Fig. 15, shows that norms of the Beaver Pond and Path End Formations and the Wadsworth sill do not plot along any kind of a single-mineral control line. The clustering of points around the natural cotectic QTZ. + OL. + CPX + LIQ. would indicate that olivine should be an important phase, however the petrography and variation diagrams indicate that olivine is insignificant if present at all. This suggests that the phase boundaries should be shifted towards the OL. corner. This is also true for the Pardy Island which, although it has some olivine, is dominated by plagioclase and clinopyroxene.

The clinopyroxene projection onto the OL. -PLAG.-NE.-QTZ. plane, Fig. 16, indicates that the natural cotectics should be moved towards the OL corner in order to agree more closely with the observed relationships. This may be due to the intermediate composition (i.e. low TiO_2, K_2O and P_2O_5) of the Burin Group between those used in the natural and

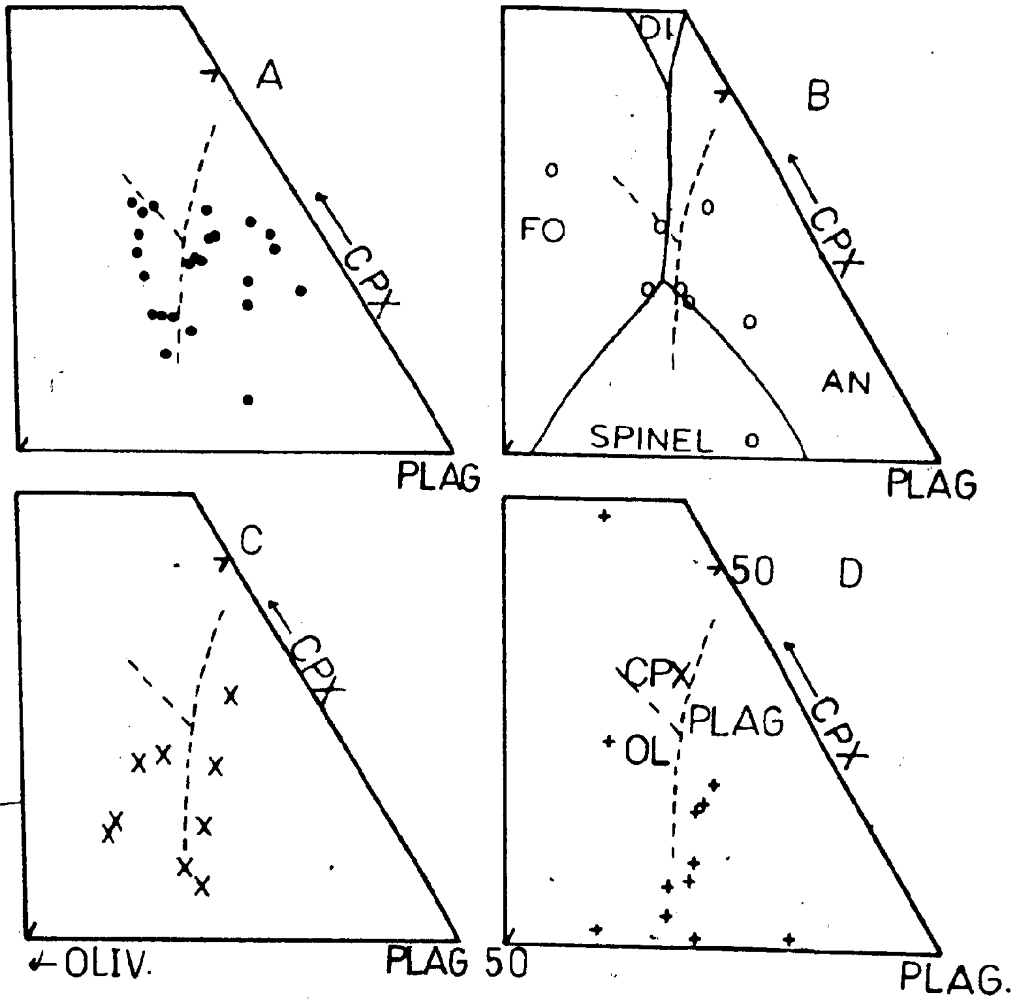

Figure 15: Basalt tetrahedron (Yoder and Tilley, 1962). Projection from quartz onto CPX.-PLAG.-OL. plane. A - Wandsworth sill; B - Beaver Pond Formation; C - Path End Formation; D - Pardy Island Formation.

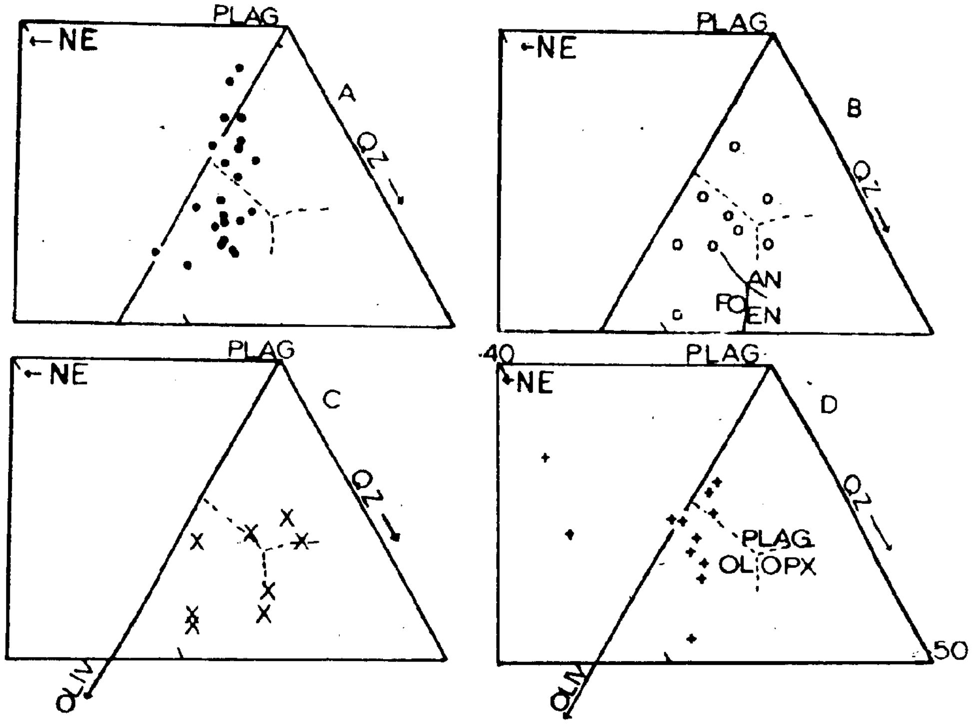

Figure 16: Clinopyroxene projection onto the PLAG.- OL.- QTZ.- NE. plane. A - Wandsworth sill; B - Beaver Pond Formation; C - Path End Formation; D - Pardy Island Formation.

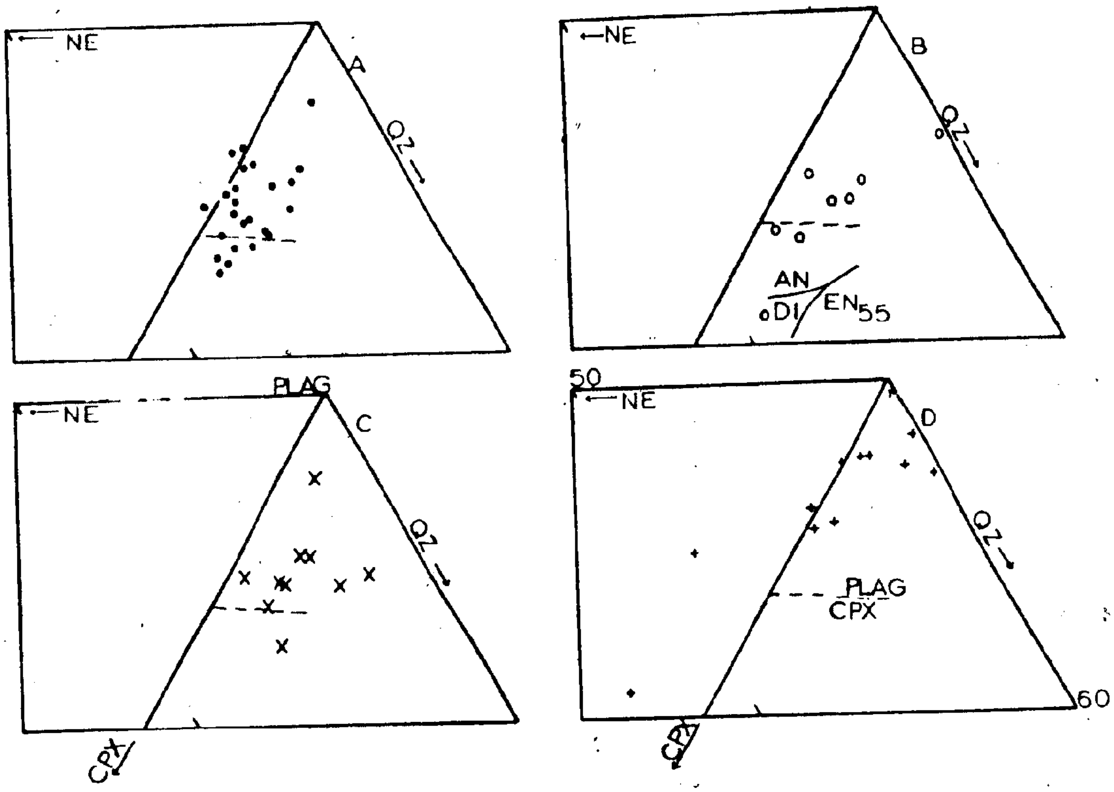

Figure 17: Olivine projection onto PLAG.- CPX.- NE.- QTZ. plane. A - Wandsworth sill; B - Beaver Pond Formation; C - Path End Formation; D - Pardy Island Formation.

those used in the synthetic system, or it may reflect a higher pressure origin for these lavas.

In the olivine projection onto the CPX.- PLAG.- NE.- QTZ. plane, Fig. 17, the Burin Group (except for the Pardy Island) forms an elongated field parallel to the clinopyroxene-plagioclase join straddling the CPX.- PLAG.- OL.- Liquid cotectic in the natural system, in agreement with the observed phase relations. The fact that the Pardy Island plots wholly within the PLAG. field may be due to an alteration effect.

5.3.4 CMAS Projections

Figs. 18 and 19 show two projections of the Burin Group within the CMAS system (O'Hara, 1968). The pressure-dependent positions of the cotectics are plotted. These cotectics are described by the equilibrium OL. + OPX. + CPX. + PLAG. (at low pressure) + LIQ., Fig. 18 is in agreement with the observed importance of clinopyroxene, with the points of the Pardy Island Formation (b) clustering at slightly higher pressures than the rest of the Burin Group (a).

The relationships can be seen more clearly on Fig. 19, the olivine projection. If the above mentioned fact, that the Burin Group is intermediate in composition to those used in the synthetic system and those used in the natural system, is considered, the natural cotectics would be shifted towards the MS corner. When this is done, it becomes apparent that the Wandsworth sill and the Beaver Pond and Path End Formations equilibrated under near-surface conditions (1 atm.) by the crystallization of plagioclase and clinopyroxene.

The Pardy Island Formation, on the other hand, appears to have

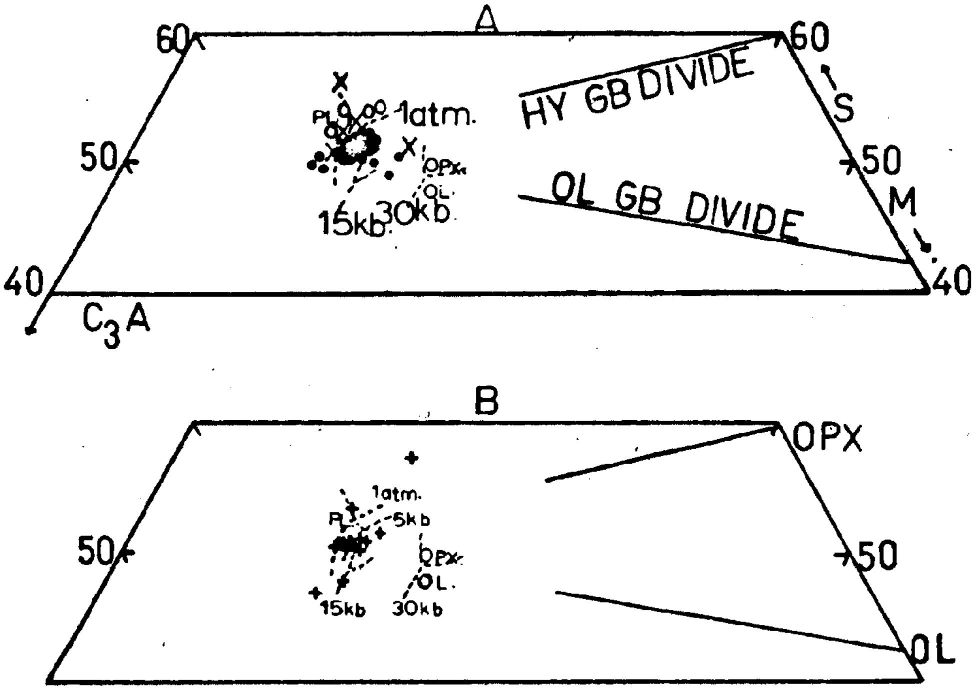

Figure 18: CMAS tetrahedron (O'Hara, 1968). Diopside (CMS_2) projection onto C_3A-M-S. A - Wandsworth sill (●), Beaver Pond Formation (o), Path End Formation (X); B - Pardy Island Formation (+).

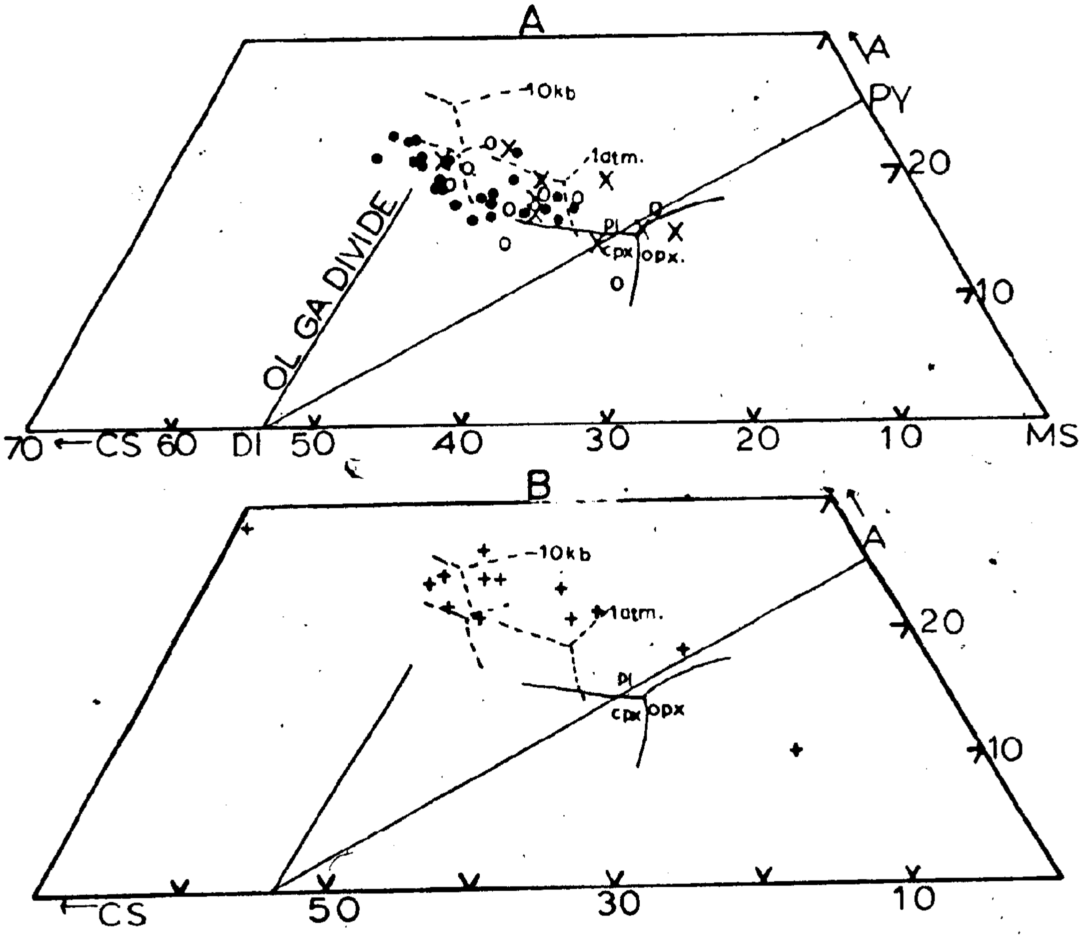

Figure 19: CMAS tetrahedron (O'Hara, 1968). Olivine (M_2S) projection onto CS-MS-A. A - Wandsworth sill (●), Beaver Pond Formation (o), Path End Formation (X); B - Pardy Island Formation (+). Broken lines - natural system; solid lines - synthetic system.

equilibrated at higher pressures (10 Kb) by the crystallization of orthopyroxene, clinopyroxene and plagioclase.

These observations are in agreement with the petrography (Chapter 4). The occurrence of orthopyroxene cores in the Pardy Island Formation in particular supports the suggestion that it formed under higher pressure than the rest of the Burin Group.

5.4 The Marystown and Mortier Bay Groups

5.4.1 General Characteristics

Fig. 20 shows that the Mortier Bay Group is a bimodal suite with basalts (Creston Formation) having a silica range of 40% to 50% (one sample containing 53 per cent silica is altered) and rhyolites with silica contents between 70 per cent and 80 per cent. The Marystown Group (within the map area) is dominantly acidic with rhyolites ranging from 65 per cent to 80 per cent silica, although abundant basalts are present outside the map area. One rock of andesitic composition is shown but this rock type is rare. Outside the map area the Marystown Group is described as a bimodal suite (Strong <u>et al.</u>, 1976) and these rocks are discussed along with the Mortier Bay Group.

Fig. 21 shows that 14 of the 18 basalts of the Creston Formation plot within the alkali field of MacDonald and Katsura (1964) and of Irvine and Baragar (1971). Fig. 9 indicates that although there appears to have been a redistribution of Na_2O and K_2O, only 4 of the analyses plot in the spilitic field and the average analysis plots within the alkali basalt field (Hughes, 1973), suggesting that the samples analyzed

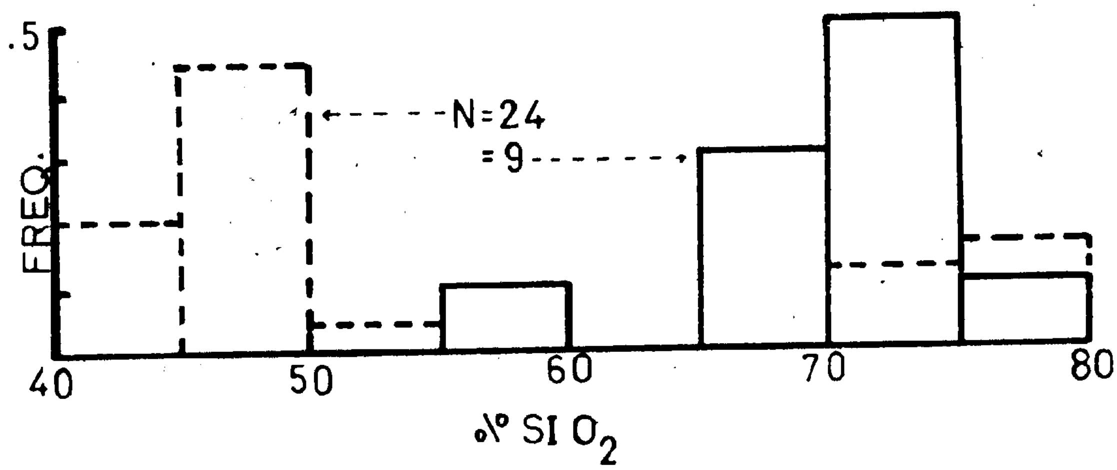

Figure 20: SiO_2 - Histogram of Marystown (solid line) and Mortier Bay (dashed line) Groups.

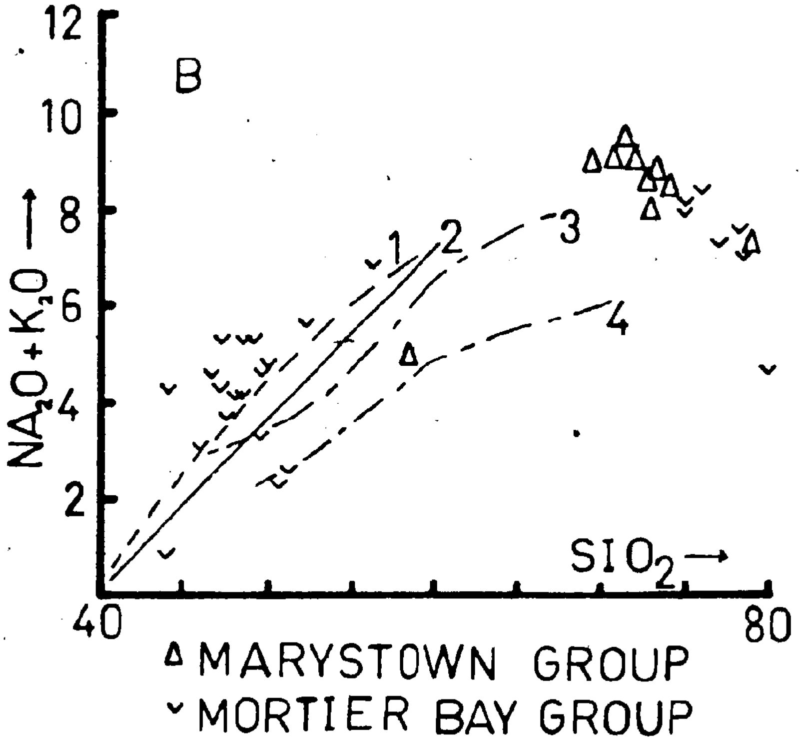

Figure 21: Alkali - silica diagram. Lines as in Figure 11.

cover the range from alkali-leached to alkali-enriched. The rhyolites of the Cashel Lookout Formation and Marystown Group show a sharp decrease in alkalis with increasing silica apparently due to removal of alkali feldspars.

The basalts range from slightly quartz normative to slightly nepheline normative, with most being olivine normative (Appendix 3, and Table 3). A substantial number (7) of the analyses are corundum normative reflecting the low CaO content of these rocks (Table 3). The rhyolitic rocks are mostly corundum normative.

The average analysis of the Creston Formation (Table 3) is most similar to the "K-poor" alkali basalts (column 5, Table 4). The former have higher Al_2O_3 and Fe_2O_3 (with a corresponding lower FeO, indicating oxidation). TiO_2 and CaO are lower.

The "non-oceanic" nature of the Creston basalts is indicated by Fig. 22, where only 3 analyses plot slightly within the oceanic field. Fig. 23 shows the comparison of the fractionation trend of the Mortier Bay and Marystown Groups with the "alkali trend" of Irvine and Baragar (1971).

The small number of analyses and the scatter due to alkali metasomatism preclude any meaningful discussion of the petrogenesis of these rocks at this time. However, it is evident from the AFM diagram (Fig. 23) the Mortier Bay Group could have originated from more advanced differentiation in the same magma which produced the Marystown Group.

It should also be noted that the position of the Anchor Drogue Pluton on Fig. 23 is in agreement with the proposal that it is cogenetic with the Marystown Group (Chapter 3). Also the boulders found within

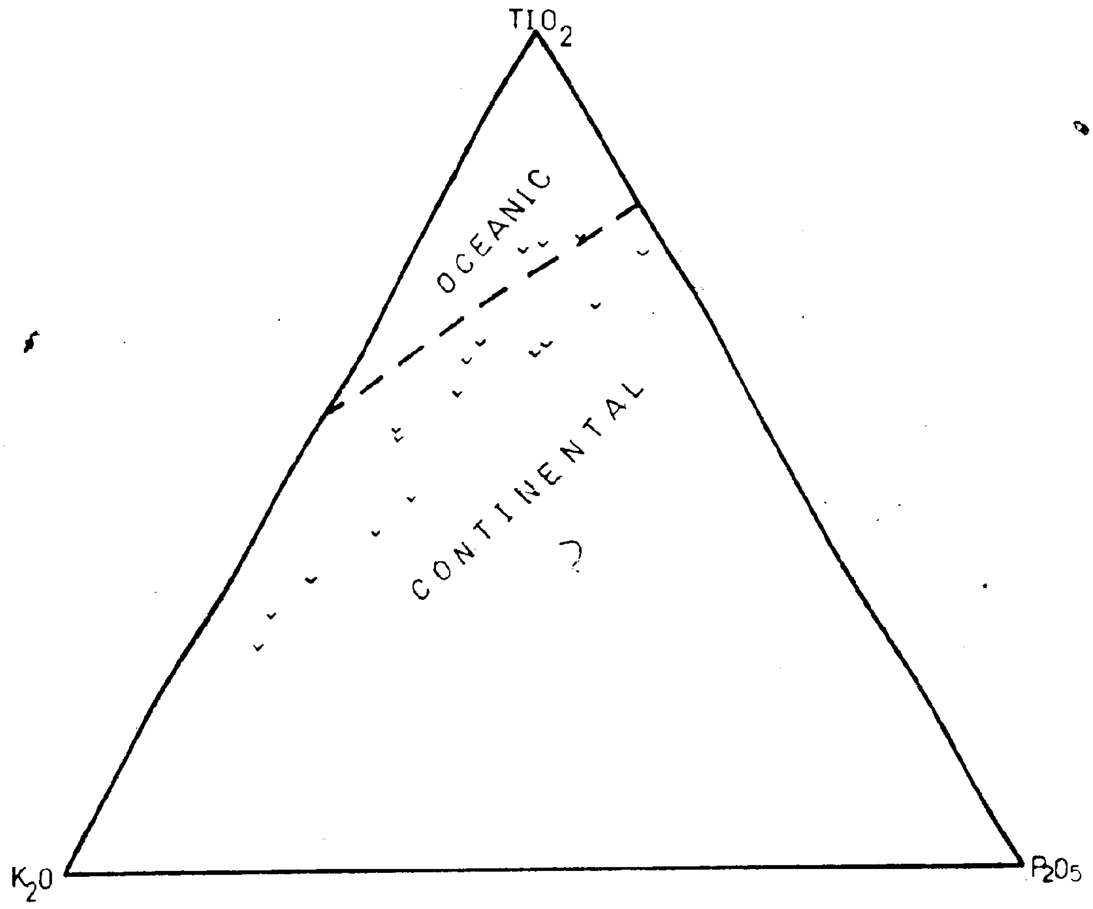

Figure 22: TiO_2 - K_2O - P_2O_5 diagram (after Pearce et al., 1975) for the Creston Formation.

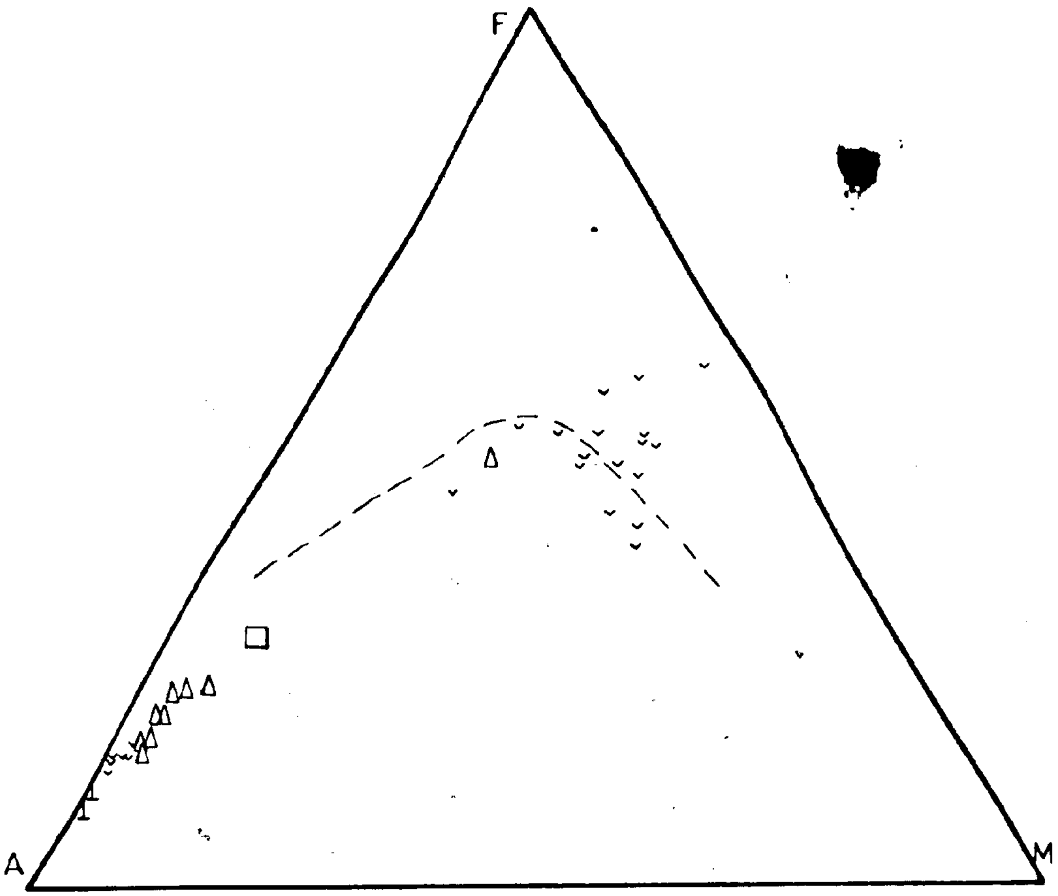

Figure 23: A($Na_2O + K_2O$), F($FeO + .899Fe_2O_3$), M(MgO) diagram.

v - Mortier Bay Group
Δ - Marystown Group
⊥ - Boulders in Rock Harbour conglomerate.
□ - Anchor Drogue Pluton

the Rock Harbour Group are more alkalic than other rocks in the map area.

The scarcity of intermediate rock types and the alkalic nature of the Marystown and Mortier Bay Groups suggests a tensional environment at the time of volcanism (Martin and Piwinskii, 1972).

5.5. Summary and Discussion

Evidence has been given which suggests that there has been three types of volcanism and intrusions within the map area: (1) ocean ridge tholeiites (the Wandsworth sill and the Path End and Beaver Pond Formations); (2) oceanic basalts which equilibrated at higher pressures than the Type 1 and are transitional between theoliites and alkali basalts (the Pardy Island Formation), and (3) "non-oceanic" alkali basalts and rhyolites (the Mortier Bay and Marystown Groups).

Type 3 volcanism is the only one which presently finds an analog elsewhere in the Avalon Zone. Papezik (1971) has indicated that the Harbour Main Group is a bimodal, mildly alkalic suite and Malpas (1972) describes the Bull Arm Formation as a bimodal suite (although he ascribes their alkalic nature to metasomatism). These rocks have apparently formed under similar tectonic conditions as the Mortier Bay and Marystown Groups.

All three types of volcanism are the result of "nonorogenic" magmatism (Martin and Pewinskii, 1972).

CHAPTER VI

CONCLUDING STATEMENTS

As a result of the geological mapping and the petrographic and geochemical work described in the preceeding chapters it is possible to draw the following conclusions:

1. The Marystown map sheet (E/2) is underlain by rocks ranging in age from Late Precambrian to Middle Cambrian (with some younger dykes).
2. The map area is divided by faults, the Lewins Cove and the Little Bay, into three segments, each characterized by different rock sequences.
3. The SE -segment (including the Rock Harbour and Burin Groups and the Wandsworth sill) consists of a Late Precambrian sequence beginning with shallow to deep water marine sedimentary rocks which had as their source area, a dominantly acid volcanic - marine sedimentary terrain not outcropping within the map area. These are overlain by pillow basalts, hyaloclastites and marine tuffaceous sandstones intruded by a gabbroic to granodioritic sill and related dykes.
4. The Rock Harbour Group is lithologically similar to the marine sedimentary rocks of the "Lower Assemblage" found elsewhere within the Avalon zone.
5. The Pardy Island Formation of the Burin Group is petrologically and geochemically distinct from the rest of that group and the Wandsworth sill.
6. The Path End and the Beaver Pond Formations and the Wandsworth

sill are a comagmatic suite which formed under similar conditions to those found at present ocean ridges, i.e. equilibration of magma under low pressure conditions.

7. The Pardy Island Formation was derived from a magma which equilibrated at greater pressures than the rest of the Burin Group.

8. The setting for the SE -segment was a shelf slope environment which changed to an environment of tholeiitic volcanism as a result of rifting apart of continental crust.

9. The Burin Group and Wandsworth sill are lithologically, petrologically and geochemically distinct from any rock group yet reported within the Avalon zone of Newfoundland. It thus represents a relatively local episode of oceanic volcanism at a time when the rest of the Avalon zone was undergoing continental volcanism. The Pardy Island Formation may represent a transitional phase between the two.

10. The NW- segment (including the Mortier Bay and Marystown Groups and the Anchor Drogue Pluton) consists of a Late Precambrian sequence (with depositional unconformities) of subaerial pyroclastic and flow rocks with minor volcanogenic sedimentary rocks. These are intruded by a co-magmatic quartz monzonite.

11. The volcanic rocks of the NW- segment are chemically and lithologically bimodal with the Mortier Bay Group representing a more differentiated but possibly the same magma as that of the Marystown Group and the Anchor Drogue Pluton.

12. The setting for the NW- segment was one of continental crust

under tensional forces resulting in periodic alkalic volcanism and contemporaneous erosion of the volcanic rocks and deposition under fluviatile conditions of volcanogenic sediments.

13. The Marystown and Mortier Bay Groups are lithologically and chemically similar to the subaerial volcanic rocks of the "Lower Assemblage" found elsewhere on the Avalon zone.

14. The central segment (Inlet Group) is underlain by a conformable sequence of subaerial to shallow marine sedimentary rocks ranging in age from Latest Precambrian (earliest Cambrian?) to Middle Cambrian.

15. The setting for the central segment was one of deposition of clastic sediments, derived predominantly from acid volcanics, in an intertidal environment which changed gradually to a shallow marine environment. This change was accompanied by a reduction in clastic sedimentation and an increase in calcite deposition. The youngest sedimentary rocks of the map area were deposited under lagoonal conditions.

16. Using the regional terminology of King <u>et al</u>. (1974), the Bay View Formation bears lithological similarities to both the Middle Assemblage as it occurs to the east and north within the Avalon zone and to the Upper Assemblage as it occurs to the west. The rest of the Inlet Group is lithologically similar to the Upper Assemblage of the eastern Avalon.

17. Since deposition of the youngest sedimentary rocks of the area, the strata have been intruded by dykes of unknown age.

18. The area was affected by one period of compressional stress

during the Acadian Orogeny. This resulted in the formation of asymmetric folds with axial planes striking to the northeast and dipping to the northwest as well as similarly oriented thrust faults.

19. Metamorphism is not related to the period of folding but mostly to burial effects or contact metamorphic effects.

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APPENDIX 1

Individual descriptions of representative, analyzed specimens.

Formation	Sample No.	Groundmass	Phenocrysts	Alteration	Comments
Pardy Island	T238B	Felty - plagioclase laths, pyroxene and opaques.	Large, twinned augites; small plagioclases.	Pyroxene to chlorite; plagioclase to sericite.	Clinopyroxene shows a reaction with the matrix (chlorite) and sometimes has an altered opx core.
	T404	Felty - plagioclase laths, pyroxene and opaques.	Large, twinned augites; small plagioclases; a few, olivines.	Clinopyroxene to chlorite; plagioclase to sericite and epidote; olivine to serpentine.	Augite shows a reaction with the matrix (chlorite).
Path End	T255B	Altered	Microphenocrysts of pyroxene now actinolite	Epidote actinolite and quartz.	Schistose and difficult to recognize primary features.
	T332	Altered	Plagioclase and pyroxene.	Actinolite, calcite, sericite, epidote and quartz.	Recognition of primary features is difficult.
Beaver Pond	T177	Fine grained and obscured by hematization.	None	Epidote and hematite.	Epidote is concentrated in and near veinlets.
	T390	Fine grained and altered.	None	Epidote, actinolite, albite.	Quartz and calcite veinlets.
Wandsworth Sill	172		Pyroxene and plagioclase (50-50).	Pyroxene altered to actinolite.	Plagioclase is altered to a high relief mineral, probably hydrogrossular.
	T034A		Opaques (5%), Qtz. (5%), Pyroxene (50%), and plagioclase (40%).	Actinolite after pyroxene.	Plagioclase is altered to epidote and hydrogrossular (?).
	T034B		Qtz. (30%), Feldspar (60%), Ferromagnesians (10%).	Epidote, calcite and sericite.	Pressure shadows in Quartz.
Creston	T407	Opaques, chlorite and plagioclase.	Plagioclase	Chlorite, calcite, epidote, quartz and zeolite.	Plagioclase phenocrysts are ~~small and altered~~ (calcite).
	T410	Opaques, plagioclase and cpx.	Plagioclase	Chlorite, calcite, albite and sericite.	Refilling of amygdules by residual basaltic fluids.
Marystown	T088	Feldspar and quartz.	Plagioclase, orthoclase and ferromagnesians.	Chlorite epidote and sericite.	Mafic material is scarce and altered to chlorite, magnetite and epidote.

APPENDIX 2

Preparation, Method of Analysis and Accuracy of Analysis

Rocks exhibiting the least apparent alteration and weathering were selected for analysis. These were broken into pieces using a sledge (weathered fragments and veins were discarded). The pieces were crushed to 1/2 inch chips with a jaw-crusher and pulverized in a tungsten-carbide TEMA swing mill to -200 mesh.

The major elements excluding P_2O_5, were analyzed using a Perkin Elmer 303 Atomic Absorption Spectrometer. .2 grams of sample were disolved in 5 cc of HF. This was further diluted with 50 cc of saturated boric acid and made up to 200 cc with distilled water. Further dilutions for CaO and MgO were made for comparison with standard blends, both artificial and U.S.G.S. rock standards. For CaO and MgO, 10 cc of La_2O_3 and 5 cc of HCl were added per 50 cc solutions to act as a releasing agent to suppress the interference of aluminum and phosphorus with these determinations. Accuracy of Atomic Absorption analysis is given in Table 5.

Trace elements were determined using a Phillips PW 1450 computerized spectrometer. A standard program to analyze only six trace elements was used (U was found to be below detection in most samples). The powders were pressed at 30 tons for 1 minute with 10% SOMAR mix as a binding agent. A molybdenite X-ray tube and LiF (200, 220) analyzer crystals were used. Excitation was 80 kV and 30 mA. The results were matrix corrected using X-RAY - 50 provided by Phillips. Accuracy and precision of these results are given in Tables 6 and 7 respectively.

Table 5. Accuracy of Atomic Absorption

Wt. %	A	B
SiO_2	54.36	54.38
TiO_2	2.24	2.28
Al_2O_3	13.56	13.45
Fe_2O_3	13.40	13.36
CaO	6.94	6.82
MgO	3.46	3.48
Na_2O	3.26	3.22
K_2O	1.67	1.65
MnO	0.19	0.19

A = Abbey's proposed values.
B = Values obtained in this study.

Table 6. Accuracy of trace element determinations.

PPM	Standard Values (BCR-1)	Values obtained in this study.
Rb	46.6	46.5
Sr	330	336
Th	6.0	2.5
Pb	15	15
Ga	23	21

Table 7. Precision of trace element determinations.

Element	No. of Determinations (on T 366)	Mean	Standard Deviation
Rb	16	3.8	.5
Sr	16	378.9	3.3
Th	16	2.0	.3
Pb	16	6.4	1.2
Ga	16	16.4	1.3

APPENDIX 3

Major element oxides, trace elements and C.I.P.W. Norms [*]

(- = not determined)

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[*] See Appendix 4

PARDY ISLAND FORMATION

SAMPLE	T372	T118A	T366	T389B	T238B	T289	T340
SIO2	49.80	45.60	50.70	52.90	52.50	47.70	49.50
TIO2	1.80	0.89	1.49	0.50	0.72	2.00	1.32
AL2O3	14.00	11.50	15.20	12.40	14.90	14.30	15.30
FE2O3	5.51	4.37	3.60	4.69	1.28	2.97	6.17
FEO	8.34	4.23	6.61	4.61	6.42	9.54	6.40
MNO	0.22	0.07	0.18	0.19	0.16	0.20	0.19
MGO	6.73	7.99	6.48	9.38	7.50	5.98	7.23
CAO	7.44	13.05	9.17	7.84	7.63	5.49	6.05
NA2O	4.46	3.74	4.11	0.28	3.95	4.27	3.50
K2O	0.31	0.59	0.19	0.15	1.35	0.60	0.21
P2O5	0.05	0.02	0.0	0.0	0.09	0.13	0.05
H2O	2.69	8.38	3.13	5.93	2.68	6.16	5.33
TOTAL	101.35	100.43	100.86	98.87	99.18	99.34	101.25
SR	156	475	380	111	652	225	142
RB	6	12	4	6	29	10	5
TH	1	4	2	2	3	0	1
U	0	0	0	0	0	0	0
GA	20	16	16	15	19	22	18
PB	10	9	6	7	6	8	7
Q	0.0	0.0	0.0	17.18	0.0	0.0	0.0
OR	1.86	3.80	1.15	0.96	8.27	3.81	1.30
AB	38.00	13.21	35.67	2.56	34.63	38.49	31.03
AN	17.58	14.00	23.04	34.70	19.62	19.44	26.63
NE	0.22	11.53	0.0	0.0	0.0	0.0	0.0
COR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DIO	16.31	45.67	19.36	5.91	15.38	7.41	3.69
HY	0.0	0.0	4.92	35.32	9.54	8.26	27.09
OL	20.21	7.52	10.73	0.0	8.68	15.49	5.23
MAG	2.21	2.37	2.23	2.35	2.25	2.34	2.28
ILM	3.48	1.84	2.90	1.03	1.42	4.08	2.63
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AP	0.12	0.05	0.0	0.0	0.22	0.32	0.12

PARDY ISLAND FORMATION

```
SAMPLE  *    T404  *    T385  *   T230A  *  6-73-5  *     64A  *     210  *     209  *

  SIO2  *   51.00  *   49.80  *   47.60  *   48.50  *   51.80  *   40.40  *   57.00  *
  TIO2  *    0.80  *    1.60  *    2.32  *    1.66  *    1.63  *    0.65  *    0.75  *
 AL2O3  *   14.20  *   15.20  *   14.50  *   17.00  *   18.80  *   14.90  *   16.80  *
 FE2O3  *    1.79  *    6.03  *    5.98  *    1.90  *    3.18  *    2.38  *    2.69  *
   FEO  *    7.57  *    6.69  *    8.61  *    8.98  *    5.55  *    6.33  *    6.52  *
   MNO  *    0.18  *    0.20  *    0.25  *    0.18  *    0.17  *    0.16  *    0.12  *
   MGO  *    9.40  *    6.27  *    6.57  *    7.24  *    4.07  *    8.49  *    2.81  *
   CAO  *    7.26  *    6.34  *    5.90  *    5.20  *    4.51  *    5.20  *    2.22  *
  NA2O  *    5.44  *    4.65  *    4.08  *    4.00  *    5.40  *    1.35  *    3.12  *
   K2O  *    1.44  *    0.55  *    0.13  *    0.05  *    1.16  *    1.51  *    3.42  *
  P2O5  *    0.09  *    0.0   *    0.14  *    0.20  *    0.20  *    0.20  *    0.40  *
   H2O  *    4.41  *    3.37  *    5.19  *    5.87  *    3.86  *    9.25  *    4.91  *
 TOTAL  *  103.58  *  100.70  *  101.27  *  100.78  *  100.33  *   90.82  *  100.76  *

    SR  *     381  *     176  *     216  *     227  *     573  *     118  *     127  *
    RB  *      28  *       8  *       4  *       5  *      20  *      47  *      78  *
    TH  *       3  *       1  *       0  *       -  *       -  *       -  *       -  *
     U  *       0  *       0  *       0  *       -  *       -  *       -  *       -  *
    GA  *      19  *      19  *      23  *       -  *       -  *       -  *       -  *
    PB  *       8  *       6  *       7  *       -  *       -  *       -  *       -  *

     Q  *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *   13.18  *
    OR  *    8.58  *    3.36  *    0.80  *    0.31  *    7.12  *   10.95  *   21.11  *
    AB  *   27.74  *   40.62  *   36.10  *   35.68  *   47.45  *   14.02  *   27.58  *
    AN  *   10.16  *   19.59  *   21.62  *   25.83  *   21.89  *   30.08  *    8.80  *
    NE  *   10.12  *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *
   COR  *    0.0   *    0.0   *    0.0   *    1.46  *    0.97  *    2.53  *    5.10  *
   DIO  *   20.73  *   10.67  *    6.51  *    0.0   *    0.0   *    0.0   *    0.0   *
    HY  *    0.0   *    0.15  *   11.20  *   23.51  *    6.61  *   32.81  *   19.50  *
    OL  *   18.71  *   20.22  *    6.33  *    7.11  *   10.00  *    4.86  *    0.0   *
   MAG  *    2.19  *    2.25  *    2.27  *    2.29  *    2.26  *    2.67  *    2.27  *
   TLM  *    1.53  *    3.14  *    4.61  *    3.32  *    3.21  *    1.52  *    1.49  *
    HM  *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *
    AP  *    0.21  *    0.0   *    0.34  *    0.49  *    0.48  *    0.57  *    0.97  *
```

PATH END FORMATION

```
SAMPLE  *     T195 *    T116A *    T255B *    T281A *     T332 *    T083C *    T083D *

  SIO2  *    54.00  *   46.40  *   51.00  *   48.10  *   48.50  *   48.80  *   46.70  *
  TIO2  *     0.48  *    1.20  *    0.48  *    0.68  *    0.44  *    0.38  *    0.40  *
 AL2O3  *    13.80  *   14.60  *   17.30  *   17.40  *   13.90  *   15.20  *   15.60  *
 FE2O3  *     2.62  *    3.60  *    3.66  *    4.52  *    0.42  *    2.69  *    2.39  *
   FEO  *     4.38  *    7.10  *    4.93  *    6.85  *    9.23  *    6.37  *    6.64  *
   MNO  *     0.16  *    0.20  *    0.16  *    0.22  *    0.17  *    0.19  *    0.19  *
   MGO  *     5.84  *    8.78  *    7.05  *    6.90  *   12.00  *   11.18  *   11.18  *
   CAO  *    11.85  *   11.10  *   12.65  *    8.42  *    8.31  *   12.38  *    9.81  *
  NA2O  *     2.25  *    2.13  *    1.73  *    2.91  *    1.90  *    1.15  *    0.86  *
   K2O  *     0.03  *    0.39  *    0.32  *    0.50  *    0.48  *    0.15  *    1.35  *
  P2O5  *     0.0   *    0.0   *    0.0   *    0.19  *    0.0   *    0.0   *    0.0   *
   H2O  *     3.40  *    3.87  *    2.84  *    4.46  *    4.43  *    3.74  *    6.90  *
 TOTAL  *    98.81  *   99.37  *  102.12  *  101.15  *   99.78  *  102.23  *  102.02  *

    SR  *      125  *     193  *     615  *     568  *     134  *     308  *     251  *
    RB  *        1  *      12  *       7  *      11  *      11  *       3  *      30  *
    TH  *        3  *       2  *       3  *       1  *       1  *       2  *       2  *
     U  *        0  *       0  *       0  *       0  *       0  *       0  *       0  *
    GA  *       12  *      20  *      18  *      17  *      12  *      16  *      16  *
    PB  *        5  *       8  *      10  *       6  *       5  *       6  *       6  *

     Q  *    10.24  *    0.0   *    2.40  *    0.0   *    0.0   *    0.0   *    0.0   *
    OR  *     0.19  *    2.42  *    1.91  *    3.07  *    2.97  *    0.90  *    8.40  *
    AB  *    19.98  *   18.92  *   14.78  *   25.55  *   16.84  *    9.89  *    7.66  *
    AN  *    28.83  *   30.57  *   38.86  *   34.18  *   29.32  *   36.47  *   36.54  *
    NE  *     0.0   *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *
   COR  *     0.0   *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *
   DIO  *    26.70  *   22.19  *   19.96  *    6.51  *   11.20  *   20.95  *   11.84  *
    HY  *    10.83  *    7.27  *   18.98  *   15.15  *   27.30  *   24.44  *   22.48  *
    OL  *     0.0   *   13.96  *    0.0   *   11.50  *    9.21  *    4.40  *   10.00  *
   MAG  *     2.28  *    2.28  *    2.20  *    2.26  *    2.28  *    2.21  *    2.29  *
   ILM  *     0.96  *    2.39  *    0.92  *    1.34  *    0.88  *    0.73  *    0.80  *
    HM  *     0.0   *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *    0.0   *
    AP  *     0.0   *    0.0   *    0.0   *    0.46  *    0.0   *    0.0   *    0.0   *
```

PATH END FORMATION

```
SAMPLE   *    T085A  *     T334  *     T115  *

  SIO2   *   53.20   *   53.20   *   58.40   *
  TIO2   *    0.55   *    0.41   *    0.68   *
 AL2O3   *   16.10   *   15.00   *   18.30   *
 FE2O3   *    4.27   *    3.55   *    4.78   *
   FEO   *    5.82   *    5.08   *    1.55   *
   MNO   *    0.18   *    0.18   *    0.14   *
   MGO   *    7.02   *    6.71   *    2.67   *
   CAO   *    9.13   *    8.87   *    5.39   *
  NA2O   *    1.60   *    2.26   *    4.11   *
   K2O   *    0.05   *    0.21   *    2.03   *
  P2O5   *    0.0    *    0.0    *    0.0    *
   H2O   *    4.06   *    4.32   *    2.45   *
 TOTAL   *  101.98   *   99.79   *  100.50   *

    SR   *     228   *     115   *     320   *
    RB   *       2   *       5   *      56   *
    TH   *       2   *       1   *       4   *
     U   *       0   *       0   *       0   *
    GA   *      17   *      15   *      22   *
    PB   *       8   *       5   *       7   *

     Q   *    9.66   *    8.57   *    8.86   *
    OR   *    0.30   *    1.30   *   12.28   *
    AB   *   13.87   *   20.07   *   35.59   *
    AN   *   37.49   *   31.67   *   26.09   *
    NE   *    0.0    *    0.0    *    0.0    *
   COR   *    0.0    *    0.0    *    0.0    *
   DIO   *    7.30   *   11.86   *    1.06   *
    HY   *   28.08   *   23.42   *   12.59   *
    OL   *    0.0    *    0.0    *    0.0    *
   MAG   *    2.23   *    2.28   *    2.23   *
   ILM   *    1.07   *    0.82   *    1.32   *
    HM   *    0.0    *    0.0    *    0.0    *
    AP   *    0.0    *    0.0    *    0.0    *
```

BEAVER POND FORMATION

SAMPLE	T147	P048B	T390	T061A	T135	T208	T051
SIO2	47.60	49.20	49.30	47.70	52.50	50.70	54.90
TIO2	1.23	0.87	1.13	0.53	0.83	0.90	0.76
AL2O3	15.70	14.00	14.60	9.90	15.30	13.70	15.80
FE2O3	6.75	1.92	6.79	1.94	4.86	2.41	0.56
FEO	3.89	8.64	4.37	7.87	3.85	9.06	7.79
MNO	0.21	0.21	0.19	0.23	0.08	0.22	0.15
MGO	5.76	7.26	5.25	12.50	4.37	7.86	4.50
CAO	10.60	12.40	12.75	12.02	8.57	9.47	5.77
NA2O	1.54	2.04	2.74	1.22	3.35	2.79	3.65
K2O	0.78	0.02	0.09	0.25	0.33	0.07	0.24
P2O5	0.0	0.11	0.0	0.0	0.0	0.0	0.12
H2O	5.77	3.75	2.18	5.34	5.07	3.45	4.99
TOTAL	100.03	100.42	99.39	99.50	99.11	100.63	99.23
SR	419	225	123	320	247	29	195
RB	17	10	2	6	7	2	7
TH	2	0	2	2	2	1	2
U	0	0	0	1	0	0	0
GA	19	22	18	13	19	15	20
PB	6	8	6	7	8	7	9
Q	2.95	0.57	0.0	0.0	6.27	0.[illegible]	10.19
OR	4.92	0.12	0.55	1.57	2.08	0.43	1.50
AB	13.90	17.87	23.98	10.97	30.25	24.32	32.74
AN	35.87	30.00	28.81	22.10	27.47	25.39	27.58
NE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COR	0.0	0.0	0.0	0.0	0.0	0.0	1.60
DIO	16.68	27.04	30.87	33.28	14.78	18.90	22.25
HY	20.86	20.18	9.78	21.80	15.15	16.45	0.0
OL	0.0	0.0	2.13	6.90	0.0	0.51	0.0
MAG	2.32	2.25	2.25	2.31	2.32	2.24	2.31
ILM	2.49	1.71	2.22	1.07	1.68	1.76	1.53
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AP	0.0	0.26	0.0	0.0	0.0	0.0	0.30

BEAVER POND FORMATION

SAMPLE	T099	T278	T277
SIO2	49.90	51.00	45.10
TIO2	0.76	0.40	1.70
AL2O3	14.40	13.60	15.10
FE2O3	2.66	2.68	10.41
FEO	7.76	3.49	6.59
MNO	0.19	0.18	0.31
MGO	7.50	5.28	6.12
CAO	9.53	16.35	8.81
NA2O	3.51	0.0	2.53
K2O	0.09	0.0	0.02
P2O5	0.0	0.0	0.0
H2O	3.10	6.77	3.84
TOTAL	99.40	99.75	100.53
SR	92	278	262
RB	2	1	1
TH	2	4	0
U	0	0	0
GA	20	15	21
PB	8	6	7
Q	0.0	15.62	0.0
OR	0.55	0.0	0.12
AB	30.88	0.0	22.35
AN	24.20	39.96	31.10
NE	0.0	0.0	0.0
COR	0.0	0.0	0.0
DIO	20.46	38.40	12.20
HY	9.80	2.85	12.48
OL	10.34	0.0	16.11
MAG	2.26	2.34	2.27
ILM	1.50	0.82	3.37
HM	0.0	0.0	0.0
AP	0.0	0.0	0.0

WANDSWORTH GABBRO

SAMPLE	T120	T258	T257	T173	T175	T383	T172
SIO2	47.70	49.50	46.30	49.00	49.30	49.50	49.80
TIO2	0.69	0.23	0.15	0.21	0.22	0.91	0.56
AL2O3	14.70	17.00	20.00	19.00	20.20	14.70	15.30
FE2O3	2.54	1.03	0.79	1.09	1.44	3.04	2.90
FEO	7.61	3.49	2.30	3.51	3.81	7.83	6.14
MNO	0.17	0.11	0.08	0.13	0.14	0.20	0.17
MGO	9.95	9.26	8.06	8.18	8.18	7.71	9.39
CAO	13.31	14.20	16.50	13.45	9.99	9.20	8.79
NA2O	1.36	1.70	1.52	2.60	2.42	3.02	2.64
K2O	0.02	0.15	0.33	0.21	0.73	0.06	0.05
P2O5	0.0	0.0	0.0	0.08	0.0	0.0	0.0
H2O	2.89	2.87	3.33	2.81	4.56	3.47	3.73
TOTAL	100.94	99.54	99.36	100.27	100.99	99.64	99.47
SR	75	127	171	412	258	111	125
RB	1	4	8	4	13	2	2
TH	2	5	6	5	4	1	2
U	0	0	0	0	0	0	1
GA	17	14	13	16	17	18	14
PB	6	5	6	6	5	5	5
Q	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OR	0.12	0.92	2.03	1.27	4.47	0.37	0.31
AB	11.75	14.87	9.36	22.56	21.24	26.62	23.37
AN	34.66	39.62	48.67	40.57	43.66	27.48	31.12
NE	0.0	0.0	2.18	0.0	0.0	0.0	0.0
COR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DIO	26.60	26.32	28.67	21.72	6.17	16.45	11.74
HY	15.43	15.14	0.0	0.89	16.32	19.46	27.53
OL	7.89	0.43	6.53	10.16	5.45	5.56	2.55
MAG	2.22	2.25	2.60	2.23	2.26	2.27	2.28
ILM	1.34	0.45	0.30	0.41	0.43	1.80	1.11
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AP	0.0	0.0	0.0	0.19	0.0	0.0	0.0

WANDSWORTH GABBRO

SAMPLE	T034A	T030	T138	T137	T136A	T274B	T139
SIO2	50.00	47.90	47.60	44.60	47.30	49.80	47.40
TIO2	0.50	0.40	0.40	0.0	0.12	0.25	0.18
AL2O3	16.10	14.80	14.80	17.50	18.40	16.60	17.50
FE2O3	3.95	3.47	2.27	1.68	0.82	1.58	1.64
FEO	5.42	5.80	6.28	4.53	2.99	3.04	4.36
MNO	0.18	0.16	0.19	0.12	0.07	0.11	0.14
MGO	7.43	10.10	9.97	12.15	10.42	9.63	9.91
CAO	12.60	12.68	14.40	12.80	15.79	14.67	14.07
NA2O	1.63	1.12	1.35	1.28	1.10	1.94	1.70
K2O	0.12	0.17	0.03	0.09	0.02	0.30	0.02
P2O5	0.0	0.0	0.08	0.16	0.0	0.0	0.0
H2O	3.27	3.42	3.06	4.45	3.06	2.81	3.73
TOTAL	101.20	100.02	100.43	99.36	100.09	100.73	100.65
SR	273	200	93	81	77	181	120
RB	2	4	1	3	0	5	1
TH	3	2	3	4	5	4	4
U	0	0	0	0	0	1	0
GA	18	14	13	14	13	11	14
PB	7	6	7	5	7	4	5
Q	2.12	0.0	0.0	0.0	0.0	0.0	0.0
OR	0.73	1.04	0.18	0.56	0.12	1.81	0.12
AB	14.12	9.83	11.74	11.41	9.59	16.77	14.85
AN	37.12	36.16	35.19	43.99	46.56	36.46	41.34
NE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DIO	21.94	23.55	30.45	17.40	26.87	29.99	24.51
HY	20.48	23.58	11.03	4.74	7.42	6.36	5.56
OL	0.0	2.79	8.20	19.22	6.96	5.94	11.03
MAG	2.23	2.26	2.24	2.29	2.24	2.22	2.24
ILM	0.97	0.79	0.78	0.0	0.23	0.48	0.35
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AP	0.0	0.0	0.19	0.39	0.0	0.0	0.0

WANDSWORTH GABBRO

SAMPLE	T141	T140	T193A	T100	T066C	T406	T068A
SIO2	49.80	48.30	45.30	48.00	46.90	49.80	48.30
TIO2	0.34	0.06	0.27	0.17	0.20	0.43	0.15
AL2O3	16.70	19.80	20.40	14.60	14.20	14.60	16.90
FE2O3	1.40	1.14	2.23	1.64	1.35	2.00	1.61
FEO	5.77	2.83	3.26	4.58	6.49	5.65	3.48
MNO	0.15	0.11	0.08	0.12	0.14	0.22	0.11
MGO	9.24	6.66	7.67	12.66	13.69	10.27	10.07
CAO	10.74	15.40	13.92	14.78	11.31	9.85	12.68
NA2O	2.06	2.15	1.93	0.86	1.38	1.98	2.33
K2O	0.01	0.05	0.07	0.08	0.22	0.21	0.54
P2O5	0.0	0.08	0.0	0.0	0.0	0.0	0.0
H2O	4.53	3.10	3.50	3.09	4.87	3.94	4.00
TOTAL	100.76	99.68	98.63	100.58	100.75	98.95	100.17
SR	402	200	252	160	111	392	296
RB	3	1	2	2	6	5	11
TH	3	6	5	3	2	3	5
U	0	0	0	0	0	0	0
GA	18	15	15	12	14	18	16
PB	6	5	5	4	4	7	6
Q	0.54	0.0	0.0	0.0	0.0	0.71	0.0
OR	0.06	0.31	0.44	0.49	1.36	1.31	3.32
AB	18.29	18.83	15.75	7.47	12.18	17.65	20.32
AN	37.62	45.78	49.23	36.67	33.27	31.94	35.43
NE	0.0	0.0	0.77	0.0	0.0	0.0	0.10
COR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DIO	14.27	26.01	18.72	30.67	20.19	15.69	23.82
HY	26.29	1.77	0.0	14.26	14.20	29.55	0.0
OL	0.0	4.73	12.26	7.88	16.14	0.0	14.46
MAG	2.26	2.25	2.29	2.23	2.27	2.29	2.26
ILM	0.67	0.17	0.54	0.33	0.40	0.86	0.30
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AP	0.0	0.19	0.0	0.0	0.0	0.0	0.0

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                                        WANDSWORTH GABBRO

SAMPLE  *    T148B *      T103 *      T405 *     T192A *     T190B *

  SIO2  *    48.10  *    47.70  *    48.80  *    42.00  *    41.80  *
  TIO2  *     0.34  *     0.20  *     0.09  *     0.17  *     1.42  *
 AL2O3  *    13.70  *    15.80  *    22.40  *     2.45  *    13.60  *
 FE2O3  *     2.57  *     2.20  *     0.95  *     4.47  *     9.71  *
   FEO  *     6.76  *     5.04  *     1.69  *     4.36  *     9.42  *
   MNO  *     0.19  *     0.15  *     0.06  *     0.14  *     0.22  *
   MGO  *     9.42  *    11.01  *     6.37  *    34.55  *     7.37  *
   CAO  *    13.40  *    13.00  *    14.78  *     1.86  *    10.74  *
  NA2O  *     1.59  *     0.72  *     2.51  *     0.0   *     1.57  *
   K2O  *     0.02  *     0.03  *     0.60  *     0.0   *     0.12  *
  P2O5  *     0.30  *     0.0   *     0.0   *     0.0   *     0.0   *
   H2O  *     3.18  *     4.41  *     2.78  *    11.07  *     3.49  *
 TOTAL  *    99.57  *   100.26  *   101.03  *   101.07  *    99.46  *

    SR  *       98  *       66  *      326  *        6  *      178  *
    RB  *        0  *        1  *       12  *        1  *        3  *
    TH  *        2  *        3  *        5  *        0  *        0  *
     U  *        0  *        0  *        0  *        0  *        0  *
    GA  *       16  *       15  *       12  *        5  *       19  *
    PB  *        8  *        5  *        4  *        5  *        7  *

     Q  *     0.0   *     0.33  *     0.0   *     0.0   *     0.0   *
    OR  *     0.12  *     0.19  *     3.61  *     0.0   *     0.75  *
    AB  *    13.97  *     6.36  *    17.17  *     0.0   *    13.85  *
    AN  *    31.35  *    41.55  *    48.92  *     7.45  *    31.23  *
    NE  *     0.0   *     0.0   *     2.40  *     0.0   *     0.06  *
   COR  *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *
   DIO  *    28.96  *    20.67  *    20.11  *     2.24  *    20.79  *
    HY  *    17.78  *    28.24  *     0.0   *    37.95  *     0.0   *
    OL  *     4.16  *     0.0   *     5.41  *    49.58  *    28.20  *
   MAG  *     2.26  *     2.27  *     2.21  *     2.42  *     2.29  *
   ILM  *     0.67  *     0.40  *     0.17  *     0.36  *     2.83  *
    HM  *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *
    AP  *     0.72  *     0.0   *     0.0   *     0.0   *     0.0   *
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WANDSWORTH GRANODIORITE.

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SAMPLE  *       146 *      T374 *      T268 *     T039A *    6-73-6 *     T034B *

  SIO2  *    68.50  *    67.20  *    65.10  *    65.60  *    66.30  *    65.30  *
  TIO2  *     0.22  *     0.33  *     0.35  *     0.40  *     0.49  *     0.34  *
 AL2O3  *    15.30  *    15.70  *    16.70  *    16.30  *    15.90  *    16.10  *
 FE2O3  *     1.31  *     2.75  *     2.27  *     1.68  *     1.82  *     2.06  *
   FEO  *     1.50  *     1.55  *     1.80  *     2.10  *     2.03  *     1.80  *
   MNO  *     0.06  *     0.08  *     0.08  *     0.07  *     0.07  *     0.08  *
   MGO  *     1.16  *     1.65  *     1.71  *     2.10  *     1.95  *     2.08  *
   CAO  *     2.55  *     4.20  *     4.05  *     4.52  *     4.87  *     4.52  *
  NA2O  *     3.78  *     3.89  *     4.32  *     3.87  *     3.89  *     3.80  *
   K2O  *     3.28  *     1.39  *     1.59  *     1.61  *     1.53  *     1.67  *
  P2O5  *     0.26  *     0.0   *     0.0   *     0.0   *     0.03  *     0.0   *
   H2O  *     4.26  *     2.10  *     2.54  *     2.44  *     2.16  *     2.71  *
 TOTAL  *   102.18  *   100.84  *   100.51  *   100.69  *   101.04  *   100.46  *


    SR  *      181  *      402  *      630  *      490  *      365  *      581  *
    RB  *       86  *       42  *       47  *       43  *       38  *       54  *
    TH  *        -  *        7  *        7  *        7  *        -  *        8  *
     U  *        -  *        1  *        0  *        0  *        -  *        0  *
    GA  *        -  *       15  *       15  *       16  *        -  *       16  *
    PB  *        -  *       11  *       10  *        8  *        -  *       10  *


     Q  *    27.33  *    28.06  *    22.66  *    23.66  *    24.64  *    24.12  *
    OR  *    19.79  *     8.32  *     9.59  *     9.68  *     9.14  *    10.10  *
    AB  *    32.65  *    33.34  *    37.31  *    33.33  *    33.28  *    32.89  *
    AN  *    11.36  *    21.10  *    20.51  *    22.75  *    21.64  *    22.45  *
    NE  *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *
   COR  *     1.48  *     0.16  *     0.52  *     0.0   *     0.0   *     0.0   *
   DIO  *     0.0   *     0.0   *     0.0   *     0.06  *     2.21  *     0.39  *
    HY  *     4.40  *     4.34  *     5.97  *     7.27  *     5.41  *     6.33  *
    OL  *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *
   MAG  *     1.94  *     4.04  *     3.36  *     2.48  *     2.67  *     3.06  *
   ILM  *     0.43  *     0.63  *     0.68  *     0.77  *     0.94  *     0.66  *
    HM  *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *
    AP  *     0.62  *     0.0   *     0.0   *     0.0   *     0.07  *     0.0   *
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CRESTON FORMATION

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  SAMPLE  *     T311 *      T112 *      T312 *      T314 *      T319 *      T407 *      T409 *

   SIO2   *   44.30  *    46.70  *    48.20  *    48.90  *    45.90  *    46.60  *    41.10  *
   TIO2   *    1.20/ *     1.00  *     1.52  *     1.20  *     1.76  *     1.60  *     1.80  *
  AL2O3   *   19.20  *    13.40  *    15.60  *    17.30  *    18.30  *    16.40  *    16.80  *
  FE2O3   *    7.91  *     6.92  *     7.93  *     7.78  *     6.95  *     3.72  *    10.39  *
    FEO   *    2.05  *     2.61  *     3.98  *     3.92  *     4.77  *     7.47  *     4.62  *
    MNO   *    0.21  *     0.17  *     0.21  *     0.20  *     0.20  *     0.17  *     0.23  *
    MGO   *    9.59  *     6.50  *     5.98  *     4.74  *     8.69  *     5.72  *     9.77  *
    CAO   *    4.64  *    11.30  *     9.15  *     4.46  *     4.57  *     6.74  *     4.81  *
   NA2O   *    3.08  *     2.23  *     2.09  *     4.31  *     3.29  *     3.00  *     3.61  *
    K2O   *    1.93  *     0.09  *     0.03  *     0.88  *     0.64  *     1.48  *     0.37  *
   P2O5   *    0.26  *     0.22  *     0.48  *     0.18  *     0.34  *     0.48  *     0.24  *
    H2O   *    5.95  *     8.55  *     4.99  *     5.85  *     5.64  *     6.41  *     5.79  *
  TOTAL   *  100.32  *    99.69  *   100.16  *    99.72  *   101.05  *    99.79  *    99.53  *

     SR   *     425  *      471  *      438  *      453  *      721  *      573  *      307  *
     RB   *      52  *        3  *        2  *       32  *       16  *       35  *       14  *
     TH   *       2  *        3  *        2  *        2  *        1  *        3  *        0  *
      U   *       0  *        0  *        0  *        0  *        0  *        0  *        0  *
     GA   *      25  *        8  *       19  *       25  *       25  *       20  *       25  *
     PB   *      10  *        9  *        8  *       10  *        8  *       15  *        8  *

      Q   *    0.0   *     1.25  *     4.34  *     0.0   *     0.0   *     0.0   *     0.0   *
     OR   *   12.17  *     0.59  *     0.19  *     5.58  *     3.99  *     9.39  *     2.36  *
     AB   *   27.81  *    20.83  *    18.71  *    39.12  *    29.35  *    27.25  *    26.69  *
     AN   *   22.77  *    29.07  *    35.01  *    22.48  *    21.58  *    28.89  *    24.03  *
     NE   *    0.0   *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *     3.37  *
    COR   *    4.51  *     0.0   *     0.0   *     1.69  *     4.95  *     0.0   *     2.46  *
    DIO   *    0.0   *    25.58  *     8.04  *     0.0   *     0.0   *     3.03  *     0.0   *
     HY   *    0.05  *    17.67  *    27.18  *    18.70  *    22.60  *    13.60  *     0.0   *
     OL   *   27.31  *     0.0   *     0.0   *     7.21  *    10.88  *    11.05  *    34.48  *
    MAG   *    2.32  *     2.40  *     2.30  *     2.33  *     2.29  *     2.33  *     2.34  *
    ILM   *    2.43  *     2.10  *     3.05  *     2.44  *     3.52  *     3.26  *     3.68  *
     HM   *    0.0   *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *
     AP   *    0.64  *     0.56  *     1.18  *     0.45  *     0.83  *     1.20  *     0.60  *
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CRESTON FORMATION

SAMPLE	T410	T411	Z25	L23	1001	1009	1010
SIO2	46.30	44.60	45.20	44.70	53.70	46.60	46.60
TIO2	1.52	1.60	1.47	1.12	1.20	1.54	1.44
AL2O3	17.40	15.50	16.92	17.90	16.20	16.30	16.90
FE2O3	3.79	2.77	6.56	4.49	4.01	4.10	4.53
FEO	6.36	8.35	5.06	6.57	4.59	6.84	6.03
MNO	0.23	0.23	0.22	0.20	0.15	0.22	0.19
MGO	6.33	7.41	7.82	6.70	3.56	10.24	8.63
CAO	6.88	6.21	8.53	9.96	5.47	4.80	5.30
NA2O	2.56	2.49	2.96	2.13	3.56	4.32	4.61
K2O	1.78	0.43	1.13	2.28	2.98	0.78	0.45
P2O5	0.44	0.48	0.26	0.19	0.28	0.36	0.42
H2O	6.55	9.74	4.19	3.53	4.28	4.95	5.31
TOTAL	100.14	99.81	100.32	99.77	99.98	101.05	100.41
SR	563	339	660	599	368	145	355
RB	35	13	19	66	56	11	16
TH	3	2	2	2	–	–	–
U	0	0	0	1	–	–	–
GA	23	22	21	19	–	–	–
PB	7	10	8	6	–	–	–
Q	0.0	0.0	0.0	0.0	2.34	0.0	0.0
OR	11.27	2.83	5.98	14.05	18.45	4.81	2.81
AB	23.20	23.43	22.09	10.18	31.56	34.75	37.77
AN	32.92	30.80	30.90	33.93	20.35	22.42	24.87
NE	0.0	0.0	2.22	4.90	0.0	1.84	1.83
COR	0.0	0.87	0.0	0.0	0.0	0.50	0.20
DIO	0.49	0.0	9.50	13.41	5.13	0.0	0.0
HY	14.64	32.32	0.0	0.0	16.82	0.0	0.0
OL	10.97	2.71	22.47	18.82	0.0	29.50	26.32
MAG	2.33	2.42	2.27	2.27	2.28	2.27	2.29
ILM	3.09	3.38	2.92	2.22	2.39	3.05	2.88
HM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AP	1.10	1.24	0.63	0.46	0.68	0.87	1.03

CRESTON FORMATION

SAMPLE	1000	1002	1008
SIO2	45.20	39.80	42.80
TIO2	1.46	1.34	1.34
AL2O3	17.10	15.20	16.30
FE2O3	7.85	5.96	4.41
FEO	3.29	4.64	6.35
MNO	0.16	0.20	0.18
MGO	6.16	6.28	5.32
CAO	10.40	16.25	13.04
NA2O	2.92	0.50	2.55
K2O	0.63	0.19	0.21
P2O5	0.30	0.44	0.22
H2O	4.85	8.85	6.87
TOTAL	100.32	99.65	99.59
SR	208	839	395
RB	8	8	8
TH	-	-	-
U	-	-	-
GA	-	-	-
PB	-	-	-
Q	0.0	0.0	0.0
OR	3.93	1.24	1.34
AB	23.08	2.75	14.29
AN	33.42	42.80	35.07
NE	1.61	1.05	4.91
COR	0.0	0.0	0.0
DIO	15.59	35.57	27.63
HY	0.0	0.0	0.0
OL	16.41	10.23	11.10
MAG	2.29	2.41	2.35
ILM	2.92	2.87	2.75
HM	0.0	0.0	0.0
AP	0.74	1.13	0.55

CASHEL LOOKOUT FORMATION

SAMPLE	T237A	T308	T310	T006	T009	T013
SIO2	73.90	74.90	77.40	76.40	77.30	73.00
TIO2	0.40	0.25	0.25	0.27	0.15	0.10
AL2O3	13.90	13.50	12.00	12.10	12.60	14.90
FE2O3	0.88	1.09	0.70	0.43	1.09	1.09
FEO	0.61	0.27	0.30	0.83	0.35	0.34
MNO	0.05	0.03	0.10	0.07	0.01	0.03
MGO	0.24	0.12	0.18	0.17	0.06	0.11
CAO	0.94	0.30	1.47	0.77	0.18	0.18
NA2O	5.70	5.69	4.13	4.29	5.50	5.80
K2O	2.13	2.57	0.37	2.52	2.05	2.13
P2O5	0.18	0.06	0.0	0.0	0.08	0.0
H2O	1.06	0.46	2.00	1.30	0.52	1.01
TOTAL	99.99	99.24	98.90	99.15	99.89	98.69
SR	168	96	161	90	72	137
RB	43	43	63	42	33	48
TH	14	15	14	14	13	14
U	0	1	3	1	1	0
GA	13	12	11	13	16	16
PB	17	12	15	19	16	16
Q	31.05	31.70	50.05	40.38	37.44	31.29
OR	12.72	15.38	2.26	15.22	12.19	12.89
AB	48.75	48.74	36.06	37.10	46.83	50.24
AN	3.54	1.11	7.53	3.90	0.38	0.91
NE	0.0	0.0	0.0	0.0	0.0	0.0
COR	0.95	0.97	2.20	0.94	1.20	2.79
DIO	0.0	0.0	0.0	0.0	0.0	0.0
HY	0.60	0.30	0.46	1.30	0.15	0.28
OL	0.0	0.0	0.0	0.0	0.0	0.0
MAG	0.98	0.25	0.59	0.64	0.73	0.93
ILM	0.77	0.48	0.49	0.52	0.29	0.19
HM	0.21	0.93	0.32	0.0	0.59	0.48
AP	0.42	0.14	0.0	0.0	0.19	0.0

MARYSTOWN GROUP

SAMPLE	T088	T105A	T157A	T160A	T265A	T266A	T159A
SIO2	72.00	69.00	73.40	78.60	68.00	71.10	71.40
TIO2	0.33	0.71	0.44	0.65	0.58	0.54	0.65
AL2O3	14.50	14.70	14.00	10.10	15.50	14.50	14.50
FE2O3	0.87	2.08	1.61	1.87	2.29	2.19	1.98
FEO	0.96	0.59	0.41	0.50	0.91	0.52	0.64
MNO	0.07	0.09	0.12	0.06	0.13	0.13	0.06
MGO	0.39	0.41	0.30	0.35	0.86	0.51	0.45
CAO	1.01	1.10	0.56	0.40	0.75	0.27	0.86
NA2O	5.31	5.24	5.67	5.18	5.70	5.97	5.17
K2O	3.37	3.80	2.81	1.99	3.14	1.83	3.92
P2O5	0.08	0.0	0.13	0.11	0.18	0.18	0.0
H2O	0.68	0.72	0.40	0.56	1.12	0.90	0.82
TOTAL	99.57	98.44	99.85	100.37	99.16	98.64	100.45
SR	168	200	66	76	95	82	231
RB	87	92	46	7	76	47	89
TH	16	13	14	14	12	12	13
U	2	0	0	1	0	0	0
GA	18	16	14	10	20	20	18
PB	16	19	13	27	18	13	19
Q	25.69	21.52	28.54	40.81	20.85	29.19	23.90
OR	20.14	22.98	16.70	11.78	18.93	11.06	23.25
AB	45.44	45.37	48.24	40.95	49.19	51.68	43.91
AN	4.54	5.49	1.95	0.0	2.61	0.18	4.28
NE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COR	0.48	0.0	0.93	0.0	1.82	2.70	0.19
DIO	0.0	0.07	0.0	0.92	0.0	0.0	0.0
HY	1.62	1.01	0.75	0.45	2.18	1.30	1.12
OL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAG	1.28	0.14	0.44	0.0	1.71	0.55	0.38
ILM	0.63	1.38	0.84	1.19	1.12	1.05	1.24
HM	0.0	2.03	1.32	0.97	1.16	1.86	1.73
AP	0.19	0.0	0.30	0.26	0.43	0.43	0.0

MARYSTOWN GROUP

```
SAMPLE  *    T375B  *     T046  *

  SIO2  *   69.10   *   56.10   *
  TIO2  *    0.43   *    0.92   *
 AL2O3  *   14.80   *   17.00   *
 FE2O3  *    1.88   *    6.41   *
   FEO  *    0.40   *    2.32   *
   MNO  *    0.06   *    0.15   *
   MGO  *    0.43   *    3.53   *
   CAO  *    0.94   *    5.04   *
  NA2O  *    6.41   *    3.86   *
   K2O  *    2.86   *    0.93   *
  P2O5  *    0.0    *    0.11   *
   H2O  *    0.72   *    3.10   *
 TOTAL  *   98.03   *   99.47   *

    SR  *      100  *      612  *
    RB  *       52  *       21  *
    TH  *       14  *        4  *
     U  *        2  *        0  *
    GA  *       11  *       22  *
    PB  *       14  *       12  *

     Q  *   19.05   *   10.26   *
    OR  *   17.37   *    5.73   *
    AB  *   55.74   *   34.07   *
    AN  *    3.25   *   25.34   *
    NE  *    0.0    *    0.0    *
   COR  *    0.0    *    0.77   *
   DIO  *    1.20   *    0.0    *
    HY  *    0.54   *   19.47   *
    OL  *    0.0    *    0.0    *
   MAG  *    0.25   *    2.27   *
   ILM  *    0.84   *    1.82   *
    HM  *    1.76   *    0.0    *
    AP  *    0.0    *    0.27   *
```

MISCELLANEOUS

T086 - Anchor Drogue Pluton

T371, T290, T365 - Dykes cutting the Rock Harbour Group

T020C, T023C, T069D - Plagioclase Porphyry dykes.

T273 - Dyke cutting the Inlet Group

T412A, T412B - Boulders in the Wild Cove Formation.

MISCELANEOUS

```
SAMPLE  *     T086 *      T371 *      T290 *      T365 *     T020C *     T023C *     T0690 *

  SIO2  *    64.50  *    50.70  *    51.40  *    47.70  *    43.40  *    52.00  *    52.20  *
  TIO2  *     0.66  *     1.13  *     1.35  *     0.80  *     1.01  *     1.08  *     0.89  *
 AL2O3  *    15.90  *    17.20  *    18.00  *    15.50  *    18.50  *    16.60  *    18.60  *
 FE2O3  *     1.77  *     1.25  *     1.89  *     1.49  *     1.88  *     3.69  *     2.22  *
   FEO  *     2.51  *     7.08  *     7.02  *     7.60  *     8.17  *     5.21  *     4.71  *
   MNO  *     0.12  *     0.19  *     0.16  *     0.22  *     0.20  *     0.16  *     0.11  *
   MGO  *     1.18  *     6.31  *     3.14  *     5.32  *     7.50  *     4.82  *     4.99  *
   CAO  *     1.39  *     6.76  *     5.70  *     7.70  *     5.90  *     6.30  *     4.28  *
  NA2O  *     4.79  *     3.04  *     4.00  *     2.60  *     4.53  *     3.22  *     5.54  *
   K2O  *     4.27  *     1.61  *     2.28  *     1.62  *     0.09  *     1.33  *     0.68  *
  P2O5  *     0.0   *     0.38  *     0.0   *     0.0   *     0.10  *     0.25  *     0.21  *
   H2O  *     1.54  *     3.48  *     2.89  *     8.77  *     7.27  *     3.63  *     3.71  *
 TOTAL  *    98.63  *    99.13  *    97.83  *    99.32  *    98.55  *    98.29  *    98.14  *

    SR  *      219  *      578  *      623  *      435  *      740  *      553  *      314  *
    RB  *      113  *       46  *       56  *       41  *        2  *       31  *       20  *
    TH  *       12  *        2  *        4  *        3  *        2  *        4  *        5  *
     U  *        1  *        0  *        0  *        0  *        0  *        0  *        0  *
    GA  *       19  *       22  *       20  *       24  *       26  *       22  *       23  *
    PB  *       24  *        7  *        9  *        8  *        8  *        8  *        7  *

     Q  *    14.95  *     0.10  *     0.0   *     0.0   *     0.0   *     4.26  *     0.0   *
    OR  *    25.99  *     9.94  *    14.20  *    10.57  *     0.58  *     8.32  *     4.26  *
    AB  *    41.75  *    26.89  *    35.67  *    24.30  *    31.91  *    28.85  *    49.68  *
    AN  *     7.10  *    29.82  *    25.74  *    28.54  *    31.37  *    28.50  *    21.06  *
    NE  *     0.0   *     0.0   *     0.0   *     0.0   *     5.47  *     0.0   *     0.0   *
   COR  *     0.90  *     0.0   *     0.0   *     0.0   *     0.51  *     0.0   *     1.55  *
   DIO  *     0.0   *     2.71  *     3.39  *    11.25  *     0.0   *     2.37  *     0.0   *
    HY  *     5.38  *    25.64  *    11.87  *    18.99  *     0.0   *    22.60  *    13.22  *
    OL  *     0.0   *     0.0   *     4.11  *     2.27  *    25.41  *     0.0   *     5.61  *
   MAG  *     2.64  *     2.27  *     2.29  *     2.40  *     2.38  *     2.30  *     2.30  *
   ILM  *     1.29  *     2.24  *     2.70  *     1.68  *     2.10  *     2.17  *     1.79  *
    HM  *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *     0.0   *
    AP  *     0.0   *     0.92  *     0.0   *     0.0   *     0.25  *     0.62  *     0.52  *
```

MISCELANEOUS

SAMPLE	T273	T412A	T412B
SIO2	47.20	80.00	78.80
TIO2	2.13	0.09	0.09
AL2O3	16.60	11.40	11.20
FE2O3	3.30	0.31	0.36
FEO	6.39	0.54	0.72
MNO	0.32	0.02	0.02
MGO	4.64	0.02	0.0
CAO	10.45	0.28	0.60
NA2O	2.94	3.49	3.85
K2O	0.77	4.51	3.98
P2O5	0.0	0.0	0.0
H2O	3.87	0.88	1.07
TOTAL	98.61	101.54	100.69
SR	503	48	70
RB	9	87	73
TH	3	30	32
U	0	1	7
GA	24	13	17
PB	10	24	20
Q	0.0	41.25	39.94
OR	4.81	26.48	23.61
AB	26.31	29.34	32.70
AN	31.54	1.38	1.53
NE	0.0	0.0	0.0
COR	0.0	0.27	0.0
DIO	19.21	0.0	1.30
HY	5.10	0.67	0.23
OL	6.44	0.0	0.0
MAG	2.30	0.45	0.52
ILM	4.28	0.17	0.17
HM	0.0	0.0	0.0
AP	0,0	0.0	0.0

APPENDIX 4

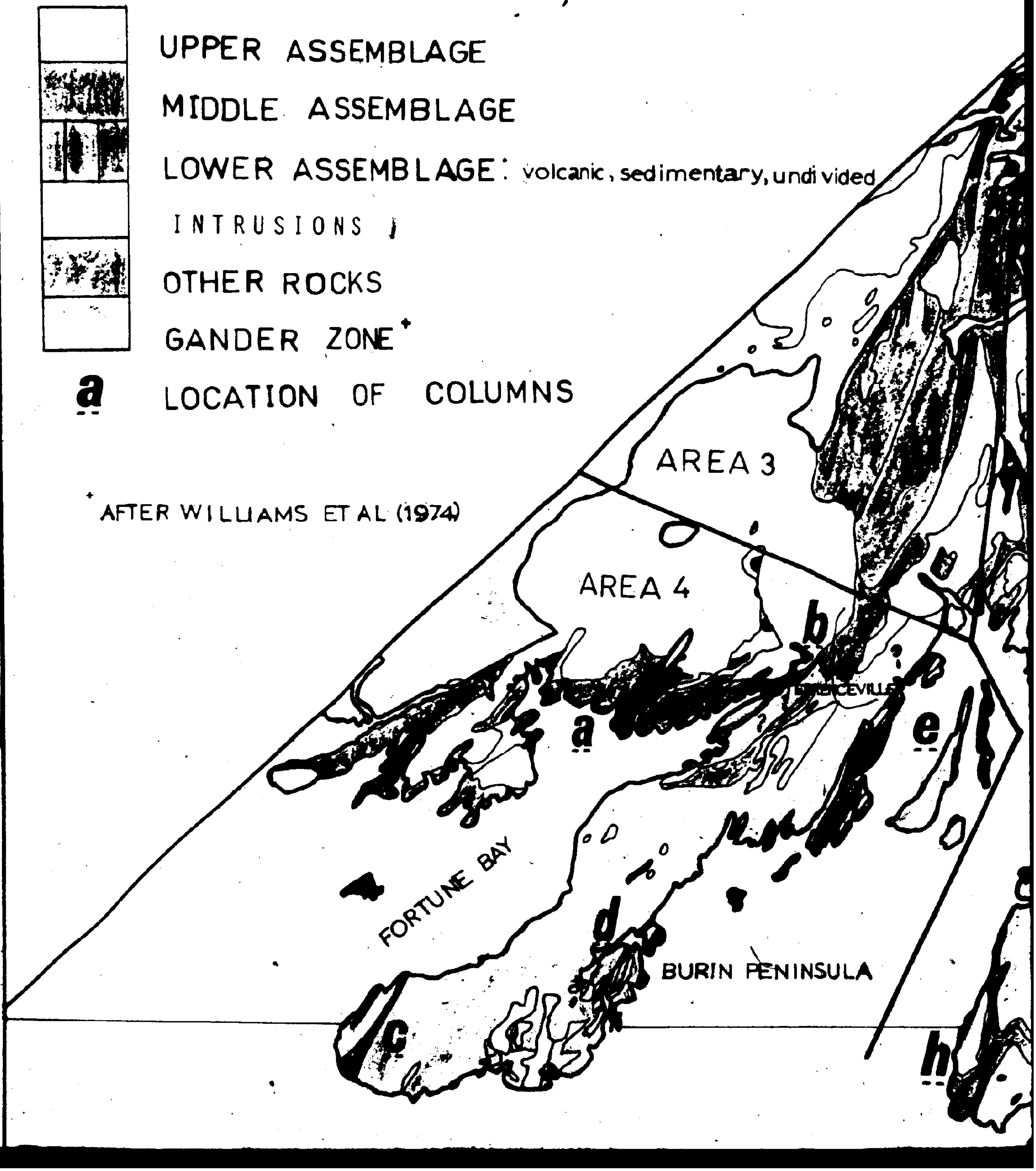
Method used to treat some effects of alteration.

An examination of Table 3 and Appendix 3 shows the effect that alteration has had on some of the basaltic samples. In particular, the "H_2O" ("loss on ignition") values and the Fe_2O_3/FeO ratios exceed the acceptable amounts proposed by Irvine and Baragar (1971).

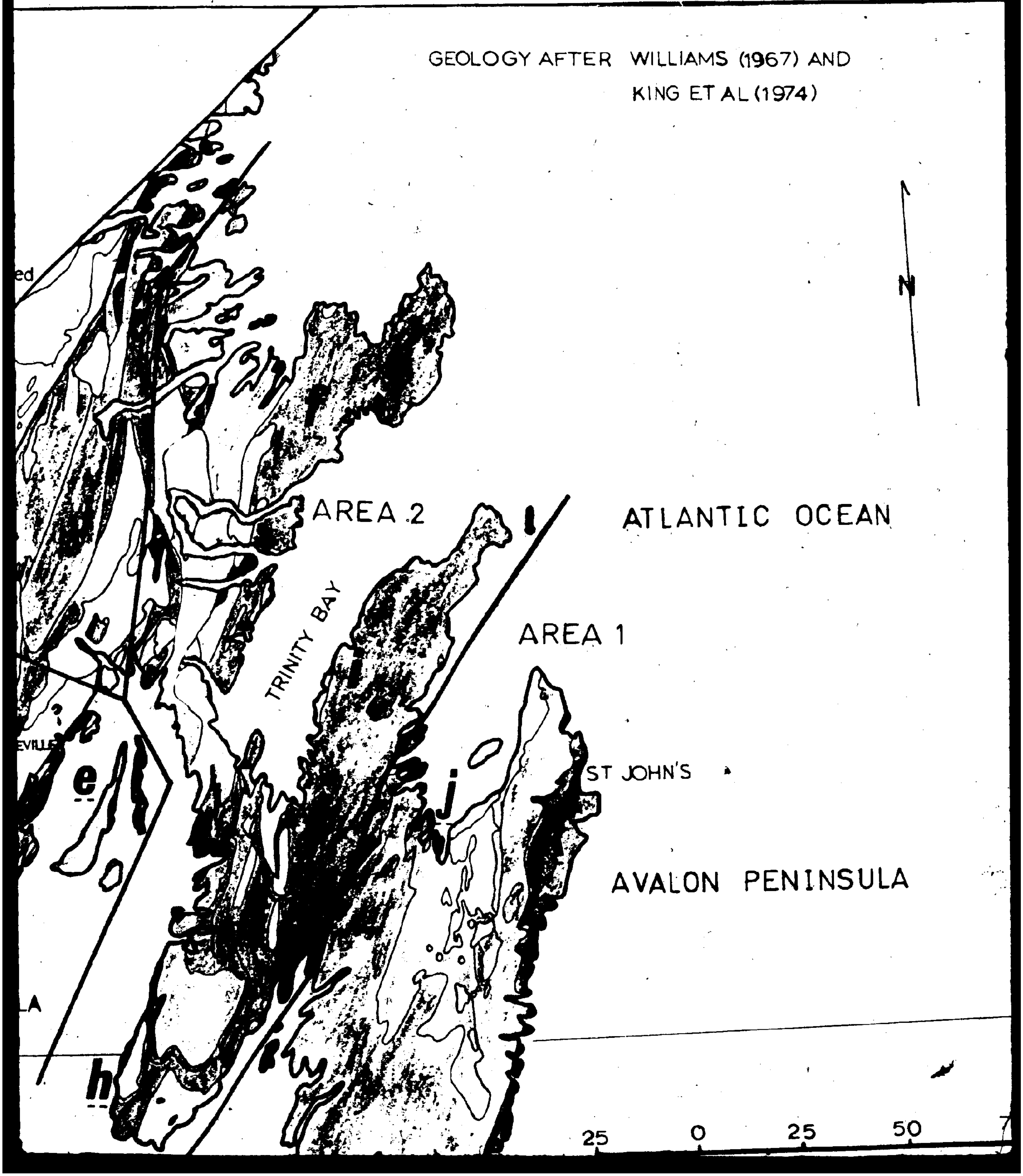
To compensate for these "effects", the methods given by Irvine and Baragar (1971) were employed before plotting of analyses and calculation of norms. The author recognizes the limitations of such methods.

1 oF

FIG.3 DISTRIBUTION OF ASSEMBLAGES OF THE AVALON ZONE⁺, NEWFOUNDLAND

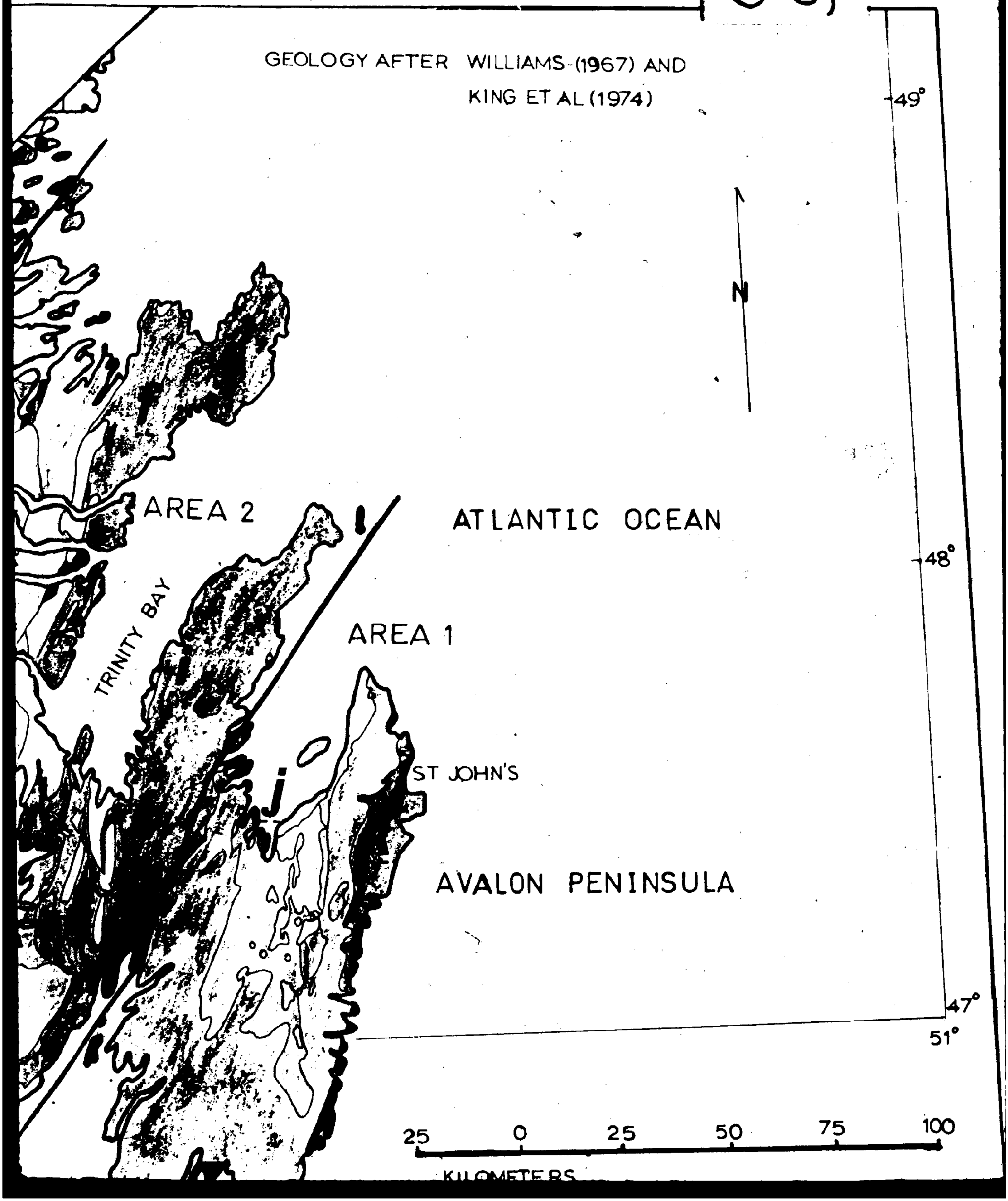


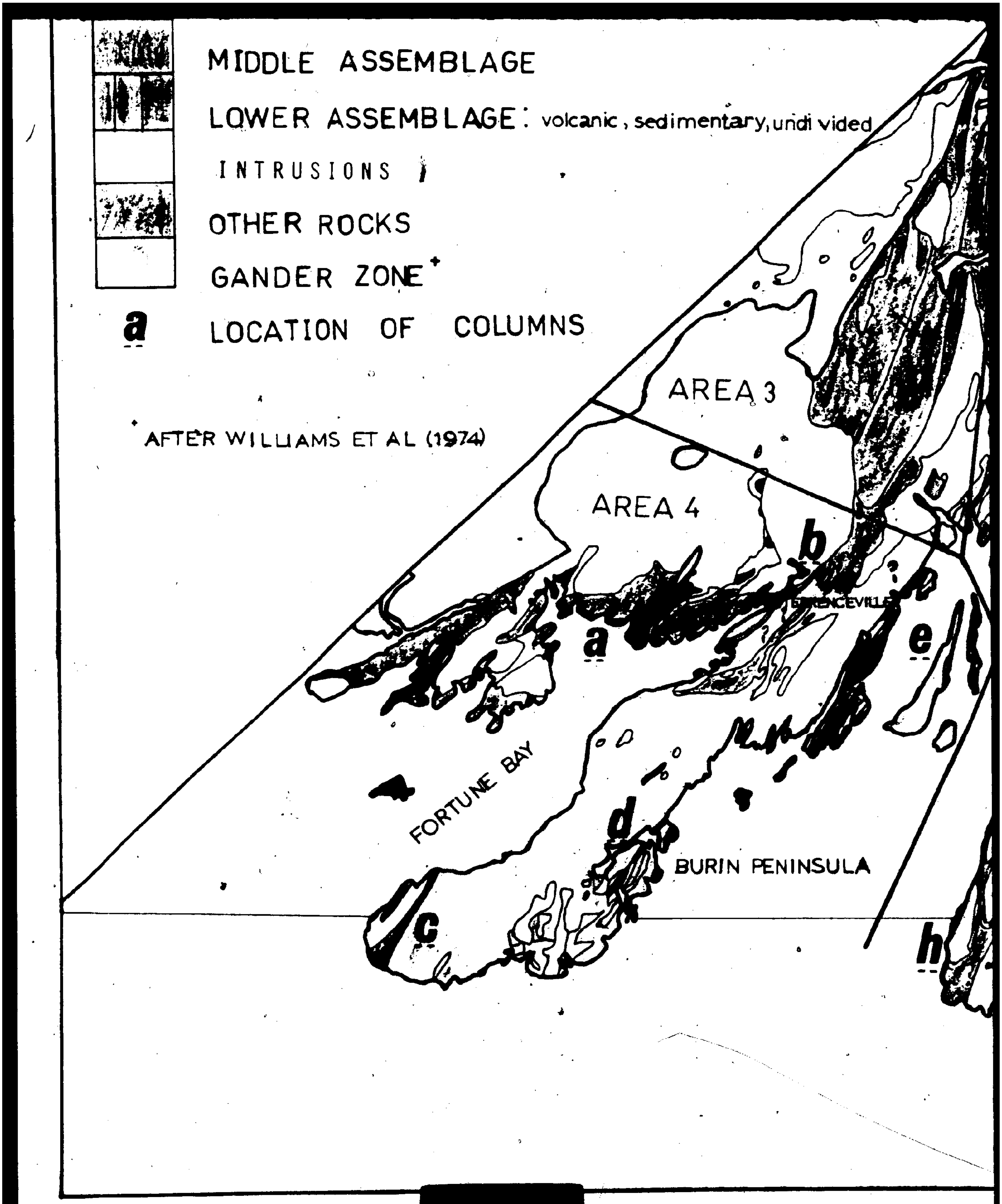
2 oF

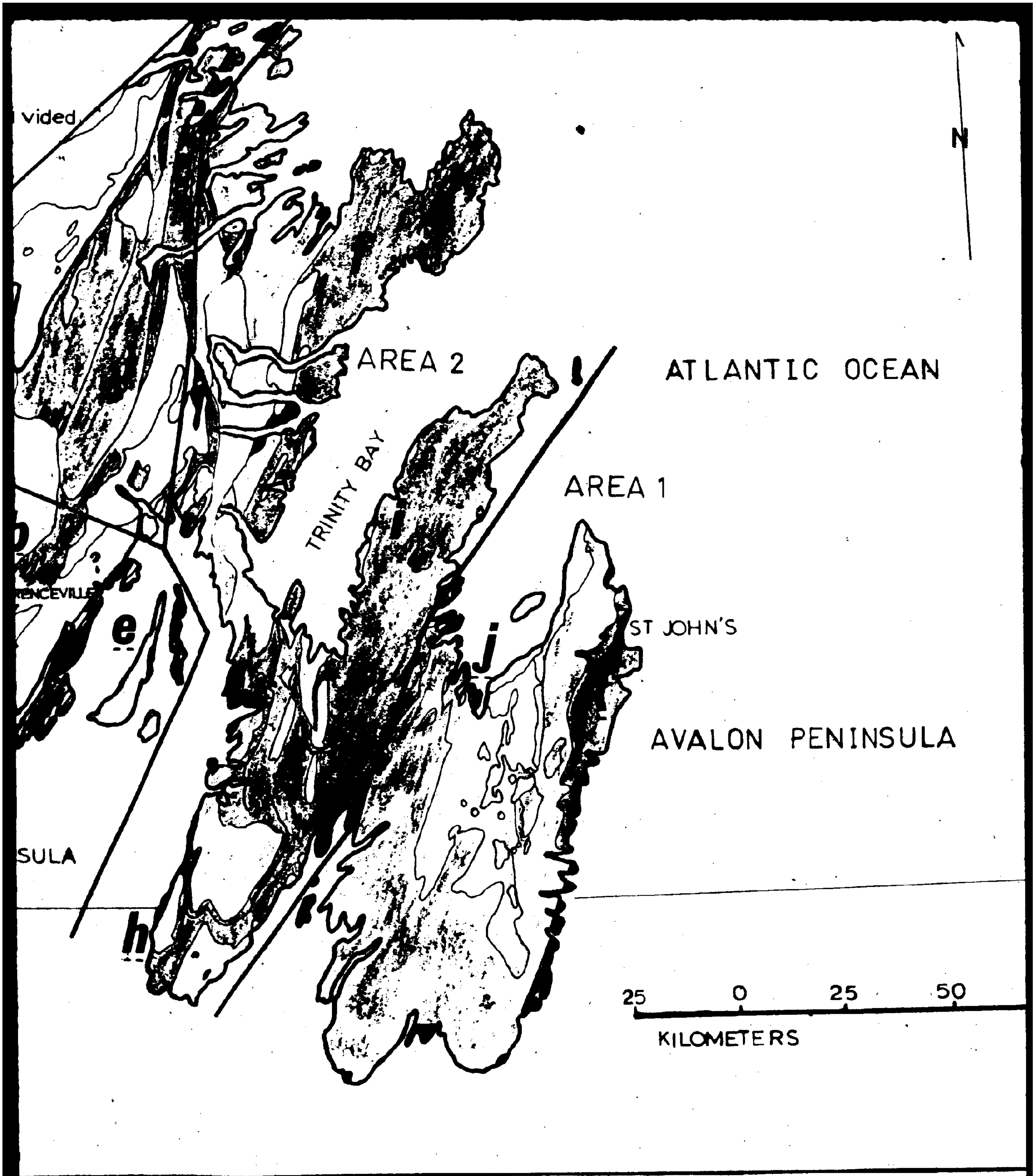


GEOLOGY AFTER WILLIAMS (1967) AND KING ET AL (1974)

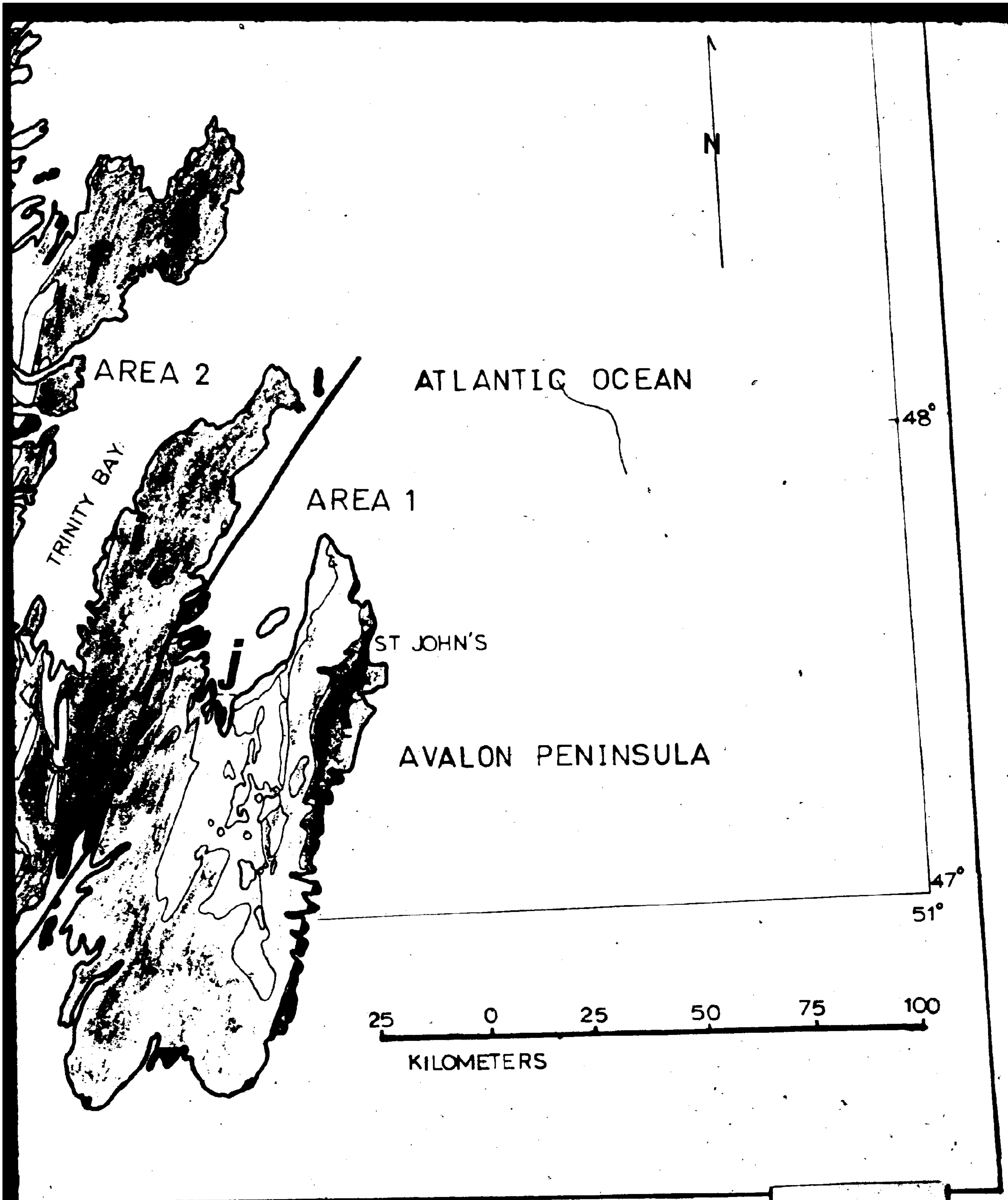
3 of


GEOLOGY AFTER WILLIAMS (1967) AND
KING ET AL (1974)
49°
N
AREA 2
ATLANTIC OCEAN
48°
TRINITY BAY
AREA 1
ST JOHN'S
j
AVALON PENINSULA
47°
51°
25
0
25
50
75
100
KILOMETERS


MIDDLE ASSEMBLAGE
LOWER ASSEMBLAGE: volcanic, sedimentary, undivided
INTRUSIONS
OTHER ROCKS
GANDER ZONE+
a LOCATION OF COLUMNS
+ AFTER WILLIAMS ET AL (1974)
AREA 3
AREA 4
b
TERRENCEVILLE
a
e
FORTUNE BAY
d
BURIN PENINSULA
c
h

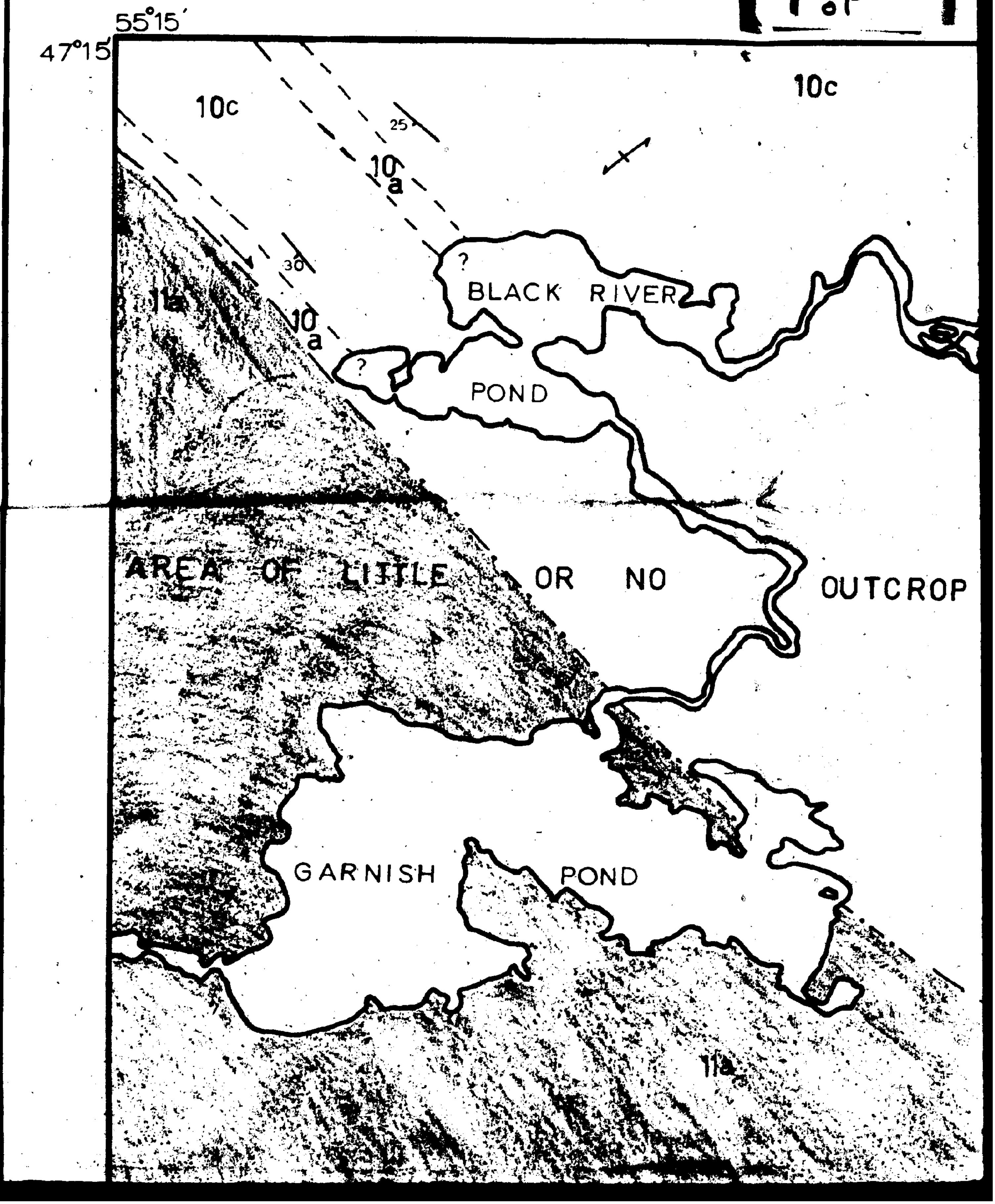

vided
N
AREA 2
ATLANTIC OCEAN
TRINITY BAY
AREA 1
RENCEVILLE
e
ST JOHN'S
j
AVALON PENINSULA
SULA
h
25 0 25 50
KILOMETERS

[redacted]

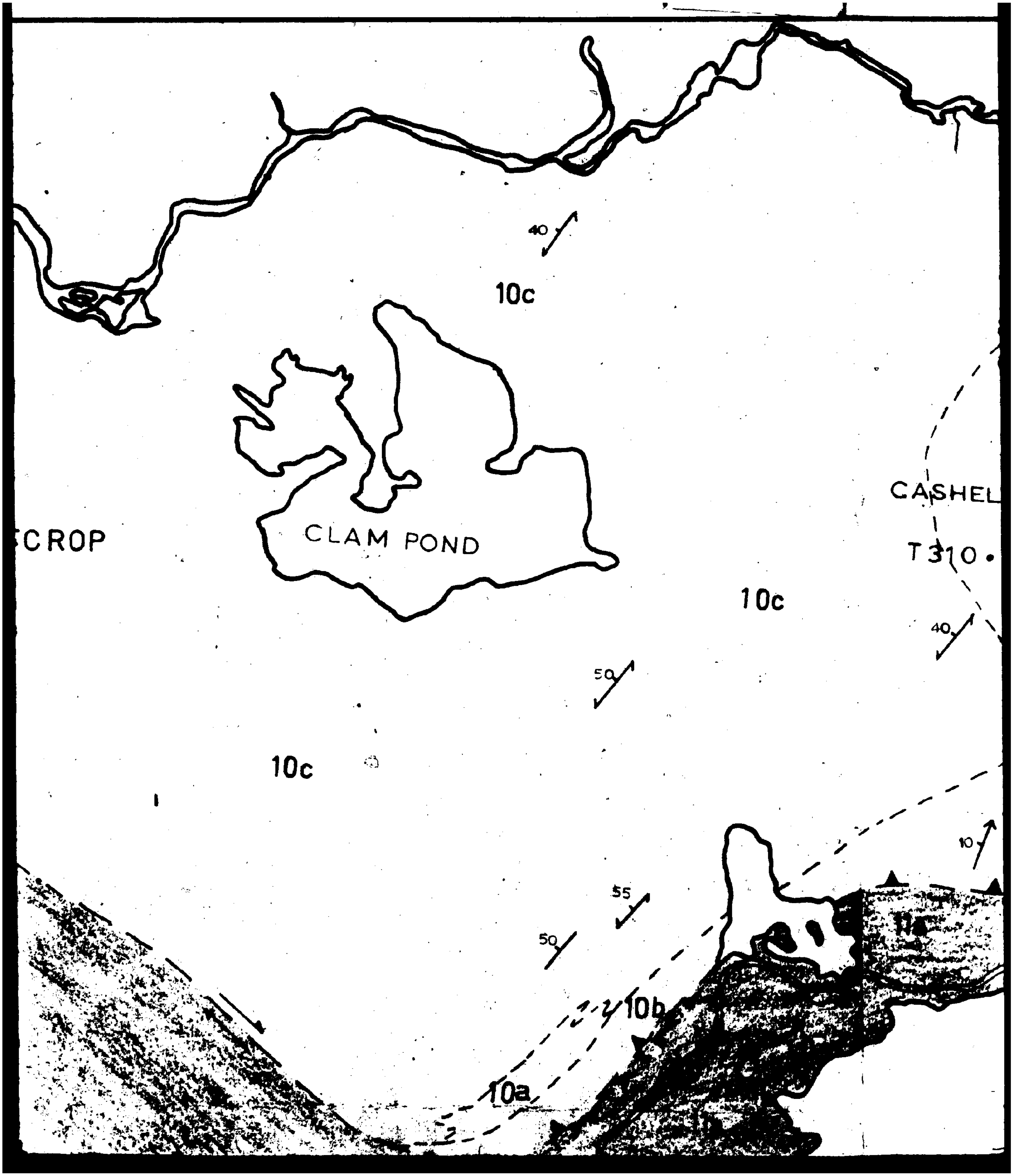

N
AREA 2
ATLANTIC OCEAN
48°
TRINITY BAY
AREA 1
j
ST JOHN'S
AVALON PENINSULA
47°
51°
25
0
25
50
75
100
KILOMETERS

6 of 6

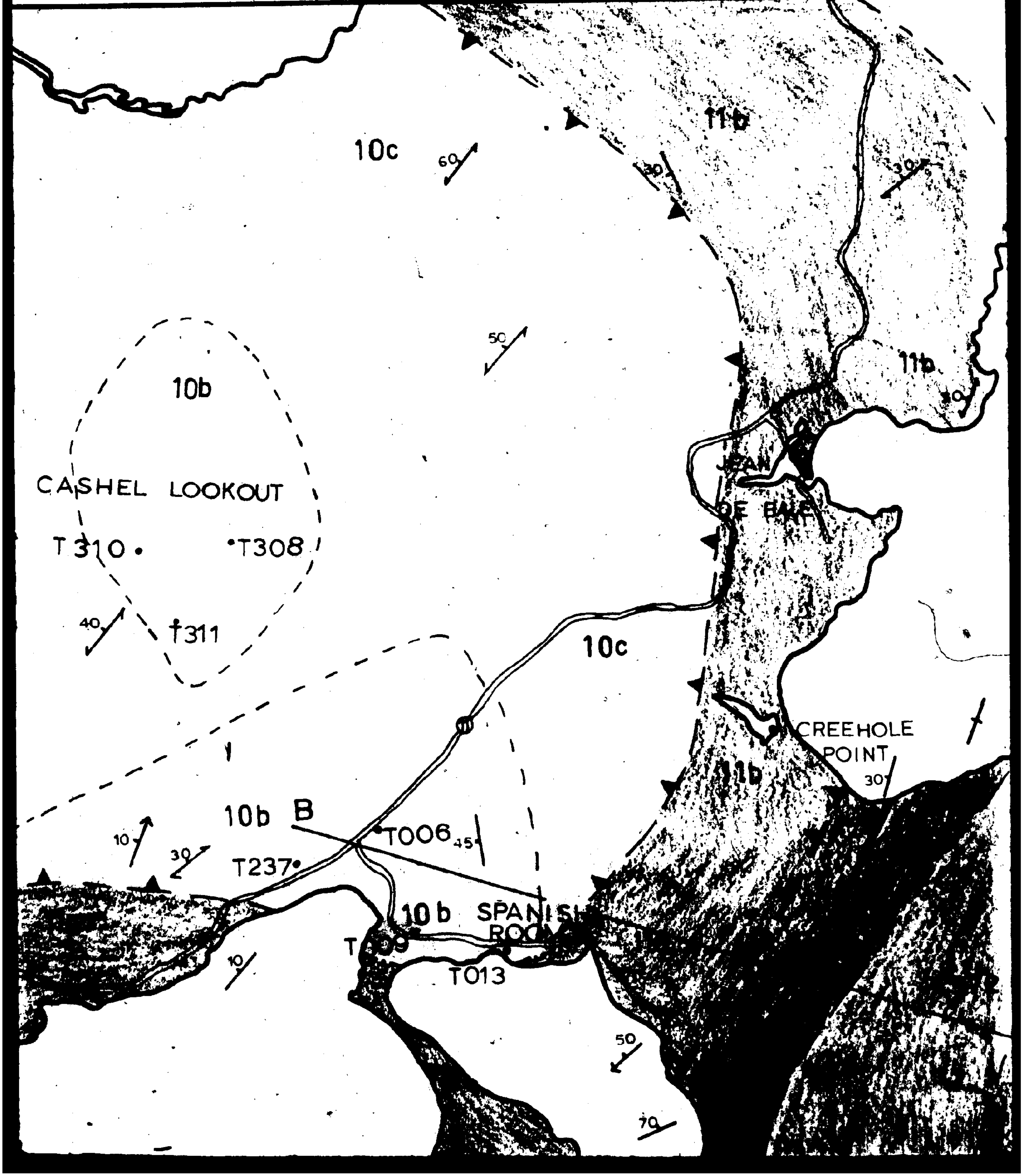
1 oF



55°15′
47°15′
10c
10c
25
10a
30
10a
11a
?
?
BLACK RIVER
POND
AREA OF LITTLE OR NO OUTCROP
GARNISH POND
11a

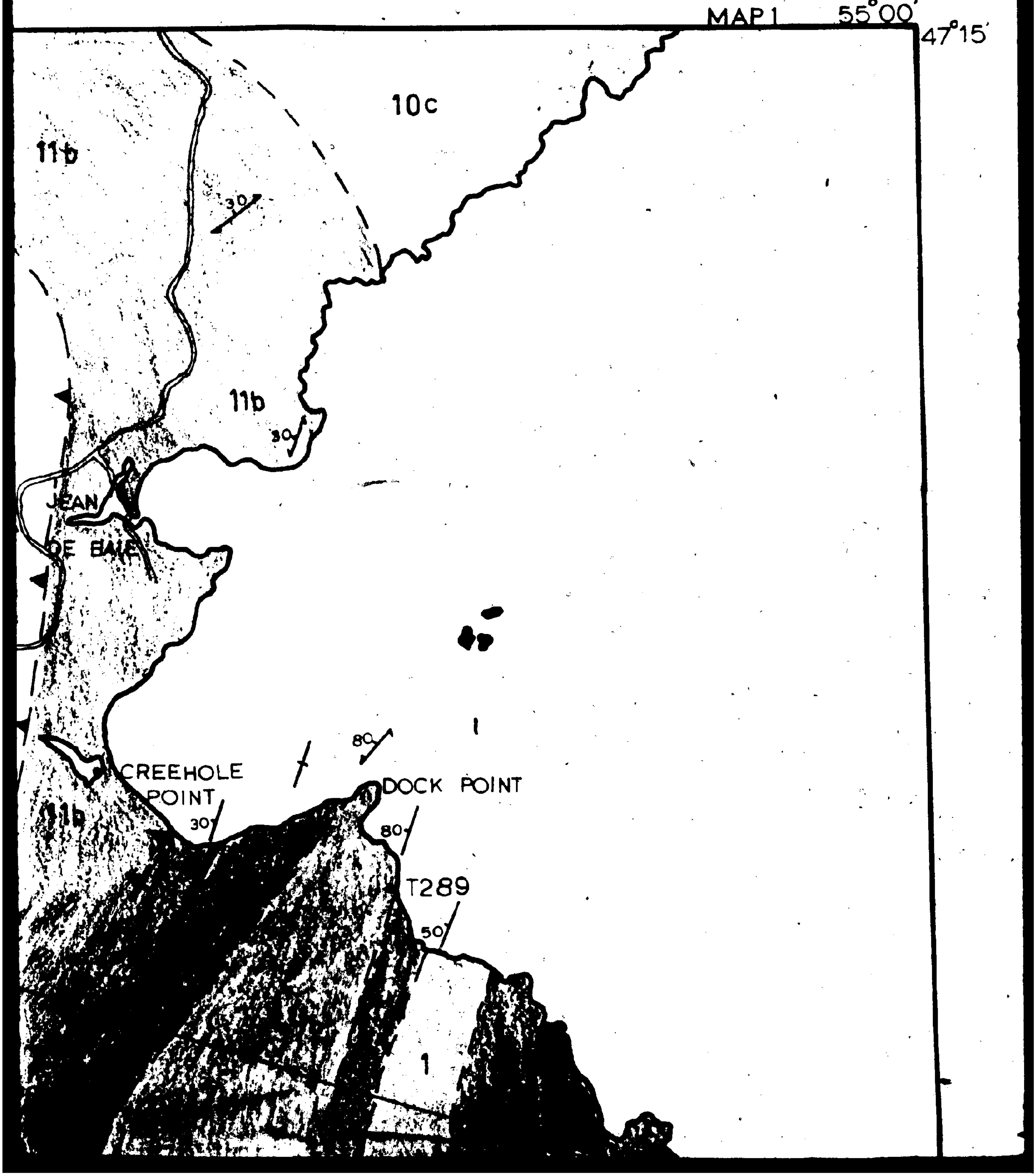

40
10c
CLAM POND
CROP
CASHEL
T310
10c
40
50
10c
10
55
50
11a
10b
10a

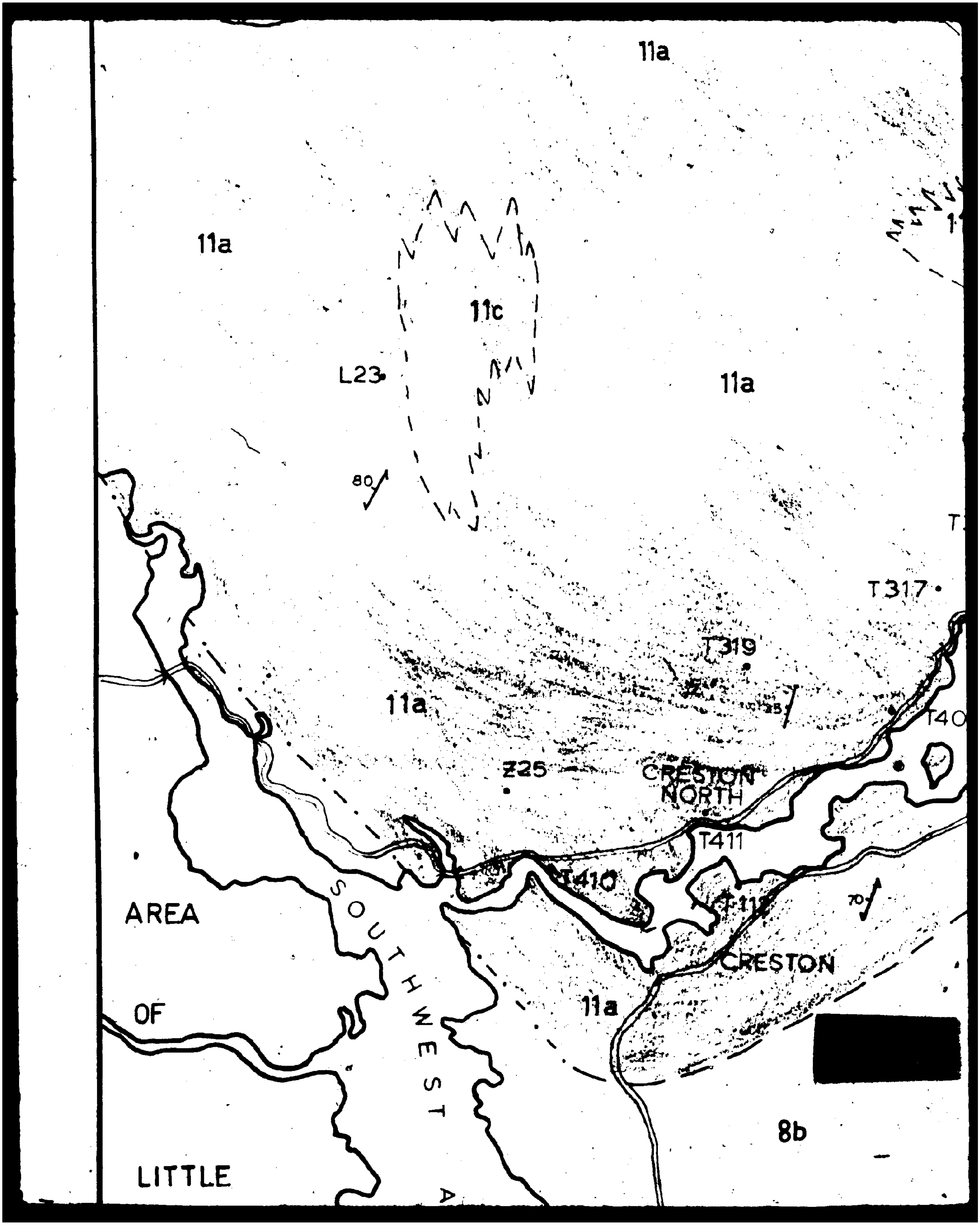
3 of

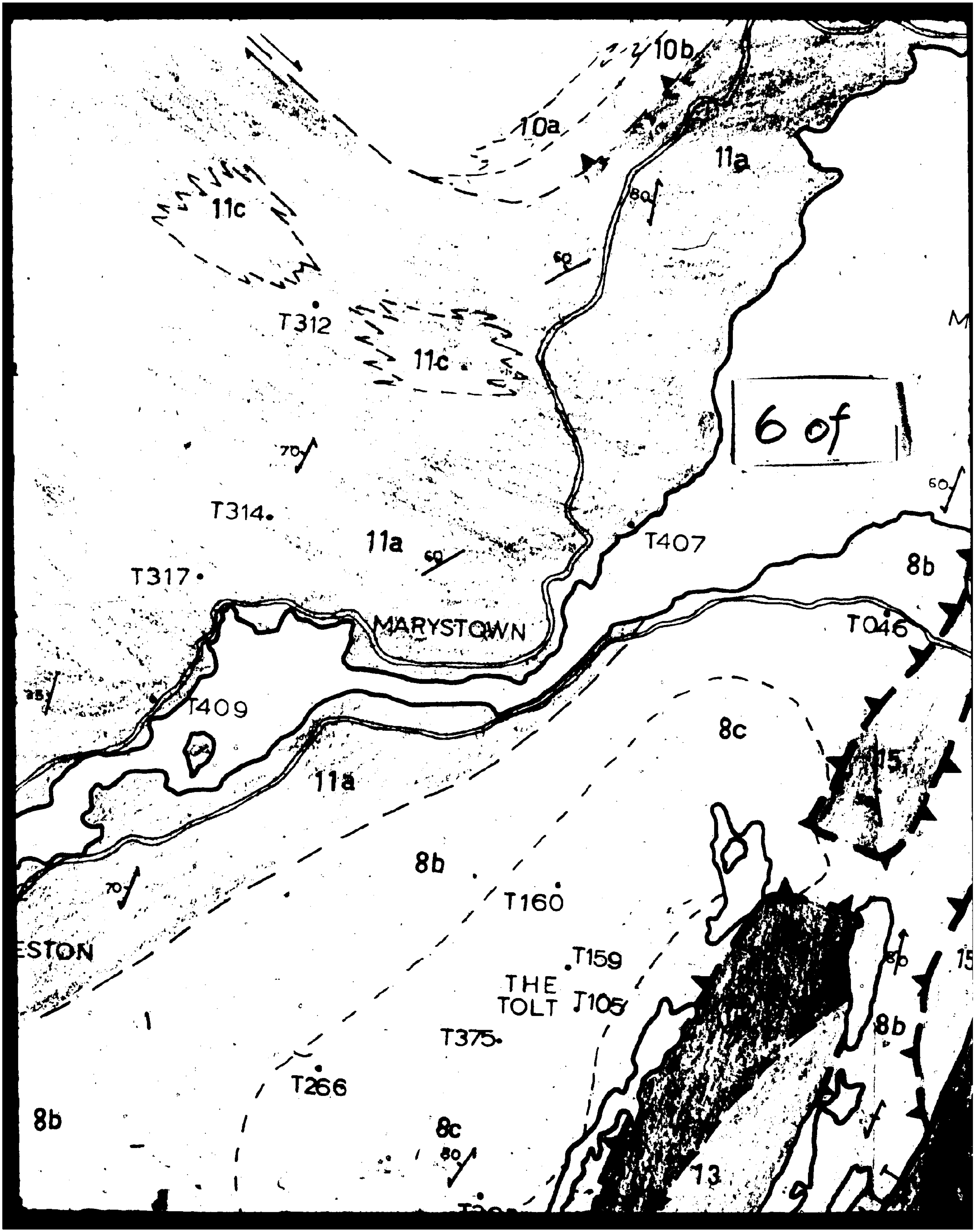

10c
60
11b
30
30
50
10b
11b
10
CASHEL LOOKOUT
T310
T308
JEAN
DE BAIE
40
T311
10c
CREEHOLE
POINT
30
11b
10b B
T006
45
10
30
T237
10b SPANISH
ROCK
T009
T013
10
50
70

[redacted]

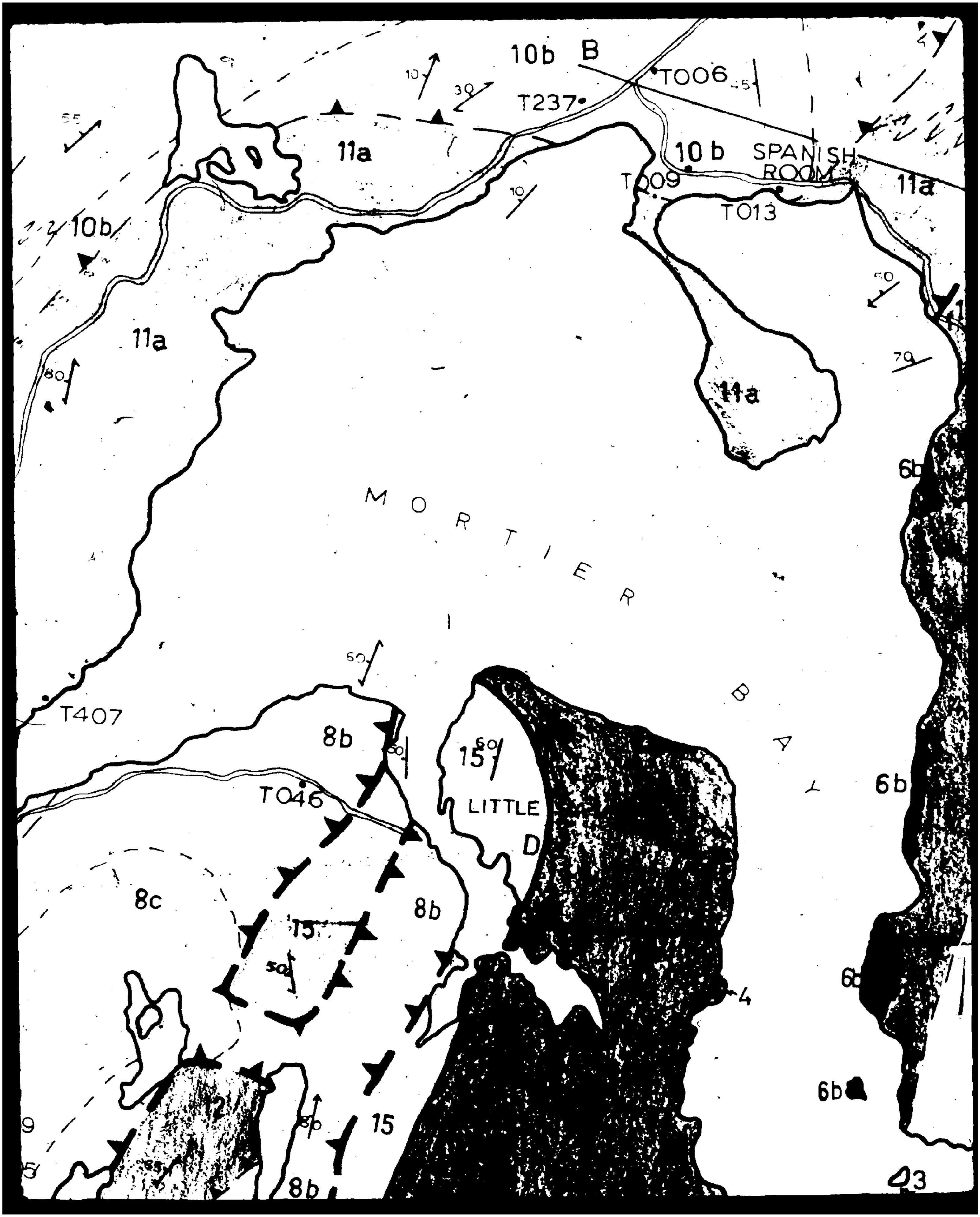
MAP 1

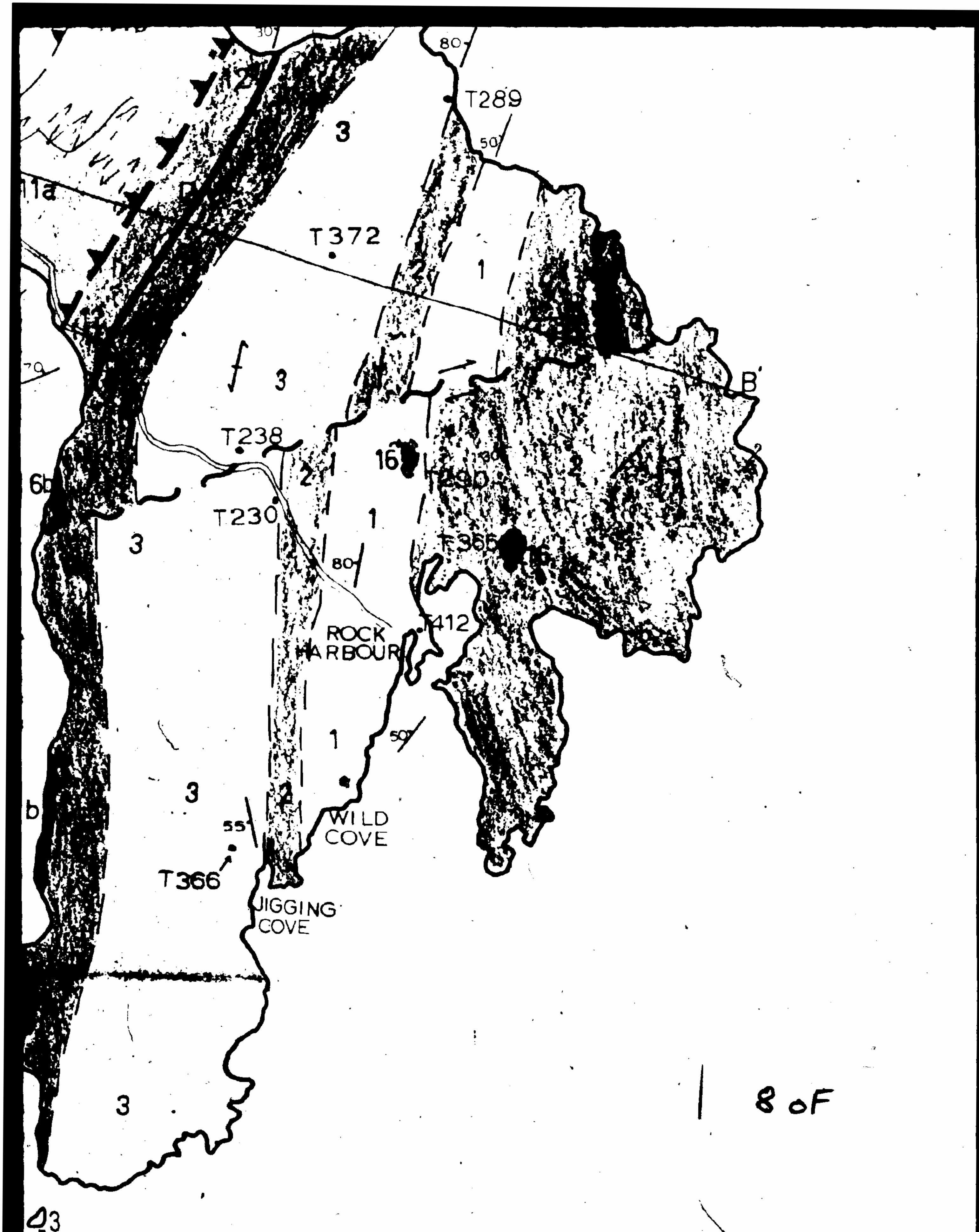



11a
11a
11c
L23
11a
80
T317
T319
25
11a
T40
Z25
CRESTON
NORTH
T411
T410
T112
70
AREA
OF
LITTLE
SOUTHWEST
A
11a
CRESTON
8b


10b
10a
11a
80
11c
60
T312
11c
M
70
T314
11a
60
T407
8b
T317
60
MARYSTOWN
T046
35
T409
8c
15
11a
8b
70
T160
ESTON
T159
80
15
THE
TOLT
T105
8b
T375
T266
8b
8c
80
13

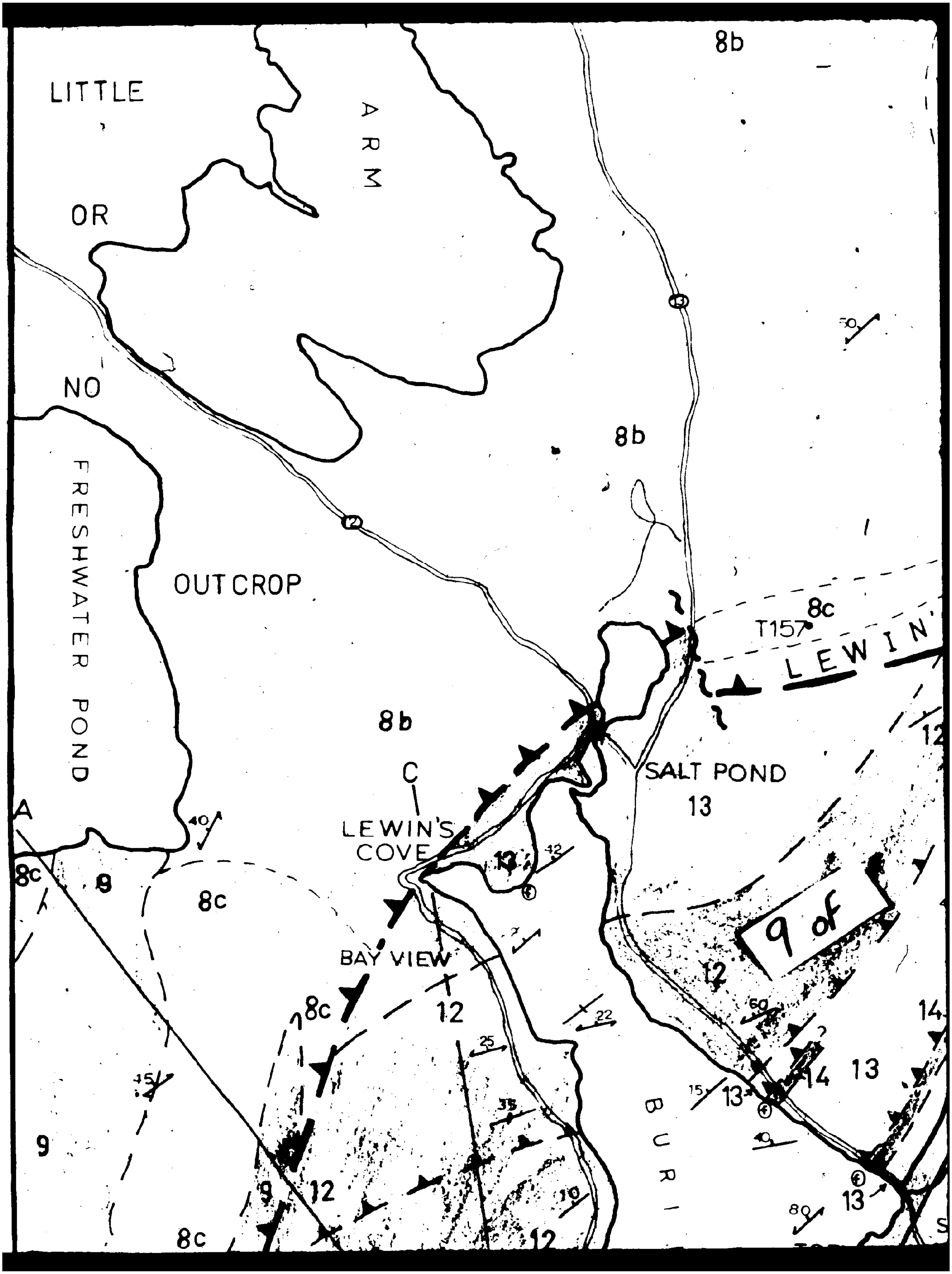
6 of

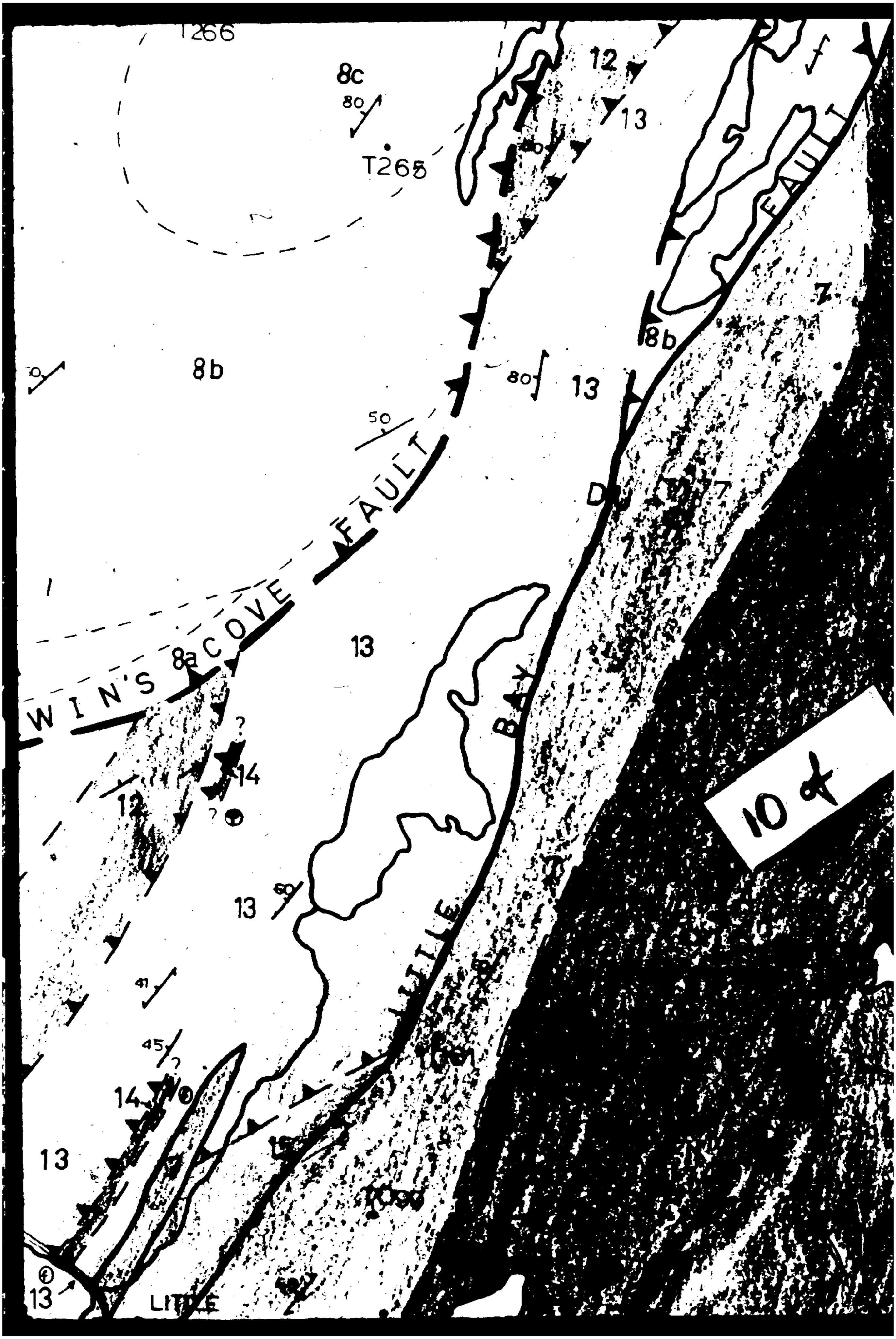

10b
B
T006
45
T237
30
10
55
11a
10b
10 b
SPANISH
ROOM
T009
T013
11a
10
11a
80
50
70
11a
MORTIER BAY
6b
60
T407
8b
60
15
60
LITTLE
D
T046
8c
8b
15
50
4
6b
6b
6b
80
15
8b
85
9
3

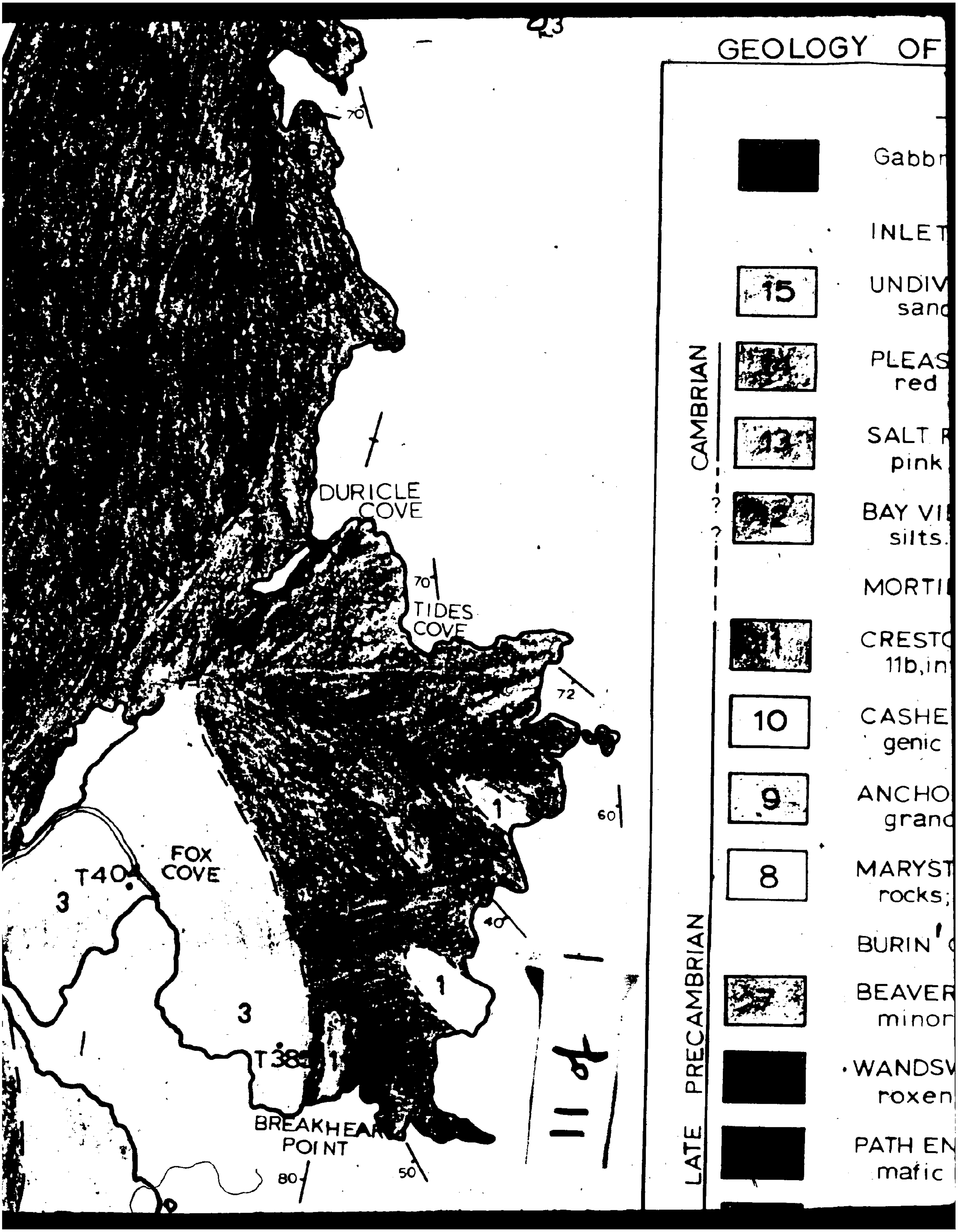


8 oF

GEOLOGY OF MAP SHEET 1M3 (E/2)


LITTLE
OR
NO
OUTCROP
ARM
FRESHWATER POND
8b
8b
8b
8c
T157
LEWIN'
12
SALT POND
13
C
LEWIN'S
COVE
A
8c
9
8c
40
42
13
BAY VIEW
12
8c
12
22
25
35
45
9
9
12
8c
12
10
9 of
12
60
14
13
14
15
13
B
U
R
I
80
13


T266
8c
80
T265
12
13
8b
8b
FAULT
7
80
13
50
WIN'S COVE FAULT
8a
13
14
12
D
7
BAY
10 a
13
50
41
LITTLE
45
14
13
13
LITTLE



GEOLOGY OF
Gabbr
INLET
15
UNDIV
sand
CAMBRIAN
14
PLEAS
red
13
SALT R
pink
?
?
12
BAY VI
silts.
MORTI
11
CRESTO
11b,in
10
CASHE
genic
9
ANCHO
grand
8
MARYST
rocks;
BURIN
LATE PRECAMBRIAN
BEAVER
minor
WANDSW
roxen
PATH EN
mafic
DURICLE COVE
TIDES COVE
FOX COVE
BREAKHEAD POINT
T40
T38
3
3
1
1
1
70
70
72
60
40
80
50

GEOLOGY OF MAP SHEET 1M3 (E/72)

LEGEND

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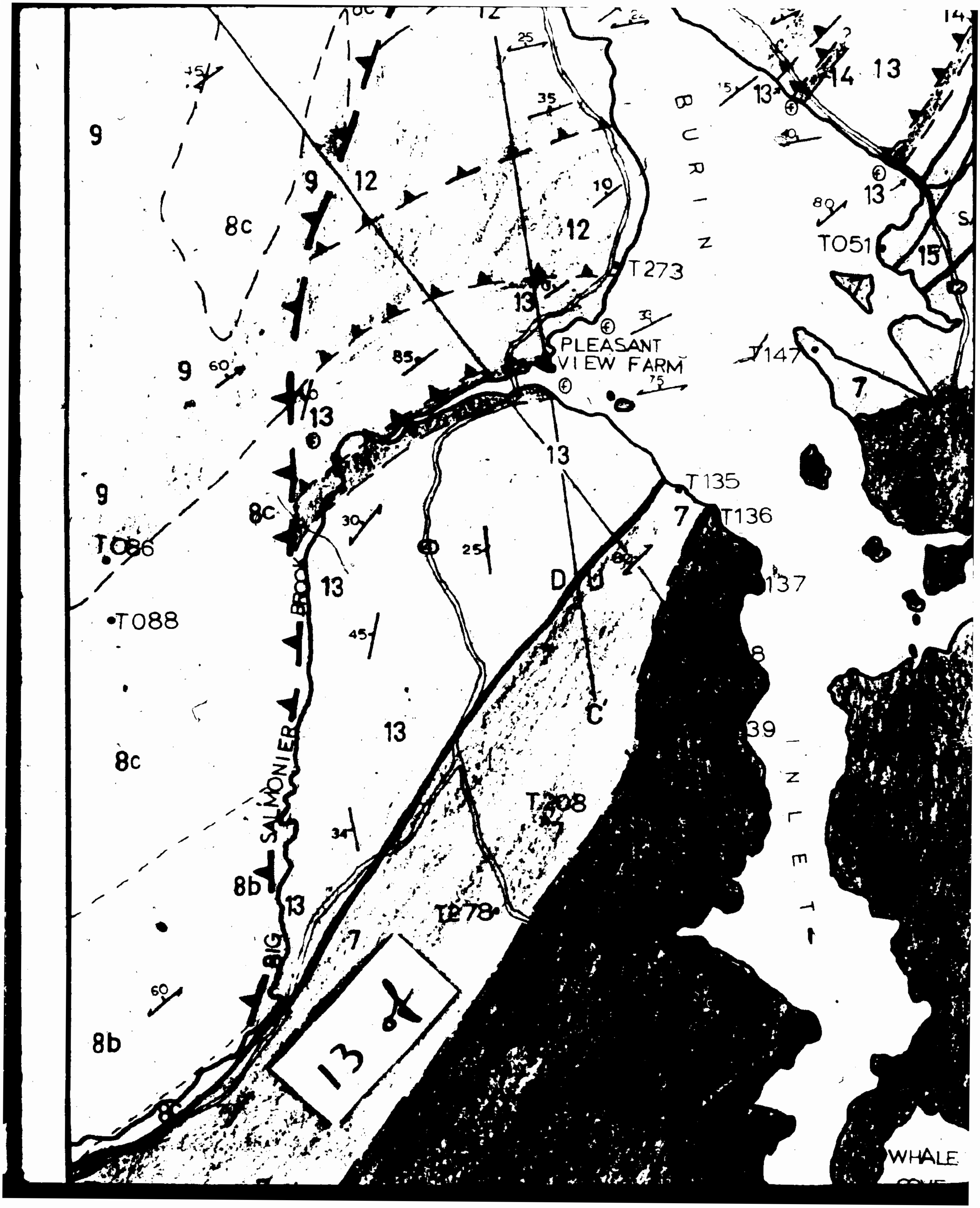
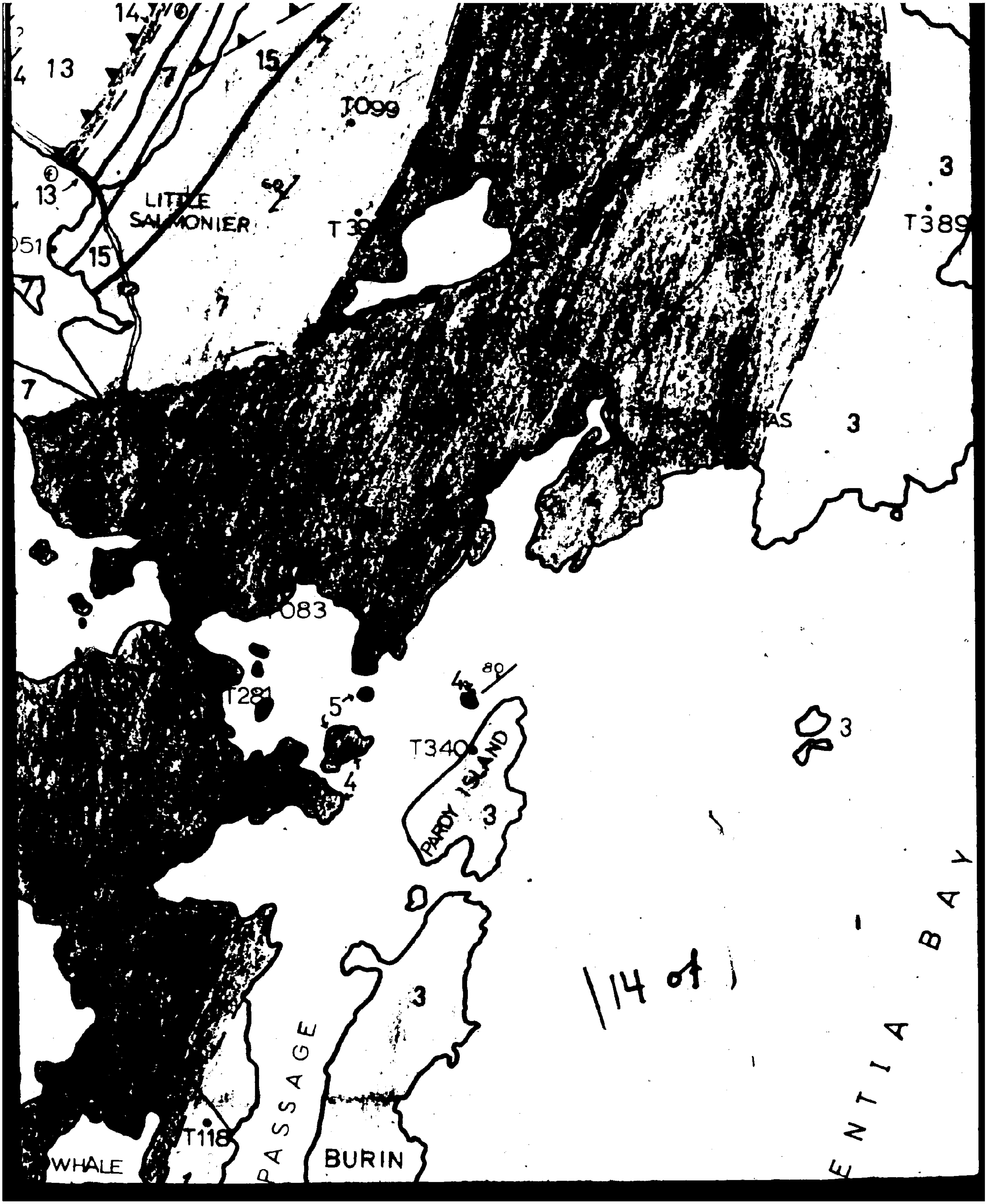
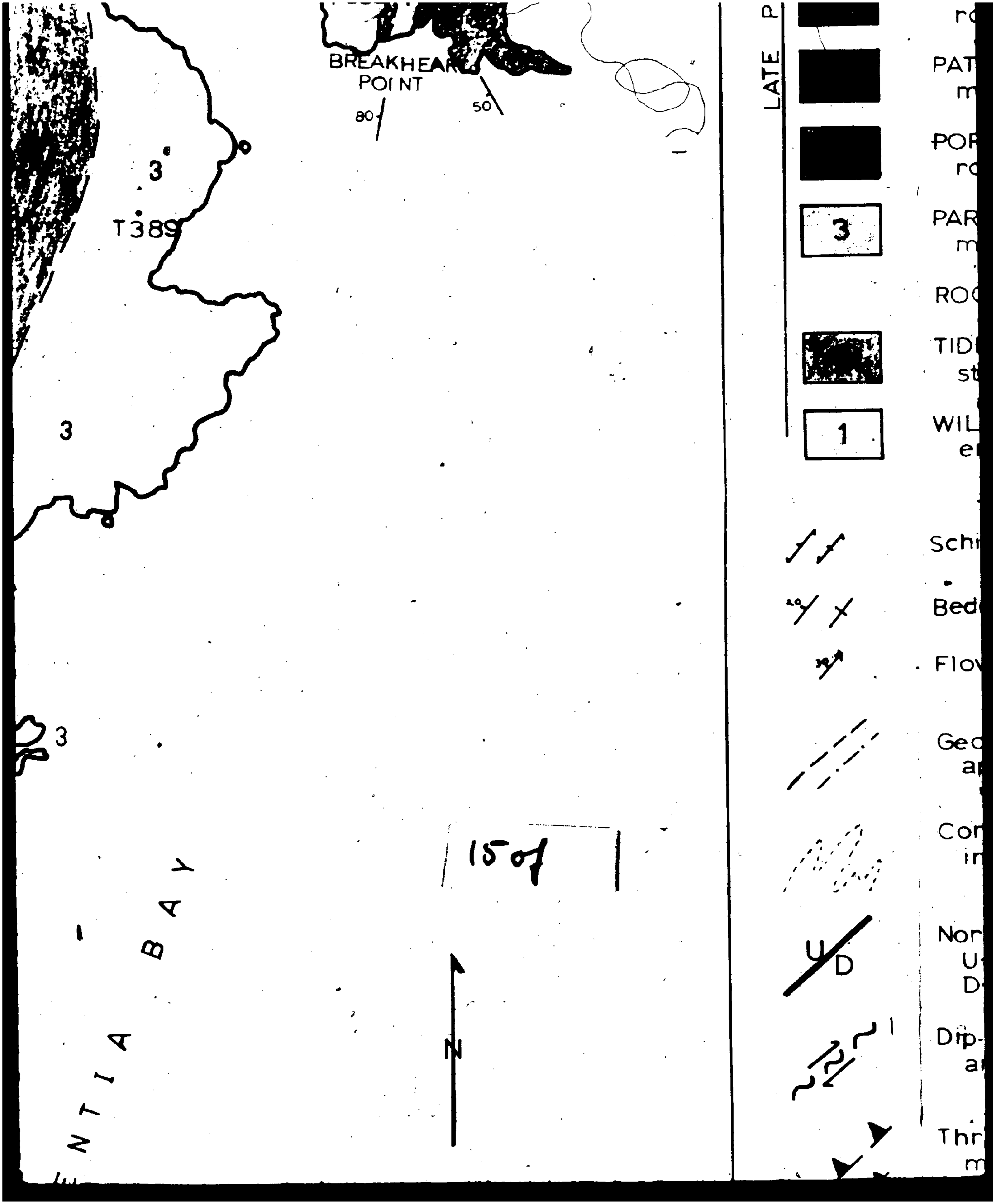
	■	Gabbroic dykes and plugs of unknown age
		INLET GROUP (12,13,14,15)
CAMBRIAN	15	UNDIVIDED: red and grey shale, siltstone and sandstone
	14	PLEASANT VIEW FARM FORMATION: green and red muds.; black and grey shale and silts.
	13	SALT POND FORMATION: red and green shale, pink, algal ls. and pink, nodular ls.
?	12	BAY VIEW FORMATION: red and green sands., silts. and shale; minor white quartzite
LATE PRECAMBRIAN		MORTIER BAY GROUP (10,11)
	11	CRESTON FORMATION: 11a, amygdaloidal basalt; 11b, intermediate pyrocl.; 11c, acid pyrocl.
	10	CASHEL LOOKOUT FORMATION: 10a, volcanogenic sed. rocks; 10b, rhyolite; 10c, pyroclastics
	9	ANCHOR DROGUE PLUTON: quartz monzonite, granodiorite and roof pendants of 8
	8	MARYSTOWN GROUP: 8a, volcanogenic sed. rocks; 8b, acid pyroclastic rocks; 8c, rhyolite
		BURIN GROUP (3,4,5,7)
	7	BEAVER POND FORMATION: pillow basalt; minor algal (?) limestone
	■	WANDSWORTH SILL: 6a, gabbro with minor pyroxenite, anorthosite; 6b, granodiorite
	■	PATH END FORMATION: pillow basalt, minor mafic pyroclastic rocks
	■	PORT AU BRAS FORMATION: mafic pyroclastic


BURIN
INLET
PLEASANT
VIEW FARM
BIG SALMONIER BROOK
WHALE
T273
T135
T136
137
39
T147
T051
T086
T088
T208
T278
D
C'
9
8c
8b
12
13
14
15
7
45
25
35
22
15
10
80
33
85
60
75
30
25
45
34
60
13


14
13
15
7
T099
LITTLE SALMONIER
T39
13
051
15
7
7
3
T389
AS
3
T083
4
80
T281
5
T340
PARDY ISLAND
3
4
3
3
PASSAGE
BURIN
T118
WHALE
ENTIA BAY

14 of


BREAKHEAD POINT
80
50
3
T389
3
3
NTIA BAY
N
LATE P
ro
PAT m
POR ro
3
PAR m
ROC
TID st
1
WIL e
Schi
20
Bed
30
Flov
Geo a
Cor in
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D
Nor U D
Dip- a
Thr m

15 of

LA

■ mafic pyroclastic rocks

■ PORT AU BRAS FORMATION: mafic pyroclastic rocks and tuff. sed. rocks; minor algal ls.

3 PARDY ISLAND FORMATION pillow basalt; minor tuffaceous sed. rocks and limestone

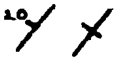
ROCK HARBOUR GROUP (1,2)

▨ TIDES COVE FORMATION: grey siltstone, sandstone, greywacke; minor limestone cong.

1 WILD COVE FORMATION: polymictic conglomerate; minor grey sandstone

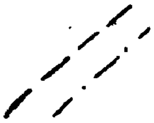
SYMBOLS


Schistosity (inclined, vertical)



Bedding (inclined, vertical)

Flow Banding


Geological Contact
approximate, assumed


Contact
intertonguing members

Normal Fault
U-upthrown side
D-downthrown side

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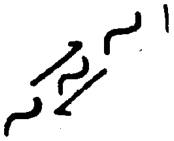
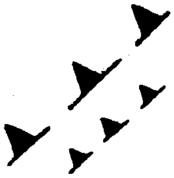
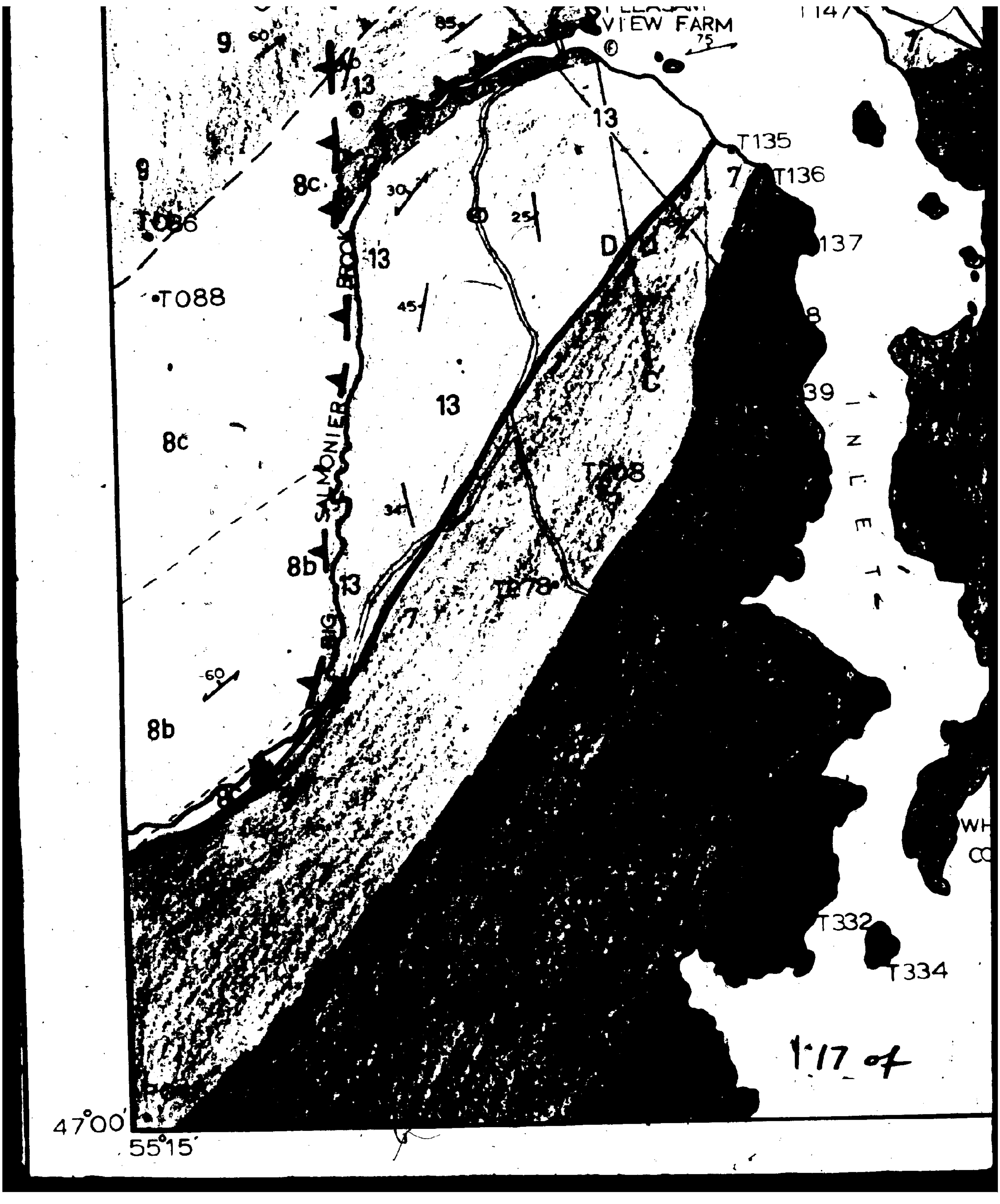
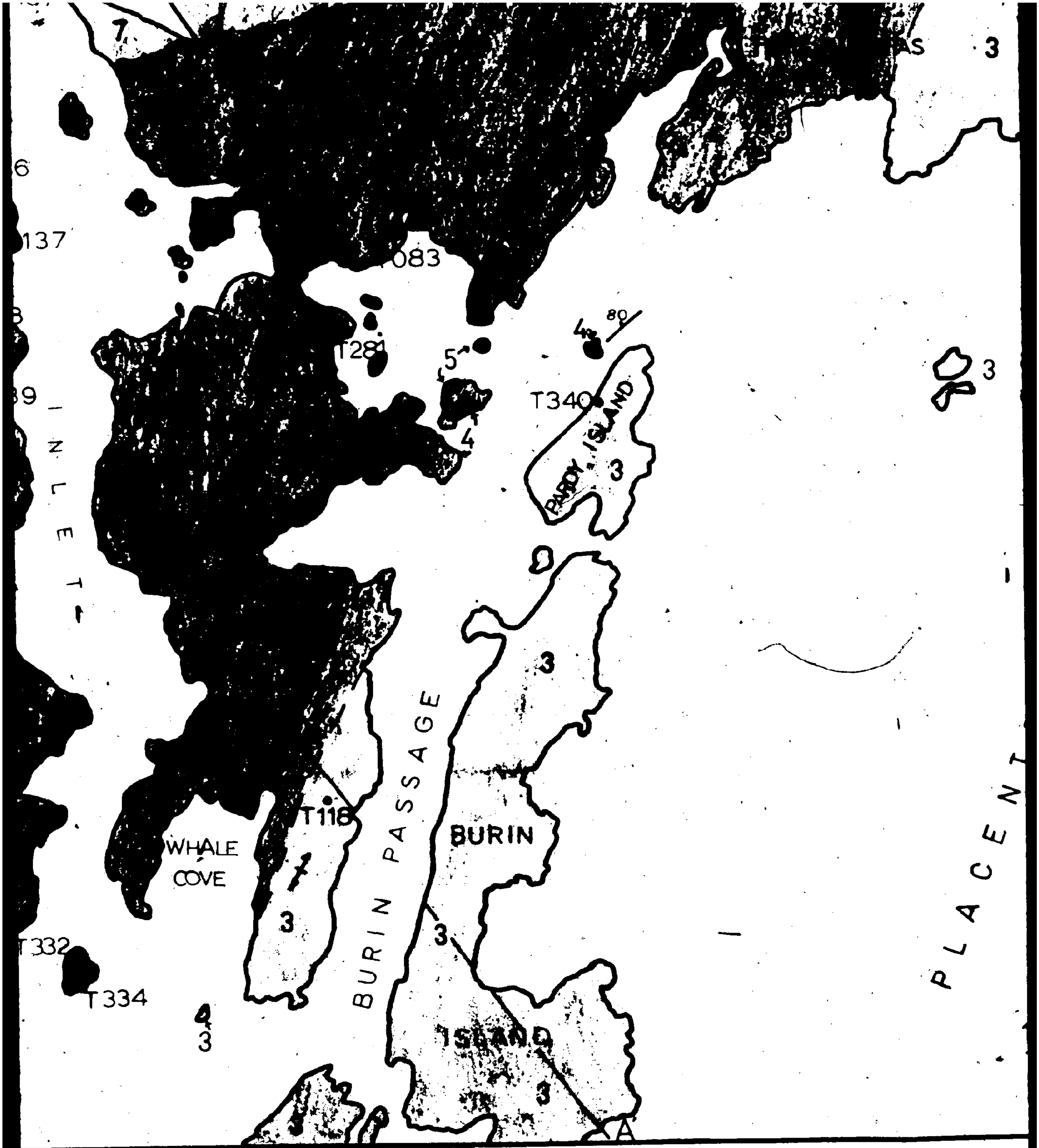

Dip-slip Fault
arrows indicate relative movement

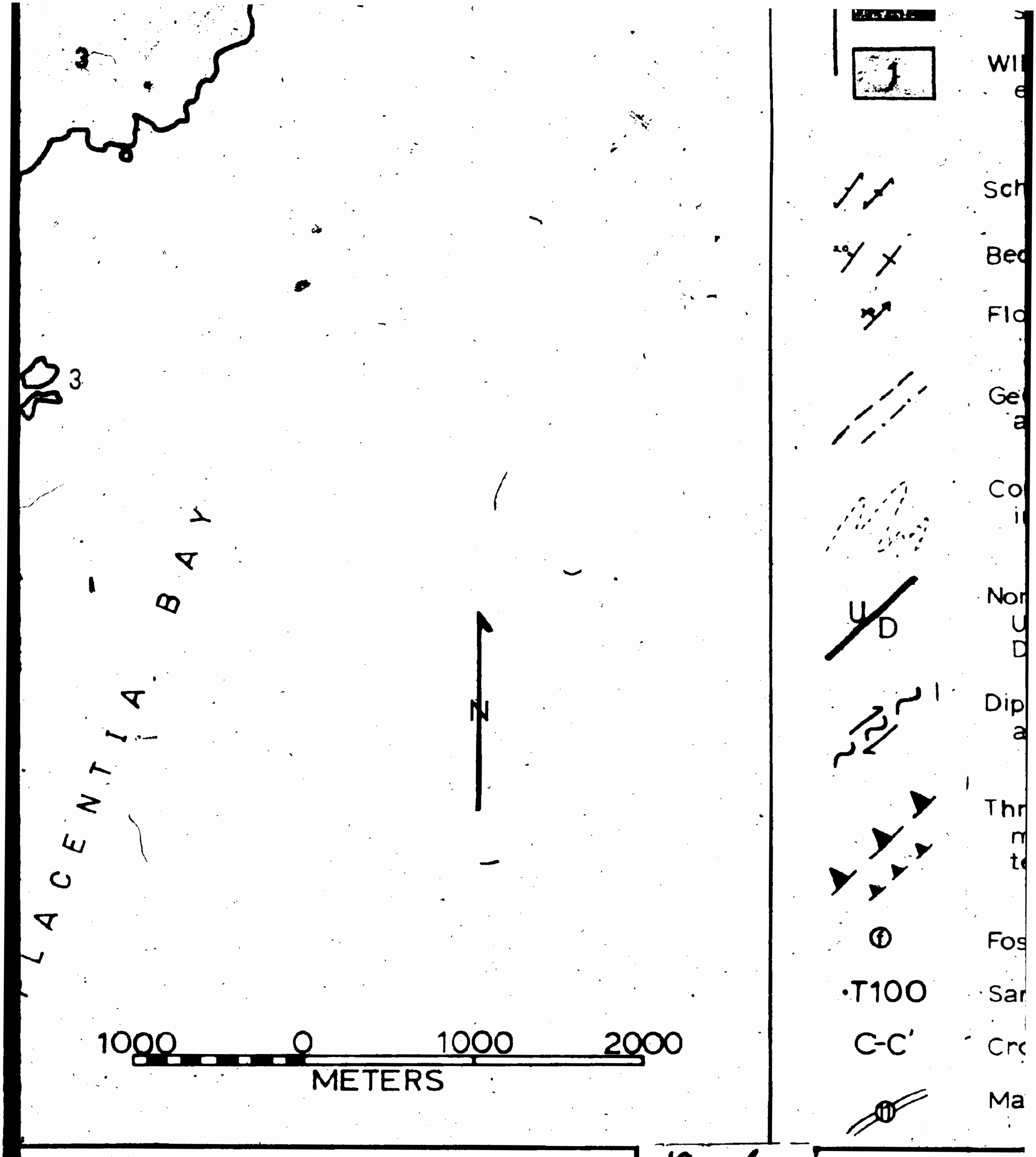

Thrust Fault
major, minor
teeth in direction of dip


PLEASANT
VIEW FARM
T147
9
60
85
13
75
13
T135
7
T136
9
8c
T086
30
60
25
D
137
BROOK
13
T088
45
8
C
39
13
INLET
8c
SALMONIER
T208
34
8b
13
T278
BIG
7
60
8b
8c
WH
CO
T332
T334
47°00'
55°15'

1·17 of


7
S
3
6
137
083
T281
5
4
80
T340
PARDY ISLAND
3
3
39
INLET
4
3
BURIN PASSAGE
T118
BURIN
WHALE COVE
3
3
T332
T334
4
3
ISLAND
3
3
A
PLACENT

18 of 1


3
3
LACENTIA BAY
N
1000 0 1000 2000
METERS
WI
e
Sch
Bed
Flo
Ge
a
Co
i
U D
Nor
U
D
Dip
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Thr
m
t
Fos
·T100
Sar
C-C'
Cro
Ma

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▨	TIDES COVE FORMATION grey siltstone, sandstone, greywacke; minor limestone cong.
1	WILD COVE FORMATION: polymictic conglomerate; minor grey sandstone

SYMBOLS

/ /	Schistosity (inclined, vertical)
20 / ×	Bedding (inclined, vertical)
30 ↗	Flow Banding
- - - - · - ·	Geological Contact approximate, assumed
· · · ·	Contact intertonguing members
U / D	Normal Fault U-upthrown side, D-downthrown side
⇅	Dip-slip Fault arrows indicate relative movement
▲ ▲	Thrust Fault major, minor teeth in direction of dip
ⓕ	Fossil Locality
·T100	Sample Location
C-C′	Cross Section
⑪	Main Road

GEOLOGY BY S.W.T.
DRAFTED BY S.W.T.

47°00′
55°00′

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